U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF ORNITHOLOGY AND MAMMALOGY

NORTH AMERICAN FAUNA

No. 8

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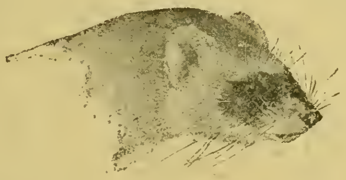


MONOGRAPHIC REVISION

OF THE

POCKET GOPHERS

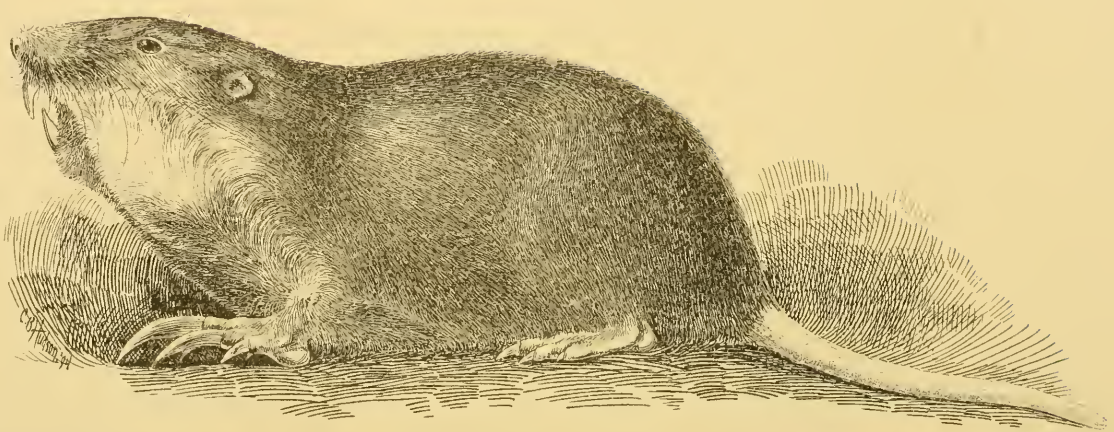
Family GEOMYIDÆ

(Exclusive of the species of *Thomomys*)

BY

Dr. C. HART MERRIAM

WASHINGTON
GOVERNMENT PRINTING OFFICE
1895



B. Meisel photo.

GEORGIA POCKET GOPHER, GEOMYS TUZA (Ord) TYPE OF THE GENUS GEOMYS no. 6, 9 never issued,—

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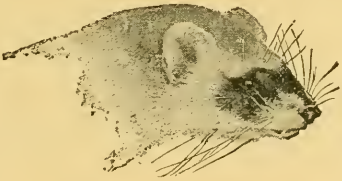

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 26, 1894.

SIR: I have the honor to transmit herewith, as No. 8 of North American Fauna, a Monographic Revision of the Family *Geomyidæ*, exclusive of the species of *Thomomys*.

In preparing a bulletin on the economic relations of the Pocket Gophers it became necessary to determine the status and geographic distribution of the various forms. This study developed the fact that the group was sorely in need of technical revision. The present paper is the outgrowth of an attempt at such a revision. It has grown so far beyond the limits originally intended that a large genus (*Thomomys*) has been of necessity omitted and will form the subject of a subsequent paper.

The results of the economic study of the group will appear as a separate bulletin prepared by my assistant, Mr. Vernon Bailey.

Respectfully,

C. HART MERRIAM,
Chief of Division of
Ornithology and Mammalogy.

HON. CHAS. W. DABNEY, Jr.,
Acting Secretary of Agriculture.

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REVISION OF THE POCKET GOPHERS, FAMILY GEOMYIDÆ, EXCLUSIVE OF THE SPECIES OF THOMOMYS.

By Dr. C. Hart Merriam.

INTRODUCTION.

The present paper is based on a study of the rich collection of Pocket Gophers belonging to the U. S. Department of Agriculture, comprising upwards of 800 specimens, exclusive of the genus *Thomomys*. This material has been supplemented by 110 specimens from my private collection, and a number from the U. S. National Museum,* making a total of about a thousand specimens, among which are by far the greater number of actual types known to be extant. The Department collection contains no less than 200 specimens from Mexico, most of which were secured by Mr. E. W. Nelson, a field naturalist of the Division. These, together with a few highly interesting specimens from Costa Rica and Guatemala in the U. S. National Museum, have enabled me not only to bring together for actual comparison all of the species previously described, and to add a considerable number heretofore unknown, but also to recognize several marked generic types whose existence had not been suspected.

Critical study of this unparalleled wealth of material has led to the discovery of some very remarkable dental peculiarities that have been deemed worthy of detailed description and illustration. Moreover, the opportunity has been utilized to contribute a chapter on the morphology of the skull, which it is hoped will prove of service to those interested in the craniology of the Rodentia.

It is a matter of deep regret that the magnificent series of specimens of living forms on which the present paper is based, has not been supplemented by a single fossil; and it is earnestly hoped that an opportunity may yet be found to study the remains of the extinct animals that have been referred to the family—correctly or otherwise—in comparison with the rich collection of living types now in our National Museum. If the theory is correct, that the group has attained its greatest expansion in the present age, we need not look to the rocks

*Placed at my disposal by the courtesy of Mr. F. W. True, Curator of Mammals.

for additional highly diversified types, but only for the links that bind the several phyla together and connect them with the more primitive forms from which they came. These would be of the utmost interest.

The author is indebted to Mr. F. W. True, Curator of Mammals in the U. S. National Museum, for the privilege of describing two species from Central America; to Dr. J. A. Allen, of the American Museum of Natural History, New York, for the privilege of examining the type of his *Geomys cherriei;* and to Mr. H. P. Attwater, of San Antonio, Texas, for the loan of a large series of the subspecies here described as *Geomys breviceps attwateri.* The author is under special obligations to Mr. Oldfield Thomas, Curator of Mammals in the British Museum, and to Dr. Paul Matschie, of the Royal Museum of Natural History in Berlin. Mr. Thomas has kindly compared specimens sent him for that purpose with his own types in the British Museum, and has also contributed measurements and other details of importance. Dr. Matschie has been good enough to remeasure the original types of Peters' *Geomys heterodus* and Lichtenstein's *Geomys mexicanus*, which specimens are still extant in the Berlin Museum, and has further taken the trouble to prepare and send me a table of cranial measurements of the skulls of these same types, with much other information of importance respecting them. And Dr. F. A. Jentink, the able director of the Leiden Museum, has done me the favor to send additional particulars about the Bullock specimen of *Geomys bursarius*, still extant in the Leiden Museum, which specimen has given rise to much controversy and is supposed to be Shaw's original type of the species.

From time to time during the preparation of the work, collectors have been sent to special localities from which new or supplemental material was desired, thus making it possible to settle many points that were originally in doubt. Much has been learned respecting the habits and mode of life of the animals from a living *Geomys lutescens* sent from Vernon, Texas, by my field assistant, Mr. J. Alden Loring. This animal was kept in confinement until sufficiently tame to permit handling freely and was the means of the discovery of a surprisingly large number of interesting facts that otherwise would have escaped detection.

Respecting the illustrations, the frontispiece was drawn by Mr. C. B. Hudson; plate 1 by Mr. Benjamin Mortimer; text figures 1 and 2 by Dr. George Marx; figures 5, 19, 63, 65, and 66 by Dr. James E. McConnell; and all of the outline camera lucida drawings of teeth by myself. Plates 2 to 19, inclusive, and all of the remaining text figures were drawn under my constant supervision by Mr. F. Müller. All of the twenty full-page plates have been reproduced by photolithography by Mr. Berthold Meisel, of Boston, and the text figures, with two or three exceptions, have been electrotyped from the originals by Mr. Harry C. Jones, of New York.

It will be observed that the generic names engraved on most of the plates (pls. 2–6, 8, and 10–16) do not agree with the generic names in the text. This misfortune is the result of having the plates printed before the genera were finally segregated. The correct names are given in all cases on the explanations facing the plates.

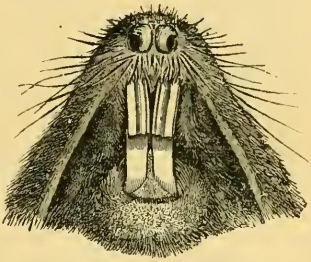
The literature relating to the group is rarely referred to in the present paper, except for original descriptions. The reason is that previous papers have been based on insufficient material. To use them at all would necessitate a large amount of explanation and criticism without corresponding advantage.

All the measurements in the present paper are in millimeters.

CHAPTER I.

GENERAL REMARKS.

The family *Geomyidæ*, comprising the mammals commonly known as Pocket Gophers, is confined to North America, where it ranges from the plains of the Saskatchewan in Canada southward to Costa Rica. It attains its highest development in the western United States and Mexico, and does not inhabit the region east of the Mississippi Valley except in the Gulf States, where it reaches the Atlantic coast in Florida and Georgia, but does not occur north of the Savannah River.



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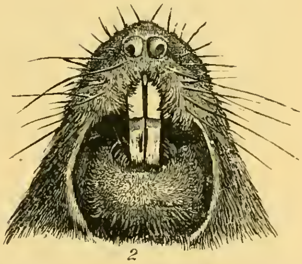

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FIG. 1.—Face of *Geomys bursarius*, showing grooved upper incisors and openings of cheek pouches.

FIG. 2.—Face of *Thomomys talpoides*, showing plane upper incisors and openings of cheek pouches.

The appearance of a characteristic species is well shown in the frontispiece, and the peculiar aspect of the face in the accompanying cut (figs. 1 and 2), which shows the openings of the cheek pouches, wholly outside of the mouth, and also the pattern of the upper incisor teeth in two of the commonest genera, *Geomys* and *Thomomys*.

All the members of the family spend their entire lives underground, and their whole organization is modified in accordance with the needs of a subterranean existence. The species, though numerous, are very much alike externally. They are short-legged, thickset animals, without an appreciable neck, without noticeable external ears, and with very small eyes. The feet are largely developed for digging. The fore paws in particular are very strong, are armed with long curved claws,* and the sides of the toes are lined with rows of bristles that evidently serve in preventing the dirt from

*The relative development of the claws is largely a matter of age and soil. They continue to increase in size throughout the life of the individual; their points are worn off in hard soil so that the claws become thick and blunt. In sandy soil they do not meet enough resistance to produce the usual wear, and, consequently, are longer and more slender than normal.

passing between the fingers (fig. 3), thus completing a more effective arrangement for keeping the tunnels clean, and for pushing the earth out of the openings in the burrows. The tail, which is of moderate length, is thick, fleshy, and usually devoid of hair, and is endowed with tactile sensibility.

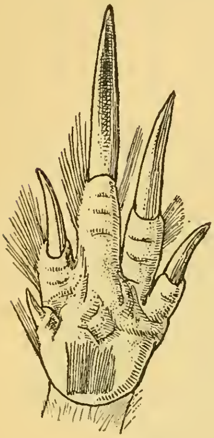


FIG. 3.—Left fore foot of *Geomys personatus*, showing the rows of bristles which form brushes on the sides of the toes.

The Pocket Gophers, in working their way through the earth in the construction of their tunnels, use the powerful upper incisors as a pick to loosen the ground. At the same time the fore feet are kept in active operation, both in digging and in pressing the earth back under the body, and the hind feet are used also in moving it still further backward. When a sufficient quantity has accumulated behind the animal, he immediately turns in the burrow and by bringing the wrists together under the chin, with the palms of the hands held vertically, forces himself along by the hind feet, pushing the earth out in front. When an opening in the tunnel is reached the earth is discharged through it, forming a little hillock that resembles in a general way the hills thrown up by moles. In many species there is a naked callosity or 'nasal pad' over the anterior half of the nose, which must be of great assistance in the construction of the tunnels. When this callosity is largely developed the nasal bones underneath are highly arched or inflated, as in *Heterogeomys hispidus*.

PROGRESSION BACKWARD AS WELL AS FORWARD.

The *Geomys lutescens* already mentioned from Vernon, Texas, which I kept alive for several months, surprised me very much by running backward as rapidly and easily as forward. This method of progression was particularly noticeable when the animal was in his own quarters where he could follow a runway or an accustomed route. When carrying food to one of his storehouses he rarely turned around, but usually ran backward to the place of deposit, returning for more, and repeating the operation again and again, the to-and-fro movement suggesting a shuttle on its track. The well-known peculiarity of the external genitalia, which are so hidden and modified that the sexes are determined with difficulty, is doubtless the result of this habit, protecting the parts from injury when the animal is moving backward.

THE TAIL AN ORGAN OF TOUCH.

Throughout the family *Geomyidæ* the tail is rather large and fleshy, and as a rule is naked or scantily haired;* it varies in length in the

* The tail is naked in most of the southern species and is more or less covered with hair in the northern species. The latter have much more hair on the tail in winter than in summer.

various species from about 65 to 115 mm. The function of this peculiar appendage had long puzzled me, but by watching the live *Geomys* above mentioned as it ran backward in its runways I saw that it was used as an organ of touch. It is doubtless endowed with special tactile sensibility and is evidently of great value in warning the animals of the presence of an enemy in the rear when they are traveling backward in their dark tunnels. So far as I am aware this is the only instance in which the tail of a mammal is used for this purpose.

POSITION OF THE FORE FEET.

In walking on soft ground the fore feet are usually held in the normal position, with the soles down, or inclined slightly inward. In walking on hard ground, however, the fore feet are turned sideways, their soles facing one another, so that the claws curve inward, and the animal walks on the outer or ulnar side of the foot. This method of using the fore foot in walking on hard substances was frequently observed, and enables the animal to walk comfortably where the long curved claws would be in the way if held in the normal position. It was also frequently noticed that the feet were held in the same position (horizontally) when at rest, and when used as a scoop in pushing loads of earth or sand out of the way. When thus engaged the feet were drawn back under the breast, the wrists near together and the long claws turned outward. By moving the body quickly forward the animal always succeeded in throwing ahead of it a considerable quantity of loose earth.

DIVISION OF THE MOUTH INTO TWO CHAMBERS.

The lips and thin furry covering of skin are drawn into the broad space between the incisors and molars, where they meet in a raphe on the roof of the mouth and then separate again to meet around the under jaw, forming a diaphragm-like partition between the incisors and molars. The orifice is small and wholly inferior, and may be completely closed by the fleshy tongue or by the falling together of the furry lips, leaving a vertical slit between. The raphe or line of union of the lips on the roof of the mouth reaches most of the way from the incisors to the upper premolars. A narrow band, not covered with fur, connects the two lips inferiorly, crossing the floor of the mouth near the posterior end of the symphysis of the mandible. Thence the lips—if the term lips may be applied to this fold of skin—pass around the lower incisors, where the skin is attached posteriorly, so that it may be retracted, leaving a bare space below the point where the tooth protrudes from the alveolus, thus giving greater freedom to the lower incisors during the act of gnawing. During the to-and-fro drill-like motion of the jaw the skin probably remains nearly stationary, while the under incisors play rapidly back and forth. The object of the diaphragm-like partition which separates the mouth into two chambers is obviously to prevent dirt and chips from entering the mouth proper during the various subterranean operations of the animal.

THE TONGUE.

The tongue is short, thick, and fleshy. Its principal function doubtless is to keep the food between the crowns of the teeth during mastication. At other times it serves as a plug to stop the opening in the furry diaphragm between the incisors and molars.

THE CHEEK POUCHES.

All of the Pocket Gophers are provided with external cheek pouches, which open on the sides of the face outside of the mouth, and are covered with fur inside. These cheek pouches are used exclusively in carrying food, and not in carting dirt as often erroneously supposed. The animals are great hoarders and carry away to their storehouses vastly more than they consume. The cheek pouches reach back as far as the shoulder and are so attached that they can not be completely everted without rupture of their connections. While the posterior part of the sack is held back by the muscle which stretches thence to the lumbar vertebræ, the skin of the inner side of the pouch, which covers the side of the face below the eye and in front of the ear, may be everted or prolapsed, hanging down as a flap below the corners of the mouth. This is probably what happened in the case of snake fright observed by Dr. A. K. Fisher at Ellis, Kansas, in June, 1893. Dr. Fisher saw a gopher snake (*Pituophis*) about 5 feet in length hunting for breakfast. He says: "Presently the snake glided into a gopher hole. In a few minutes I saw a gopher (*Geomys lutescens*) run out as fast as possible from the other end of the line of hills. I soon caught up to it. It appeared very much frightened, and its cheek pouches were hanging out. The gopher evidently had only scented the snake, for it was apparent that the snake had not seen the mammal, as it came out of the hole by which it entered and glided off deliberately in another direction."

HOW GEOMYS PUTS FOOD INTO ITS CHEEK POUCHES.

A live *Geomys* from Vernon, Texas, has been carefully observed for the purpose of ascertaining how the reserve food is placed in the cheek pouches. The animal soon became sufficiently tame to eat freely from the hand, and was commonly fed bits of potato, of which he was particularly fond. The manner of eating was peculiar and interesting, and showed an ability to use the huge fore feet and claws in a way previously unsuspected. After satisfying the immediate demands of hunger it was his practice to fill one or both cheek pouches. His motions were so swift that it was exceedingly difficult to follow them with sufficient exactness to see just how the operation was performed. If a whole potato was given him, or a piece too large to go into the pouch, he invariably grasped it between the fore paws and proceeded to pry off a small piece with the long lower incisors. He would then raise himself slightly on his hind legs and hold the fragment between his fore paws while eating, for he usually ate a certain quantity before putting any into the pouches. If small pieces were given him he took them promptly and passed them quickly into the pouches. Some pieces were thus disposed of at once; others were first trimmed by biting off projecting angles. As a rule one pouch was filled at a time, though not always, and the hand of the same side was used to push the food in. The usual course is as follows: A piece of potato, root, or other food is seized between the incisor teeth, and is immediately transferred to the fore paws, which are held in a horizontal position, the tips of the claws curving toward one another. If the food requires reduction in size, the trimming is done while held in this position. The piece is then passed rapidly across the side of the face with a sort of wiping motion which forces it into the open mouth of the pouch. Sometimes a single rapid stroke with one hand is sufficient; at other times both hands are used, particularly if the piece is large. In such cases the long claws of one hand are used to draw down the lower side of the opening, while the food is poked in with the other. It is obviously impossible for the animal to pass food from the mouth to the pouches without the aid of its fore claws.

The most remarkable thing connected with the use of the pouches is the way they are emptied. The fore feet are brought back simultaneously along the sides of the head until they reach a point opposite the hinder end of the pouches; they are then pressed firmly against the head and carried rapidly forward. In this way the contents of the pouches are promptly dumped in front of the animal. Sometimes several strokes are necessary. I am not prepared to say that the animal can not empty the pouches by means of the delicate investing muscles, but I have never seen them emptied in any other way than that here described.

THE FOOD.

The food consists chiefly of roots, tubers, and other rather hard vegetable substances, though grass and the succulent parts of plants are sometimes eaten. In agricultural districts the animals are highly injurious, destroying potatoes and other tubers in large quantities, and gnawing off the roots of fruit trees. In fields of grain and fodder they sometimes do considerable damage by the aggregate area covered by the little mounds of earth thrown up from the tunnels.

COLOR PHASES.

In most species of the *Geomyidæ* two color phases occur, a plumbeous or dusky phase and a chestnut-brown or yellowish-brown phase. The latter varies greatly in the different species—from pale straw color or buffy ochraceous in *Thomomys perpallidus* of the Colorado and Mohave deserts, to dark liver-brown in *Geomys bursarius* of the Upper Mississippi Valley. Taking the group as a whole, the brown phase is by far the commonest and may be regarded as normal; but in certain species in nearly all the genera the plumbeous phase prevails, as in *Thomomys orizabæ*, *Platygeomys fumosus*, and *Zygogeomys trichopus*—all from southern Mexico. The plumbeous pelage is commonly more or less metallic and sometimes even iridescent. It is rare in the United States species, though common in *Thomomys nevadensis* from central Nevada and *Geomys breviceps* from Louisiana. It has not yet been observed in *Cratogeomys castanops* or *Geomys lutescens*, and the red pelage has not been observed in *Zygogeomys trichopus*. So far as known, only a single color phase occurs in the genera *Heterogeomys* and *Orthogeomys*, both of which are dark seal brown in fresh pelage and a dull faded brown in worn pelage.

Seasonal differences in coloration.—Some of the species vary but little with season, as *Geomys bursarius* from the Upper Mississippi Valley; still even this animal is considerably darker in winter than in summer. Others present two well-marked color phases, according to season. In the latter category are *Geomys lutescens*, *breviceps*, and to a less degree *personatus* also. In *lutescens* the summer pelage differs from the winter in the absence of the dark dorsal band which is usually present from October to April or May, and sometimes even as late as June. Apparently the absence of this stripe in summer specimens is sometimes due to wear, the dark tips of the hairs when worn leaving the pale subapical zone exposed. This can not always be the case, however, since one specimen from Chadron, Nebraska, collected April 30, has the dorsal stripe plumbeous throughout with but a faint trace of the pale subapical zone.

In typical *Geomys breviceps*, and also in specimens from the western limit of the range of the species where it seems to be shading toward *lutescens* and *texensis*, the same thing occurs, though the renewal of the pelage takes place at a somewhat different date. This is very apparent in specimens from Gainesville, in the valley of the Red River in northeastern Texas. A specimen taken August 10 has a broad dark dorsal band, while two specimens taken March 27 and March 29 show no trace of this band except on the head, the back being a uniform reddish brown more or less mixed with dusky.

SEXUAL VARIATION.

Sexual variation is marked throughout the genus and in some species is extraordinary. It may be conveniently discussed under two heads, (1) difference in size; (2) difference in cranial characters.

(1) *Difference in size.*—The females are always considerably smaller than the males; the discrepancy is greater in some species than in others. Reference to the tables of measurements shows that the dif-

ference in total length often amounts to 25 or 30 mm.; in length of tail to 12 or 15 mm.; and in hind foot 3 or 5 mm. The difference in the size of the skull is equally marked, and is well shown in the tables of cranial measurements.

(2) *Difference in cranial characters.**—Independent of the conspicuous differences in size between male and female skulls of the same species from the same locality, other and more important differences exist which not infrequently prove troublesome in identifying specimens, particularly if skulls of both sexes are not at hand for comparison. The female as a rule has the brain case broader and flatter, the zygomata narrower and less angular, the jugal narrower anteriorly, the rostrum and nasals shorter, and the skull as a whole smoother. In other words, the cranium of the female is much less specialized than that of the male and often points suggestively to the stock from which the species was derived. It thus happens in the case of series of species in which the successive forms in the development of a particular type are still extant (as in the *texensis-bursarius* series) that the female resembles the male of the species next below in the line of descent more than the male of her own species.

In several forms in which the males have well developed sagittal crests, the females have a sagittal area bounded by distant temporal impressions; and in species in which the males have prominent temporal ribs, the females commonly have more widely separated temporal impressions which rise as ridges from the outer side but not from the inner side, the interspace being more or less thickened.

INDIVIDUAL VARIATION.

The family *Geomyidæ* presents the usual range of individual variation, both in size and in cranial characters. While the male and female skulls of a species agree very well among themselves, showing strong average characters, there are in every large series one or two skulls which depart from the type in one or more particulars. These departures are most common in the form and manner of ending of the nasals and ascending branches of the premaxilla. In all such cases sexual differences should be carefully eliminated before assuming that the departure is individual.

Individual variation is always more marked in the secondary or accessory cranial structures than in the more important and less variable elements. Thus the peripheral processes and expansions for the attachment of muscles are always more variable than other parts of the skull. The degree of lateral production of the squamosal, and of the angular process of the mandible in *Platygeomys gymnurus*, and the variations in

* The sexual organs are so arranged in the *Geomyidæ* as to be difficult of determination in the flesh, except during the rutting season; hence the sex marks on labels may be safely ignored if they conflict with the cranial characters.

detail of the occipital basin, are illustrations of this kind. Still, in studying large series of skulls of a single species, one is much more deeply impressed by the strong tendency toward the development in each bone of a particular type of form than by the departures therefrom.

The animals continue to grow for several years, so that the majority of breeding individuals are still far from the full size of their species. This is very apparent in the skulls, which not only continue to increase in actual size but also, in many species, in the ratio of zygomatic breadth to length, and in the development of ridges and processes for muscular attachments.

SUBDIVISIONS OF THE FAMILY GEOMYIDÆ.

A superficial examination of the skulls of the various species of *Geomyidæ* is sufficient to show the existence of several widely different types. Heretofore the common practice has been to divide the family into two genera, *Thomomys* and *Geomys*, according to the absence or presence of distinct grooves in the upper incisors, and to subdivide the genus *Geomys* into two series, unisulcate and bisulcate. The number of grooves was believed to be correlated with certain cranial characters, the members of the unisulcate series having widely spreading zygomatic arches, the outer angles of which were broadly expanded, while the bisulcate series had narrower arches and lacked the expansion; but no attempt was made to separate them, even subgenerically. The recent discovery of a large number of new forms in Mexico and Central America, comprising several highly diversified types, renders this classification inadequate. After subtracting the strongly marked genus *Thomomys*, which differs from all the others in numerous important characters heretofore overlooked, a heterogeneous assemblage remains, comprising the animals commonly lumped under the generic name *Geomys*, and also the new forms here first described. Of these, the bisulcate series may be divided into two very distinct and two minor types, while the unisulcate series contains at least six well-marked subdivisions.

In attempting a logical classification of the group, one is met at the outset by the difficulty that some of the specialized or peripheral types are more or less closely connected with the trunk line by existing intermediate forms, making it exceedingly difficult to draw hard and fast lines without unnecessary subdivision. The genus *Geomys* as here restricted is such a case. It comprises two quite distinct branches, *Geomys tuza* and *G. bursarius*, which are connected with one another and with the trunk line, or something very near it, by a series of generalized species, the *texensis-breviceps* series. In cases of this kind two courses are open, either to separate the extreme peripheral forms from the less specialized species leading up to them, or to unite the entire branch under a single genus. The latter course has been followed in the present instance. But each case must be decided on its merits. One that has been treated differently is the large limb whose ends, as now known, are represented by two of Mr. Thomas's species, *bulleri* and *merriami;* the former is not far removed from the trunk line of the group; the latter is one of the terminal branches. But the two forms differ in cranial and dental characters of great weight, and are furthermore separated by an enormous gap which is not bridged at any point by any of the species yet discovered. For these reasons they are treated as independent genera. Still another reason for this course, if another were needed, is the circumstance that the branch ending in *merriami* is only one of four equally specialized terminal boughs, all apparently springing from and bearing the same relation to the single limb or main stem whose base is marked by *bulleri.*

In dividing the family into genera the aim has been to select as types the most specialized peripheral forms and to assemble around them the less specialized species. A study of the enamel pattern of the molariform teeth shows that the *Geomyidæ* may be divided primarily into five groups, several of which are of supergeneric value, and a study of the fundamental cranial characters leads to the recognition of nine genera. By means of the following brief key, any of the species now known may be easily referred to its proper genus without cutting the skull:

KEY TO GENERA.

(1) NO ENAMEL ON POSTERIOR FACE OF UPPER PREMOLAR.

Posterior enamel plate present on first and second upper molars.
- Upper incisor bisulcate .... *Geomys.*
- Upper incisor unisulcate
  - Frontal strongly constricted (biconcave) between orbits ..... *Pappogeomys.*
  - Frontal not constricted between orbits; very broad .... **Orthogeomys.*

Posterior enamel plate absent in first and second upper molars.
- Breadth of cranium across squamosals much less than zygomatic breadth; lambdoid crest not sinuous (simply convex posteriorly); angle of mandible short .... *Cratogeomys.*
- Breadth of cranium across squamosals greater than zygomatic breadth; lambdoid crest strongly sinuous; angle of mandible very long .... *Platygeomys.*

(2) ENAMEL PRESENT ON POSTERIOR FACE OF UPPER PREMOLAR.

Posterior enamel plate of upper premolar restricted to inner side.
- *Posterior enamel plate present and complete on first and second upper molars.*
  - Frontal not constricted between orbits; very broad; pterygoids long .... **Orthogeomys.*
  - Frontal strongly constricted between orbits; pterygoids short.
    - Postorbital process absent; palatopterygoids long and slender (pterygoid part narrow) .... *Heterogeomys.*
    - Postorbital process strongly marked; palatopterygoids short and broad (pterygoid part very broad) .... *Macrogeomys.*

**Orthogeomys* presents an exceptional condition of the enamel pattern of the upper premolar. The posterior enamel plate of this tooth is evidently disappearing; it is present on the inner side in *O. latifrons*, but is altogether absent or reduced to a very narrow strip in *O. grandis* and *scalops*.

Posterior enamel plate of upper premolar complete.

Posterior enamel plate present on inner (lingual) side only of first and second upper molars.

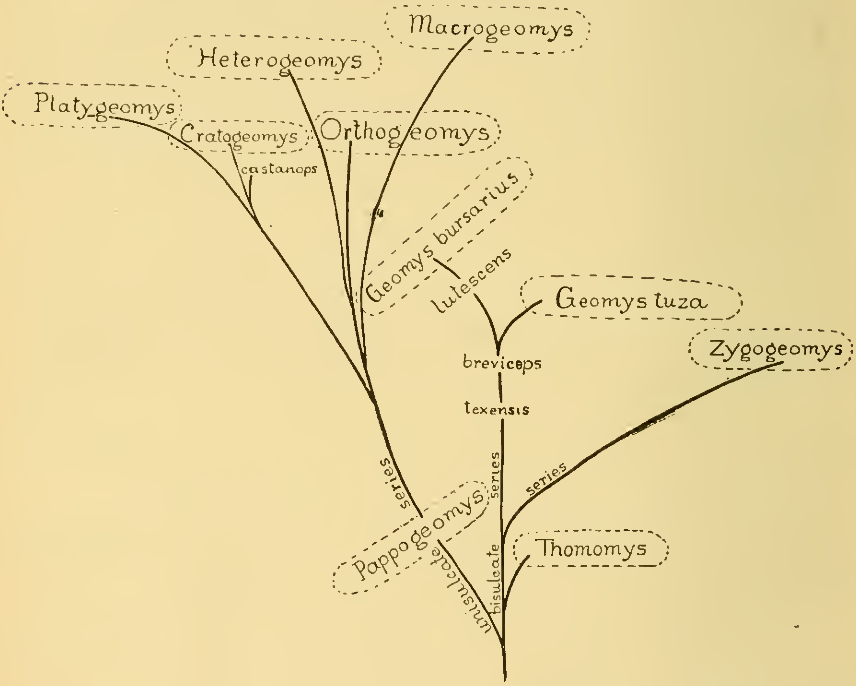
Zygomatic arch complete without jugal (jugal inferior); incisors bisulcate .... *Zygogeomys.*

Posterior enamel plate present and complete on first, second, and third upper molars.

Incisors not grooved, or with a single fine sulcus on inner side.. *Thomomys.*

PHYLOGENETIC TREE OF THE GENERA.

The accompanying phylogenetic tree is intended to represent the author's conception of the interrelations of the nine living genera of



Phylogenetic tree of the Geomyidæ.

the *Geomyidæ* now known. It is introduced with a full knowledge of the modern tendency to disregard and even belittle such attempts; but I am aware of no way in which the results of painstaking research respecting the affinities of organisms may be expressed so graphically. Apparently there were four forks to the early *Paleo-Geomine* phylum: one running into *Thomomys*, another producing the bisulcate series of *Geomys*, beginning with *texensis* or *arenarius* and ending in *bursarius;* the third developing the anomalous bisulcate *Zygogeomys;* the fourth, a strictly unisulcate series, of which *bulleri* and *albinasus* are the least specialized forms now known, splitting into four very distinct branches, each of which now forms a well-marked genus. In the case of the branch leading up to *Geomys bursarius* the series of living forms is practically complete; in the case of the other branches the connecting links are unknown. It is evident that both *Pappogeomys bulleri* and *Geomys texensis* branched off from points not very remote from the place where *Thomomys* left the trunk line, and that they have undergone relatively little modification since.

The evolution of some types takes place in a very direct way, apparently by uninterrupted progress in a definite direction, and the species comprising such a series, as *texensis*, *breviceps*, *lutescens*, and *bursarius*, may be looked upon as stages in the evolution of the type. The origin of other types is more circuitous and less easily understood. Fortuitous variations lead to the appearance of numerous side branches, most of which abort before developing any very pronounced individuality. Others are more fortunate. Chancing to fit some phase of the environment previously unutilized, they go on until a maximum of departure compatible with the balance of the organism as a whole is attained. There are several of these highly specialized departures from the main stem in the *Geomyidæ*, such as *Cratogeomys*, *Platygeomys*, *Macrogeomys*, and *Zygogeomys*.

LIST OF THE GENERA AND SPECIES.

Genus GEOMYS Rafinesque.

Name of species.	Type locality.
Geomys tuza (Ord)	Augusta, Georgia.
tuza floridanus (Aud. and Bach.)	St. Augustine, Florida.
tuza mobilensis subsp. nov	Mobile Bay, Alabama.
bursarius (Shaw)	Minnesota?
lutescens Merriam	Western Nebraska.
breviceps Baird	Mer Rouge, Louisiana.
breviceps sagittalis subsp. nov	Galveston Bay, Texas.
breviceps attwateri subsp. nov	Rockport, Aransas County, Texas.
texensis sp. nov	Mason, Texas.
arenarius sp. nov	El Paso, Texas.
personatus True	Padre Island, Texas.
personatus fallax subsp. nov	Corpus Christi, Texas.

Genus PAPPOGEOMYS nob.

Pappogeomys bulleri (Thomas)	Talpa, Mascota, Jalisco, Mexico.
albinasus sp. nov	Guadalajara, Jalisco, Mexico.

Genus CRATOGEOMYS nob.

Cratogeomys merriami (Thomas)	Valley of Mexico.
perotensis sp. nov	Cofre de Perote, Mexico.
estor sp. nov	Las Vigas, Vera Cruz, Mexico.
peregrinus sp. nov	Mount Iztaccihuatl, Mexico.
oreocetes sp. nov	Mount Popocatapetl, Mexico.
castanops (Baird)	Las Animas, Colorado.
castanops goldmani subsp. nov	Cañitas, Zacatecas, Mexico.
fulvescens sp. nov	Chalchicomula, Puebla, Mexico.

Genus PLATYGEOMYS nob.

Platygeomys gymnurus Merriam .... Zapotlan, Jalisco, Mexico.
tylorhinus sp. nov .... Tula, Hidalgo, Mexico.
planiceps sp. nov .... Northern slope Volcan Toluca, Mexico.
fumosus Merriam .... Colima City, Colima, Mexico.

Genus ORTHOGEOMYS nob.

Orthogeomys scalops (Thomas) .... Tehuantepec, Mexico.
grandis (Thomas) .... Dueñas, Guatemala.
latifrons sp. nov .... Guatemala.
nelsoni sp. nov. .... Mt. Zempoaltepec, Oaxaca, Mexico.

Genus HETEROGEOMYS nob.

Heterogeomys hispidus (LeConte) .... Near Jalapa, Vera Cruz, Mexico.
torridus sp. nov .... Chichicaxtle, Vera Cruz, Mexico.

Genus MACROGEOMYS nob.

Macrogeomys heterodus (Peters) .... Costa Rica.
dolichocephalus sp. nov .... San José, Costa Rica.
costaricensis sp. nov .... Pacuare, Costa Rica.
cherrici (Allen) .... Santa Clara, Costa Rica.

Genus ZYGOGEOMYS nob.

Zygogeomys trichopus sp. nov .... Nahuatzin, Michoacan, Mexico.

GEOGRAPHIC DISTRIBUTION OF THE FAMILY AND GENERA.

The area inhabited by the family *Geomyidæ* stretches from the dry interior of British Columbia and the Plains of the Saskatchewan southward to Costa Rica. In an east and west direction the group covers the continent from ocean to ocean, except that it is absent from the region north of the Savannah River and east of the Mississippi Valley, as shown by the accompanying maps (maps 1, 2, and 3). The group is clearly of Sonoran origin and reaches its highest development on the southern part of the table-land of Mexico. The great majority of the species inhabit the upper and lower Sonoran zones, though a few specially modified forms range upward on favorable mountain sides through the Transition and even into the lower edge of the Boreal zone. On the other hand, two species inhabit the tropical belt of Mexico.

Distribution by genera.—The present distribution of the genera coincides very nicely with their systematic relations.

The genus *Thomomys* (map 1, A) has by far the most extended range of any single genus, inhabiting suitable localities from the valley of Mexico and Mount Orizaba northward to British Columbia and the North Saskatchewan river, and from the Pacific coast eastward to the Great Plains.

The genus *Geomys* (map 1, B and B′) inhabits a broad belt across the middle part of the United States, from the Red River Valley in northwestern Minnesota and northeastern North Dakota southward to the

Mexican boundary along the Rio Grande; and also the southern half of Alabama and Georgia, and the northern half of Florida. The genus does not occur west of eastern Wyoming, east-central Colorado, and the Rio Grande Valley in New Mexico. (See also map 4.)

The genus *Cratogeomys* (map 2) inhabits the Great Plains of the United States from the Arkansas River in eastern Colorado southward, and the eastern table-land region of Mexico to its extreme southern edge in the States of Mexico and Puebla.

The genus *Pappogeomys* (map 3[1]) is known only from the State of Jalisco in Mexico.

The genus *Platygeomys* (map 3[2]) inhabits a rather narrow belt along the southern border of the Mexican table-land in the States of Jalisco, Colima, Michoacan, Mexico, and Hidalgo.

The genus *Orthogeomys* (map 3[5]) inhabits elevated parts of the States of Oaxaca and Chiapas, in extreme southern Mexico and adjacent parts of Guatemala.

The genus *Heterogeomys* (map 3[4]) inhabits the tropical plains of Vera Cruz, below the edge of the table-land, and extends thence southerly to Coban in Guatemala, probably following the low coastal plain of Tabasco to the Rio Usumacinta and thence up the valleys of the San Pedro and its tributaries to the interior of Guatemala.*

The genus *Macrogeomys* (map 3[6]) inhabits the highlands and mountains of Costa Rica and is not known elsewhere.

The genus *Zygogeomys* (map 3[3]) inhabits the Sierra Madre of the State of Michoacan on the southern part of the table-land of Mexico.

NUMBER AND DISTRIBUTION OF THE SPECIES.

Omitting the genus *Thomomys*, the number of species recognized by Baird in 1857 was 7, as follows: *G. bursarius*, *breviceps*, *pinetis* [=*tuza*], *clarkii*, *castanops*, *hispidus*, and *mexicanus*. The number recognized by Coues twenty years later, in 1877, was 5, as follows: *G. bursarius*, *tuza*, *castanops*, *hispidus*, and *mexicanus*. Coues degraded 2 of Baird's species to synonomy, uniting *breviceps* with *bursarius*, and *clarkii* with *castanops*. The same fate overtook *G. heterodus* of Peters, described in the interval between Baird and Coues; it was made a synonym of *hispidus*.

The number of species and subspecies recognized in the present paper is 37, of which 21 are described as new. The remaining 16 are accounted for as follows: Four out of the 5 admitted by Coues are retained, namely, *bursarius*, *tuza*, *castanops*, and *hispidus*, but the fifth, *mexicanus*, is rejected as preoccupied by an unidentifiable species (see

* While this paper is passing through the press, a specimen of *Heterogeomys* has been received from Mr. Nelson, collected by him at Reyes, about 50 miles north of the city of Oaxaca, in the State of the same name, and 33 miles south of the boundary of Vera Cruz and Puebla.

postea, p. 200). Baird's *breviceps* and Peters's *heterodus* are reinstated as valid species, and *floridanus* of Audubon and Bachman is admitted as a subspecies of *tuza*. The remaining 9 have been described since the publication of Coues's Monograph—in fact, during the past five years—and no less than 6 of them are from Mexico and Guatemala. These species are: *personatus* of True; *bulleri*,* *grandis*, *scalops*, and *merriami* of Thomas; *lutescens*, *fumosus*, and *gymnurus* of Merriam, and *cherriei* of Allen. Of the 21 new forms here described, 6 are from the southern United States (1 from Alabama and 5 from Texas), 12 from southern Mexico, 2 from Costa Rica, and 1 from Guatemala. Of the total number here recognized (37), 10 are restricted to the United States; 2 (probably 3†) are common to the United States and northern México; 17 are restricted to the southern half of Mexico; 2 are common to southeastern Mexico and adjacent parts of Guatemala, and 5 are known from Guatemala and Costa Rica only. Thus no less than 24 species, representing, as will be shown later, 7 distinct groups or genera, are absolutely confined to southern Mexico and northern Central America. The extraordinary and unexpected richness of this part of tropical America in members of the group,‡ and the even more remarkable diversity of structure presented by the various types, are of the utmost interest in view of the time and place of origin of the family to which they belong.

UNITED STATES SPECIES.

The Pocket Gophers of the United States fall naturally into two principal subdivisions, (1) those having the upper incisors deeply marked by a median longitudinal furrow (*unisulcate series*), and (2) those having the upper incisors double grooved, a narrow sulcus on the inner margin of the tooth and a larger and deeper one near the middle (*bisulcate series*). The unisulcate series is represented by a single species, *castanops* of Baird, which inhabits the western plains from middle Colorado southward into Mexico. The members of the bisulcate series inhabit-

* *G. bulleri* was described almost simultaneously by Mr. Thomas and myself, but Mr. Thomas's description was issued first and his name *bulleri* has priority over my name *nelsoni*.

† These are *Geomys arenarius*, which is common on both sides of the Rio Grande at El Paso, Texas, and Juarez, Mexico, and *Cratogeomys castanops*, which inhabits extensive areas in western Texas and Chihuahua. A third species, *Geomys personatus*, inhabits the lower Rio Grande region in Texas and in all probability occurs on the Mexican side also (in the state of Tamaulipas).

‡ When it is remembered that only about half a dozen specimens, all told, have been examined from Costa Rica and Guatemala, as compared with 200 from Mexico, it must be evident that the possibilities of Central America have been by no means exhausted. Furthermore, no specimens have been seen from Yucatan, though the family is represented there by at least one species. (Biologia Centrali-Americana, Mammalia, 1880, p. 160.)

ing the United States are 12 in number. These, with their type localities, are as follows:

Geomys tuza (Ord)	Augusta, Georgia.
tuza floridanus Bach.	St. Augustine, Florida.
tuza mobilensis subsp. nov	Mobile Bay, Alabama.
bursarius (Shaw)	Minnesota ?.
lutescens Merriam	Birdwood Creek, western Nebraska.
breviceps Baird	Mer Rouge, Louisiana.
breviceps sagittalis subsp. nov	Galveston Bay, Texas.
breviceps attwateri subsp. nov	Rockport, Aransas County, Texas.
texensis sp. nov	Mason, Texas.
arenarius sp. nov	El Paso, Texas.
personatus True	Padre Island, Texas.
personatus fallax subsp. nov	Corpus Christi, Texas.

Geomys bursarius is the common Pocket Gopher of the northern Mississippi Valley, from eastern North Dakota and western Minnesota south to southeastern Missouri. It is a dark liver-colored animal with pure white forefeet, in sharp contrast to the color of the surrounding parts, and has the longest claws of any of the bisulcate species.

Geomys lutescens is a pallid form of the *bursarius* type, inhabiting the arid sand hills of western Nebraska and extreme eastern Wyoming, and ranging thence southerly into northwestern Texas.

Geomys breviceps inhabits the alluvial lands of Louisiana, Arkansas, and eastern Texas, the typical form coming from Prairie Mer Rouge, in Morehouse Parish. It extends thence northwesterly up the valley of the Arkansas River nearly to the Kansas border. It is a rather small dark species. On the south, along the coast region of Texas, it splits up into the two following subspecies:

Geomys breviceps sagittalis inhabits the gulf coast of Texas about Galveston Bay. It is smaller than true *breviceps*.

Geomys breviceps attwateri inhabits the coastal plain and islands of Texas, from Nueces Bay northward to Matagorda Bay, and ranges into the interior nearly to San Antonio. It is considerably larger than typical *breviceps*.

Geomys texensis in its typical form inhabits central Texas. On the north and northwest it probably passes into *lutescens*, while on the east it may intergrade with *breviceps*. It is much smaller than *bursarius* or *lutescens* and has a pure white belly. Its upper parts are reddish-brown, paler than *bursarius*, but darker and brighter than *lutescens*.

Geomys arenarius inhabits a very restricted area in the upper Rio Grande Valley in extreme northern Chihuahua, western Texas, and southern New Mexico. So far as known it is completely isolated, not coming in contact with any other bisulcate species. It is of medium size, has a relatively long tail, and the upper parts are drab.

Geomys personatus inhabits Padre Island and the adjacent coast of Texas from Santa Rosa southward, extending inland as far as Carrizo, on the Rio Grande; its range, together with that of its subspecies *fallax*, thus coincides with the northern arm of the arid tropical belt along the

Gulf coast. In external appearance *personatus* much resembles *G. lutescens* of the Great Plains, from which it may be distinguished at once by its larger size, larger and more naked tail, and by important cranial characters.

Geomys personatus fallax inhabits a small area on the Gulf coast of Texas, immediately south of Nueces Bay. It is smaller and darker than true *personatus*.

Geomys tuza, a rather large cinnamon-brown species, inhabits the pine barrens of eastern Georgia, where it is locally known as the 'Salamander.' The same name is applied to the following subspecies:

Geomys tuza floridanus is a Florida form of *tuza*, as its name indicates, and does not differ materially in external appearance.

Geomys tuza mobilensis inhabits southern Alabama and northwestern Florida and is a strongly marked form. It is very much darker than *tuza*. (For distribution of United States species see map 4).

DISTRIBUTION OF THE MEXICAN SPECIES.

At my request Mr. Nelson has prepared the following note, embodying his personal knowledge of the geographical and vertical distribution of the species obtained by him in Mexico, exclusive of the genus *Thomomys*:

"One of the most remarkable and interesting features connected with the Mexican Pocket Gophers is the small area within which most of the known species occur. This area is a belt about 400 miles in length by 60 in breadth, stretching from the Pacific coast to the Gulf of Mexico, between the nineteenth and twentieth parallels of north latitude. It contains the thirteen highest peaks of Mexico,* all of which attain an altitude of 12,000 feet or upward. The most notable of these are Iztaccihuatl (17,000 feet), Popocatapetl (17,523 feet), and Orizaba (18,314 feet).†

*The only peak in Mexico attaining an altitude exceeding 12,000 feet, in addition to those here enumerated, all of which lie in the *Geomys belt*, is Mount Zempoaltepec, in the State of Oaxaca. This peak is said to reach 12,000 feet, and is inhabited by a new species of gopher here named *Orthogeomys nelsoni*.

†The complete list with approximate altitudes, beginning at the westernmost, is as follows:

	Feet.	
Sierra Nevada de Colima	14,000,	State of Jalisco.
Volcano de Colima	12,000,	Do.
Pico de Taneitaro	12,653,	State of Michoacan
Pico de Patamban	12,290,	Do.
Volcano de Toluca	15,000,	State of Mexico.
Cerro de Ajusco	12,000,	Do.
Popocatapetl	17,523,	State of Puebla.
Iztaccihuatl	17,000,	Do.
Cerro de Telapon	13,575,	Do.
Cerro de Malinche	13,462,	State of Tlaxcala.
Orizaba	18,314,	State of Puebla.
Sierra Negra	15,000,	Do.
Cofre de Perote	14,000,	State of Vera Cruz.

"The main chain of the Cordillera or Sierra Madre extends along this line and forms here the southern limit of the plateau or table-land region. The mountains throughout this district are of volcanic origin. They inclose numerous high valleys, such as that of Toluca (8,600 feet) and the valley of Mexico (7,400 feet). The main body of the range takes the form of high rounded ridges between 7,000 and 9,000 feet in altitude. On the north the ridges slope down to the adjacent tablelands; on the south a longer slope carries their bases into the low hot valleys of the streams that lead out to the sea. The average elevation of the belt under discussion is far greater than that of any other equal area in Mexico or Central America; this belt also contains the only peaks of the region that are permanently capped with snow.

"The characteristic trees of all these mountains are pines, firs, and alders. In descending toward the hot coast country, below 7,000 feet, oaks come in, and as the descent is continued they in turn give way before the subtropical and tropical species. Although most of the area within the limits given is high and cool, yet at each end a sharp descent leads to the low, hot coast country.

"Gophers occur throughout this area, from the hot coast districts up to the scattered vegetation about timber line. *Geomys fumosus*, the extreme westernmost species, burrows in the damp clayey soil among the cocoanut palms about the city of Colima, at an altitude of from 1,000 to 2,500 feet. *Geomys hispidus*, the easternmost representative of the group, inhabits the coffee and sugar-cane fields of Vera Cruz. In the intervening district the other species range from 4,000 feet up to timber line. Although several reach as high as 12,500 or even 13,000 feet, the great majority of individuals of all species occur below 9,000 feet, and a vertical section of the country from 4,000 to 9,000 feet would include all of the species and nearly all of the individuals of the interior forms. By far the greatest development of the group is reached between the altitudes of 6,000 and 8,500 feet. This area is along the lower border of the pine and oak forest and reaches out along the adjacent treeless plains for a short distance. Considered faunally, this area is Upper Sonoran and Transition. The northern base of this part of the Cordillera forms the southern limit of many species of birds and mammals belonging to the great interior deserts of the United States and the plateau of Mexico, while their southern base and adjacent slopes form the northern limit of various tropical species.

"It was observed also that whenever the route led to the north or south of this belt the pocket gophers became rapidly less numerous, and ceased entirely except in a few places.

"By far the greater number of species now known from Mexico are absolutely restricted to limited areas within this district, while others push out only a little beyond.

"The animals, as a group, are generally found in rather loose soil and avoid stony areas. In some cases, as with *G. fumosus*, the soil may be a tough clay, but this is exceptional. Wherever found in cultivated districts they invade fields, and frequently commit serious damage to crops of both grains and tubers. It is a common practice for the land-owners to pay a fixed bounty to their field hands for them. The owner of a hacienda near Atlisco, Puebla, told me he had thus paid for seventy dozen on his hacienda in a single year, at the rate of 6 cents a head."

The most interesting and unexpected result of Mr. Nelson's explorations is the knowledge that the family *Geomyidæ* attains its highest development in a belt about 400 miles in length by 60 in breadth which crosses Mexico from west to east along the southern edge of the tableland. Within this belt Mr. Nelson collected 175 specimens, not counting the genus *Thomomys*. These specimens belong to six different genera and represent 15 species, no less than 12 of which were previously unknown.*

WEIGHT OF CHARACTERS.

Nothing is more difficult, in entering upon the study of a new group, than to determine the relative weight of characters. Structures of known stability in one group may be highly variable in another, so that characters that are of generic value in the one may be of only specific value in the other. In framing genera and higher groups therefore it is desirable to select deep-seated structures and those that are not easily affected by external influences. In the case of the skull, it is convenient to divide the characters into two categories, fundamental or primary, and superficial or secondary. *Fundamental* characters are based on structures and relations that enter into the ground plan of the skull, and are of high morphologic weight; *superficial* characters are the result of special adaptations and particular muscular strains, and are of little value except as affording recognition marks for species, and in some instances for genera also. The fundamental structures are mostly hidden, comprising the floor of the brain case, the craniofacial axis, and the turbinated bones. They are seen to best advantage in vertical longitudinal sections and in skulls from which the vault of the cranium has been removed. On the outside of the skull the palatopterygoid plates, and perhaps the frontals also, may be regarded as belonging to the same category. The superficial structures are those that appear on the outer side of the cranium and are most easily modified by muscular strain, or are the secondary result of dental peculiarities. They comprise the zygomatic arches, muzzle, nasals, occiput, and such parts of

* Since the above note was written—in fact just as this paper is going to press—Mr. Nelson has sent me 15 specimens of large gophers from the State of Oaxaca, in extreme southern Mexico. Ten of these, from Cerro San Felipe, are the species recently described by Mr. Oldfield Thomas as *Geomys scalops;* the remaining 5 are a new species, *Orthogeomys nelsoni*. They were collected at three localities: Mount Zempoaltepec, Totontepec, and Comaltepec. All of the specimens from the State of Oaxaca belong to a genus (here named *Orthogeomys*) quite distinct from any of the genera inhabiting Mr. Nelson's *Geomys* belt.

the outside of the vault of the cranium as are materially altered in form and extent (as the squamosals) without sensibly changing their relations on the inner side of the brain case.

LIST OF SPECIMENS EXAMINED.

Geomys tuza (Ord)	32
tuza floridanus (Aud. and Bach.)	25
tuza mobilensis subsp. nov	23
bursarius (Shaw)	116
lutescens Merriam	136
breviceps Baird	195
breviceps sagittalis subsp. nov.	26
breviceps attwateri subsp. nov.	53
texensis sp. nov	31
arenarius sp. nov	43
personatus True	33
personatus fallax subsp. nov.	22
Pappogeomys bulleri (Thomas)	6
albinasus sp. nov	1
Cratogeomys merriami (Thomas)	31
perotensis sp. nov	13
estor sp. nov	10
peregrinus sp. nov	1
oreocetes sp. nov	1
Cratogeomys castanops (Baird)	43
castanops goldmani subsp. nov	5
fulvescens sp. nov	11
Platygeomys gymnurus Merriam	10
tylorhinus sp. nov	9
planiceps sp. nov	3
fumosus Merriam	11
Orthogeomys scalops (Thomas)	13
nelsoni sp. nov	5
latifrons sp. nov	1
Heterogeomys hispidus (Le Conte)	9
torridus sp. nov	27
Macrogeomys heterodus (Peters)	1
dolichocephalus sp. nov	2
costaricensis sp. nov	1
cherriei (Allen)	1
Zygogeomys trichopus sp. nov	12

CHAPTER II.

MORPHOLOGY OF THE SKULL.

1. THE CRANIUM AS A WHOLE.

While diversity prevails in the form of the cranium as a whole and in a multitude of minor details, all the members of the family *Geomyidæ* agree in the following important characters: The top of the skull is flattened, the nasals, frontals, and parietals usually forming nearly a straight line (though the line is decidedly convex in *Cratogeomys castanops* and *fulvescens*). The *tympanic* or audital bullæ are rather large, and the external meatus is a long tube directed forward as well as outward, and opening externally immediately behind the posterior angle of the zygoma. There is a well-developed *mastoid bulla* which is wholly on the occipital plane, never reaching the top of the skull. The *squamosals* are largely developed, always overlapping the lower part of the parietals and hinder part of the frontals, and sending out posteriorly a lateral arm which enters into the occipital plane and overreaches the mastoid process of the mastoid bulla. They articulate broadly with the alisphenoid, but leave a long slit-like vacuity between the postero-inferior margin and the audital bulla. The *basisphenoid* and *presphenoid* are higher than broad. The former develops air cells in its body; the latter is a thin vertical plate always perforate anteriorly opposite the sphenoidal fissure, so that in viewing the skull from the side one sees completely through it below the orbitosphenoids. The *alisphenoids* are larger and reach, or nearly reach, the upper surface of the cranium; they are inseparably ankylosed to the basisphenoid before birth. The *orbitosphenoids* are small and horizontal and are not united to the alisphenoids except in *Zygogeomys* and *Thomomys*. The *turbinated bones*, while presenting important differences in the several genera, agree in the following particulars: Anteriorly there is a single *maxillo-turbinal*, always attached to the premaxilla; above and parallel to it is a large *naso-turbinal*, always attached to the nasal; posteriorly, and attached to the cribriform plate and os planum are the *endoturbinals* (of Harrison Allen), always four in number and always decreasing in size from above downward; the uppermost is expanded anteriorly.

The *bony palate* is long and narrow, broader posteriorly than anteriorly, and composed chiefly of the *maxilla*, the body of the *palatine* being relatively small and situated far back. There is a deep pit on each side of the palate between the hindermost molars. Posterior to this pit the palatines usually bifurcate and unite with the pterygoids to form a lingulate or strap-shaped *palatopterygoid plate* on each side of the posterior nares. On the outside of the skull the palatines are restricted to the posterior end of the bony palate, but on the inside they reach forward along the crano facial axis all the way to the nasal chamber—a wholly unnecessary condition so far as the present structure and needs of the animal are concerned, but a highly interesting and significant relic of the primitive relations of these bones. The case is an excellent illustration of the persistence of useless parts.

The *premaxilla* is large and heavy, subquadrate in section, and articulates rather broadly with the frontal. It completely incloses the small incisive foramina except in *Zygogeomys*.

The *jugal* is a highly variable bone (as will be seen hereafter), but it is always restricted to the horizontal part of the zygoma, never creeping upward anteriorly toward the lachrymal, or inward posteriorly toward the glenoid fossa.

The *vomer* bifurcates and sends backward two long vertical wings, which articulate with the sides of the presphenoid, never with its inferior surface.

The *zygomatic arch* varies exceedingly in size and form in the different subgenera, but its horizontal part in transverse section is always distinctly triangular anteriorly, while posteriorly it is flat or rounded. Posteriorly it presents two faces, inner and outer; anteriorly a third is added—a supero-external face. The latter rarely reaches further backward than the middle of the arch and is usually set off from the outer face by a well-defined ridge, which passes obliquely backward and upward from the antero-external angle to the tip of the squamosal arm. This ridge marks the upper limit of attachment of the zygomatic part of the masseter muscle.

There is no true *postorbital process of the frontal* except in *Macrogeomys*, but the apex of the alisphenoid and adjoining anterior border of the squamosal commonly unite to form a decided *postorbital ridge*, which slopes obliquely downward and backward from the point where the frontal, alisphenoid, and squamosal meet, just behind the orbit. This ridge is made up of the edges of the alisphenoid and squamosal, and serves to sharply separate the orbit from the adjoining outer side of the brain case. In *Macrogeomys* there is a strongly developed circumscribed postorbital process, which, with the help of a corresponding eminence on the middle of the horizontal part of the zygoma, serves to sharply distinguish the orbital from the temporal fossa. In its component elements it is peculiar. Its base consists of the frontal, which bone is notched immediately in front of it, thus emphasizing the apparent size of the process. The summit of the process is made up of the apex of the alisphenoid, which here reaches the plane of the upper part of the skull and is slightly overlapped posteriorly by the antero-external angle of the squamosal.

The *paroccipital processes* stand out sideways above the condyles and are more or less expanded and flattened—never cylindrical or conical (figs. 4 and 55 *pp*, and pl. 15, figs. 6 and 7).

The *floor of the brain case*, as exposed by sawing off the vault of the cranium, affords characters of the utmost value in subdividing the group into genera (figs. 9, 56, and 68^3, and pl. 17). As will be seen on consulting fig. 9, the tympano-periotic capsules, with the inclosed basioccipital and posterior part of the basisphenoid, form about half of the floor of the brain case. The alisphenoids (fig. 9, *as*) are next in importance, the horizontal part forming a bridge across the floor of the skull above the pterygoid fossæ and immediately in front of the tympanic bullæ, while the ascending wings push forward on each side, reaching or nearly reaching the orbitosphenoids (*os*), and forming the posterior and outer boundaries of the large sphenoid fossa. Anteriorly the orbitosphenoids fill or nearly fill the front part of the floor of the brain case, on the plane of the orbital constriction. In front of this constriction, and behind the cribriform plate, the orbital or descending plates of the frontal commonly meet in the median line, forming the floor of the olfactory fossa. In young skulls, as in fig. 9, and in adults of the genera *Pappogeomys* (fig. 56), *Orthogeomys*, and *Thomomys* (fig. 68^3), the frontals do not meet below, but the orbitosphenoids reach forward and articulate directly with the cribriform plate.

A conspicuous and highly important pair of fossæ occupy the anterior part of the floor of the brain case on each side of the median line, where they are completely surrounded by the several sphenoid bones. They may be termed the *sphenoid fossæ*. They are directly continuous and inseparably connected posteriorly with the *pterygoid fossæ* proper, which latter are widely open in front and are roofed over by the transverse part of the alisphenoid only. The resulting elongated fossa as a whole may be named the *spheno-pterygoid fossa* (fig. 9, *ptf*). The shape and extent of the sphenoid fossa varies materially in the different genera, as shown in pl. 17: in *Geomys* (fig. 3) and *Heterogeomys* (fig. 1) it is much elongated, reaching anteriorly to the descending plate of the frontal. In *Cratogeomys* (fig. 9, pl. 17, and fig. 5), and also in *Pappogeomys* (fig. 56) and *Orthogeomys*, it is cut off anteriorly by the orbitosphenoids. In *Zygogeomys* (pl. 17, fig. 2) it is still further shortened by the posterior enlargement of the orbitosphenoids, which are broadly ankylosed with the alisphenoids.

The anterior end of the alisphenoid canal (fig. 9, *ac*) always opens into the outer side of the posterior part of the sphenoid fossa, and its position is essentially the same throughout the family (see pl. 17, and text figs. 9 *ac*, 52 and 54 *alc*, 56, and 68).

The *pterygoid fossæ* are large and widely open (fig. 12, *ptf*). Posteriorly they are bridged by the narrow horizontal arm of the alisphenoid (fig. 9, *as*); anteriorly they are not closed or roofed over, but are broadly continuous with the large and deep sphenoid fossæ (fig. 9, *ptf*), which open into the orbit by means of the broadly expanded lower part of the sphenoidal fissure. Their floor consists posteriorly of palatine and anteriorly of maxillary. On the inner side they are bounded by the pterygoid, the vertical plate of the palatine, the basisphenoid, and the presphenoid. On the outer side they are bounded inferiorly by the external pterygoid plate of the palatine (fig. 12, *epl*), and superiorly by the descending wing of the alisphenoid. The outer wall of the posterior part of the pterygoid fossa thus proves to be double, and the inner bone—*the external pterygoid plate*—belongs to the palatine and is overlapped by the descending wing of the alisphenoid, as shown in figs. 4 and 12.

The *sphenoidal fissure* is a large and nearly vertical pyriform vacuity at the bottom of the orbit, separating the anterior border of the alisphenoid from the descending or orbital plate of the frontal (fig. 55^3). It separates also, to a varying degree, the alisphenoid from the orbitosphenoid (fig. 9, *sf*). Superiorly (above the horizontal plane of the orbitosphenoids) it is a narrow slit sloping obliquely upward and forward between the brain case proper and the olfactory fossa, and ending at the base of the thickened interorbital constriction of the frontal (which continues the line of separation between the olfactory fossa and cerebral chamber). This slit is permanently open except in *Zygogeomys* (in which it is closed by the orbitosphenoid), looking completely through the skull from side to side. Inferiorly (below the horizontal plane of the orbitosphenoids) the fissure is suddenly dilated, forming a broad and widely open door between the deep lateral fossa of the floor of the brain case and the bottom of the orbit. The corresponding basal parts of the fissure on the two sides of the skull are incompletely separated by a perforate septum consisting of the vertical plate of the presphenoid, and in some cases of an ascending wing of the palatine also. The sphenoidal fissure is bounded by three bones: posteriorly by the ali-

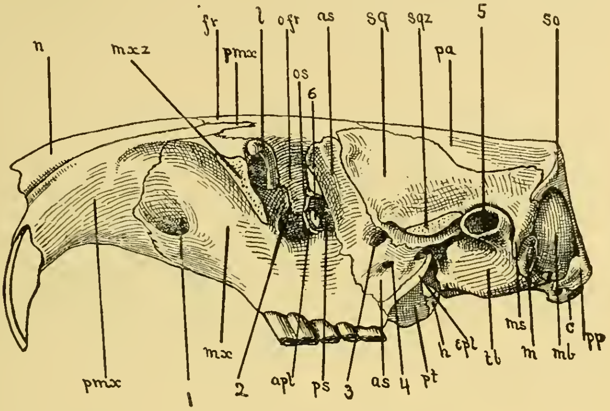


FIG. 4.—Side view of skull of *Cratogeomys merriami* from the outside. Zygomatic arch sawed off to show bottom of orbit. Animal not quite adult. Specimen from Amecameca, Valley of Mexico. (This figure should be compared with the corresponding view of *Geomys bursarius*, fig. 55.)

1 Infraorbital foramen.
2 Posterior (orbital) opening of infraorbital canal.
3 Foramen rotundum.
4 Foramen ovale.
5 Meatus auditorius externus.
6 Fenestrum in anterior part of presphenoid (the line pointing to it crosses the upper part of the sphenoidal fissure).
apl Ascending wing of vertical plate of palatine.
as Alisphenoid (the upper line rests on the ascending wing; the lower on the descending wing).
c Condyle of exoccipital.
epl External pterygoid plate of palatine bone.
fr Frontal.
h Hamular process of pterygoid bone.
l Lachrymal.
m Mastoid process of mastoid bulla.
mb Mastoid bulla.
ms Mastoid process of squamosal.
mx Maxilla.
mxz Zygomatic root of maxilla (sawed off to show orbit).
n Nasal.
ofr Orbital or descending plate of frontal.
os Orbitosphenoid.
pa Parietal.
pmx Premaxilla.
pp Paroccipital process of exoccipital.
ps Presphenoid.
pt Pterygoid.
so Supraoccipital.
sq Squamosal.
sqz Squamosal root of zygoma (sawed off).
tb Tympanic or audital bulla.

sphenoid; anteriorly by the frontal and maxilla; and inferiorly by the maxilla. The longitudinal vertical septum which forms the floor of the large inferior part of the sphenoidal fissure is likewise made up of three bones, the orbitosphenoid, presphenoid, and palatine—though the latter is usually so reduced that it appears in the antero-inferior corner only, and in some forms can not be seen from the outside at all. But in the elongated skulls of *Geomys bursarius* and *tuza* the lower part of the fissure is broadened antero-posteriorly, and the ascending wing of

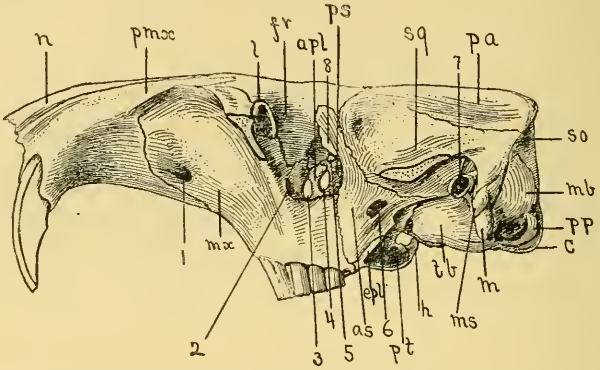


FIG. 55.—Side view of skull of *Geomys bursarius* from outside, zygomatic arch sawed off to show bottom of orbit. Animal fully adult ♂. From Knoxville, Iowa. (This figure is duplicated for easy comparison with the corresponding view of *Cratogeomys merriami*, fig. 4).

1. Infraorbital foramen.
2. Posterior (orbital) opening of infraorbital canal.
3. Vacuity in front of presphenoid and ascending wing of palatine.
4. Vacuity in presphenoid, behind ascending wing of palatine.
5. Optic foramen (in orbitosphenoid bone).
6. Foramen rotundum and foramen ovale (which have here coalesced).
7. External auditory meatus.
8. Sphenoidal fissure (upper part).

apl. Ascending wing of vertical plate of palatine.
as. Alisphenoid.
c. Condyle of exoccipital.
epl. External pterygoid plate of palatine bone.
fr. Frontal.
h. Hamular process of pterygoid bone.
l. Lachrymal.
m. Mastoid process of mastoid bulla.
mb. Mastoid bulla.
ms. Mastoid process of squamosal.
mx. Maxilla.
n. Nasal.
pa. Parietal.
pmx. Premaxilla.
pp. Paroccipital process of exoccipital.
ps. Presphenoid.
pt. Pterygoid.
so. Supraoccipital.
sq. Squamosal.
tb. Tympanic or audital bulla.

the palatine is enlarged and extended, reaching upward alongside the presphenoid (in front of the usual fenestrum) to articulate broadly with the frontal and orbitosphenoid, on or near the plane of the top of the presphenoid (fig. 55). In front of the palatine (and also in front of the presphenoid, which is here clasped between the ascending wings of the palatine on the two sides of the skull) is a second fenestrum (fig. 55[3]) anterior to the usual one (fig. 55[4], which is in the presphenoid), and likewise looking completely through the skull. This latter opening is bounded in front by the maxilla and behind by the palatine. It is situated midway between the sphenoid fenestrum and the orbital end of the infraorbital canal.

The *infraorbital canal* is small and does not pierce the root of the zygoma, but is deeply buried in the maxillary bone, passing backward and inward from the infraorbital foramen (fig. 4[1]) (on the lower part of the side of the muzzle just behind the premaxillary suture) to the deepest part of the orbit (fig. 4[2]), its course being wholly internal to the zygomatic root of the maxillary. It curves around the inner side of the base of the socket of the long upper incisor, and is separated from the nasal chamber by only a thin lamella of bone rising from the maxillary floor of the nasal passage and articulating above with the inferior border of that part of the os planum which supports the endoturbinals.

The *foramen rotundum* (fig. 4[3]) is always situated above the *foramen ovale* (fig. 4[4]), and both open into the large longitudinal alisphenoid canal. In rare instances they coalesce (fig. 55[6]).

The *narial passage* is a narrow vertical ellipse, about twice as high as broad (fig. 7, *np*).

While most species of the genera under consideration develop a prominent *sagittal crest* in adult life, some do not, the temporal impressions remaining permanently distant, defining a well-marked *sagittal area*. The members of the latter category may be divided into two sets, (1) those in which the temporal impressions are actual ridges rising above the level of the surrounding bone on both sides, as in *Heterogeomys hispidus* (pl. 4), *Geomys tuza* (pl. 7, fig. 1), and *G. arenarius* (pl. 9, fig. 1); and (2) those in which the space between the temporal impressions (the *sagittal area*) is thickened and as high as the impressions, which thus appear as ridges only when looked at from the outer side, as in *Geomys breviceps* (pl. 9, fig. 6) and *Cratogeomys oreocetes* and *peregrinus* (pl. 8, figs. 2 and 3).

The *lambdoid crest* is broadly and gently convex posteriorly throughout the group (pls. 1, 2, 5–9, etc.), except in *Platygeomys*, in which genus (pl. 3 and pl. 11, fig. 4) it is strongly sinuous—forming a deep and broad reentrant angle on the median line, beyond which, on each side, it is first strongly convex backward and then slightly convex forward—the extreme mastoid ends curving backward as well as outward. The bones that take part in the formation of the lambdoid crest are the supraoccipital, squamosals, parietals, and interparietal.

There is no ossified tentorium in the *Geomyidæ*.

2. THE INDIVIDUAL BONES.

In the *Geomyidæ* there are normally thirty-three distinct bones in the skull, not counting the separate parts of the tympano-periotic capsule, the turbinated bones of the nasal chamber (which are reckoned with the bones to which they are attached) or the paired bones that coalesce before birth. The latter are the premaxillæ, maxillæ, palatines, and frontals.

The thirty-three bones that go to make up the skull (exclusive of the paired bones that are fused in the embryo) are:

Basioccipital	1	Vomer	1
Exoccipital	2	Pterygoid	2
Supraoccipital	1	Palatine	1
Interparietal	1	Maxilla	1
Basisphenoid	1	Premaxilla	1
Alisphenoid	2	Lachrymal	2
Squamosal	2	Jugal	2
Parietal	2	Nasal	2
Presphenoid	1	Periotic	2
Orbitosphenoid	2	Mandible	2
Frontal	1		
Ethmoid	1		33

The *basioccipital* is commonly truncate-wedge-shaped, with the posterior edge (*basion*) rather deeply notched. Its posterior corners enter

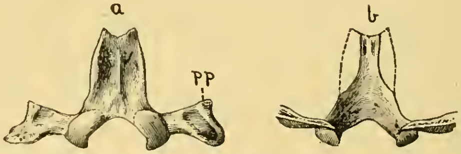


FIG. 5.—Basioccipital of *Cratogeomys merriami*, showing difference in form of upper and lower surfaces (ankylosed exoccipitals shown also): *a*, inferior surface; *b*, superior surface; *pp*, paroccipital process.

very slightly into the formation of the occipital condyles. The inferior surface of the body of the basioccipital is normally broader posteriorly than anteriorly and the decrease in breadth from behind forward is gradual (pl. 12, fig. 2, *a*); but in one species, *Cratogeomys castanops*, the body of the bone is rectangular, its sides being parallel (pl. 12, fig. 1, *a*). In another, *Orthogeomys scalops*, they may be nearly parallel or even slightly divergent anteriorly (pl. 19, fig. 2). The basioccipital varies in breadth according to the development of the audital bullæ, by which its sides are always more or less excavated. Its outer borders are usually grooved to receive a projection from the bulla. The superior surface (on floor of brain case) is always narrower than the inferior surface. The difference is very marked in some species (see fig. 5, *a* and *b*). The basioccipital early ankyloses with the exoccipitals,* but usually

* The exoccipitals coössify with the basioccipital very early in *Zygogeomys* and *Geomys* proper; somewhat later in *Cratogeomys*, *Platygeomys*, and *Heterogeomys*.

remains distinct from the basisphenoid, with which it unites by synchondrosis.

The *exoccipitals* form the whole of the condyles except the extreme lower ends, into which the outer corners of the basioccipital enter. They early ankylose with the basioccipital, forming a single bone long before the animal becomes adult. No part of the exoccipital ever projects downward below the plane of the condyles. The paroccipital processes stand out sideways and impinge upon the base of the mastoid bulla immediately behind the audital bulla; they are commonly more or less flattened and expanded, and their distal ends often project backward (fig. 12, *pp*). In *Platygeomys* they attain their maximum development and form the lateral parieties of a deep basin-shaped depression, the upper boundary of which is formed by the backward projecting lambdoid crest (pl. 15, fig. 7). The exoccipitals are in contact anteriorly with the mastoid bullæ and periotic capsules, which they partly overlap. Viewed from behind, they form the inner boundary of the exposed part of the mastoid bullæ. Vertically they reach the upper edge of the foramen magnum, and their upper border forms nearly a straight line across the plane of the occiput.

The *supraoccipital* forms a small part of the roof of the brain case and the greater part of the occipital plane, comprising all of the occipital element above the foramen magnum. On the top of the skull it reaches much farther forward in *Platygeomys* than in the other genera, (fig. 53, *so*), but is usually nearly concealed in adult life by being overlapped by the parietal and squamosal. On the occipital plane its inferior border forms the superior boundary of the foramen magnum; its outer sides curve around the basal part of the exposed mastoid bullæ, though rarely reaching laterally as far as the free ends of the mastoids. Anteriorly the supraoccipital articulates with the squamosals and parietals, and with the interparietal also in those cases in which the latter bone has an independent existence. [As a rule the interparietal is not separate from the supraoccipital.]

The *interparietal*, which has proved of considerable importance in furnishing specific characters in the *Heteromyidæ*, is small and of little consequence in most species of *Geomyidæ*, except in the single genus *Thomomys*. Even in very early life it forms an inseparable part of the supraocciptial in the *castanops* series of *Cratogeomys*, in *Platygeomys gymnurus*, in the *bursarius* series of *Geomys* proper, and in *Pappogeomys*, *Heterogeomys*, and *Zygogeomys*. It is distinct all around in early life in most species of *Thomomys*, in the *merriami* series of *Cratogeomys*, in the *tuza* series of *Geomys* proper, in *Geomys texensis* and *breviceps*, in *Platygeomys tylorhinus* and *planiceps*, but not in *P. gymnurus*. From its variability in closely related species it is evidently of little importance for purposes of classification, though its value in *Thomomys* is much greater than in any of the other genera; and it is of some value in the restricted genus *Geomys* also. In the young it is commonly subquadrate or broadly oval and of relatively large size, but with advancing age it becomes smaller and narrowly triangular or wedge-shaped, its outer borders being resorbed from pressure of the parietals, which are constantly crowding toward the median line. Thus in *Platygeomys tylorhinus* several skulls from the same locality (Tula, Hidalgo, Mexico) present the following variations in the interparietal:

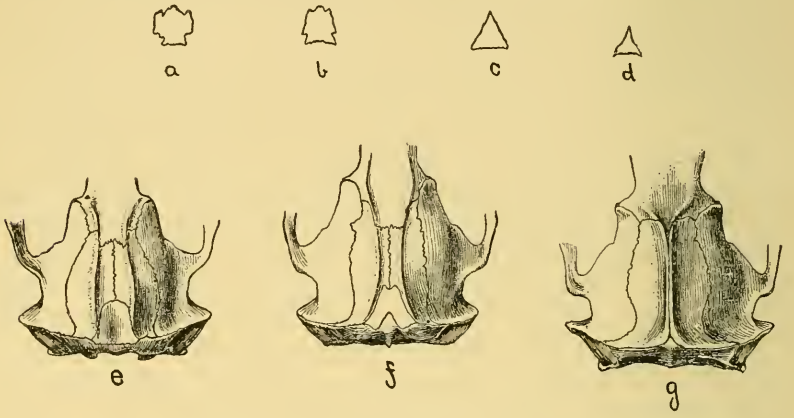


FIG. 6.—Forms of interparietal. *a, b, c, d, Platygeomys tylorhinus* showing changes with age. *e. Geomys tuza* ♂ ad. Augusta, Ga. *f* and *g G. mobilensis:* ♂ *f* yg. ad.; *g* ♂ ad. Milton, Fla. All natural size.

A very young male (fig. 6, *a*, No. 51882) has it roughly subquadrate and broader than long; an immature but older female (fig. 6*b*, No. 51884) has it of the same shape, but narrower and longer than broad; a still older specimen (fig. No. 6, *c*) has it broadly triangular; while an adult (fig. 6, *d*, No. 51883, ♂) has it reduced to a small wedge-shaped piece squeezed in between the hinder edges of the parietals.

In the young of *Zygogeomys trichopus* the interparietal is even larger than in *Platygeomys tylorhinus*, and is about twice as broad as long (measuring 8 mm. in breadth in No. 50104 juv. fig. 15, *a*). In shape it is broadly convex anteriorily and slightly (flatly) convex posteriorly. The progressive development of the powerful temporal muscles with consequent enlargement of the parietals posteriorly encroach upon its size and change its shape, pressing it into an equilateral triangle (as in No. 47186 ♂ im., fig. 15, *b*). Its size now decreases rapidly, and as the temporal impressions meet in a well-developed sagittal crest in the adult skull it nearly or quite disappears from the upper surface of the cranium (as in No. 50100 ♂ ad., fig. 15, *c*).

The interparietal is more stable in form in several of the species of the restricted genus *Geomys* than in any of the other genera under consideration. This is due chiefly to the circumstance that in this genus several species have permanently distant temporal impressions—for nothing is so destructive to an interparietal as the development of a sagittal crest. In the species possessing a crest (*bursarius*, *lutescens*, *personatus*, *fallax*, and *mobilensis*) the interparietal is normally reduced in adult life to an inconspicuous subtriangular wedge. In the species having a permanent sagittal area it remains of considerable size and its form is reasonably constant. In *G. arenarius* it is normally subquadrate, though the anterior border may become convex from rounding off of the corners, and it is always truncate behind and persists in old age (pl. 9, fig. 1). In *G. texensis* it is normally elliptical or oval (broader than long) and convex posteriorly as well as anteriorly, projecting nearly as far behind as in front of the lambdoid suture (pl. 9, fig. 2). In *G. breviceps* it is usually reduced to a highly irregular 'wormian' bone, much cut up by contortions of the sutures (pl. 9, fig. 6). In *G. tuza* it is very large, occupying nearly half of the broad sagittal area, and is convex in front, truncate behind (fig. 6*e*). In the closely related *G. mobilensis* it is deeply notched behind and is encroached upon and finally nearly obliterated by the union of the temporal ridges (fig. 6, *f* and *g*).

The *basisphenoid* is invariably ankylosed with the alisphenoids and pterygoids, even in early life, and sooner or later usually coossifies with the presphenoid; it commonly, though not always, remains distinct from the basioccipital. Its vertical height is generally greater than its breadth, and air cells commonly develop in its substance (fig. 7, *bs*). Its chief peculiarity is the slight development of the pituitary fossa, which ordinarily is so shallow as to escape notice. But in *Heterogeomys* it is a real depression, and in *H. hispidus* it is normally a pit and completely perforates the bone. In the related species, *H. torridus*, it is much less conspicuous and never perforates (so far as the series of 26 skulls goes).

The basisphenoid articulates with the basioccipital, presphenoid, alisphenoids (by ankylosis), pterygoids (by ankylosis), and vertical plates of the palatines (by contact antero-inferiorly—see fig. 7).

The *alisphenoid* is a very important bone, serving to bind firmly together the middle segment of the vault of the cranium with the posterior part of the upper jaw, and to anchor both securely to the basicranial axis. It may be described as consisting of three parts, (1) a *horizontal* or *transverse* part, (2) an *ascending wing*, and (3) a *descending wing*.

(1) The *transverse* or horizontal part is little more than a narrow bar, inseparably connected with the middle of the outer side of the basisphenoid (figs. 9, *as* and 54, *alh*); it forms the floor of the brain case immediately in front of the periotic, and the roof of the posterior part of the pterygoid fossa, the anterior part being uncovered. In passing outward it bifurcates to inclose the large longitudinal alisphenoid canal, above which it becomes continuous with the ascending wing, and below with the descending wing. Posteriorly, the base of the horizontal part of the alisphenoid is excavated, and usually presents a cup-shaped enlargement to receive the apex of the audital bulla. It also descends alongside the basioccipital to unite with the pterygoid posteriorly.

(2) The *ascending wing* of the *alisphenoid* differs widely in form as viewed from the inside or outside of the brain case. On the outer side of the skull (fig. 4, *as*) it is a long rectangular blade ascending obliquely in front of the squamosal, with the anterior border of which it articulates. It also overlaps the posterior part of the orbital face of the frontal, rising nearly to the upper surface of the skull, which it sometimes reaches. The upper part is always roughened, and, with the overlapping edge of the squamosal, forms an oblique postorbital ridge or prominence. Sometimes the apex pushes up to the top of the skull, where it is thickened and forms the major part of a distinct *postorbital process*, resting on the frontal, and overlapped posteriorly by the antero-external corner of the squamosal. This process attains its highest development in *Macrogeomys* (see pl. 11, fig. 2, and text fig. 17[3]). Posteriorly the ascending wing is extensively overlapped by the squamosal,

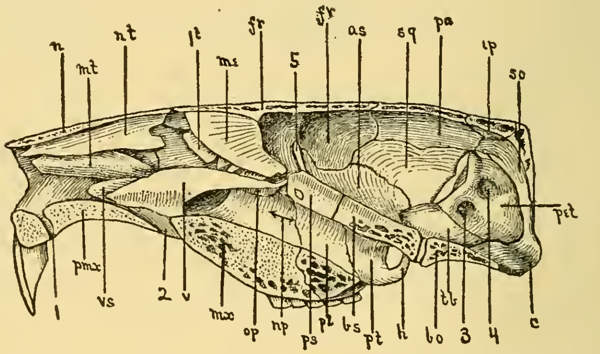


FIG. 7.—Longitudinal vertical median section of skull of *Cratogeomys merriami*, showing interior of brain case and nasal chamber. Vomer and mesethmoid in place.

1 Anterior palatine foramen.
2 Incisive foramen.
3 Meatus auditorius internus.
4 Floccular fossa.
5 Upper part of sphenoidal fissure.
as Alisphenoid.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
fr Frontal.
h Hamular process of pterygoid.
ip Interparietal.
me Mesethmoid plate.
mt Maxillo-turbinal.
mx Maxilla.
n Nasal.
nt Naso-turbinal.
op Lower border of os planum.
pa Parietal.
pet Petrous part of periotic capsule.
pl Palatine.
pmx Premaxilla.
ps Presphenoid.
pt Pterygoid.
so Supraoccipital.
sq Squamosal.
tb Tympanic bulla (antero-superior part, which alone appears within the brain case).
v Vomer.
vs Vomerine sheath of maxilla
1*t* First endoturbinal (below and somewhat behind it the anterior ends of the second, third, and fourth endoturbinals may be seen).

as appears when examined from the inner side of the brain case (fig. 7, *as*). Therefore, while the outer face is an obliquely-vertical plate, with essentially parallel sides, the inner face is elongated horizontally, with an irregularly convex upper border—the difference being due to the fact that the outer side overlaps the frontal anteriorly and is overlapped by the squamosal posteriorly. The alisphenoid may be separated from the orbitosphenoid as in *Heterogeomys* and *Geomys* (pl. 17, figs. 1 and 3), or the two bones may be in contact anteriorly as in *Cratogeomys* (pl. 17, fig. 5, and text fig. 9), or they may be firmly and broadly ankylosed together as in *Zygogeomys* (pl. 17, fig. 2).

(3) The *descending wing* of the *alisphenoid*, on the outer side of the skull, is a flattened plate continuous in breadth, plane, and direction with the ascending wing, and passing obliquely downward and backward between the posterior border of the maxilla and the antero-inferior edge of the squamosal (fig. 4, *as*, lower pointer). Anteriorly it forms the outer wall of the pterygoid fossa; posteriorly it overlaps the external pterygoid plate of the palatine. It articulates with the maxilla, palatine, and squamosal; and is pierced by two foramina, the *foramen rotundum* and the *foramen ovale*, which, in rare cases, merge into one. The *foramen rotundum* (fig. 4[3]) is very much larger than the *foramen ovale*, and is situated immediately below the anterior end of the squamosal root of the zygoma. It opens into the anterior part of the large alisphenoid canal, and sometimes also directly into the deep sphenoid fossa of the floor of the brain case. In *Geomys* proper it is higher up than usual and consequently opens downward into the alisphenoid canal. The *foramen ovale* (fig. 4[4]) is a small slit-like opening beneath the *foramen rotundum:* it opens obliquely upward (and usually backward) into the lower part of the alisphenoid canal. The *foramen ovale* presents considerable variation in its position and relations, affording characters of some value in separating the genera. In *Cratogeomys* it is near the anterior border of the lower part of the alisphenoid, directly beneath the *foramen rotundum* and far below the alisphenoid canal, which it reaches posteriorly by an obliquely upward and backward course. In *Platygeomys* and *Heterogeomys* it is similarly situated, except that it is nearer the middle than the anterior border of the descending wing of the alisphenoid, and is decidedly nearer the alisphenoid canal and *foramen rotundum*. In *Heterogeomys* it is not infrequently confluent on one side with the *foramen rotundum*. In *Platygeomys* it is somewhat posterior to the *foramen rotundum* and nearer it than in *Heterogeomys*. In *Zygogeomys* it is immediately below and close to the *foramen rotundum* and sometimes confluent with it; it is high up and opens *directly* into the alisphenoid canal. In *Geomys* proper it is high up also, and often becomes confluent with the *foramen rotundum* (as in fig. 55[6]). In the *tuza* series its size is unusually small.

The alisphenoid as a whole articulates with the frontal, squamosal, maxilla, palatine, basisphenoid, pterygoid, tympanic capsule, and in some genera with the orbitosphenoid also.

The *squamosal* is a large and highly important bone in the *Geomyidæ* (figs. 4, 7, 8, and 9, *sq*). It overlaps to a considerable extent the other bones of the parieties of the brain case, imparting great power of resistance to the vault of the cranium. Antero-inferiorly it articulates with the alisphenoid for its entire length. Postero-inferiorly a long slit-like vacuity separates it from the audital bulla, though in some cases it is in contact with parts of the bulla. Posteriorly it overspreads the superior face of the outer part of the supraoccipital and the mastoid bulla and sends a lateral arm out sideways (the mastoid arm), which overreaches and articulates with the end of the mastoid process of the mastoid bulla. Superiorly it covers the posterior part of the frontals and broadly overlaps the parietals for their entire length—actually concealing them in one species, *Cratogeomys merriami*. The squamosal gives off the posterior root of the zygoma and articulates with the jugal. In *Zygogeomys trichopus* and *Macrogeomys costaricensis*, owing to the much-reduced size of the jugal, the squamosal arm reaches far forward and articulates directly with the maxilla—a most exceptional condition among mammals. Below the squamosal root of the zygoma is the elongated and ill-defined *glenoid fossa*, which is completed posteriorly and on the inner side by the tympanic bulla. The

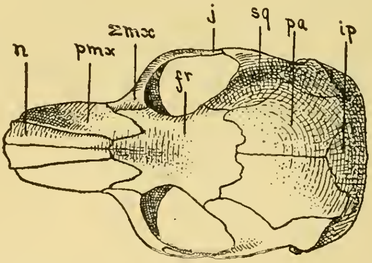


FIG. 8.—Skull of very young *Geomys bursarius* from Elk River, Minnesota. Upper surface, showing frontals ankylosed together, and interparietal inseparable from supraoccipital at birth.

fr, frontal; *ip*, interparietal; *j*, jugal; *n*, nasal; *pa*, parietal; *pmx*, ascending branch of premaxilla; *sq*, squamosal; *zmx*, maxillary root of zygoma.

form of the postglenoid notch varies from broadly U-shaped in *Platygeomys* and some others to narrowly V-shaped in *Geomys bursarius*. In *Platygeomys* and *Cratogeomys* the glenoid fossa is produced anteriorly a long distance in front of the squamosal root of the zygoma.

The mastoid arm of the squamosal enters the outer part of the occipital plane above the mastoid bulla and external to the supraoccipital, where it forms the whole thickness of the lambdoid crest (see pl. 15, figs. 3, 4, 6, and 7). In *Heterogeomys* it is vertically expanded, taking a more prominent part than usual in the occiput. The variations in the squamosal are described later (pp. 66–67).

The *parietals* complete the roof of the brain case posteriorly (fig. 8, *pa*). They do not present any unusual variations in the *Geomyidæ;* they overlap the frontal anteriorly and the supraoccipital and interparietal posteriorly, and are overlapped for their full length inferiorly by the squamosals, which in *Cratogeomys merriami* gradually overspread and conceal them. The parietals are always separate in early life, but usually coalesce in the adult. The temporal impressions may remain permanently distant, defining a sagittal area, or they may unite in a prominent sagittal crest.

The *presphenoid* is a thin vertical plate of bone bridging the gap between the basisphenoid and mesethmoid cartilage and supporting, from its superior surface, the horizontally flattened orbitosphenoids (figs. 4, 7, and 9, *ps**). It is perforated anteriorly by a rather large opening, which, being opposite the sphenoidal fissure, enables one to see completely through the skull at this point (figs. 46, 10⁴, and 55⁴). A second fenestrum often exists behind the first, and in *Orthogeomys* one or two small perforations usually occur in front of it. Superiorly the presphenoid supports the orbitosphenoids (fig. 9, *os*), with which it is

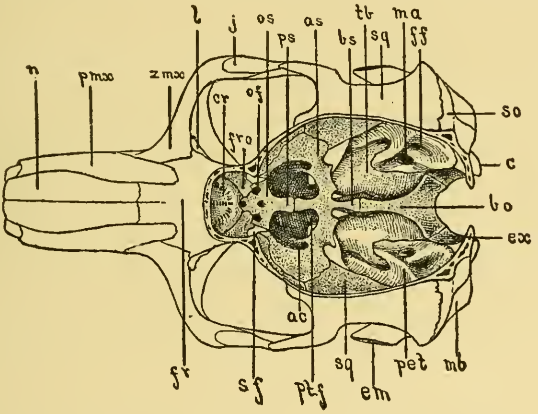


FIG. 9.—Young skull of *Cratogeomys merriami* from Amecameca, Mexico, with vault of cranium removed to show floor of brain case.

ac Anterior opening of alisphenoid canal.
as Alisphenoid bone.
bo Basioccipital.
bs Basisphenoid.
Condyle of exoccipital.
cr Cribriform plate of ethmoid.
em External auditory meatus.
ex Exoccipital.
ff Floccular fossa.
fr Frontal.
fro Descending or orbital plate of frontal (the animal is so young that the plates of the two sides have not yet united below).
Jugal.
Lachrymal.

ma Meatus auditorius internus.
mb Mastoid bulla.
n Nasal.
of Optic foramen.
os Orbitosphenoid.
pet Petrous part of periotic.
pmx Ascending arm of premaxilla.
ps Presphenoid.
ptf Spheno-pterygoid fossa.
sf Apex of sphenoidal fissure.
so Supraoccipital.
sq Squamosal.
tb Superior face of tympanic or audital bulla.
zmx Zygomatic root of maxilla.

inseparably ankylosed; anteriorly it abuts against the mesethmoid cartilage and is in contact with the ethmoid and usually the vomer; posteriorly it abuts against the basisphenoid, with which it commonly becomes ankylosed before the animal is fully adult. The ascending

*In fig. 9, which is a young skull, the presphenoid is covered by the orbitosphenoids, making it appear very much broader than it really is.

wings (vertical plates) of the palatines clasp the sides of the presphenoid inferiorly, rising anteriorly. The ends of the vomer reach it also, clasping it laterally, but never underlying it as in many mammals. The presphenoid ends anteriorly in a somewhat thickened head, with a disk-shaped cavity in front, which receives the hinder end of the mesethmoid cartilage.

The *orbitosphenoids* are a pair of thin horizontal shelves resting upon and invariably ankylosed to the upper border of the presphenoid, and articulating anteriorly with the orbital plate of the frontal (fig. 9, *os*, and pl. 17). They are normally perforated near the anterior border by the *optic foramen* (fig. 9, *of*), but in *Heterogeomys* this foramen is incomplete superiorly (pl. 17, fig. 1) except in the young. The antero-external corner sometimes protrudes through the sphenoidal fissure, bends upward, and slightly overlaps the posterior border of the descending wing of the frontal, appearing as a small scale in the bottom of the orbit. This is most often observed in young skulls. In *Zygogeomys*, *Pappogeomys*, and some forms of *Thomomys* the ascending tongue of the orbitosphenoid completely closes the upper part of the sphenoidal fissure, except a small point at its apex, which is left as a permanent foramen (pl. 18, fig. 2), and becomes ankylosed to the frontal anteriorly and the alisphenoid posteriorly (pl. 17, fig. 2). With these exceptions it does not appear in the parieties of the cranium, though it may always be seen crossing the sphenoidal fissure, which it divides into two parts. Anteriorly the orbitosphenoid invariably articulates with the upper surface of the presphenoid and the descending wings of the frontal, as already stated, and sometimes also with the palatine, maxilla, and posterior edge of the cribriform plate; posteriorly it often touches the edge of the alisphenoid, to which it becomes fixed in *Cratogeomys*, *Orthogeomys*, *Pappogeomys*, *Zygogeomys*, and some forms of *Thomomys*.

The relations of the orbitosphenoids anteriorly vary in the several groups and in some cases are exceedingly difficult to ascertain, owing to early ankylosis with the presphenoid. In *Geomys bursarius* the ascending wings of the palatine rise high on the sides of the presphenoid and articulate broadly with the orbitosphenoids, but in most forms it is uncertain whether or not the palatine is reached. The uncertainty is due to the impossibility of determining how far the orbitosphenoid descends anteriorly below the top of the presphenoid, with which it is inseparably fused. For the same reason it is uncertain whether or not the orbitosphenoids always reach the cribriform plate of the ethmoid. They seem to do so in all cases along the median line, but I have been unable, even in very young skulls, to find the place of separation anteriorly between the orbitosphenoids and presphenoid. In those genera in which the descending or orbital plates of the frontal do not meet inferiorly behind the cribriform plate, the orbitosphenoids articulate broadly with the cribriform (as in *Pappogeomys*, *Orthogeomys*, and *Thomomys*).

In *Geomys* proper the orbitosphenoids are narrower than in any of the other genera, and do not reach the alisphenoids. In *Heterogeomys* and *Platygeomys* also they usually fall short of the alisphenoid, though in extreme cases they sometimes cross the anterior edge of the alisphenoid. In *Cratogeomys* and *Orthogeomys* they articulate with the alisphenoid anteriorly for a short distance, but do not follow the upper part of the sphenoidal fissure, though in *Orthogeomys* they sometimes send a tongue upward covering part of the fissure. In *Pappogeomys* and some species of *Thomomys* they go a step further, articulating firmly and broadly with the alisphenoid and normally closing the greater part of the sphenoidal fissure above the plane of the presphenoid. *Zygogeomys* presents a still more extreme phase, the orbitosphenoid almost completely closing the upper part of the sphenoidal fissure and ankylosing broadly with the alisphenoids. From what has been said it must be clear that the orbitosphenoids play a more important part than any other bones in determining the form of the floor of the brain case, for the reason that by their expansion or contraction anteriorly they completely change the size and shape of the sphenoid fossa, which is the most conspicuous of the variable landmarks of the floor of the brain case, as may be seen on consulting pl. 17.

The *frontals* coalesce very early (probably before birth), forming a single large bone (fig. 8, *fr*) which constitutes the middle third of the upper surface of the skull and dips deeply into the orbits, where it makes important connections with the maxilla and other bones. It forms the roof of the olfactory chamber of the nasal cavity, and the roof and part of the side walls of the anterior segment of the brain case. The main body of the frontal articulates anteriorly with the ethmoid, nasals, premaxilla, maxilla, and lachrymals, and posteriorly with the parietals, squamosals, and alisphenoids. It is so extensively overlapped by the alisphenoids and squamosals that when viewed from the outside it appears much smaller than it really is.

The descending or orbital processes of the frontal (figs. 4, *ofr*, and 9, *fro*) reach far downward, burying themselves deeply among the bones of the base of the cranium and face. They articulate with the anterior border of the orbitosphenoids, clasp the sides of the presphenoid and palatines anteriorly, and articulate firmly with the maxillaries. Anteriorly, except in *Thomomys*, *Pappogeomys* (fig. 56), and *Orthogeomys*, they completely encircle the cribriform plate of the ethmoid (with which they early unite by ankylosis) and meet in the median line below it, thus reaching around the olfactory lobes of the brain case and forming the floor as well as the roof and sides of the olfactory fossa. At the point where the two arms come together in the median line, at the posterior base of the cribriform plate, a small opening is commonly left which remains as a perforating foramen passing obliquely forward and downward between the presphenoid and mesethmoid plate, and opening anteriorly into the olfactory chamber of the nasal cavity immediately behind the lower part of the fourth endoturbinals. In *Thomomys* (fig. 61), and in the young of most of the other genera (as in *Cratogeomys*, fig. 9, *fro*), the orbital plates of the frontal are separated inferiorly by the orbitosphenoids. The variations in the form of the frontal are described further on (p. 65 and fig. 17).

The *ethmoid* is a highly complicated bone occupying the posterior part of the olfactory chamber of the nasal cavity, which it completely separates from the brain case. No part of it appears on the outside of the skull. It may be described under five heads: (1) the *cribriform plate;* (2) the *mesethmoid;* (3) the *os planum;* (4) the *ectoturbinals*, and (5) the *endoturbinals.* There is no apparent 'crista galli' in the *Geomyidæ.* [The naso- and maxillo-turbinals are completely detached, and are described under the bones to which they are respectively ankylosed, namely, the nasal and premaxilla.]

(1) The *cribriform plate* is a transverse perforated partition, separating the olfactory fossa of the brain case from the olfactory chamber of the nasal cavity (fig. 9, *cr*). It is nearly circular in outline and slopes or curves forward from the base upward. Posteriorly, in most of the genera, its entire circumference articulates (and early ankyloses) with the frontals, which usually separate it inferiorly from the orbitosphenoids, though the latter may always reach it near the median line by pushing forward beneath the frontals. To its anterior face are attached the *ectoturbinals*, *endoturbinals*, and *mesethmoid.*

(2) The *mesethmoid* bone, or perpendicular plate of the ethmoid, is a longitudinal median partition incompletely dividing the olfactory chamber into two parts (fig. 7, *me*). Its superior border is firmly and inseparably ankylosed to the frontal; its posterior to the cribriform plate. Antero-inferiorly it abuts against the cartilaginous mesethmoid, which latter reaches forward from the presphenoid and is embraced between the lateral wings of the vomer, completing the partition between the two sides of the olfactory chamber. The shape of the bony lamella varies in the different groups and seems to be quite constant in members of the same genus. In *Cratogeomys* (pl. 18, fig. 4), *Orthogeomys* (fig. 60), and *Geomys* proper (pl. 18, fig. 1), it is somewhat like a half crescent, with the base above, and the apex pointing to the end of the presphenoid, the anterior border being convex downward. In *Platygeomys* it is similar, except that the upper part is strongly rounded anteriorly, the upper edge being shorter than that part of the lamella immediately below it (pl. 18, fig. 5). In *Heterogeomys* it is relatively small and strongly convex anteriorly (pl. 18, fig. 3). In *Zygogeomys* it is nearly rectangular and the front edge is nearly straight (pl. 18, fig. 2). In *Pappageomys* (fig. 57) it is higher than long, and its inferior border dips down between the wings of the vomer—a unique condition.

(3) The *os planum* is a thin sheet of bone which lines the posterior part of the olfactory chamber (fig. 10, *op*). It supports the endoturbinals and binds them together (as may be seen by consulting fig. 10 and

pl. 19, figs. 3, 4, and 5 of *Geomys bursarius*, *Heterogeomys*, and *Zygogeomys*). Inferiorly it articulates with the vertical lamella of the maxillary which lines the nasal passage, and with the anterior ends of the ascending wings of the palatines. Near its lower border (just below the fourth turbinal), it gives off a lateral shelf, which is firmly ankylosed to the outer side of the posterior third of vomer. In *Cratogeomys* its antero-inferior border is cut off close to the turbinal folds, giving the latter a

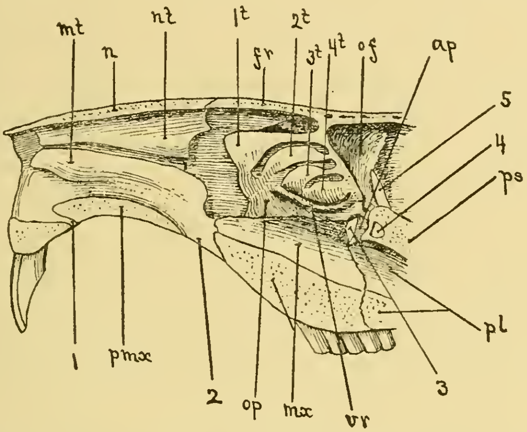


FIG 10.—Longitudal vertical median section of front part of skull of *Geomys bursarius*. Mesethmoid and vomer removed to show turbinated bones.

1 Anterior palatine foramen.
2 Incisive foramen.
3 Vacuity in front of presphenoid (present in *Geomys bursarius* and *tuza* only. It is partly overlapped posteriorly by the ascending wing of the vertical plate of the palatine, *ap*.).
4 Presphenoid fenestrum. Present in all species.
5 Upper part of sphenoidal fissure.
1t First or superior endoturbinal.
2t Second endoturbinal.
3t Third endoturbinal.
4t Fourth endoturbinal.
ap Ascending wing of vertical plate of palatine.
fr Frontal.
mt Maxilio-turbinal.
mx Maxilla (the upper pointer rests on the maxillary surface of the narial passage, the lower on the sawed body of the bone).
n Nasal.
nt Naso-turbinal.
op Os planum.
pl Palatine (the upper pointer rests on the palatine face of the narial passage, the lower on the sawed horizontal body of the bone).
pmx Premaxilla.
ps Presphenoid.
vr Vomerine ridge of os planum (unites with the lateral wing of the vomer).

particularly neat and finished appearance (pl. 19, fig. 6). In *Geomys bursarius*, on the other hand, it falls directly downward from the first turbmal, projecting as a thin sheet considerably in front of the others (fig. 10 and pl. 19, fig. 3).

(4) The *ectoturbinals* * arise from the upper and outer corners of the cribriform plate and occupy a small chamber at the maxillary root of the zygoma, incased chiefly by the frontal and maxillarybones. When the lachrymal is removed, they may be seen from the orbital side.

(5) The *endoturbinals* * arise from the outer sides of the anterior face of the cribriform plate (on the inner side of the ectoturbinals) and project into the nasal chamber (fig. 10). They are four in number throughout the family. Their outer sides are continuous with and form a part of the *os planum*. The first or uppermost is always the largest, longest, and most broadly expanded anteriorly. The others decrease in length from above downward, and are broadest in the middle or posteriorly. The fourth or lowermost is broader and shorter than the two middle ones. The first or uppermost is the only one that need be considered from the standpoint of variation of form in the several groups. Its front border usually slopes strongly backward (from above downward), as in *Platygeomys*, *Cratogeomys*, and *Zygogeomys;* but in *Heterogeomys* it is straight or slightly emarginate, vertical, and very broad, and carries with it the second fold (see pl. 19, fig. 5). In *Platygeomys* it is long and relatively slender, and its apex projects anteriorly behind the posterior border of the nasoturbinal (pl. 19, fig. 7). In *Zygogeomys* also it is pointed and projects far forward (pl. 19, fig. 4). In *Geomys bursarius* it is rather bluntly rounded (fig. 10, and pl. 19, fig. 3).

The *vomer* is a long and narrow plate of bone, cleft above and bifurcate posteriorly, which forms the lower part of the longitudinal vertical septum between the lateral chambers of the nasal cavity (fig. 7, *v*). It consists of a median plate and two wings. The median plate is embraced inferiorly between the wings of the vomerine sheath (which rises from the floor of the premaxilla and extreme anterior part of the maxilla). Superiorly it is split lengthwise from above, forming the two wings, between which the mesethmoid cartilage is received. These wings are narrowed posteriorly and reach the front end of the presphenoid, which they clasp laterally, but they do not appear on the inferior surface of the presphenoid, as they do in most mammals. Posteriorly the wings of the vomer separate slightly and are not united inferiorly. On the outer side they are inseparably united with the *os planum* just below the fourth endoturbinal, thus continuing anteriorly the roof of the narial passage, which is here sharply separated from the olfactory chamber above. The vomer articulates with the premaxilla, maxilla, ethmoid, presphenoid, and palatines.

The *pterygoids* are more or less quadrangular vertical plates, forming the lateral walls of the posterior nares (figs. 4 and 7, *pt*). Anteriorly they articulate with the vertical plates of the palatines; superiorly they are firmly ankylosed to the basisphenoid, and usually also with the posterior downward extension of the transverse arm of the alisphenoid.

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* These terms are adopted from Dr. Harrison Allen's admirable paper on the Ethmoid.—(Bull. Mus. Comp. Zool., Cambridge, X, No. 3, 1882, 136.)

They commonly develop a hamular process (figs. 4 and 7, *h*), which curves upward and reaches or nearly reaches the audital bulla (except in *Heterogeomys*). The inferior surface of the pterygoid is usually flattened, either horizontally or obliquely; it may be of uniform breadth (fig. 11²), or much broader anteriorly than posteriorly (figs. 11³ and 11⁴). It reaches its maximum length and slenderness in *Zygogeomys* (fig. 11¹); its maximum breadth and shortness in *Macrogeomys* (fig. 11⁵). The two arms may be divergent posteriorly, convergent posteriorly, or parallel.

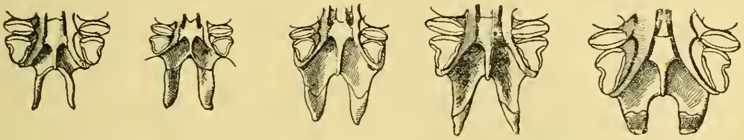

FIG. 11.—Principal types of palato-pterygoids.

1. *Zygogeomys trichopus.* 2. *Geomys lutescens.* 3. *Geomys bursarius.* 4. *Heterogeomys hispidus.* 5. *Macrogeomys heterodus.*

In the share they take in the formation of the palato-pterygoid plates on the roof of the mouth, and the manner of articulation with the palatine bones, the pterygoids present five types, as follows:

(1) They completely surround the postpalatal notch like a horseshoe, meeting or so nearly meeting anteriorly that at most a narrow spicule of the palatine reaches the notch in the median line. This type occurs in the genus *Zygogeomys* only (fig. 11¹).

(2) They form the whole or practically the whole of the sides of the postpalatal notch, but are separated anteriorly by the full breadth of the notch itself. This is the commonest type and prevails in the genera *Geomys* and *Cratogeomys* (fig. 11²).

(3) They are lingulate in shape and do not reach the base of the postpalatal notch, the palatine bones extending out a considerable distance to meet them. This is the ordinary condition in *Geomys bursarius* (fig. 11³).

(4) They are very much reduced, forming only the terminal part of the palato-pterygoid plates, the palatine part of which is greatly elongated. This condition obtains in *Heterogeomys* (fig. 11⁴).

(5) They are short, broad, and abruptly upturned, capping the ends of the very broad palatines. This type is restricted to *Macrogeomys* (fig. 11⁵).

The *palatine* bones contribute an insignificant part to the external surface of the skull (fig. 12, *pl*), but internally their connections are extensive and important (fig. 7, *pl*, and fig. 10, *pl* and *ap*). They early unite (probably before birth) in the median line, forming a single bone, which may be described as consisting of a body, two vertical plates, and two lateral wings or external ptergoid plates. The *body* or horizontal part enters the roof of the mouth posteriorly, forming a wedge between the hinder part of the maxillaries, and never reaching further forward than the middle molars (fig 12, *pl*). This part is cut away posteriorly, so that its inferior surface is on two planes. Anteriorly it is continuous with the plane of the bony palate; posteriorly with the pterygoids. The break in the palatines between these two planes occurs suddenly between the posterior molars, forming a step or pit on each side between the last molar and a median azygos projection of the palate, which connects the two more gradually. Posteriorly the palatals may terminate opposite the anterior end of the postpalatal notch (as usual in *Cratogeomys*), or they may extend out a short distance beyond the apex of the notch (as in *Geomys* proper), or they may push back still farther, forming more than half of the side walls of the notch (as in *Heterogeomys*), or they may fail to reach the notch at all, the pterygoids coming forward to the median line (as in *Zygogeomys*). [See fig. 11 *supra.*]

The *vertical plates* are thin lamellæ, which reach upward on each side from the body of the bone to the presphenoid, surrounding the middle section of the narial passage between the maxilla and pterygoid (fig. 7, *pl*). Their upper borders reach the basisphenoid anteriorly and are in contact with the presphenoid for its entire length; anteriorly they clasp the sides of the presphenoid and articulate with the ethmoid and frontal—the descending processes of the latter overlapping their anterior prolongations. The front border of the vertical plate of the palatine, on the side of the narial passage, articulates with the corresponding part of the maxilla; the hinder border with the pterygoid. In *Geomys bursarius* the vertical plate rises anteriorly in an *ascending wing* which hugs the prespenoid anteriorly and articulates broadly with the orbitosphenoid, frontal, and maxilla (fig. 10, *ap*).

Posteriorly the body of the palatine sends off, on each side, a lateral wing—the *external pterygoid plate*—which pushes its way around behind the maxilla and along the inner side of the descending wing of the alisphenoid as far as the point where the latter is joined by the transverse arm of the same bone (immediately below the alisphenoid canal), and sometimes sends a spicule backward to the audital bulla (fig 12, *epl*). The external pterygoid plate of the palatine thus forms the outer wall of the pterygoid fossa inferiorly. It is completely overlapped externally by the descending wing of the alisphenoid, except along its inferior margin, which projects slightly below the alisphenoid, thus appearing on the outer side of the skull (fig. 4, *epl*).

The palatines articulate with the maxilla, pterygoids, alisphenoids, basisphenoid, presphenoid, frontals, vomer, and ethmoids and sometimes also within the orbitosphenoids and the tympanic bullæ.

The *maxilla* is the largest, and after the ethmoid the most complicated bone of the skull, and comprises, roughly speaking, about one-third of the entire cranium (fig. 12, *mx*). It primarily consists of two parts, which are firmly united by ankylosis in very early life (probably before birth), forming a single strong bone for the support of the grinding teeth. It articulates with nearly all the bones of the face and with those of the anterior segment of the brain case, as follows: Anteriorly with the premaxilla, ethmoid and lachrymals; superiorly with the presphenoid and frontal; posteriorly with the palatines and alisphenoid, and externally with the jugals. The maxilla forms nearly the whole of the roof of the mouth, the palatines entering it merely as a wedge from behind. The densest and hardest part of the skull, after the floor of the premaxilla, is the median part of the maxilla between the

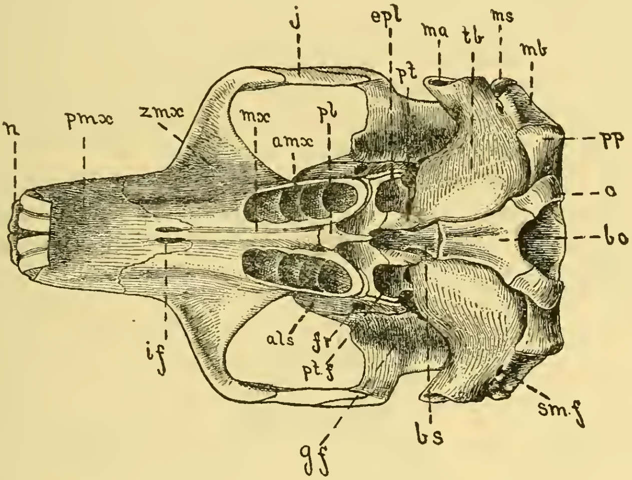

FIG. 12.—Under side of young skull of *Cratogeomys merriami*. (Specimen from Amecameca, Valley of Mexico.)

als Alisphenoid.
amx Alveolar border of maxilla.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
epl External pterygoid plate of palatine.
fr Foramen rotundum.
gf Glenoid fossa.
if Incisive foramen.
Jugal.
ma External auditory meatus.
mb Mastoid bulla.
ms Mastoid process of squamosal.
mx Maxilla.
n Nasal.
pl Palatine.
pmx Premaxilla.
pp Paroccipital process of exoccipital.
pt Pterygoid.
ptf Pterygoid fossa.
smf Stylo-mastoid foramen.
tb Tympanic or audital bulla.
zmx Zygomatic process of maxilla.

molariform teeth. The infraorbital canal is deeply imbedded in the maxilla and is very long, reaching back from near the premaxillary suture on the side of the muzzle to the bottom of the orbit. In the *Geomyidæ* it never perforates the zygomatic root of the maxilla, but passes deeply behind it.

The maxilla gives off anteriorly a vertical lamella, which rises from the median line of the floor of the nasal chamber and projects forward a short distance into the posterior part of the vomerine sheath of the premaxilla (fig. 13, *ms*). It is split lengthwise to receive the posterior part of the median plate of the vomer, but the resulting wings do not spread apart as in the premaxillary part of the vomerine sheath.

On each side of the nasal passage the body of the maxilla gives off a thin vertical plate or lamella, which may be termed the *internal vertical plate of the maxilla.* It forms a lining for the narial passage and articulates above with the lower edge of the os planum of the endoturbinal. The infraorbital canal passes for nearly its entire length between this thin plate and the main part of the maxilla.

The *premaxilla* is a single bone in the *Geomyidæ* (its two halves uniting before birth, fig. 12, *pmx*). It constitutes the greater part of the rostrum and forms the floor and lateral walls of the anterior half of the nasal chamber. Superiorly it embraces the nasals and articulates with the frontal and the maxillary root of the zygoma; laterally it articulates with the outer side of the maxilla a little anterior to the plane of the infraorbital foramen; inferiorly it articulates with the maxilla posterior to the middle of the rostrum, and reaches far enough backward to inclose the *incisive foramina* (fig. 12, *if*) in all except *Zygogeomys trichopus.* Anteriorly it is perforated on the median line by the

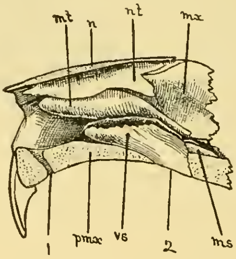

FIG. 13.—Longitudinal vertical section of nasal chamber of *Cratogeomys merriami.* The vomer has been removed to show the vomerine sheath and anterior turbinated bones.

1 Anterior palatine foramen.
2 Incisive foramen.
mt Maxillo-turbinal.
ms Maxillary part of vomerine sheath (which passes anteriorly into the premaxillary part of the sheath).
mx Maxillary.
n Nasal.
nt Naso-turbinal.
pmx Premaxilla.
vs Vomerine sheath of premaxilla.

anterior palatine foramen, which descends from the floor of the nasal chamber to the roof of the mouth, immediately behind the incisors (figs. 7, 10 and 13 [1]). On the inner side it supports the *maxillo-turbinals* and the *vomerine sheath*, which latter structure attains a high development in this group, particularly in *Platygeomys* and *Cratogeomys.*

The *vomerine sheath* (fig. 13, *vs*) is a double lamella rising from the floor of the premaxilla on the median line and projecting into the nasal cavity. It is elongated antero-posteriorly, reaching from the hinder end of the premaxilla forward over half or two-thirds the floor of the bone. Posteriorly it receives the anterior end of the corresponding (but very much smaller and narrower) part of the maxilla; superiorly it receives the median vertical plate of the vomer.

The *maxillo-turbinal*, or *inferior turbinated bone* (figs. 7, 10, and 13, *mt*), is the lower of the two turbinated bones of the anterior half of the nasal cavity (the upper being attached to the nasal). It is nearly horizontal, though usually sloping downward posteriorly, and is attached to the middle part of the inner side of the premaxilla; its free posterior end projects slightly over the front of the maxilla.

The premaxilla articulates with the nasals, frontal, maxilla, vomer, and ethmoid.

The *jugal* completes the zygomatic arch, and is always restricted to the horizontal part, never reaching down posteriorly into the glenoid fossa, and never creeping up anteriorly toward the lachrymal (figs. 9 and 12, *j*). But its variations in size and form are remarkable (fig. 14 and pl. 13). In some species it is very large and broadly expanded anteriorly (fig. 14[1]); in others it is reduced to an insignificant splint, and the zygomatic arch is complete without it (fig. 14[6]). It is commonly larger and broader in the male than the female, and sometimes

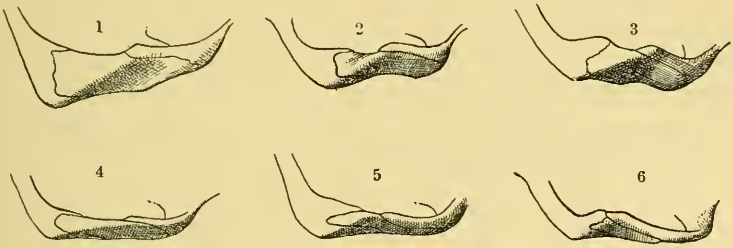

FIG. 14.—Left zygoma, showing several types of jugal.

1. *Platygeomys tylorhinus.*
2. *Heterogeomys hispidus.*
3. *Macrogeomys heterodus.*
4. *Geomys bursarius.*
5. *Cratogeomys perotensis.*
6. *Zygogeomys trichopus.*

varies greatly in species of the same genus and even in the same section. Thus, in *Platygeomys* it is greatly expanded in *gymnurus* and *tylorhinus*, and is slender throughout in *planiceps*. Similarly, in *Cratogeomys* it is broad anteriorly in *merriami*, *fulvescens*, and *castanops*, while in *perotensis* it is slender and small in every way.

The *lachrymal* is a small L-shaped bone, consisting of a *vertical* scale-like part, which closes the vacuity between the frontal and maxillary root of the zygoma at the inner corner of the orbit; and a thickened *horizontal* part which projects outward from the frontal on the upper surface of the skull and articulates also with the maxillary root of the zygoma. Its distal end is sometimes elongated and slightly recurved, and projects freely over the corner of the orbit. The principal or vertical part of the lachrymal is grooved vertically on its outer side, just anterior to the orbital face, for the lachrymal duct which passes down into the nasal chamber.

The *nasal* bones fill the interspace between the ascending arms of the premaxilla on top of the rostrum, thus completing the roof of the nasal cavity, which they slightly overhang anteriorly (figs. 8 and 9, *n*).

They are commonly ankylosed together in middle life, and not infrequently become ankylosed to the frontals also. Their actual length varies greatly in the different species. They are shortest in *Cratogeomys estor* and longest in *Zygogeomys trichopus* and *Geomys tuza*. They are commonly truncate wedge-shaped; the increase in breadth from behind forward may be gradual or abrupt. In the latter case the expansion is usually near the middle. In the *Geomys tuza* group the shape of the nasals is peculiar. They are very long and are constricted near the middle, giving them an hour-glass shape. In most of the genera (*Geomys*, *Cratogeomys*, *Platygeomys*, *Zygogeomys*) the nasals are nearly flat, though they are always more or less decurved anteriorly and rounded off laterally in front. But in some groups (notably in *Heterogeomys*) they are broadly and highly *arched* anteriorly, giving them an inflated appearance. This elevated part of the nasal supports the naked nasal pad or callosity. Inferiorly the nasals give off a descending lamella, the *nasoturbinal* bone, which is elongated antero-posteriorly and is broadest behind.

The nasals articulate with the premaxilla, frontal, and ethmoid.

The *tympano-periotic capsule* incompletely fills a broad gap in the posterior segment of the skull, between the basioccipital and squamosal (figs. 4, 7, and 9). It is held in place by several bones with which its connection is more or less intimate, but is never ankylosed to any of them except in extreme age, when the mastoid process of the mastoid bulla sometimes unites with the mastoid process of the squamosal. Its principal stays are the exoccipital and the mastoid process of the squamosal, between which the mastoid bulla is firmly grasped posteriorly. In addition to these supports, the inner border of the audital bulla commonly fits into a groove on the outer edge of the basioccipital, and the apex of the bulla rests against the base of the horizontal arm of the alisphenoid near its junction with the basisphenoid. The tympano-periotic mass as a whole thus has four normal attachments, two of which hold it firmly in place, while the others simply steady it in its position. In old age the lower edge of the squamosal sometimes reaches the upper side of the bulla and presses firmly against it.

The *tympano-periotic capsule* consists of three parts, firmly ankylosed together: (1) the *tympanic*, or audital bulla; (2) the *petrous*, or periotic proper; (3) and the *mastoid* bulla. Of these, the mastoid is posterior to the others, both of which are inseparably ankylosed to its anterior face. The tympanic protrudes from the base of the skull, forming the *audital bullæ*. The *petrous* projects into the brain case and contains the organ of hearing. No suture or other line of demarcation indicates the exact place of meeting of the mastoid with either the petrous or tympanic, but anteriorly the line of union between the two latter is always distinct. The three elements may be described as follows:

(1) The *tympanic* or audital bulla is almost wholly inferior, projecting from the under surface of the outer segment of the cranium between the

basioccipital and squamosal (figs. 4 and 12, *tb*). Anteriorly it is bounded by the *foramen lacerum medium basis cranii*, in front of which is the transverse bar of the alisphenoid. Superiorly it is separated from the squamosal by a long, irregular vacuity reaching upward and backward from the foramen lacerum medium to the tube of the external meatus, which latter articulates with the squamosal. Posteriorly it abuts against the mastoid process of the squamosal above, and the exoccipital below, and is continuous with the mastoid bulla. Externally it sends off at right angles a long tube which partly fills the postglenoid notch and opens just behind the posterior angle of the zygoma (fig. 12, *ma*). This is the external auditory meatus (fig. 4[5]). The tube of the meatus curves forward and somewhat upward as well as outward, and forms the posterior boundary of the glenoid fossa, against which the condyle of the jaw strikes during the to and fro movement of mastication. The adjoining upper part of the outer side of the bulla forms the inner side of the glenoid fossa. It is thus apparent that this fossa, while mainly in the squamosal, is completed posteriorly by the tympanic bulla. The inner side of the bulla fits into a longitudinal groove on the outer edge of the body of the basioccipital, and the extreme anterior end just above the entrance of the Eustachian canal rests against the horizontal arm of the alisphenoid, which sometimes, as in *Cratogeomys*, sends back a small tongue of bone to cover its apex. The canal for the internal carotid artery is absent. On the inferior surface, between the mastoid and tympanic bullæ, is a small opening, the *stylomastoid foramen* (fig. 12, *smf*). The tympanic bulla arches over and protects the tympanum and the openings leading into the internal ear.

(2). The *petrous*, or periotic proper, in which is lodged the organ of hearing, is not visible from the outer side of the skull, but is conspicuous on the inner side (figs. 7 and 9, *pet*), where it is saddled upon the tympanic capsule, which it does not completely cover, a considerable part of the bulla protruding anteriorly (figs. 7 and 9, *tb*). The line of demarcation between the two is always evident. The anterior border of the petrous begins near the middle of the inferior margin of the inner surface of the bulla and curves upward and forward to the front end of the ridge that separates the inner from the superior surface of the bone. On the outer side of this ridge it turns back, forming a deep reentrant angle, at the apex of which is a small foramen. The petrous is commonly described as a very hard bone. It is not so in the *Geomyidæ*, but is soft and spongy, being made up of cancellous tissue like the rest of the tympano-periotic capsule. It contains the cochlea (coiled in a compact cone of 4½ turns), the semicircular canals, and the three small bones of the internal ear—the *malleus*, *incus*, and *stapes*. The petrous may be described as presenting two surfaces, a *superior* and an *inner*. The *superior* surface is narrow, slopes downward from behind forward, and is scooped out lengthwise. It is more or less completely separated from the inner surface by a ridge, which in some forms is sharply marked; in others is inconspicuous. This ridge presents various degrees of development in the different groups. It is rounded off in *Platygeomys*, but is elevated into a distinct crest in *Cratogeomys*, *Zygogeomys*, *Heterogeomys*, and *Geomys* proper (pls. 17 and 18). It usually reaches upward and backward to the upper part of the audital mass, but in *Heterogeomys* it fails posteriorly, but forms a sharply elevated ridge from the plane of the flocculus downward (pl. 18, fig. 3). The *inner* face of the *petrous* is always perforated by the *internal auditory meatus* (fig. 7^3 and fig. 9, *ma*), above which is a depression called the *floccular fossa* (fig. 7^4 and fig. 9, *ff*). The *floccular fossa* varies in size and form in the several genera. Its position is always above and posterior to the internal meatus, from which it is separated by an elevation which sometimes amounts to a strongly developed ridge (see pls. 17 and 18). The ridge is marked in *Cratogeomys*, but not in *Platygeomys*, *Heterogeomys*, or *Geomys* proper. In *Zygogeomys* it is not only present, but a supplementary ridge bounds the floccular fossa posteriorly, leaving another depression behind it, so that the bone presents the appearance of having two floccular fossæ (pl. 17, fig. 2, and pl. 18, fig. 2).

(3) The *mastoid bulla* forms the hindermost part of the auditory apparatus (fig. 4, *mb*). It appears on the outer side of the occipital plane as a more or less rounded subtriangular mass, convex posteriorly, with the base toward the median line and the blunt apex (*mastoid process* proper, fig. 4, *m*) directed outward. It is grasped and held in place by the paroccipital process of the exoccipital below (figs. 4 and 12, *pp*), and the long mastoid process of the squamosal above (fig. 4, *ms*). The former fits into a notch on the under side between the mastoid and audital bullæ. The latter reaches far outward and curves down upon the head of the mastoid process, which it overreaches enough to effectually oppose the action of the exoccipital. The mastoid bulla, viewed from behind, differs considerably in form in the several genera, and presents specific differences also (pl. 15, figs. 3–7). It is short and rounded in *Zygogeomys* and *Geomys* (particularly in the *tuza* series). It is strongly triangular in *Macrogeomys dolichocephalus;* triangular with a constricted and elongated neck in *M. heterodus*, and much produced laterally with the inferior border concave in *Platygeomys*. Internally the mastoid bulla is made up of fine cancellous tissue.

The *mandible* is usually a large and heavy bone, strongly marked by processes and ridges for the attachment of the powerful muscles that move it. To be understood, it should be studied as a part of the cutting and slicing machine, for it consists, on each side, of a curved beam or plate built expressly to carry the ponderous chisel-edged incisors and the series of parallel cutting blades of the lower molariform teeth. The two halves are joined together by an elongated symphysis which admits of a certain amount of movement, and the adjustment is aided by a transverse muscle which helps bind the jaws together above the posterior half of the symphysis. Each half of the mandible is strongly and rather shortly curved upward longitudinally, and is broader behind than in front; it also curves outward. There is no separation into horizontal and ascending rami, although when viewed from the inner side the condylar and coronoid part might be regarded as forming an ascending ramus. The outer side gives off posteriorly, at right angles to its axis, a strongly defined *angular process* which is always important and in some forms, particularly in *Platygeomys*, attains enormous proportions (pl. 10, fig. 8). Between the angular process and condyle is a subglobular prominence which covers the root of the long incisor. The coronoid process is broad at the base anteroposteriorly; its apex is hamular and rises above the plane of the condyle. In some forms (notably in *Platygeomys*) a strong shelf-like ridge runs from the anterior base of the coronoid to the angular process. The *masseteric fossa* is always well defined and reaches anteriorly to the plane of the front of the premolar. On the outer side of the last two molars is a large and deep pit for the insertion of the principal part of the temporal muscle (pls. 1–7). The dental foramen enters the ramus just behind this pit and just below the condylar process. Behind the symphysis, inferiorly, is a flange-like prominence for the insertion of the digastric muscle. The principal differences in the form of the mandible as a whole result from the amount of spreading posteriorly and the degree of development of the angular processes. The various types, as seen from below, are shown on Pl. 10. In some cases the base of the angular process is notched anteriorly, as in *Geomys mobilensis* (pl. 10, fig. 2.)

3. CHANGES WITH AGE.

Throughout the *Geomyidæ*, except in *Pappogeomys*, and some species of *Thomomys*, the form of the cranium as a whole, and the pattern of the sutures on the upper surface change greatly with age. The change marks the transition from immaturity to maturity—from the generalized type that stands for the group to the specialized type that bears the impress of the species. When the skull of a species fails to show marked differences with age, that species may be set down as a generalized type—one that is probably but little removed from the ancestral line. For this reason *Pappogeomys bulleri* is looked upon as very near the trunk line of the group.

The principal changes in the form of the skull as a whole resulting from age are: The broadening out of the zygomatic arches, elongation of the rostrum, expansion of the squamosal, and development of the crests and ridges that come with maturity. The anterior or maxillary root of the zygoma at first slopes strongly backward in all species, and the arches themselves are narrower anteriorly than posteriorly (as is the rule in adults of *Thomomys*). With advancing age they spread apart anteriorly until in most species they are much broader anteriorly than posteriorly. At the same time the maxillary root stands out more and more squarely until it sometimes forms almost a right angle to the axis of the skull. The remarkable growth of the squamosal has been already described. Before birth the ascending branches of the premaxilla end about on a plane with the nasals (sometimes anterior to it), but they soon push back over the frontals, attaining their permanent relations at an early age. The muzzle increases in length from birth to maturity. This may be roughly expressed in the growth of the nasals as shown in the accompanying figure (fig. 15). In a young skull of *Zygogeomys trichopus* the nasals form 37 percent of the total length of the upper surface of the skull, while in an adult skull of the same species they form 44 percent of the total. The frontal, like the interparietal, though to a less degree, suffers from the encroachment of the parietals, and in some species from the inordinate growth of the squamosals also. In young skulls the frontal is broad posteriorly and

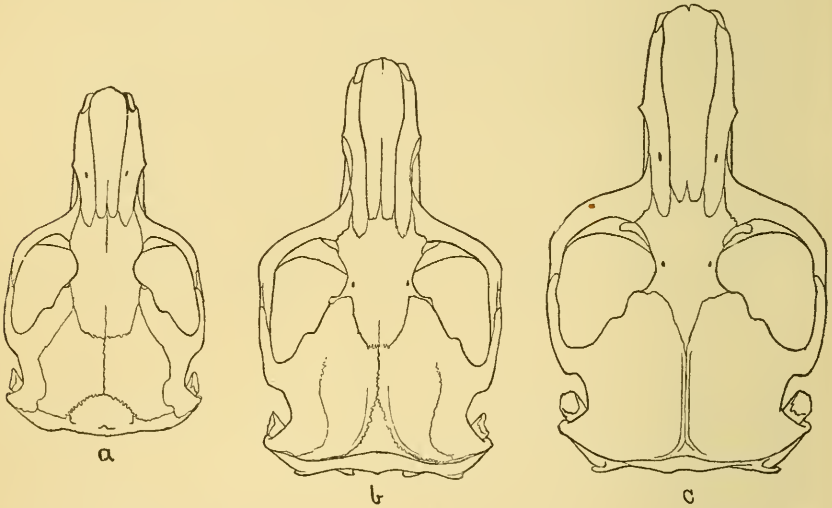

FIG. 15.—*Zygogeomys trichopus*, showing changes with age. *a*, Young; *b*, young adult; *c*, adult.

forms an important part of the roof of the brain case, as seen from above (figs. 8, 15*a*, and 16*b*). In old skulls it is reduced posteriorly, in most species, to a small wedge between the greatly expanded anterior extremities of the parietals and squamosals (see pl. 1; pl. 15, fig. 2; and text fig. 15, *c*, for adults of same species figured in figs. 8, 15, *a* and 16, *b*).

The changes in the suture pattern result mainly from the growth of the parietals both anteriorly and posteriorly, with consequent shrinkage of the interparietal, and the progressive development of the squamosal. The decrease in the size of the interparietal corresponds with the movement of the temporal impressions, which approximate with age, and in many species finally meet in a sagittal crest. The parietals not only tend to cover the interparietal by meeting posteriorly above it, but anteriorly they overlap the sides of the frontal, altering its shape entirely. The progressive development of the squamosals in some species, as elsewhere shown, is even more remarkable than that of the parietals.

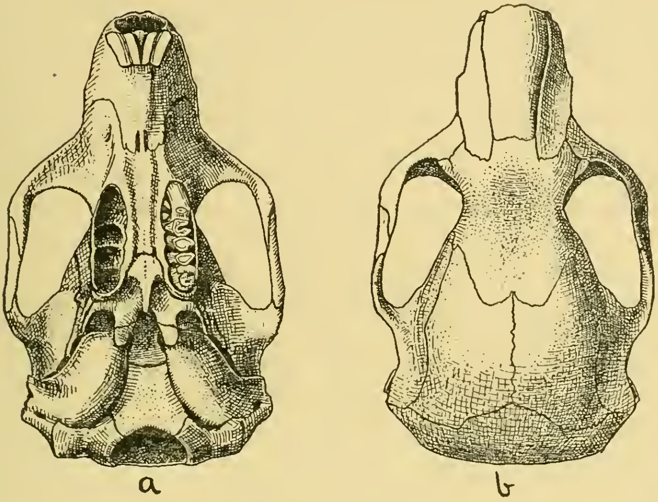

FIG. 16.—Skull of very young *Heterogeomys torridus* from Motzorongo, Mexico (No. 63643). *a*, lower surface; *b*, upper surface. For key to bones see figs. 8 and 12.

4. COÖSSIFICATION OF THE PAIRED BONES.

Nearly all the paired bones that meet in the median line become firmly ankylosed together before birth or in very early life. Those that are thus coossified are the premaxillaries, maxillaries, palatines, parietals, frontals, and frequently the nasals also. Of these, all except the parietals and nasals are ankylosed before birth (see figs. 8 and 16).

The single bones forming the basicranial axis are early ankylosed with the adjoining paired bones of the same segments. Thus the presphenoid is inseparably united with the orbitosphenoids; the basisphenoid with the alisphenoids and pterygoids; the basioccipital with the exoccipitals. The union of the lateral with the median elements of the sphenoidal segments occurs before birth; that of the occipital segment later. The exoccipitals are always distinct in early life (figs. 12 and 16), but soon become ankylosed with the basioccipital below and the supraoccipital above. The latter, except in a few species, is inseparable from the interparietal. The parietals in adult life are commonly ankylosed with the squamosals.

5. CRANIAL VARIATIONS—DEPARTURES FROM THE TRUNK LINE.

In external appearance the members of the family *Geomyidæ* are very much alike, but in cranial characters they present several marked generic types. The skulls of these types differ in size, massiveness, and degree of development of the crests, ridges, and processes from the small, thin, and smoothly rounded skulls of *Geomys texensis* and *bulleri* to the huge angular craniums of *Platygeomys gymnurus* and *Cratogeomys merriami;* and the large, massive skulls differ in the breadth of the cranium and lateral production of the angle of the mandible from the extraordinarily broad and flat *Platygeomys gymnurus* to the long and narrow *Orthogeomys scalops* and *Macrogeomys dolichocephalus.* The skulls differ further—and this is much more important—in the relative development and relations of certain bones which here assume proportions and conditions previously unknown. Most if not all of these remarkable extremes of form are clearly secondary modifications resulting from the highly specialized types of dental armature possessed by the animals, as shown later.

The parts of the skull that exhibit the widest variation and play the most important part in giving to each type its peculiar impress or physiognomy are the *zygomatic arches*, the *roof of the brain case*, and the *occiput.* The individual bones that present the greatest range in size and form are the *frontal*, *squamosal*, *jugal*, *pterygoid*, and *mandible.*

The *zygomatic arch* varies exceedingly in size, form, and the relative development of its component elements, according to its importance as a support for the jugal part of the masseter muscle. It may be small and slender, with the horizontal part reduced to a mere rod, as in *Pappogeomys bulleri* (pl. 13, fig. 15) and *Orthogeomys latifrons* (pl. 13, fig. 16), or it may be large and massive, with the angle and horizontal arm broadly expanded, as in *Platygeomys* (pl. 13, figs. 1 and 2), *Cratogeomys* (pl. 13, fig. 4), and *Heterogeomys* (pl. 13, fig. 20). The area for the attachment of the jugal part of the masseter muscle may be small and posterior (fig. 49, *jo*), or large and extending the full length of the outer side of the zygoma (fig. 50, *jo*). The arches may be small and narrow with their outer sides nearly parallel, as in *Macrogeomys dolichocephalus* (pl. 5) and *Orthogeomys scalops* (pl. 19, fig. 1), or they may be massive, widely spreading, and broadly divergent anteriorly, as in *Platygeomys* (pl. 3) and *Cratogeomys* (pl. 2). The ratio of their breadth to the basal length of the skull varies from 54 percent in *Macrogeomys dolichocephalus* to upward of 88 percent in *Platygeomys tylorhinus*, a difference of 34 percent. They may be slightly or strongly decurved; the horizontal part may be lowest anteriorly as in *Platygeomys gymnurus* (pl. 13, fig. 2), or highest anteriorly, as in *Macrogeomys dolichocephalus* (pl. 13, fig. 19), and the angle may be small (pl. 13, figs. 15, 16, and 24) or broadly expanded (pl. 13, figs. 1, 2, 4, 17, and 18). The expansion, which normally covers the antero-external angle, as in *Platygeomys*, *Cratogeomys*, and *Heterogeomys* (pl. 13, figs. 1, 2, 4, etc.) may be drawn backward so as to occupy the middle part of the horizontal arm, as in *Macrogeomys costaricensis* and *dolichocephalus* (pl. 13, figs. 19 and 23). In the latter the zygomatic arch presents a peculiarity not observed in any other member of the group. It is narrow, broadly rounded antero-externally, without the expansion of the angle common to *Cratogeomys*, *Platygeomys*, and *Heterogeomys*, but with a moderate expansion near the middle of the horizontal arm. This expansion is wholly on the upper or orbital side, and is restricted to the maxillary part of the arch, which here reaches much farther back than usual. On comparing the arch carefully with that of *Macrogeomys heterodus* a curious explanation is suggested, namely, that in the extreme elongation of the skull of *M. dolichocephalus* the anterior root of the zygoma has been moved forward (the posterior root being fixed), increasing the length of the maxillary arm, decreasing the breadth of the arch, obliterating the antero-external angle, elongating the laminar expansion on the orbital side, and carrying its highest point backward to or behind the middle of the orbito-temporal fossa (pl. 13, fig. 19, and text fig. 49). At the same time the upper anterior angle of the jugal has been rounded off, and the maxillary and squamosal arms of the zygoma have nearly clasped hands above it. Furthermore, the zygomatic arch as a whole has been lifted up by the main body of the masseter muscle and as a consequence the anterior end has been raised higher than the posterior (fig. 49, which should be contrasted with the corresponding view of *Platygeomys gymnurus*, in which the front of the arch is drawn down, fig. 50).

The form of the *occiput* as a whole varies considerably in the several groups. In the less specialized forms, such as *Geomys texensis*, *arenarius*, and *breviceps*, and *Pappogeomys bulleri* (pl. 15, fig. 5), it is rounded and bulges posteriorly to such a degree that the lambdoid suture is left a considerable distance in front of it. In *Zygogeomys*, *Cratogeomys*, and *Geomys bursarius* and *lutescens*, the occiput is squarely truncated. In *Heterogeomys* (pl. 15, fig. 4), *Macrogeomys* (pl. 15, fig. 3), and *Orthogeomys* it is rather high and slopes strongly forward; and in *Heterogeomys* it is particularly high above the mastoid bullæ. In *Platygeomys* it is depressed and elongated transversely and presents a unique appearance, the broad flange-like paroccipital processes curving strongly backward, defining laterally a deep basin-shaped cavity which is completed above by the overhanging lambdoid crest (pl. 15, fig. 7).

The form of the *frontal* as seen from above varies greatly in the different groups. In *Geomys*, *Cratogeomys*, *Platygeomys*, and *Zygogeomys* it is narrow and is strongly biconcave between the orbits, with the orbital margins more or less thickened and raised, leaving a longitudinal depression or groove between them (fig. 17¹). In *Heterogeomys* it is broad, flat on top, moderately biconcave between the orbits, and shield-shaped posteriorly, owing to the elevated temporal ridges; but the orbital margins are not rounded, thickened, or raised (fig. 17²). In *Macrogeomys* it is moderately broad and deeply constricted between the orbits posteriorly. Immediately behind the constriction it expands abruptly at right angles to its axis, forming well-marked postorbital processes which are capped by the apex of the alisphenoid and partly overlapped posteriorly by the squamosal (fig. 17³). In *Orthogeomys* it is remarkably broad throughout and is not constricted between the orbits (fig. 17⁴), though the peculiar inflations at the anterior corners of the orbits in *O. grandis* produce the appearance of a constriction behind them.

The *jugal* varies in size and shape from the large and greatly expanded plate that forms the major part of the outer side of the zygomatic arch in *Platygeomys tylorhinus* (pl. 13, fig. 1), to the rudimentary splint or scale that adheres to the inferior side of the zygoma in *Zygogeomys trichopus*, the arch being complete above without it (pl. 13, fig. 24).

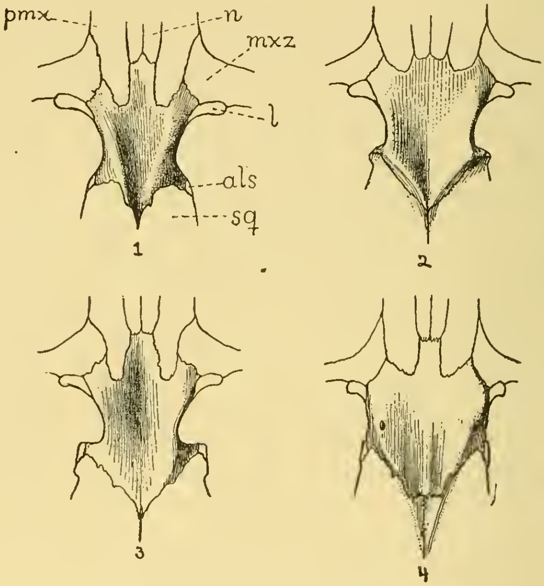

FIG. 17.—Types of frontal.

1. *Cratogeomys merriami.*
2. *Heterogeomys torridus.*
3. *Macrogeomys heterodus.*
4. *Orthogeomys scalops.*

als, apex of alisphenoid; *l*, lachrymal; *mxz*, maxillary root of zygoma; *n*, nasal; *pmx*, ascending or nasal branch of premaxilla; *sq*, squamosal.

The variation in the *squamosal* is hardly less extreme. Throughout the genus, except in the most generalized forms, this bone exhibits a singular tendency toward expansion. In *Geomys* proper the tendency is restricted to a slight overlapping of the postero-lateral moiety of the frontal and lower edge of the parietals. But in the genus *Cratogeomys* its ambition in this direction is not satisfied until the whole of the posterior half of the cranium is covered. In *Cratogeomys merriami* as the animal grows old the upper edges of the squamosals gradually creep up over the parietals until the latter are completely arched over and concealed, the squamosals actually meeting above them along the median line. In doing this the squamosals cover the posterior part of the frontal as well as the whole of the parietals and most of the interparietal, and curve up posteriorly to take part in the formation of the lambdoid crest for its entire length, thus roofing the brain with two distinct layers of bone, the upper of which on each side, consisting of a single bone, overlaps in whole or in part five bones of the lower layer (frontal, parietal, interparietal, supraoccipital, and alisphenoid). The object of this unique arrangement is not only to furnish a brace to the zygoma, to which the powerful masseter muscles are in large part attached, but also to strengthen the vault of the cranium where the huge temporal muscles take origin. The various steps in the development of this extraordinary condition can be distinctly traced in the series of skulls of different ages of *Cratogeomys merriami* collected by Mr. Nelson in the Valley of Mexico. In *Platygeomys* another condition prevails, the squamosal expansion being chiefly *away* from the median line. On the inner side it overlaps the lower part of the parietals as usual; it then extends outward in a broad shelf, carrying the squamosal root of the zygoma far beyond its normal position, and spreading outward and backward so as to completely roof over the postglenoid space, behind which it pushes still further outward and overreaches the extreme end of the transversely elongated mastoid. In *Platygeomys gymnurus*, *tylorhinus*, and *planiceps* the lateral expansion is so excessive that the breadth of the cranium across the squamosals posteriorly is actually greater than the breadth across the widely spreading zygomatic arches (pl. 3).

The *pterygoids* vary surprisingly in size, form, and the extent to which the inferior surface enters into the lateral walls of the postpalatal notch, as already shown (pp. 52–53, and fig. 11). In *Zygogeomys* they are long and slender and encircle the notch like a horseshoe, meeting or nearly meeting in the median line behind the palate (pl. 14, fig. 1). In most species of *Geomys*, *Cratogeomys*, *Pappogeomys*, and *Orthogeomys* they are more or less parallel plates forming the greater part of the walls of the notch but not approximating anteriorly (pl. 14, figs. 7, 11, 13, 15). In *Geomys bursarius* they are more posterior, and taper to nearly a point behind, being lingulate in shape (pl. 14, fig. 2). In *Macrogeomys* they are short and broad and bend abruptly upward, capping the ends of the short and broad palatines (pl. 14, fig. 3). In *Heterogeomys* they are small, and simply form the narrow ends of the elongated posterior arms of the palatines (pl. 14, fig. 12).

The *mandible* is relatively small and light in *Geomys*. It is large and massive in *Cratogeomys*, *Platygeomys*, and the remaining groups. It is long and narrow, with short truncate angular processes, in *Macrogeomys dolichocephalus* (pl. 10, fig. 7). It is broadly spreading, with greatly elongated angular processes, in *Platygeomys gymnurus* (pl. 10, fig. 8).

The degree of development of the angular processes is correlated with definite types of molariform teeth, and affords a key to the dominant movement of the jaw in mastication, the so-called 'grinding movement' being very different in the species with and those without the greatly elongated processes. Where these processes reach their highest development, as in *Platygeomys gymnurus* (pl. 3 and pl. 12, fig. 8, and text figs. 53 and 54) the posterior part of the masseter muscle, arising from the jugal and squamosal arm of the zygoma, is correspondingly large and effective; and since the direction of its fibers is nearly transverse to the axis of the skull, it is evident that the resulting movement of the jaw must be largely lateral. If the two parts of the masseter contract simultaneously, the resulting motion of the jaw would be oblique; if they contract independently, a to-and-fro movement would alternate with a sidewise movement.

In the species in which the lateral production of the angle of the jaw is reduced to a minimum, as in *Macrogeomys dolichocephalus* (pl. 5 and pl. 12, fig. 7; and text figs. 51 and 52) the posterior part of the masseter must be relatively unimportant, and the principal movement must be to and fro. That this is really the case is shown by the greatly restricted area of attachment for the jugal end of this part of the muscle (fig. 49 *jo*), and also by the character of the teeth. As would be expected, the crowns of the molars are broader antero-posteriorly than in the *gymnurus* group, and the tooth row on each side is bowed downward—the crowns of the upper series as a whole being convex, the lower concave, antero-posteriorly (fig. 46). Moreover, the obliquity of the plane of contact of the upper and lower series is less in *dolichocephalus* than in *gymnurus* (see figs. 52 and 54, *f*).*

* The types of molariform teeth coordinated with the two principal types of jaw movement, and hence secondarily with the development of the angular processes, are discussed at greater length under the head '*Mechanism and Dynamics of the cutting machine*' (pp. 93–97).

CHAPTER III.

THE DENTAL ARMATURE.

THE TEETH.

The dental formula of the *Geomyidæ* is the same throughout the family, as follows: $i\frac{1}{1}, c\frac{0}{0}, pm\frac{1}{1}, m\frac{3}{3} \times 2 = 20$

All of the teeth of the Pocket Gophers are simple rootless* tubular prisms, closed at the top and open at the base. In life the lower part is filled with a soft, pulp-like substance, supplied with blood vessels which replenish the tooth from below, enabling it to grow as long as the animal lives. The hardening of the pulp within the tooth forms

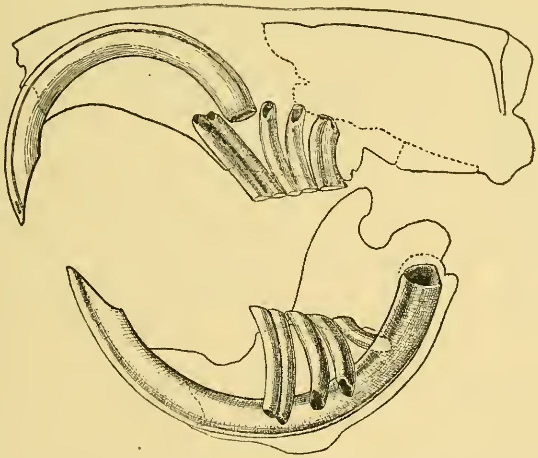

FIG. 18.—Outline of skull of *Platygeomys gymnurus*, showing teeth in situ.

the dentine and osteodentine; the enamel and cement are deposited on the outside. In the adult† the crowns of the teeth are never complicated by infoldings of the enamel; the enamel never envelops the prism continuously and never dips into the interior, but is always attached to the outside in the form of vertical bands or plates like the staves on

*Although the teeth have no true roots, it is convenient to speak of the basal or growing end as the root. The term is used in this sense in the present paper.

†The enamel caps of the young teeth, and changes in the enamel pattern due to immaturity, are fully described under a separate heading (pp. 83-86).

a barrel (pl. 16, fig. 12). The number of enamel plates on each tooth varies from one to four. When the tooth is looked at from the side, the alternating bands of enamel and cement are found to extend vertically from base to crown; and since the tooth is constantly worn down from above and as constantly replenished by growth from below, its original form is preserved and no sensible change in the enamel pattern takes place.

THE INCISORS.

The incisors are long and heavy, with trenchant, chisel-like edges (figs. 18 and 19). Their massiveness varies greatly in the different genera. The upper incisor is shortly curved in a single plane, forming a little more than a complete semicircle, and its root rests either in the upper part of the interspace between the divaricating roots of the premolar and first molar, as in *Platygeomys* (fig. 18), or directly above the root of the first molar, as in some of the other genera. The lower incisor is much longer, less shortly curved, and does not form a complete semicircle. It passes backward beneath and on the inner side of the molars, its own root rotating outward in a partial spiral like the beginning of the twist in a ram's horn, and terminates in a thin capsule of bone on the outer side of the condylar process. The lower incisor is thus considerably longer than the greatest length of the jaw, from which it projects at both ends.

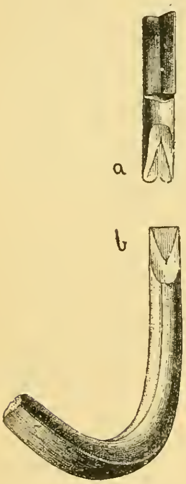

FIG. 19.—Incisors of *Platygeomys gymnurus* seen from behind. *a* upper; *b* lower.

Both upper and lower incisors have their anterior faces covered with a plate of enamel, the edges of which are bent back over the sides of the tooth far enough to hold it securely (fig. 20, *a*, *b*, and fig. 24) so that it can withstand, without danger of loosening, the great strain to which it is subjected in cutting hard roots.

On the inner side of the tooth the inflexed border of the enamel is beveled (fig. 20, *a*); on the outer side it retains its normal thickness (fig. 20, *b*). The inner edge of the tooth is squarely angular or nearly so, while the outer edge is always broadly rounded (figs. 20, 21, 22). In the lower incisor the front face of the tooth is always flat or nearly so (fig. 24); in the upper incisor it is flat in *Macrogeomys* and *Heterogeomys* (fig. 20), nearly flat or twice convex in *Cratogeomys* (fig. 21[1] and [3]), *Platygeomys* (fig. 21[2]), and *Pappogeomys* (fig. 21,[4]); and thrice convex in *Geomys* proper (fig. 22[2] and [3]) and *Zygogeomys* (fig. 22[1]).

The enamel face of the upper incisor is invariably marked (except in some species of *Thomomys*) by a conspicuous longitudinal groove or furrow, resulting from an infolding of the enamel. A second and much smaller groove is sometimes present also, always near the inner edge of the tooth. The form and position of the grooves vary in the different species; there is also considerable range of individual variation.* Five types of sulcation prevail, as follows:

Bisulcate series:
- Principal sulcus on *outer* side of median line .... *Geomys*
- Principal sulcus on *inner* side of median line .... *Zygogeomys*

Unisulcate series:
- Sulcus median or slightly on inner side of median line; rather broadly open.................... *Cratogeomys, Platygeomys, Pappogeomys, Orthogeomys*
- Sulcus at junction of inner and middle thirds; usually rather narrow and deep.. *Heterogeomys, Macrogeomys*
- Sulcus close to inner side or absent...................................... *Thomomys*

In *Geomys* proper the principal sulcus is decidedly on the outer side, and the small inner groove is about one-fourth or one-fifth the distance from the inner edge to the principal sulcus; it is nearer the inner border in the *tuza* series (fig. 22[3]) than in the *bursarius* series (fig. 22[2]).

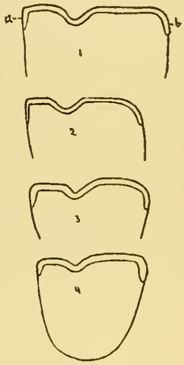

FIG. 20.—Transverse section of upper incisor in the unisulcate species in which the sulcus is strongly on the inner side. (1) *Macrogeomys dolichocephalus;* (2) *Heterogeomys hispidus;* (3) *M. costaricensis;* (4) M. *cherriei* (showing enamel face and single sulcus), *a* inner end of enamel plate; *b* outer end of enamel plate.

In *Pappogeomys* there is only a single groove (fig. 21[4]), and it is median or nearly so, as in *Cratogeomys*, and very deep, with the convexities on both sides strongly rounded.

In *Zygogeomys* (fig. 22[1]) the principal sulcus is median or slightly on the inner side, and the fine inner sulcus is *on* the convexity of the enamel about one-third the distance from the inner side to the median sulcus. It is not so near the inner side as in *Geomys* proper. In the latter the inner convexity is flatter and the small sulcus is on its inner side instead of on the convexity itself.

In *Heterogeomys and Macrogeomys* (fig. 20) the groove is always far on the inner side and sometimes wholly within the inner third. As a rule it is deeper and more abrupt than in the other genera, and the face of the tooth is flatter.

In *Cratogeomys and Platygeomys* (fig. 21) the groove, as seen by the

*The exact position of the principal sulcus varies not only in individuals of the same species from the same place, but even on the two sides in the same skull. Thus in *Cratogeomys merriami* and *Platygeomys gymnurus* of the unisulcate series it is usually on the inner side of the median line, but several skulls of each species are at hand in which it is median on one or both sides. Similarly, in *Geomys bursarius* and *tuza* of the bisulcate series, its distance from the outer side of the tooth is sometimes noticeably different on the two teeth. Its exact position therefore can not be relied upon as a character in distinguishing species, though its approximate position is important

Many of the unisulcate teeth show, when examined closely, a faint inner groove in addition to the deep median furrow. The presence of this indistinct sulcus seems to be purely fortuitous, occurring here and there irrespective of sex, age, or species, sometimes on one side, sometimes on both, and is of no value whatever as a character. Another fortuitous variation is the occasional presence of a fine bead in the median sulcus. When present at all it is rarely symmetrical on the two teeth.

unaided eye, ordinarily appears to be median; but when the tooth is magnified it is nearly always found to lie slightly on the inner side.

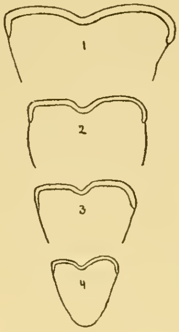

FIG. 21.—Transverse section of upper incisor in the unisulcate species in which the sulcus is median or nearly median—
(1) *Cratogeomys merriami.*
(2) *Platygeomys gymnurus.*
(3) *Cratogeomys perotensis.*
(4) *Pappogeomys bulleri.*

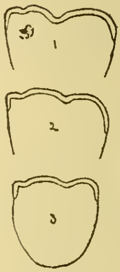

FIG. 22.—Transverse section of upper incisor in bisulcate series—
(1) *Zygogeomys trichopus.*
(2) *Geomys bursarius.*
(3) *Geomys tuza.*

It sometimes differs noticeably in position in the two incisors, and in some specimens of *C. merriami* is further away from the middle than usual.

In *Orthogeomys* the groove is on the inner side, but is usually so widely open that its outer side reaches the median line.

FIG. 23.—Transverse section of upper incisor of *Thomomys douglasi* showing shallow sulcus close to inner side of tooth.

In *Thomomys* the groove is close to the inner edge of the tooth (fig. 23) or absent. It is usually present, though sometimes very small and shallow. In a few species it is deep and strongly marked, as in *T. monticola* Allen.

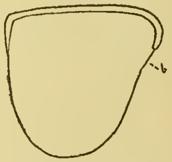

FIG. 24.—Transverse section of lower incisor of *Cratogeomys merriami*: *b*, bevel on outer side.

The outline of the incisor in cross section varies in the different species. In some forms the antero-posterior diameter exceeds the transverse; in others the transverse equals or exceeds the antero-posterior. Usually the outer side of the tooth is an even curve from the point where the inflexed border of the enamel stops, to the posterior convexity of the tooth, but this is not always the case. In the upper incisor of *Cratogeomys oreocetes*, and the lower of *C. merriami*, the outer side is emarginate, forming a distinct bevel immediately behind the reflexed enamel edge (fig. 24, *b*).

THE PREMOLARS.

The premolars are double prisms, like a figure 8 in transverse section (fig. 25 and pl. 16, figs. 8, 12, and 13). Their crowns are worn obliquely to the axis of the tooth, hence the prisms are of unequal length; the posterior prism is longest in the upper premolar and the anterior in the lower. In size the two prisms of the upper premolar are subequal or the anterior is only slightly smaller than the posterior; in the lower, the anterior is commonly considerably narrower and more elongated antero-posteriorly. In form both prisms of the upper premolar and the posterior of the lower are transversely elliptical like the molars; but the anterior prism of the lower premolar is cylindrical or subcylindrical. Its transverse section is more nearly circular in *Zygogeomys trichopus* and the *Geomys bursarius* series than in the others. In *Macrogeomys cherriei* it is more elongated transversely than usual in the group. The neck connecting the anterior and posterior prisms is usually on or near the median line of the tooth, but in the upper premolar of *Heterogeomys hispidus* it is decidedly on the inner side.

The premolars are larger than the molars, and the lower premolar is the largest of the molariform series (fig. 26). The upper premolar is implanted very obliquely and invariably *slopes* strongly backward from root to crown, the vertical plane of the root being far anterior to that of the crown. The lower premolar is strongly curved; it is always concave anteriorly and convex posteriorly. It is implanted vertically or nearly so, though its root curves forward. The upper premolar is decidedly longer than the lower in the genus *Geomys* (both in *Geomys* proper, comprising the *bursarius-tuza* series, and in the *Pappogeomys bulleri* series); the two are subequal in all the other genera. The shaft of the upper premolar may be either straight or curved. When curved it may be convex forward or concave forward. It is straight in *Geomys lutescens*, but decidedly concave anteriorly in all the other species of *Geomys* proper and in *Pappogeomys* and *Orthogeomys*; it is strongly or moderately convex anteriorly in *Cratogeomys* and *Macrogeomys*, and faintly convex or nearly straight in *Heterogeomys*, *Zygogeomys*, and *Platygeomys*. In the latter genera it is commonly straight in the young and slightly curved in the adult.

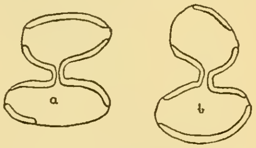

FIG. 25.—Crowns of upper and lower premolars of *Macrogeomys dolichocephalus*: *a* upper, *b* lower.

The length of prism of the upper premolar in *G. bursarius*, *tuza*, and *mobilensis* is at least one-third greater than the total length of the tooth row on the crowns (fig. 26[3]); in *G. texensis* it about equals the length of the tooth row. Various intermediate conditions occur in the other species. The length of the upper premolar with reference to the molars affords two series: (1) in which the premolar and m^1 and m^2 are of about the same length (comprising *G. bursarius* and most of the species in the other genera, fig. 26[1] and [2]); and (2) those in which the premolar is decidedly longer than m^1 and m^2 (*G. tuza* and *mobilensis* and *Pappogeomys bulleri*, fig. 26[3]). The length of the upper and lower premolars with reference to each other also affords two series: In the genus *Geomys* the lower is *much* shorter than the upper (fig. 26[3]); in the other genera (*Cratogeomys*, *Heterogeomys*, and *Zygogeomys*) the two are subequal or the lower is slightly the longer (fig. 26[1] and [2]).

THE MOLARS.

The true molars, except the last upper one (m^3), are simple single tubular prisms, elliptical in transverse section. The last upper molar is a single prism in some forms; a double prism in others. In both upper and lower series the posterior molar is the shortest tooth (fig. 26). In the lower series the teeth are successively shorter from premolar to last molar. In the upper series the premolar may or may not be longer than the first molar; the first and second molars may be subequal or either may be slightly longer than the other. As a rule throughout

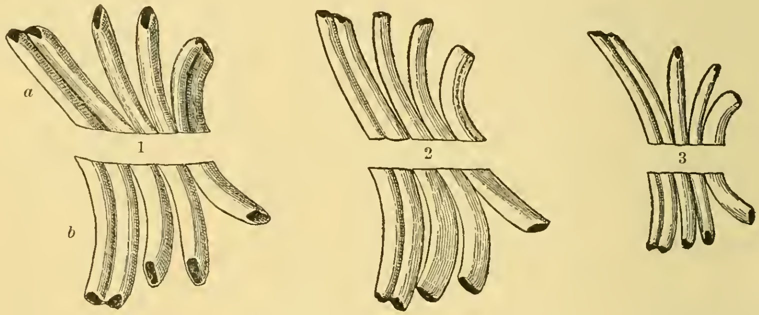

FIG. 26.—Types of molariform teeth (seen in profile): *a* upper series; *b* lower series.
1. *Heterogeomys hispidus.*
2. *Cratogeomys merriami.*
3. *Geomgs tuza.*

the group, the first and second upper molars are as long or nearly as long as the premolar. This is the case in *Geomys bursarius;* but in other species of *Geomys* proper (*tuza*, *breviceps*, and *texensis*) and in the genus *Pappogeomys* they are very much shorter. In *Pappogeomys bulleri* and the *Geomys tuza* series the longest upper molar is only about two-thirds the length of the premolar, and m^3 is only half as long as the premolar.

In the lower jaw the molariform teeth are successively shorter from before backwards, but diversity prevails in the relative lengths of the several teeth comprising the series. Thus in *Heterogeomys hispidus* m_3 is but little more than half the length of $\overline{pm}$; while in other species it is more than three-fourths. The relative length of the individual molars varies in the different species and is subject to considerable individual variation also.

The last upper molar is always the largest of the true molars. Its prism may be either single or double, or incompletely double; when double it nearly equals the premolar in size of crown, but never in length of shaft. It is invariably the shortest tooth of the upper series, and in some species is as short as the last lower molar. It always curves backwards and the curvature is sometimes so great as to form the arc of a small circle. When a double prism, the posterior prism is always much narrower than the anterior. For purposes of classification m^3 is by far the most important tooth in the skull, its size, shape, form of crown, and enamel pattern furnishing characters of much value, as will be seen later.

The *last lower molar* is ordinarily the shortest tooth in the skull, and is always curved—the concavity posterior. In addition to the curvature, it is implanted obliquely, sloping strongly backward from crown to root, the vertical plane of the root being far behind that of the crown. Its root is also rotated backward and inward, enabling it to lie flat against the inner side of the incisor, which passes between the roots of m_2 and m_3 (fig. 41). Owing to the strong slope of the shaft of m_3, the crown is always truncated very obliquely to the axis of the tooth (fig. 18).

The prisms of the *intermediary molars* in both jaws invariably curve outward, so that their outer borders are concave and inner borders convex. The curvature is stronger in the lower than in the upper series, and strongest in m_2, whose root stands further outward (away from the median line) than any other in the series. The outer borders of the prisms are shorter than the inner borders, hence the open root-ends of the teeth always face obliquely outward. The antero-posterior curvatures of the prisms of the intermediary molars above and below take the same direction in each jaw, but vary in degree in the different genera and sometimes in species of the same genus. All of the superior molars curve backward from crown to root; the inferior intermediary molars curve forward from crown to root. In the genus *Geomys* the antero-posterior curvature of m^1 and m_2 is so slight that their prisms may be described as essentially flat (fig. 26^3). If any curvature is apparent, it is backward in m^1 and forward in m_2, in accordance with the rule. In *Zygogeomys* and *Heterogeomys* the curvatures are slight; in *Orthogeomys* they are marked, and in *Macrogeomys*, *Cratogeomys*, and *Platygeomys* they are very strong, m^1 and m^2 curving strongly backward and m_1 and m_2 strongly forward (fig. 26^1 and ^{2}).

In addition to the curves described, the molar prisms are always more or less twisted on their axes. If the teeth were long enough these twists would result in spiral curves.

The axes of the elliptical crowns of the intermediary molars are in a general way transverse to the axis of the skull; but they rarely stand out at right angles. As a rule they slope obliquely forward or obliquely backward. When the crowns of the upper molars slope backward from the median line the crowns of the lower molars are transverse or slope forward, and *vice versa*. The axis of the crowns of m^1 and m^2 normally slopes backward in *Geomys*, *Pappogeomys*, and *Cratogeomys;* it is normally transverse or slopes forward in *Platygeomys*, *Orthogeomys*, *Macrogeomys*, *Heterogeomys*, and *Zygogeomys*.

VARIATION IN FORM OF LAST UPPER MOLAR.

The form of the last upper molar affords excellent characters. In its simplest type, as in the genus *Geomys* (comprising both the *tuza* series and the *texensis-bursarius* series) it is a single prism and the shape of the crown varies from suborbicular to subtriangular (figs. 27[1] and 33). In *Pappogeomys* (fig. 27[2]) the form of the tooth is similar except that there is a decided emargination on the outer side, anterior to the middle, behind which the prism is abruptly narrower. This is the first step in the formation of the 'heel' or posterior lobe, which is so conspicuous in *Orthogeomys*, *Heterogeomys*, and *Macrogeomys* (fig. 27[6] and [7]).

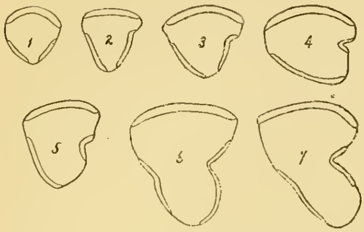

FIG. 27.—Types of form of crown of last upper molar (m^3).

1. *Geomys breviceps.*
2. *Pappogeomys bulleri.*
3. *Platygeomys gymnurus.*
4. *Cratogeomys estor.*
5. *Zygogeomys trichopus.*
6. *Macrogeomys dolichocephalus.*
7. *Macrogeomys heterodus.*

In the genus *Cratogeomys* the tooth is partly converted into a double prism by a vertical groove on the outer side (fig. 27[4]). This genus presents the widest latitude of individual variation known in the family, indicating that the tooth is in a transition state and has not yet attained a condition of stable equilibrium.

It is much more variable in *Cratogeomys* than in *Platygeomys*. Taking both genera together the crown presents all sorts of intermediate patterns, from a form in which the posterior prism is hardly more differentiated than in *Pappogeomys bulleri*, to forms having this prism produced to such a degree that the superficial resemblance to *Heterogeomys* is marked (fig. 35). But it lacks the stability of form and fixity of enamel pattern characteristic of the members of the latter genus.

The variation is greater in the adult than the young, as would be expected from the increased obliquity of the crown with reference to the axis of the tooth in advanced age, and naturally is most marked in the length and form of the heel. Sometimes in old age the crown is worn so obliquely that the heel actually overhangs, acquiring an exaggerated length very different from its transverse section (as in fig. 28, *d*).

FIG. 28.—Variations in crown pattern of m^3 in *Cratogeomys fulvescens*.

In *Cratogeomys fulvescens* (fig. 28) the variations in form and enamel pattern of crown are pronounced, but most of them are easily reducible to one or the other of two types: (1) An obcordate crown, deeply notched between the prisms on the outer side, with the axis of the posterior loop or heel nearly transverse and the outer enamel plate reduced to a small U-shaped piece protecting the sulcus (fig. 28, *a*); and (2) a more or less subtriangular or even trefoil-shaped crown with the axis of the posterior loop very oblique (sloping strongly backward as well as outward), and the outer enamel plate more or less elongated (fig. 28, *c*, *d*). In form the second is easily derived from the first by a slight backward rotation of the transverse axis of the posterior loop. Regarding the shape of the crown as more or less subtriangular, the apex of the triangle is always toward the median line of the skull and the notch or emargination always on the outer (buccal) side. *Cratogeomys castanops* (fig. 29) stands somewhat apart from the other species. The double character of the prism is not well marked; the posterior part of the crown is rather broadly rounded, the lateral enamel plates are rather short, and the inner one is situated far back. Both tend to disappear in extreme age—doubtless from atrophy of the enamel organ.

FIG. 29.—Variations in crown pattern of m^3 in *Cratogeomys castanops*.

In the genus *Platygeomys* the crown is subtriangular, narrow behind the anterior prism, and the axis of the heel is normally antero-posterior, as in *Pappogeomys* (fig. 27^3).

In *Macrogeomys*, *Heterogeomys*, and *Orthogeomys* (fig. 34), the tooth is a double prism, the anterior and posterior moieties of which are separated by a groove or depression on each side—that on the outer side being invariably the deeper, that on the inner side being in rare cases obsolete. The posterior prism is always narrower than the anterior (the narrowing is chiefly on the outer side), and its antero-posterior diameter is usually greater. The crown as a whole is thus longer than broad, and is composed of two parts or lobes: an anterior which is broader than long (being transversely elliptical, like the other molars); and a narrow posterior lobe or 'heel' which is commonly longer than broad, and varies in form and proportions in the different species.

In *Heterogeomys* the grooves on the two sides are nearly opposite, and the anterior prism is narrowly elliptical. In *Orthogeomys* and *Macrogeomys* the sulcus on the inner side is commonly decidedly posterior to the plane of the outer sulcus. In *Macrogeomys* the anterior prism is broadly elliptical, and the posterior is elongated antero-posteriorly. In *Macrogeomys heterodus* the posterior lobe or heel is very long and slopes obliquely outward; the inner face of the tooth as a whole is unusually flat (fig. 27^7).

In *Zygogeomys* the last upper molar is an imperfect double prism, the depression on the inner side being slight, while that on the outer side is much deeper. The crown as a whole is longer than broad, and the posterior loop or heel ends in a broad lip-like extension not protected by enamel and hence subject to change of shape by wear (see fig. 27^5),

ARRANGEMENT OF THE ENAMEL.

After the enamel cap of the newly born young has been ground down far enough to expose the upper ends of the cement bands, the arrangement of the enamel remains the same throughout the life of the individual and affords excellent generic and in some cases specific characters. The enamel never envelops the prism in a continuous sheet, but is deposited in the form of vertical plates or bands which always alternate with bands of cement. These bands are disposed in a definite manner on each tooth of the series. In the under jaw the number in each tooth is the same throughout the group; in the upper jaw the number varies in the several genera.

Premolars.—The permanent *upper* premolar has three enamel plates (one anterior and one lateral on each side *) in the genera *Geomys* proper, *Pappogeomys*, *Cratogeomys*, and *Platygeomys*—the posterior being altogether absent (fig. 30^1). In *Zygogeomys*, *Heterogeomys*, *Macrogeomys*, and *Orthogeomys* the number is increased to four by the addition of a posterior plate, which, however, never covers more than half of the posterior face of the posterior prism, and is always restricted to the inner or lingual side (fig. 30^2 c). In *Orthogeomys* the posterior plate is sometimes obsolete. The permanent lower premolar always has four enamel plates, the posterior being invariably present and covering the whole hinder face of the tooth (fig. 25, *b*, and fig. 32).

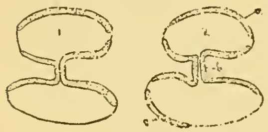

FIG. 30.—Types of enamel pattern of upper premolar.
(1) *Cratogeomys merriami;*
(2) *Heterogeomys hispidus;* (*a*) anterior enamel band; (*b*) lateral band; (*c*) posterior band.

First and second upper molars.—In the first and second upper molars, which are simple elliptical prisms, the normal number of enamel plates is two, one covering the anterior, the other the posterior face of the tooth, with a narrow interval filled with cement at each end between them (fig. 31^1). In many species, however, the posterior plate is obsolete (fig. 31^2). It is present and covers the whole hinder side of the tooth in *Geomys*, *Pappogeomys*, *Macrogeomys*, *Heterogeomys*, and *Orthogeomys*. It is present but restricted to the inner or lingual half of the tooth in *Zygogeomys* (fig. 31^3), and is altogether absent in *Cratogeomys* (fig. 31^2) and *Platygeomys*.

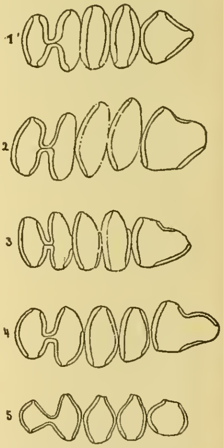

FIG. 31.—Types of enamel pattern of upper molariform series in the different groups:

1. *Geomys bursarius.*
2. *Cratogeomys castanops.*
3. *Zygogeomys trichopus.*
4. *Macrogeomys cherriei.*
5. *Thomomys bulbivorus.*

* In both upper and lower premolars the anterior enamel plate is convex forward; the lateral are strongly bent, conforming to the sulcus between the prisms and extending from the convexity of one to that of the other. The resulting shape in transverse section is usually like that of the letter U, with the opening directed outward and the base resting on the median line of the tooth.

Last upper molar.—Throughout the *Geomyidæ*, except in *Thomomys*, the last upper molar has three enamel plates—one anterior, one on the inner side, and one on the outer side, with interspaces (cement bands) of varying breadth between (fig. 27). In *Orthogeomys scalops* the outer plate is normally divided (fig. 62). The anterior plate always covers the whole front face of the tooth, and is the same in all species; the two others vary in length and shape, and furnish excellent characters. In *Thomomys* there are but two plates, an anterior and a posterior (fig. 31^5).

Lower molars.—Except in *Thomomys*, the lower molars have each but a single enamel plate; it completely covers the posterior face of the tooth, the anterior face and sides being covered with cement (fig. 32, *a*). In *Thomomys* each lower molar has two enamel plates, an anterior and a posterior (fig. 32, *b*).

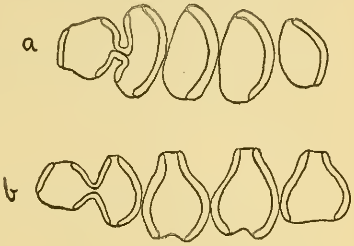

FIG. 32.—Crowns of lower molariform series: (*a*) *Geomys bursarius*; (*b*) *Thomomys bulbivorus*. Except in *Thomomys* (*b*) the enamel pattern is the same throughout the family (as in *a*).

PRINCIPAL DIVISIONS INDICATED BY THE ENAMEL PLATES.

The foregoing study of the enamel plates shows that all of the 37 species and subspecies herein described, and all the species of *Thomomys*, may be arranged in five principal groups, according to the presence, absence, or relations of the posterior enamel plate in the upper molariform series, as follows:

1. Posterior enamel plate absent in *pm* and present in m^1 and m^2 .... *Geomys, Pappogeomys, Orthogeomys.**
2. Absent in both *pm* and m^1 and m^2 .... *Cratogeomys, Platygeomys.*
3. Present on inner (lingual) side in both *pm* and m^1 and m^2 .... *Zygogeomys.*
4. Present on inner (lingual) side in *pm* and complete in m^1 and m^2 .... *Heterogeomys, Macrogeomys, Orthogeomys.**
5. Present in *pm* and m^1, m^2, and m^3 .... *Thomomys.*

NORMAL NUMBER OF ENAMEL PLATES—SUMMARY.

The number of enamel plates actually present in the different teeth has been shown to vary from one to four. The number on each tooth has been found constant in the lower series; inconstant in the upper series. The lower premolar (which is a complete double prism) invariably has four, and the lower molars one each, except in *Thomomys* in which they have two (fig. 32). The upper premolar (a complete double prism) has four in some genera; three in others. The upper intermediary or elliptical molars (m^1 and m^2) have two in some genera; one in

**Orthogeomys* is losing the posterior enamel plate of the upper premolar. It is present in *O. latifrons*, but greatly reduced or altogether absent in *nelsoni* and *scalops*.

others. The last upper molar (an incomplete double prism) invariably has two in *Thomomys* and three in all the other genera. These facts indicate that the normal number of enamel plates in simple elliptical prisms is two, and that one has been suppressed in all of the elliptical molars having only one (the lower molars in all except *Thomomys* and the first and second upper in *Platygeomys* and *Cratogeomys*), and in the upper premolar when it has only three plates (as in *Platygeomys*, *Cratogeomys*, *Pappogeomys*, and *Geomys* proper). This view is supported by a study of the mechanics of the grinding process. (See pp. 90–97, 107–108).

VARIATIONS IN ENAMEL PLATES OF LAST UPPER MOLAR (m^3).

Throughout the family, except in *Thomomys*, the last upper molar is strengthened by three vertical plates or bands of enamel, alternating with three interspaces filled with cement (figs. 33, 34). The anterior of the three enamel plates is constant in form and relations; the two others inconstant. The anterior invariably covers the whole front face of the tooth and is convex forward (the convexity may be slight or great). The others vary in position, shape, and relative breadth. In a single species, *Orthogeomys scalops*, the outer plate is normally divided (fig. 62). In the simplest forms, in which the tooth is a subcylindric or subtriangular prism, as in *texensis*, *breviceps*, and allied species (fig. 33), they are simple vertical bands of enamel, subequal in size, one on

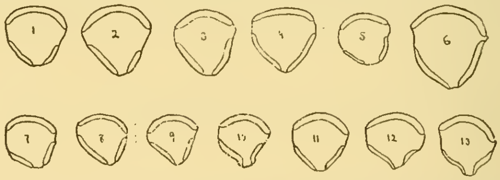

FIG. 33.—Variations in form of crown and enamel pattern of m^3 in restricted genus *Geomys*.

1, 2. *Geomys tuza.*
3. *tuza floridanus.*
4. *mobilensis.*
5. *arenarius.*
6. *Geomys personatus.*
7—10. *texensis.*
11—13. *breviceps.*

either side of the tooth posteriorly, separated from one another and from the anterior enamel plate by similar vertical plates or bands of cement. The genus *Geomys* proper presents no variations from this type except in the relative breadth of the inner (lingual) and outer (buccal) enamel bands. The inner is more constant than the outer and is commonly somewhat broader.* Sometimes the two tend to define a lip posteriorly (fig. 33^{10} and ^{13}). Marked departures from this simple type occur in those species in which the last upper molar is a double instead of a single prism; and since various intermediate conditions in

*In *G. tuza* the outer plate is much narrower or shorter than the inner. Since the teeth are commonly looked at endwise from above, the enamel pattern is ordinarily seen in transverse section, and the three enamel plates appear as narrow bands on the periphery of the prism. Their *breadth* on the sides of the tooth is shown in the *length* of the band as it appears on the crown. In describing the pattern, therefore, it is convenient to use the term *length* instead of *breadth* to designate the relative width of the vertical enamel plates.

the evolution of the double prism are presented by living species, so the several stages in the adaptation of the lateral enamel plates to the development of a posterior loop or heel are clearly shown. These changes consist in a lengthening or shortening of the enamel plate (as it appears on the crown of the tooth) and in the development of a bend or flexure by virtue of which the enamel conforms to the curvature of the anterior and posterior loops, resulting from the development of a deep sulcus on one or both sides of the tooth in those species that have a double prism. And since the sulcus on the outer side appears first and is always deepest, it follows that the outer enamel plate is the one most affected and shows the greatest range of variation (fig. 34).

Outer (buccal) enamel plate.—The first step in the formation of a distinct and permanent flexure may be seen in *Pappogeomys bulleri* (fig. 34,[1]), in which species the anterior end of the outer enamel plate bends

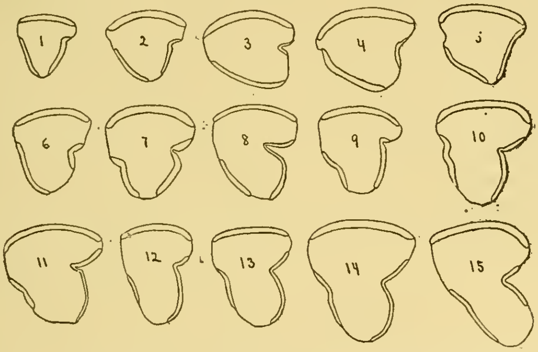

FIG. 34.—Forms of crown and enamel pattern of m³ in the genera in which this tooth is a double prism.

1. *Pappogeomys bulleri.*
2. *Platygeomys gymnurus.*
3. *Cratogeomys estor.*
4. *oreocetes.*
5. *peregrinus.*
6. *Zygogeomys trichopus.*
7. *Orthogeomys latifrons.*
8, 9. *Orthogeomys nelsoni.*
8. *Totontepec;* 9. *Comaltepec.*
10. *Heterogeomys hispidus.*
11. *torridus.*
12. *Macrogeomys cherriei.*
13. *costaricensis.*
14. *dolichocephalus.*
15. *Macrogeomys heterodus.*

outward in front of the vertical sulcus that marks the outer side of the tooth. A slightly more accentuated condition is found in *Platygeomys gymnurus* (fig. 34,[2]). The extreme development of this flexure is attained in the genera *Heterogeomys* (fig. 34,[10] and [11]), *Macrogeomys* (fig. 34,[13],[14],[15]), and *Orthogeomys* (fig. 34,[7] and [8]), in all of which the bend is essentially a right angle—a result of the deepening of the sulcus between the prisms. At the same time the posterior arm of the enamel plate is considerably lengthened in order to protect the elongated posterior lobe or heel to which it conforms. In *Orthogeomys* and all the known species of *Heterogeomys* and *Macrogeomys* the posterior limb is about double the length of the anterior; and except in *M. heterodus* it actually reaches the hinder border of the tooth. In *Orthogeomys scalops* a very remarkable condition prevails; the outer enamel plate is normally divided (fig. 62).

In *Platygeomys* the outer enamel band is normally either straight or bent outward at the extreme anterior end—not U shaped as in *Cratogeomys* proper.

In the remaining groups a widely different condition obtains: The outer enamel plate is much reduced, and as a rule the two arms are subequal. This type prevails in *Cratogeomys* proper and in *Zygogeomys*—groups whose interrelations are distant and obscure. In *Cratogeomys* the outer plate is normally (?) reduced to a mere angle or U-shaped piece at the bottom of the sulcus that gives the outer side of the tooth the semblance to a double prism (fig. 35, [5] and [6]), leaving a wide unprotected interval (cement band) on each side. It is variable, however, and in some specimens the posterior arm reaches nearly to the end of the heel (fig. 35, [8]). The difference may be sexual; but owing to the difficulty in determining the sex in these animals, which difficulty is greatly increased in the case of the young, it is unsafe to place much reliance on the sex marks accompanying the specimens. Still there is reason for suspecting that those specimens in which the outer plate is elongated posteriorly are females. The variation is much greater in some species than in others. It is most extreme in *C. castanops* (fig 29), and least, so far as our material goes, in *C. perotensis* and *estor*. In advanced age it sometimes happens that the lateral enamel bands become abnormally short on one or both sides and very rarely become divided in the middle. Accidents of this sort are probably the result of shrinkage or atrophy of the enamel organ.

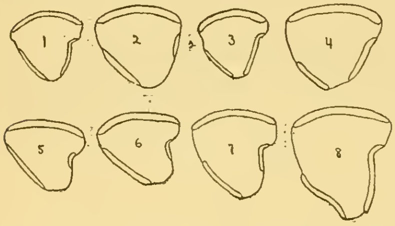

FIG. 35.—Variations in form of crown and enamel pattern of m³ in *Platygeomys* and in *Cratogeomys merriami*.

1, 2. *Platygeomys gymnurus*.
3. *Platygeomys tylorhinus*.
4. *Platygeomys fumosus*.
5–8. *Cratogeomys merriami* (all from Amecameca, Mexico).

In the genus *Zygogeomys* the outer angle is more open and the enamel plate covers about half of the outer side of the tooth.

The outer enamel plate is slightly longer than the inner in *Platygeomys*, and much longer in *Heterogeomys*, *Orthogeomys*, and *Macrogeomys* (except in *M. heterodus*); it is subequal or shorter in all the other known forms.

Inner (lingual) enamel plate.—The inner plate is much less variable than the outer, as previously stated. It is straight or slightly convex, except in the few species that have a real sulcus on the inner side, converting the tooth into a complete double prism. In these its anterior part curves or bends outward. This condition is known in the three genera, *Heterogeomys*, *Macrogeomys*, and *Orthogeomys*. In *Heterogeomys* the outward curvature is slight (fig. 34, [10] and [11]); in *Macrogeomys dolichocephalus* and *Orthogeomys latifrons* it is strong (fig. 34, [14] and [7]). In length and position the inner plate is much more variable: It reaches the hinder end of the tooth in *Geomys* proper, *Cratogeomys*, *Pappogeomys*, *Platygeomys*,* *Zygogeomys*, and *Orthogeomys;* falls slightly short of the end in *Macrogeomys*, and very considerably short in *Heterogeomys*. In *Heterogeomys* it barely covers half of the inner side of the tooth; in all the other known species it covers nearly two-thirds or more than two-thirds of the inner side. The condition in *Heterogeomys* therefore is clearly exceptional.

CHARACTERS OF THE UNWORN TEETH.

Specimens of pocket gophers young enough to show the deciduous premolars and the unworn crowns of some of the molars are so exceedingly rare that I have seen but four in the entire series of specimens of this genus examined in the preparation of the present paper. Two of these are *Geomys bursarius* from Elk River, Minn., collected by Vernon Bailey April 29, 1888, and May 14, 1886 (Nos. 4909 and 2927, Merriam collection); the third is a young *Geomys mobilensis* from Milton, Florida. The fourth is a juvenile specimen of *Heterogeomys torridus* from Motzorongo, Mexico, collected by E. W. Nelson March 5, 1894 (No. 63643, U. S. N. M.). The unworn teeth are so much alike in the two genera that they may be described together.

Incisors.—In both genera the grooves in the front face of the upper incisors are very much deeper and larger than in the adult, and the convexities are much more strongly rounded. In the young of *Geomys bursarius* the two grooves do not present the disproportion characteristic of the adults, the small inner groove being relatively much deeper and larger, though by no means so large as the median groove.

Deciduous premolars.—The crown of the upper deciduous premolar is much elongated and has an anterior prism in addition to the double prism of the permanent tooth (pl. 16, figs. 1 and 3). The double prisms are united on the inner (lingual) side, forming a U-shaped grinding surface (with the opening directed outward) in front of which, separated by sulcus, is the small transversely elongated summit of the anterior prism. The crown of the lower deciduous premolar is likewise much elongated, and it is irregularly and incompletely divided into three lobes (pl. 16, figs. 2 and 4*b*). Both upper and lower premolars have the anterior and posterior roots far apart, and the permanent premolar may be seen between them (fig. 36, and pl. 16, figs. 1–4, *a*).

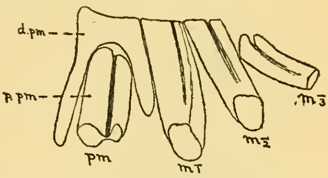

FIG. 36.—Lower molariform teeth of a very young *Geomys bursarius*, showing deciduous and permanent premolar in situ, and unworn crown of m_3 which has not yet reached the plane of the crowns of the other teeth.

*In *Platygeomys fumosus* the inner enamel band seems to be normally shorter than the outer, and only half or less than half the length of the anterior band (fig. 35^4).

Permanent premolars.—One of the upper deciduous premolars (pl. 16, fig. 1*b*) has been removed from the baby skull of *Heterogeomys torridus*, exposing the unworn crown of the permanent premolar (pl. 16, fig. 1*x*). The permanent premolar also has been removed and figured in several positions to show the form, size, and relations of its primitive enamel cap (pl. 16, figs. 5, 6, and 7). For ready comparison, the corresponding tooth in an adult of the same species has been figured also (pl. 16, fig. 12). On reference to pl. 16 it will be seen not only that the crown of the young premolar is completely enveloped with enamel, but that the enamel cap reaches down over the shaft of the double prism, covering nearly half of the tooth (figs. 5, 6, and 7) and passing continuously into the four enamel bands that alone remain in the adult (fig. 12*). The fact that the young of the various species as usually obtained rarely show any trace of the enamel cap indicates that the growth of the young teeth and grinding down of the crowns progress with surprising rapidity. A very young *Cratogeomys castanops* from Las Animas, Colo., collected by Dr. A. K. Fisher, has only a remnant of the enamel cap left (pl. 16, fig. 14).

The unworn crown of the *upper* premolar (pl. 16, figs. 1 *x*, 5, 6, 7) has a single transverse crest on the anterior prism, an incompletely double transverse crest on the posterior prism, and an oblique ridge connecting the two on the inner side. The single crest of the anterior prism is notched or bifid at the apex, and has a small upright lobule at the base of the notch on the inner side. The double crest of the posterior prism is open on the outer side, and the crest as a whole is roughly and narrowly U-shaped. The summit of the anterior crest is bilobate; that of each arm of the posterior crest is irregularly trilobate or trituberculate.

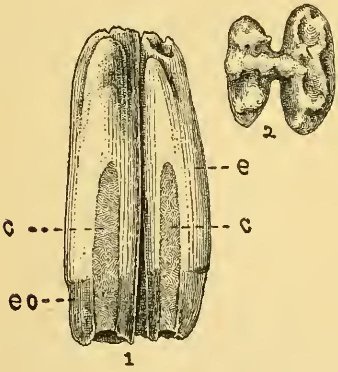

FIG. 37.—Right lower unworn permanent premolar of *Heterogeomys torridus*: (1) inner or lingual side; (2) enamel cap from above; *c*, cement bands; *e*, enamel; *eo*, enamel organ.

The enamel cap of the permanent *lower* premolar is a complete double prism, each moiety of which bears an independent transversely elongated crest (fig. 37). The summit of the anterior crest (fig. 37²), is trituberculate; that of the posterior is incompletely double, being split lengthwise into two unequal parts, the posterior of which is the shorter and more irregular. The trituberculate crest of the anterior prism is bilaterally symmetrical. There are two large tubercles or lobes, one on each side, and a smaller median one, which is much elongated antero-posteriorly and is continuous with the ridge connecting the anterior and posterior prisms.

*In figs. 5, 6, 7, and 12 the cement bands are shaded, thus serving to bring out the enamel more distinctly.

Molars.—In all of the young skulls under consideration the deciduous premolar and the intermediary molars (m 1 and 2) have been used, and their enamel caps have been partly ground down, while the permanent premolars and last molars have not yet suffered attrition. The *premolar* has been already described. The enamel cap of the *last lower molar*, which has not yet reached the plane of the crowns of the other teeth (fig. 38 and pl. 16, figs. 2, *d*, 4, *d*, and 9, *d*), presents two complete transverse crests, each of which has an undulating summit incompletely divided into three lobes. The two crests are separated by a deep furrow and show no tendency to come together at any point. The enamel cap covers a little more than half of the tooth (fig. 38, *e*). The *last upper molar* (pl. 16, figs. 1, *c* and 3, *c*) has just reached the level of the other teeth. Its unworn crown in both genera presents a well-defined anterior and a less distinctly defined posterior crest, separated by an interspace which is bridged over by an oblique enamel ridge on the inner side of the median line. The anterior crest is incompletely trilobate. The posterior crest is thickened and less symmetrical than the anterior, and in *Heterogeomys torridus* (pl. 16, fig. 1, *c*) it is incompletely double, being partly divided by a transverse excavation.

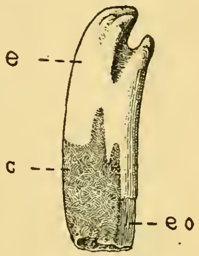

FIG. 38.—Right last lower molar of very young *Heterogeomys torridus* (from same specimen as fig. 37); inner or lingual side, showing unworn enamel cap, and relations of enamel and dentine lower down: *c*, cement bands; *e*, enamel; *eo*, enamel organ.

The crowns of the first and second upper molars present different degrees of wear in the three young specimens at hand, and none of them are young enough to show the transverse crests by which they were undoubtedly crowned before the tops of their enamel caps were ground down. The wearing, however, has not progressed so far as to obliterate the double crowns characteristic of immaturity except in the upper molars of one specimen of *G. bursarius* (No. 4909). In the other skull of this species (No. 2927) a transversely elongated loop of enamel incompletely divides the grinding surface of m^2, indicating the former presence of two transverse loops, as in the lower molars. In the lower series the double crowns are well shown in both *Geomys bursarius* (pl. 16, fig. 4) and *Heterogeomys torridus* (pl. 16, fig. 2). In one skull of *Geomys bursarius* (pl. 16, fig. 4) the second lower molar is only slightly worn, and its crown presents two transverse loops separated by a decided depression. In the other skull it is more worn, but still is incompletely divided. The crown of the first lower molar in both skulls is deeply notched on the inner side and slightly on the outer, showing that when unworn it resembled the others.

Summary.—The summits of the unworn molariform teeth in *Geomys* and allied genera are not only completely covered with enamel, but the enamel cap is complicated by crests and tubercles. The permanent premolar, which is a double prism, has a single transverse crest over the anterior prism and a partly double crest over the posterior. The true molars are bilophodont, each carrying two transverse crests. In the case of the last upper molar, the posterior crest is thickened and somewhat irregular and may represent the coalescence of two crests. It is joined to the anterior by an oblique ridge on the inner side. In the premolar and last molar, above and below, the summit of each crest is more or less distinctly divided into two or three lobes or tubercles. There is every reason to believe that the crowns of the intermediary molars (m^1 and ^{2}) are similarly crested-tuberculate when in the unworn condition, but in the specimens at hand their summits are worn down too far to show it.

The crowns of the unworn teeth are bilophodont in all the lower molars and in the first and second upper molars. The premolar and last upper molar (m^3) may be considered as imperfectly trilophodont, the posterior prism in each instance being incompletely double.

The theory that permanently rootless teeth with flat grinding crowns are more primitive and less specialized than rooted teeth with tuberculate crowns receives a decided setback in the circumstance that the young unworn molars in the *Geomyidæ* are provided with crested-tuberculate enamel caps, and that the adult teeth, though simple when considered singly as individual prisms, constitute, when taken collectively, one of the most highly specialized grinding and cutting machines thus far discovered.

CHANGES IN FORM AND ENAMEL PATTERN OF YOUNG TEETH RESULTING FROM WEAR.

As already stated, the bilophodont crowns of the embryo and very young molars are hardly ever seen, the wearing down of the primitive enamel cap proceeding so rapidly that the youngest specimens ordinarily coming under the eye of the naturalist have flat grinding surfaces as in the mature animal. During the reduction of the young crown four different types of enamel pattern, representing as many stages of wear, succeed one another as follows:

First stage (before the crests are completely obliterated): *two parallel disconnected transverse loops.*

Second stage (when the sulcus between the crests is reached): *a figure 8.*

Third stage (after the sulcus is passed and before the tops of the cement bands are reached): *a continuous ring or circle.*

Fourth stage (after the tops of the cement bands are reached): *the pattern of the mature tooth*, consisting of from one to three bands of enamel alternating with the same number of bands of cement, as already explained in detail.

The first stage is of brief duration; the second still more evanescent; the third decidedly longer than the first and second together; the fourth continues throughout the life of the animal.

During the early part of the fourth stage the form of the shaft of the tooth changes, the double prism characteristic of extreme youth giving place to the single elliptical prism of the adult (except in the last upper molar, which in some genera remains permanently double). It seems remarkable that a tooth having a large double crown like the first and second lower molars of the very young animal (pl. 16, figs. 2 and 4) should be capable of changing its form to that of the single transverse ellipse of the adult (pl. 16, fig. 17) in a very brief period and without molting the tooth. That it does so is not open to question, and may be demonstrated by making a section of the lower part of the young tooth. This has been done in the case of the second lower molar, as shown in pl. 16, fig. 4, where 4*x* is a transverse section of the same tooth from the lower fourth. The antero-posterior diameter of the tooth decreases from above downward and the vertical groove on each side becomes shallower and shallower and finally disappears. The change in the shape of the crown takes place naturally by the rapid wearing down of the grinding surface, which brings successively lower parts to the top.

THE ENAMEL ORGAN.

Throughout the group the enamel organ is situated at the base of the teeth, as usual in rodents having prismatic molars. In the young tooth the enamel organ is very much larger than in the adult, owing doubtless to the greater rapidity of growth in early life. Thus on referring to pl. 16 (figs. 5, 6, and 7) it will be seen that the enamel organ occupies about one-fifth of the length of the upper premolar in a very young animal, while in the corresponding tooth of an adult of the same species (fig. 12) it occupies only about one-fifteenth of the length of the tooth. In extreme age partial atrophy of the enamel organ sometimes takes place, causing a shortening of the enamel on that side. In a few instances an enamel plate has been found divided in the middle, due doubtless to atrophy or injury of the enamel organ in the same vertical plane.

OSTEODENTINE.

A core of osteodentine traverses the central part of each tooth. In the premolars and all of the molars except m^3 it forms a large elliptical shaft in the middle of each prism. In m^3, whether single or double, the osteodentine is a single core, conforming in shape to the shape of the tooth. On all sides it passes into the true dentine, by which it is completely enveloped except at the free ends. At the lower end it passes insensibly into the growing pulp. In other words, the osteodentine is a central core consisting of the hardening pulp and containing the vessels by means of which the tooth is nourished. In the *Geomyidæ* it forms a considerable part of the substance of the tooth, as usual in prismatic teeth growing from persistent pulps. In the genera *Geomys* and *Cratogeomys* it is pale buffy or yellowish brown in color, and consequently not conspicuous. In the genera *Heterogeomys* and *Zygogeomys* it is dark brown, in striking contrast to the white of the rest of the tooth.

MECHANISM AND DYNAMICS OF THE CUTTING MACHINE AS A WHOLE.

The individual teeth have been described. It remains to consider them as parts of a complex and highly specialized mechanism for cutting and slicing the food, to describe the muscles that operate the machine, to mention other structures concerned in the act of mastication, and to show how a bit of root or other hard vegetable tissue is cut loose, sliced, and reduced to pulp ready to pass into the stomach.

The primary object of the dental armature is twofold: (1) To enable the animal to bite or chisel off pieces of the hard vegetable substances on which it feeds, and (2) to reduce these pieces to a condition of minute subdivision suitable to be turned over to the stomach for digestion. The incisors serve the additional purpose of bars, axes, and picks in helping the animal overcome the various obstacles encountered in driving its tunnels through different soils. When the front teeth are used for this purpose, the resulting dirt and chips are kept out of the mouth proper by a furry partition, elsewhere described, which divides the mouth as a whole into two chambers.

MANNER OF ATTACHMENT OF THE TEETH.

The way the teeth are fastened in their sockets is in harmony with the other remarkable adaptations of the grinding apparatus. The attachment is effected by means of the periosteum of the alveolus, which does not invest the teeth, but is firmly adherent to the cement bands, leaving the enamel faces free. Thus each tooth is suspended by one or more vertical cushions, which extend all the way from root to gum. This method of attachment not only relieves the tender pulp at the base of the tooth from pressure, but gives to the cutting edge or edges an elasticity that must be highly effective. In the case of the incisors, the area of attachment is very extensive, comprising the whole of the tooth below the gum except the enamel face. The lower molars throughout the entire group, and the intermediary upper molars in the genus *Cratogeomys*, are attached in the same way on one side only—the side opposite to the enamel or cutting edge. In the case of the upper premolars the principal attachment is along the posterior face of the posterior prism, while a supplementary band on each side of the anterior prism serves to keep the cutting edges always in place. In those species in which the posterior prism of the upper premolar develops an enamel band on its inner or lingual side, the tooth is suspended by four cement bands. The lower premolar is attached by four narrow lateral bands. The last upper molar is invariably held firmly in place by three cement bands, one on each side anteriorly and one on or near the median line behind.

DYNAMICS OF THE INCISORS.

The upper incisor has been shown to curve in the arc of a circle, to cover a little more than a complete semicircle, and to lie in a single plane (figs. 18 and 19). Its root is very long with relation to the length of the muzzle, always overreaching the first upper molar. It is implanted in such manner that its cutting edge is directed downward and slightly backward. The lower incisor has been shown to curve outward in an incomplete spiral, and to traverse the entire length of the mandible—its root projecting on the outer side of the condylar process, where it is incased in a thin capsule of bone. This small capsule contains the pulp from which the tooth continually grows to replace the wear at the other end. The extreme development of these teeth is proportionate, of course, to the strain put upon them in chiseling hard roots. The upper incisor is subjected to less strain than the lower, and its principal function seems to be to anchor the cutting machine to the substance operated on, while the greatly elongated lower incisor does most of the work. The free end of the lower incisor slopes forward and upward, its angle of implantation being different from that of the upper. Thus, while the upper incisor remains stationary, its recurved and usually divided tip enabling it to hold fast to the object to be cut, the lower incisor plays rapidly back and forth like a steam drill, its straight enamel edge doing the cutting.

The great length of the incisors within the alveolus is necessary in order to counterbalance the length of the part that protrudes beyond the jaws, and also to afford a large surface for attachment within the alveolus so as to relieve the growing root from pressure. The way the teeth are attached to the jaw by a long belt or cushion, which envelops all but the enamel face, gives to the cutting edge an elasticity that must be of great service, not only in increasing the efficiency of the act of chiseling, but also in relieving the tooth from jar.

It remains to notice the interesting secondary modifications of the skull and molariform teeth, by means of which the animal is enabled to open the front part of the mouth wide enough to use the incisors to advantage. The molariform teeth stand much higher out of the jaw anteriorly than posteriorly, and their roots increase in length proportionally (fig. 18). The premolars, both above and below, protrude twice or more than twice as far as the last molars. Thus, when the mouth is shut and the teeth pressed firmly together, the jaws are at least twice as far apart at the anterior as at the posterior end of the molar series. Now, the distance from the crown of the premolar to the cutting edge of the upper incisor is two and one-half to three times the length of the molariform series on the crowns, and the axis of the skull is nearly parallel to the plane of the crowns of the molar teeth. Hence, without any other help and with the mouth shut, the ends of the jaws (where the incisors cut the gums) would be from five to six times further apart than at the plane of the posterior molars.* This arrangement permits the necessary protrusion of the incisors, the cutting edges of which, as a rule, reach the plane of the crowns of the molars in the upper jaw and slightly pass this plane in the lower jaw. The great advantage of this arrangement is most apparent during the act of biting off hard roots, when a very slight opening of the mouth proper, entailing only a slight separation of the molars, is sufficient (multiplied along the length of the strongly divaricating jaws) to separate the chisel ends of the incisors widely, enabling them to grasp objects of comparatively large size.

DYNAMICS OF THE MOLARIFORM TEETH.

(a) *Manner of implantation and curvatures.*

The angle of implantation of the molar series as a whole in both upper and lower jaws is peculiar. A transverse section of the skull (fig. 39) shows that the roots of the upper molars are nearer the median line than the crowns.† It follows that the upper tooth rows are strongly *divergent* from root to crown (fig. 39, *e*). In the lower series the converse occurs, the tooth rows *converging* from root to crown (fig. 39, *f*). The upper molars slope strongly and curve moderately outward from root to crown, while the lower molars both slope and curve strongly outward from crown to root.

The crowns of the opposing series do not meet in a horizontal plane, but are obliquely truncated: the upper series face obliquely *downward and outward;* the lower series obliquely *upward and inward* (fig. 39). When the jaws are shut, lateral movement in a horizontal plane is impossible. If a circle is drawn around the upper molars (fig. 40) it is at once apparent that during the lateral movement of the mandible the crowns of the teeth move sideways in the arc of a circle, thus giving the utmost possible mechanical advantage. The axis of rotation is in or near the basicranial axis, and the axis or arc of oscillation is short, as in a pendulum. To enable the teeth to withstand the great pressure to which they are thus subjected, they have developed very long roots

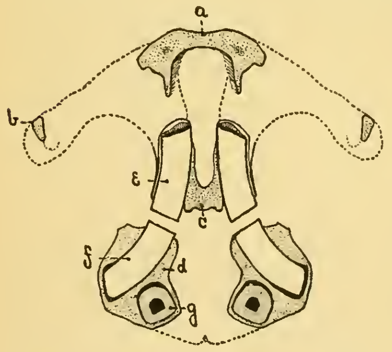

FIG. 39.—Transverse section of skull of *Platygeomys gymnurus*, showing manner of implantation and relations of molariform teeth. *a*, Frontal; *b*, zygoma; *c*, palate; *d*, mandible; *e*, upper molar; *f*, lower molar; *g*, incisor.

* The actual condition is not exactly as here described. In the case of the lower jaw the distance is *decreased* by the upward curvature of the anterior end of the jaw and the shortening of the diastema. In the upper jaw it is *increased* by the excavation of the under side of the rostrum between the molars and incisors.

† The roots of the upper premolars are even nearer together than those of the molars; they are, in fact, almost in contact.

and a system of complex curvatures and oblique implantations, and are suspended in their sockets by vertical bands of periosteum, as already described. When the jaws are shut, the molars on each side curve outward so strongly that the distance between them below (between roots of lower series) is several times greater than above (between roots of upper series). The result of this arrangement is that the molar teeth, during the lateral movement of the act of grinding the food, press upon the opposing series not only in such manner as to secure the greatest mechanical advantage, but also so as to produce the least jar, since the pressure in both directions is distributed over arcs of circles. But this is not all, for if the tooth rows are viewed from the side another remarkable complex of curvatures appears (figs. 18 and 26). It is now seen that in addition to the lateral curvatures there are strongly developed antero-posterior curves and incomplete spiral curves. In the upper series the premolar always slopes strongly forward, and the molars curve backward from crown to root. In the lower jaw the premolar and intermediary molars (m_1 and m_2) curve forward from crown to root and the posterior molar backward. The lower premolar is the largest and heaviest tooth of the molariform series; it is strongly concave forward, convex backward, and is implanted nearly vertically. The last molar is the smallest tooth, and both slopes and curves strongly backward from crown to root. The end teeth of each series thus act as braces to support the tooth row as a whole during the antero-posterior movement of the jaws in grinding, and to keep the molars constantly 'keyed up,' so preventing any tendency to spacing between the crowns.

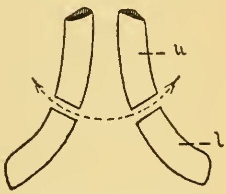

FIG. 40.—Upper and lower molars of *Platygeomys gymnurus* in normal position, showing angle of truncation of crowns, necessitating lateral movement in arc of circle.

In addition to the curvatures described, the molariform teeth are usually more or less twisted spirally on their vertical axes, so that the two ends lie in different tangential planes. Furthermore, the outer (concave) edge is commonly shorter than the inner (convex) edge.

FIG. 41.—Cross section of mandible of *Platygeomys gymnurus*, showing how roots of m_2 and m_3 straddle the incisor.

The molariform teeth are so implanted that the roots of each lateral series, above and below, lie in at least two antero-posterior planes, the roots of the premolar and last molar in both jaws being nearer the median line of the skull than those of the intermediary molars. The discrepancy is most marked in the lower series, where the posterior lower molars (m_2 and m_3) actually straddle the root of the incisor (fig. 41). The roots of m_1 and m_2 curve down outside (on the buccal side) of the incisor, while that of m_3 lies on its inner (lingual) side. In order to do this the latter tooth (m_3) not only curves strongly backward but is twisted on its own axis sufficiently to enable its root to lie flatwise against the inner side of the incisor.

(*b*) *Influence of the direction of the jaw movement on the molariform teeth.*

The direction of the dominant movement of the jaw exerts a marked effect upon the size, curvatures, proportions, and number of enamel plates of the molariform teeth. This is well shown in comparing teeth from skulls of the same size of *Macrogeomys dolichocephalus* and *Platygeomys gymnurus*.

(1) *Effect on the size and curvature of the prisms.*—The length of the molariform series on the crowns is approximately the same in both. In *M. dolichocephalus*, in which the principal movement is antero-posterior or nearly so, the premolars and last molars, which form the end posts of the series, are very much lengthened and enlarged, while the intermediary molars are essentially the same size as in *P. gymnurus*, in which animal the principal movement is transverse or obliquely transverse. The lower premolar of *dolichocephalus* (fig. 42, *a*) contrasted with that of *gymnurus* (fig. 42, *b*) is not only larger and longer, but its root curves forward much more strongly, increasing its resisting power as a brace. Throughout the group this tooth (the lower premolar) acts as an immovable post or buttress against which the molars press during the to and fro grinding movement; hence it is naturally largest in those species in which the principal movement is antero-posterior (see fig. 26).* The intermediary upper molars (m^1 and m^2) are longer and less curved in *dolichocephalus* than in *gymnurus;* the intermediary lower molars (m_1 and m_2) are essentially equal in length in the two forms and are equally curved, but the curvatures are different: In *M. dolichocephalus* the upper half of the prism is nearly straight, particularly in m_2; the curvatures are more abrupt; the anterior curve is much greater than in *gymnurus*, and the spiral twist is more pronounced, the root end of the teeth rotating more strongly inward. The posterior molar, both above and below, is much broader and heavier in *dolichocephalus* than in *gymnurus*, and the upper one is more strongly curved backward. The strong outward inclination of the roots of the end teeth of the series tends to keep the molars perpetually keyed up, preventing any spacing between the crowns. The destructive effects of the to-and-fro movement of the powerful planing machine are thus successfully offset.

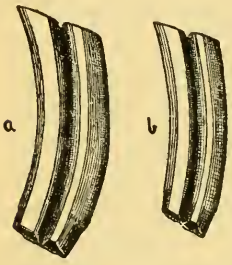

FIG. 42.—Lower premolar showing difference in size and curvature according to whether the dominant jaw movement is to and fro or sideways. *a Macrogeomys dolichocephalus; b Platygeomys gymnurus.*

*What the lower premolar accomplishes by its massiveness and fixed position, the upper premolar accomplishes by its length and angle of implantation.

(2) *Effect on the proportions of the prisms.*—The breadth of the molar prisms with respect to their antero-posterior diameter is materially affected by the direction of the dominant movement of the jaw. This is readily seen in the crowns which are much more elongated transversely in those species in which the principal movement is obliquely transverse (*P. gymnurus* and others) than in those in which it is chiefly antero-posterior (*M. dolichocephalus* and others). In the former series the transverse diameter of the crown (of upper molars) averages two and one-half times the antero-posterior; in the latter, only two times.

(3) *Effect on the number and size of the enamel plates.*—Perhaps the most conspicuous and important of the differences in the molariform teeth, resulting from the direction of the dominant movement of the jaw, is in the number of the enamel plates on the upper intermediary molars. Two plates are invariably present in those forms in which the dominant movement is antero-posterior (genera *Geomys*, *Zygogeomys*, *Orthogeomys*, *Macrogeomys*, and *Heterogeomys*); while only one is present in those in which the movement is obliquely transverse (genera *Platygeomys* and *Cratogeomys*). In the latter case the enamel is restricted to the front face of the tooth, the posterior plate being obsolete, and the upper premolar resembles the molars in this respect, the posterior enamel plate being invariably absent.

ARRANGEMENT AND MODE OF OPERATION OF THE CUTTING BLADES.

The arrangement of the enamel plates and the direction of the dominant movement of the jaw in mastication present two widely different types in the animals under consideration. In one of these types the principal movement is obliquely transverse; in the other it is antero-posterior. They may be best considered separately.

(*a*) *Dominant movement of jaw obliquely transverse.*—When the upper tooth row of *Platygeomys gymnurus*, or any other species in which the dominant movement is obliquely transverse is examined as a whole, it is found to be made up of five flattened columns of dentine arranged seriatim one in front of another, and each faced in front with a vertical plate of enamel which projects a short distance beyond the crown (fig. 43 [1]). These five enamel plates are strongly convex forward and their curvatures are essentially parallel (fig. 44 [1]). An additional enamel plate covers the posterior face of the anterior pillar of the premolar and the isthmus connecting the two parts of this tooth; and the two lateral plates of the last upper molar may be considered as together forming another cutting plate, making seven in all in the upper series. Turning now to the opposing series—the lower molars—the opposite or complementary condition prevails, a curved enamel plate covering

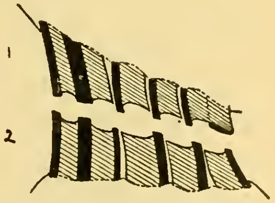

FIG. 43.—Longitudinal section of molariform teeth of *Platygeomys gymnurus* (diagrammatic). (1) Upper; (2) lower.

the posterior face of each of the five flattened columns of dentine (figs. 43^2 and 44^2). Two additional transverse plates complete the armament of the lower premolar, making seven in all, as in the upper series. It should be observed further that the concave sides of the five regular enamel plates face *backward* in the upper series and *forward* in the lower series. If now the two series are superimposed in the position they naturally assume in the mouth (fig. 45), and the lower series is moved obliquely forward and outward in the direction it normally takes when drawn by the masseter, the two sets of curved enamel blades come together like the opposing blades of seven pairs of shears working almost simultaneously, with this difference in favor of the teeth, that in addition to the antero-posterior closing movement the curved blades slide over one another laterally, thus giving the greatest possible advantage in slicing the hard roots and other unyielding substances on which the animals feed. The length of the blades gives a long sweep, while the curvature* insures the passage of

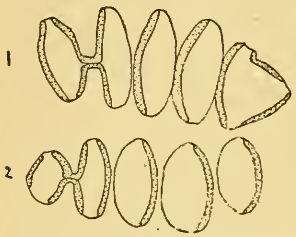

FIG. 44.—Crowns of molariform teeth of *Platygeomys gymnurus*. (1) Upper series; (2) lower series.

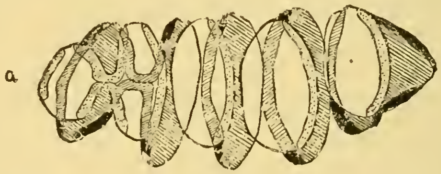

FIG. 45.—Superimposed molar series of *Platygeomys gymnurus* showing relations of enamel blades (light outlines lower series; dark, upper); *a* front end.

each particle of food against the cutting edges. The action is still further favored by the oblique truncation of the molar crowns and the peculiar method of suspension already described whereby the unyielding enamel blades gain an elasticity which gives them a shearing motion of the highest efficiency. The cutting is done during the obliquely forward movement of the mandible; the complementary movement is simply one of recovery and has no effect on the food.

The forward movement is evidently complex and apparently consists of three independent motions by which the mandible is shifted from side to side in a zigzag manner, as follows: (1) The mandible is carried obliquely forward and to one side until each of the enamel blades has completed a shearing cut against one of the blades of the upper series; (2) it is then carried obliquely forward in the opposite direction until each blade completes another cut; (3) it then turns again and the molar blades accomplish a third cut, leaving the upper and lower series

* The concave sides of the enamel blades move toward and over one another, inclosing the food in a rapidly contracting loop, the opposite sides of which meet and pass, leaving no chance for food to escape.

nearly in the same vertical plane. The lower series has been carried forward so that each tooth stands considerably in advance of the corresponding tooth of the upper series. A fourth movement, that of recovery, brings the mandible back to the starting point. The limit of the to-and-fro movement is nearly the same throughout the family *Geomyidæ* and is measured by the antero-posterior diameter of the crown of the premolar, which it slightly exceeds. When the jaws are at rest the front face of the lower premolar rests on or slightly behind the corresponding face of the upper premolar. When the jaw is drawn forward until the lower incisor strikes the posterior beveled face of the upper incisor, the lower premolar stands free from and wholly anterior to the upper. Hence, the thickness of the premolar is slightly less than the distance covered in the to-and-fro movement of the jaw. This being the case, it is easy to ascertain the number of cuts made by the enamel blades during each stroke of the jaw in mastication. By superimposing tracings of the upper and lower molar series (fig. 45) and moving the latter obliquely forward and outward under the former it appears that of the four cutting blades of the lower premolar the first is unimportant, the second glides over two cutting edges of the upper premolar during each stroke, the third and fourth cut against three edges each, and the single blade of each of the three true molars cuts over three enamel plates of the upper series (counting as one the two lateral plates of the last upper molar against which they cut), making seventeen cuts for each stroke of the jaw.

In a tame *Geomys lutescens* it was found (by actually counting the contractions of the temporal muscle) that the mandible makes 200 complete strokes a minute, which, at the rate of 17 cuts with each stroke, is equivalent to 3,400 cuts by a single pair of blades. This is the number of cuts made by the blades of a single ramus; but since the blades of both sides doubtless act simultaneously the number should be doubled, making a total of 6,800 cuts each minute!

The enamel plates are so spaced, by means of slight differences in the antero-posterior diameters of the upper and lower molars, that when the jaws are shut together and the movement of mastication takes place, only one pair of cutting edges comes into bearing at a time. The seven sets of blades, therefore, instead of cutting simultaneously, follow one another in rapid succession, one pair just completing its stroke as the next begins. By means of this delicate adjustment only one-seventh the power is required that would be necessary if all operated together.

If, in the animals having the above described shearing movement of the molars, a posterior enamel plate was present in the upper intermediary molars, or an anterior plate in the lower molars, the possession of such plates would obviously be a mechanical disadvantage, as they would not only be of no use but would be actually in the way. Hence, in the evolution of this specialized type one plate has been suppressed;

and the fact should be emphasized that the loss of a useless enamel plate is as clearly a sign of specialization as the development of an additional plate where needed. In the less specialized genus *Thomomys* both plates are always present (fig. 32, *b*).

(*b*) *Dominant movement of jaw antero-posterior.*—In the remaining groups the movement of the jaw is chiefly antero-posterior, the crowns of the teeth are more broadly elliptical, and enamel plates are present on both sides of the upper molars (figs. 46 and 47). In some genera the posterior plate, which is always thinner than the anterior, covers the whole hinder face of the tooth; in others it is restricted to the inner side, according to the exact axis of jaw movement. Whenever the ellipse is broad, and is so directed with reference to the enamel plates of the adjacent teeth that it presents a free edge *toward* the food that is being ground, this edge is invariably protected by a plate and cutting edge of enamel. Conspicuous illustrations of this law may be seen in the upper premolar of *Zygogeomys*, *Macrogeomys*, and *Heterogeomys*, and in the upper intermediary molars of *Zygogeomys*, in all of which the posterior enamel plate is restricted to the *lingual* side—the side impinged upon by the food. On the other hand, non-cutting edges protected by the enamel plates of adjacent teeth are better off without enamel of their own, because such enamel, if present, would not only be of no use, but would be actually in the way, as already explained.

FIG. 46.—Longitudinal section of molariform teeth of *Macrogeomys dolichocephalus* (diagrammatic). (1) Upper series; (2) lower.

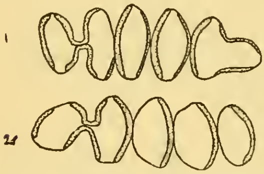

FIG. 47.—Crowns of molariform teeth of *Macrogeomys dolichocephalus*. (1) Upper; (2) lower.

By superimposing tracings of the upper and lower molar series of *Macrogeomys dolichocephalus* (fig. 48) and moving the lower backward and forward under the upper as nearly as possible in the way they are moved by the living animal, it is found that the cutting blades make nineteen cuts during each forward stroke of the jaw, as follows: The anterior plate of the lower premolar does not cut at all, or, if it cuts its action is so limited as to be of no particular consequence; the posterior plate of the anterior prism makes two cuts; the anterior plate of the posterior prism, three cuts; the posterior plate of the premolar and that of

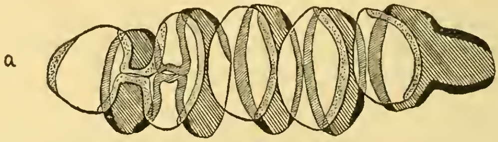

FIG. 48.—Superimposed molar series of *Macrogeomys dolichocephalus* showing relations of enamel blades. Light outlines, lower series; dark, upper. *a* front end.

the first molar make four cuts each; the second and third molars, three cuts each (counting the two lateral plates of the upper molar, against which m_3 acts, as if they were a single plate), making nineteen in all. During the return movement fourteen cuts are made, as follows: The second and third transverse plates of the premolar make two cuts each; the fourth, three; the first molar, three; the second and third molars, two each. The backward stroke is evidently less powerful and less effective than the forward stroke.

Since the teeth on both sides of the mandible cut simultaneously, the total number of cuts during each complete stroke will be double the number above mentioned, or 38 for the forward stroke and 28 for the backward stroke. Assuming that the number of complete strokes each minute is the same as in *Geomys lutescens*, namely, 200, the total number of cuts made each minute on the forward stroke would be 7,600, and on the backward stroke 5,600, making a grand total of 13,200 cuts each minute while the jaws are in active operation!

Stroke of the jaw.—There being no postglenoid process, the backward movement of the jaw is not interrupted until the condyle strikes the auditory bulla at the base of the tube of the meatus. When the condyle rests in this position and the molar series are in apposition, the front faces of the premolars above and below are in line. The forward movement of the jaw is stopped by the incisors and reaches its limit when the front face of the lower incisor strikes against the posterior face of the beveled edge of the upper incisor. When this happens the upper premolar usually rests on the back part of the first lower molar.

From the foregoing account it must be clear that the molars, which, considered as individual teeth, are simple elliptical tubes, lacking the complicated enamel patterns of the beaver, porcupine, and many other rodents, are so constructed that collectively they form one of the most powerful and highly specialized cutting and slicing machines known. The way the narrowly elliptical crowns are placed side by side flatwise, the hard projecting enamel blades alternating with surfaces of soft dentine, results in the production of a cutting and rasping apparatus equal if not superior to that possessed by those rodents and ungulates that have complicated enamel folds within the substance of the teeth. The obliquity of the crowns, whereby the upper and lower series are brought together in the arc of a circle, gives them remarkable power under the transverse movement of the jaws, while the way the teeth are suspended on vertical cushions, together with the angle of implantation and the double curvatures of their prisms, enables them to withstand the great strain to which they are subjected without danger of displacement and without injury to the tender pulps at their bases.

The secondary modifications of the skull resulting from the action of the muscles operating this wonderfully effective machinery are discussed elsewhere (pp. 104–107).

TREATMENT AND COURSE OF THE FOOD.

The circumstance that all the members of the *Geomyidæ* live underground has an important bearing on the kind of food habitually eaten, and is thus the remote cause of the special adaptations of the dental armature, and of the secondary cranial modifications necessitated thereby. The animals sometimes come to the surface and cut the stems and leaves of plants, which they draw into their subterranean tunnels, but in the main the choice of food is restricted to such parts of plants as may be found within the ground. The food therefore consists chiefly of tubers and roots, including the hard roots of trees and shrubs, the tough rootstalks of the mescal or agave, and the like. In dealing with these unyielding substances the animal gains one decided advantage—the roots on which it feeds are held firmly in place by the earth while pieces are chiseled off by the broad, trenchant cutting edges of the powerful incisors. In the case of certain relatively soft substances, such as potatoes, the lower incisors are sometimes used alone, both as a pry to dislodge pieces and as a scraper to scrape off thin slices, but as a rule both upper and lower incisors operate together. The principal function of the upper incisors seems to be to transfix the tuber and oppose the action of the lower while the latter do most of the work, moving rapidly backward and forward (and at the same time upward), until a piece of food is cut loose or sufficiently undermined so that it may be torn loose by a backward movement of the head while the teeth are held firmly together. The bit of food thus dislodged is either reduced in size by trimming—during which operation it is held between the large forefeet, the long claws turned inward toward one another—or is passed directly into the mouth or cheek pouches. The mouth proper, it should be remembered, is separated from the incisors by a furry partition which is directly in front of the molars. This diaphragm-like partition is of great service to the animal, keeping dirt and chips out of the mouth. When the food reaches the mouth proper the tongue and lips keep it between the teeth, where it undergoes the treatment commonly described as grinding. But in the highly specialized forms of the *Geomyidæ* no real grinding occurs—the whole process is one of cutting or slicing. The arrangement of the enamel plates that form the blades of the cutting machine has been already described in detail. In those species in which the principal movement of the jaw is antero-posterior the mechanism is essentially a *planing* machine, while in those in which the dominant movement is obliquely transverse it is a *shearing* or *slicing* machine. In either case the tough vegetable fibers composing the food are quickly reduced to a pulp, which is promptly passed on to the stomach for digestion.

MUSCLES THAT OPERATE THE CUTTING MACHINE.

The principal muscles concerned in the movements of the jaw are (1) temporal, (2) masseter, (3) internal pterygoid, (4) external pterygoid,

(5) digastric, and (6) transverse mandibular. Of these, by far the most important single muscle is the masseter.

The *temporal* muscle occupies the whole of the upper surface of the cranium behind the orbits, covering the parietal, squamosal, and posterior part of the frontal as far forward as the postorbital prominence. It arises from the flat upper surfaces of these bones and from the lambdoid and sagittal crests. The muscle is indistinctly divided into two parts—a superficial and a deep—which are not well defined in their origin. The fibers of the muscle as a whole converge anteriorly; those of the superficial part are inserted into the apex, posterior edge, and inner side of the coronoid process; those of the deep part play over the trochlear groove and at the margin of the orbit drop vertically downward and are inserted by a dense aponeurosis on the anterior edge of the basal half of the coronoid ramus from the plane of the molar crowns upward to a point slightly above the plane of the coronoid notch; posteriorly the muscle remains fleshy and covers the inner side of the coronoid ramus where its insertion extends downward to the bottom of the deep pit between the ramus and the posterior molar. The function of the temporal muscle is to shut the mouth, and in some species to draw the mandible slightly backward. Operating in connection with the digastric, it performs the backward stroke of the to-and fro movement of the jaw in the *dolichocephalic* series, the masseter producing the forward stroke.

The *masseter* is a large complex muscle and is by far the most important of the muscles concerned in the act of mastication. It is incompletely divided into three parts, which, from their principal sources of origin, may be described as the rostral or superficial, maxillary, and zygomatic parts.

(1) The *rostral* or superficial part arises by a long and dense aponeurosis from the outer side of the rostrum on the line of the premaxillo-maxillary suture, its upper border being immediately in front of the infraorbital foramen. It passes thence obliquely downward and backward, developing muscular fibers and spreading out posteriorly into a flat muscular band which is inserted upon the inferior crest of the masseteric fossa and the inferior surface of the mandible from the digastric crest posteriorly to the base of the angular process, its insertion being wholly fleshy. It is the most powerful muscle in drawing the jaw straight forward, and is aided in the *dolichocephalic* species by the zygomatic branch of the masseter.

(2) The *main body of the masseter* arises from the side of the anterior part of the maxilla and adjacent parts of the maxillary root of the zygoma. Anteriorly it slightly overlaps the posterior part of the premaxilla immediately below the top of the rostrum, where it forms a distinct crest continuous with the anterior edge of the maxillary root of the zygoma. The principal origin covers the whole of the anterior face of the vertically expanded zygomatic process of the maxilla, and

in addition a thin supplementary sheet takes origin from the posterior face of the same bony plate (within the orbital chamber). Posteriorly its origin is limited on the outer side by a thick aponeurosis, which is firmly attached to the inferior surface of the antero-external angle of the zygoma. The part within the orbit follows the inner face of the horizontal part of the zygoma all the way back to the glenoid ligament, to which its posterior fibers are attached. This part of the muscle is inserted on the outer side of the neck of the condylar ramus just above the incisor capsule.

(3) The *zygomatic part* of the masseter arises from the outer side of the horizontal part of the zygoma, its origin embracing the outer surface of the squamosal root of the zygoma and the outer side of the jugal below the oblique crest which marks the limits of its insertion above and in front. It arises also from the aponeurotic septum which separates it from the main body of the muscle. It is inserted upon the angular process of the mandible, its insertion covering the upper surface of this process from the incisor capsule outwardly to and over the head of the process, and also the under surface of the process to its very base, where its insertion becomes continuous with that of the main body of the muscle. Its function in *Geomys* proper and in all the *dolichocephalic* species is to draw the jaw forward. In the *platycephalic* species its insertion is carried so far outward by the great elongation of the angular process that it serves to move the jaw sideways, in which act it is aided by the pterygoid muscles.

The *internal pterygoid muscle* arises from the pterygoid fossa of the skull, which it completely fills. Passing directly outward and slightly downward, it is inserted into the pterygoid fossa of the jaw, where its line of attachment has developed a strong crest along the posterior edge of the angular process. Its function in *Geomys* proper and in all of the *dolichocephalic* species seems to be to bring the posterior end of the molar series firmly together when the jaw is shut. In the *platycephalic* species it aids the masseter in moving the jaw sideways.

The *external pterygoid* arises from the alisphenoid bone on the outer side of the root of the last upper molar and is inserted into the inner side of the neck of the condyle. Its function is evidently mainly the same as that of the internal pterygoid, though in addition it tends to move the mandible slightly forward.

The *digastric* arises from the paroccipital process and adjacent parts of the mastoid and audital bullæ, and is inserted on the digastric crest, which projects backward from the hinder part of the symphysis of the mandible. It is largely developed, its function being not merely to open the mouth, but, operating with the temporal, to draw the jaw strongly backward in the to and fro movement of mastication in the *dolichocephalic* series. Its action is very direct and powerful.

The *transverse mandibular muscle* connects the two halves of the lower jaw immediately behind the symphysis, where, in many species, there is a distinct fossa for its lodgment. It must fulfill an important function in regulating the adjustment of the tooth rows during mastication.

MUSCLES OF THE CHEEK POUCHES.

I have not dissected the muscles of the cheek pouches, but they have been described by Dr. C. E. McChesney* and Prof. H. L. Osborn.† Dr. McChesney states that the aperture of the pouch is surrounded by a narrow delicate constrictor muscle, and that the long pouch itself, which extends back to the shoulder, is enveloped by a contractor muscle which seems to be a modified part of the *platysma myoides*. This muscle consists of two parts: (1) a retractor part, reaching from the extreme posterior end of the pouch backward over the muscles of the back and ending in a broad thin tendon which blends with the tendons of the superficial dorsal muscles, to be inserted into the spines of the three last lumbar vertebræ; (2) an anterior part which envelops the pouch proper. This latter is in turn subdivided into two parts—external and internal. The former covers the upper or outer portion of the pouch and is inserted into the maxillary bone (probably *pre*maxillary). The latter covers the inner and under sides of the pouch and is attached to the mandible, though the uppermost fibers join those of the former division, to be inserted on the upper jaw. Dr. McChesney states that the lower and inner surface of the muscle is thickest, the outer surface being thin and of little power.

Prof. Osborn describes the muscles of the pouch as follows: "There are three distinct sets of muscles; these are, first, a circular muscle that runs around the margin of the pocket in its outer bounding fold. This by its contraction would seem to purse the opening of the pocket. The second set of muscles are those that I will call the protractors of the pockets. These are two in number on each side. They are spread out in the skin of both the inner and outer posterior portions of the pockets, and their fibers converge forward to finally form somewhat definite bands. The outer of these is attached in the skin at the origin of the fold on the upper jaw. The other is attached to the lower attachment of the fold at the lower jaw. These two muscles thus surround the pocket, and their contraction pulls its recess forward to the opening of the vestibule. The third set of muscles are the retractors of the pocket. These arise funnel-wise from surface of the pocket, both on its inner and outer aspects, and they run backward and dorsally parallel to the fibers of the latissimus dorsi and totally free from the skin. They form a band three or four inches long and nearly an inch wide, and are finally inserted in the tendinous aponeurosis that covers the insertion of the latissimus dorsi and is attached to the neural spines of the anterior lumbar vertebræ. These by their action retract the pockets."

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* Bull. U. S. Geol. and Geog. Survey Terr., IV, No. 1, Feb., 1878, 214–215.

† Science, XXIII, Feb. 23, 1894, 102–103.

PRINCIPAL MUSCLES CONNECTING THE HEAD WITH THE NECK.

The *sterno-mastoid* muscle arises by a tendinous aponeurosis from the manubrium of the sternum and is inserted into the mastoid process of the squamosal immediately behind the auditory meatus.

The *cleido-mastoid* arises from the middle part of the clavicle and is inserted on the upper or dorsal aspect of the mastoid process of the squamosal immediately over or above the insertion of the sterno-mastoid. Its fibers are but little separated from those of the trapezius.

The *trapezius* muscle arises from the ventral surface of the outer third of the clavicle and the adjacent acromial process of the scapula and the spine of the scapula for its entire length; near the median line its fibers seem to be continuous with those of the median part of the *latissimus dorsi*. It is inserted on the lambdoid crest for its entire length, its outer edges being continuous with the insertion of the *cleido-mastoid*.

The *rhomboideus* lies immediately below the trapezius. It is much less extensive than the latter, but considerably thicker. It arises from the superior face of the spine of the scapula and the adjacent anterior part of the vertebral border of the scapula, and is inserted into the posterior face of the lambdoid crest immediately beneath the insertion of the trapezius.

ANALYSIS OF JAW MOVEMENTS.

Turning now from the consideration of the individual muscles to the study of the origin of the complex movements of the jaw in chiseling and slicing the food, even greater difficulties are encountered. The following attempt, therefore, is subject to correction.

(1) *The act of chiseling.*—From what has been said it appears that the act of chiseling is performed in essentially the same way in both the *platycephalic* and *dolichocephalic* members of the group, and that it is due to the joint action of the masseter and temporal muscles, the former being more effective than the latter.

The thin enamel edge of the upper incisors is used chiefly as an anchor to fasten the cutting machine firmly to the object operated upon, while the lower jaw plays back and forth like a drill in accomplishing the work. The exserted part of the upper incisors, therefore, is curved downward and inward, and the edge, which is very thin and sharp, is broken by one or more grooves, which enable it to penetrate hard substances more easily than if it were straight. The face of the lower incisor slopes strongly forward as well as upward and the axis of its movement in cutting must be obliquely forward and upward. The principal muscle concerned in chiseling is the *masseter*, which is aided by the *temporal*, and in some cases also probably by the *pterygoids*. The way the posterior part of the ramus of the mandible curves upward in the arc of a circle has a highly important bearing on the efficacy of the action of the masseter, and has doubtless been molded into its present shape by this all-important muscle. The rostral part of the masseter is nearly horizontal; from its aponeurotic origin on the sides of the rostrum it spreads out posteriorly and is inserted broadly over the posterior curvature of the upturned ramus of the mandible, its action being to draw the mandible as a whole directly forward. The main body of the muscle is nearly vertical, but slopes slightly backward from its maxillary origin to its insertion on the outer side of the mandible; in contracting draws the jaw slightly forward and powerfully upward. In those species in which the zygomatic part of the masseter is nearly vertical instead of transverse this part of the muscle aids the rest in moving the jaw forward and upward. The masseter is aided still further by the temporal muscle, which, using the condyle as a fulcrum, moves the lower incisors upward.

(2) *The act of slicing.*—The act of slicing the food is performed in different ways in the two series of animals, being chiefly a to-and-fro movement in the *dolichocephalic* species and a transversely oblique rotary movement in the *platycephalic* species. In the *dolichocephalic* species both the forward and backward movements are important, while in the *platycephalic* species the backward movement is merely one of recovery. In the *dolichocephalic* series, therefore, the forward movement produced by the masseter requires a powerful counter movement in bringing the jaw back. This is supplied, apparently, by the joint action of the digastric and the deep part of the temporal. The latter holds the teeth firmly together and draws the jaw slightly backward, while the digastric, contracting at the same time, pulls the jaw powerfully backward, the superficial part of the temporal, which is inserted on the coronoid process, preventing it from opening the mouth.

In the *platycephalic* series, as already stated, the principal movement is obliquely transverse, the jaw being drawn outward and forward. The muscles producing this action are the zygomatic part of the masseter and the pterygoids. It is probable that they are largely aided by the deep portion of the temporal, which is inserted into the pit on the outer side of the posterior molars. The fibers of this part of the temporal muscle being vertical, bring the teeth firmly together and draw the under jaw slightly outward, which movement, in connection with the angle of truncation of the crowns of the teeth, must result in the transverse rotary motion.

The mouth is opened by means of the digastric muscle, which is beautifully adapted to this end, its origin taking hold of the posterior part of the cranium on each side of occipital condyles, while its insertion is carried forward all the way to the symphysis of the jaw. The digastric does not appear to be assisted by any other muscle in performing its function of opening the mouth.

INFLUENCE OF THE MASSETER MUSCLE IN MOLDING THE SKULL AND MODIFYING THE TEETH.*

Throughout the *Geomyidæ* the masseter muscle has profoundly modified the form of the skull and the character of the teeth, and is largely responsible for the extraordinary cranial peculiarities that distinguish the several genera. Perhaps it would be better to say that slight differences in the direction of the principal movement of the jaw in grinding the food, which have proved an advantage to the animal, have by natural selection developed certain fibers or parts of the muscle at the expense of other parts, and that the differences thus originated have been perpetuated and intensified until the muscle has in turn molded the bones to which it is attached, and also those with which it comes in contact, thus altering the form and proportions of the cranium as a whole, and giving rise to extreme variations in the size, shape, and position of the zygomatic arch and in the development of the angle of the jaw. At least two very distinct types of skull have been established in this way—a broad or *platycephalic* type (pl. 3) and a narrow or *dolichocephalic* type (pl. 5).†

By contrasting the accompanying figures of representative skulls of these two types, with respect to the areas of attachment of the princi-

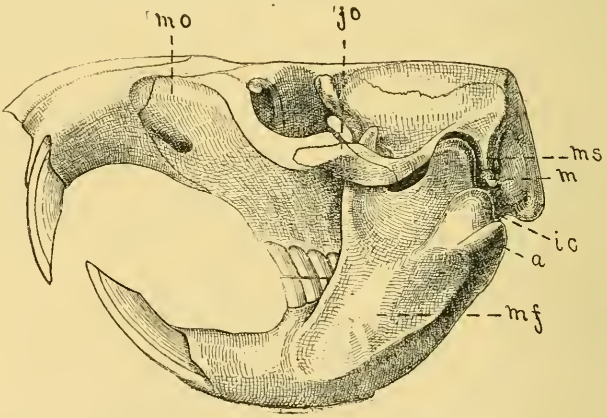


FIG. 49.—Side view of skull of *Macrogeomys dolichocephalus*, showing relations of mandible, and fossæ for attachment of muscles.

a Angle of mandible.
ic Incisor capsule.
jo Jugal origin of masseter.
m Mastoid process of mastoid bulla.
ms Mastoid process of squamosal.
mf Masseteric fossa.
mo Maxillary origin of main body of masseter.
mss Mandibular shelf (leading to angle in *Platygeomys gymnurus*).

pal parts of the masseter, the action of the muscle and its effects on the skull may be better understood. Without repeating the detailed

*For an important chapter on the general subject of the influence of the muscles in shaping the skull in the Rodentia, see Herluf Winge, Jordfundne og nulev. Gnavere fra Lagoa Santa, Minas Geraes, Brasilien, 1888, 103-110.

† These extremes in the form of the skull are brought about mainly by alterations in the superficial or outer parts, the fundamental structures and relations remaining very much the same in both, as shown by sectionized skulls (pls. 17 and 18).

descriptions already given under the head of the muscle (p. 99), it may be stated that the principal part of the masseter arises from the side of the maxilla in front of the zygomatic arch, and from the adjacent parts of the premaxilla and the maxillary root of the zygoma (fig. 49, *mo*). It is inserted upon the outer side of the mandible, and the area covered by its insertion—the *masseteric fossa*—extends from the angle to the plane of the front of the premolar (fig. 49, *mf*). Its origin, insertion, and relations are essentially the same throughout the group. The jugal part arises from the horizontal arm of the zygoma and is inserted upon the upper side and end of the angle of the jaw. Its size, form, area of origin, axis, and relative importance differ conspicuously in the various members of the series. In some forms it arises from the entire length of the horizontal part of the arch (fig. 50, *jo*); in others from the posterior part only (fig. 49, *jo*). The upper limit of its origin is marked by an oblique line and a change of direction in the outer face of the jugal.*

Effect on the skull.—In the long and narrow skulls, of which *Macrogeomys dolichocephalus* may be taken as a type, the great body of the

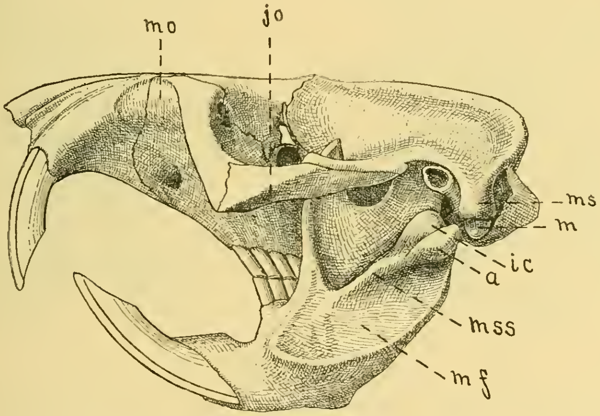


FIG. 50.—Side view of skull of *Platygeomys gymnurus* showing relations of mandible and fossæ for attachment of muscles. Lettering same as in fig. 49.

masseter is parallel to the side of the face, its function being to close the jaws firmly and draw the mandible forward. Its principal origin is maxillary, the jugal part being small and posterior to the plane of the middle of the orbit (fig. 49, *jo*). The resulting principal movement of the jaw is antero-posterior. The action of the muscle has narrowed the zygomatic arches, rounded off their anterior angles, and lifted them out of the way until the horizontal part of the arch is much nearer the

* Owing to the scarcity of material for dissection the masseter muscle itself has been actually examined in two forms only, namely, *Geomys bursarius* and *Macrogeomys dolichocephalus*. Its relations in these species, studied in connection with the well defined fossæ on the skull marking its origin and insertion, furnish a very good guide to its modifications and to the part it has played in producing the several types of cranium known in the group.

top of the skull in front than behind (fig. 49). The fibers of the jugal branch are nearly vertical, and are of little use except in drawing up the back part of the jaw. This may be seen from fig. 52: the muscle passes downward from the zygoma (*zy*) to the angle of the jaw (*a*).

In the broad and flat skulls, of which *Platygeomys gymnurus* may be taken as a type (fig. 50), the jugal branch of the masseter is largely developed, its function being to move the jaw sideways at the same time that the maxillary part brings the teeth firmly together. The resulting principal movement of the jaw is obliquely transverse. In producing this lateral movement the jugal branch is aided by the pterygoid muscles, but the latter must have played a very subordinate part in molding the skull. The jugal part of the masseter in the *platycephalic* series is not only of relatively large size, but the area of its origin is greatly extended (fig. 50, *jo*) and the axis of its fibers has become more nearly horizontal than vertical (fig. 54, *a* to *zy*). Its origin occupies the outer and inferior surface (and probably most of the inner surface also) of the horizontal part of the zygomatic arch for

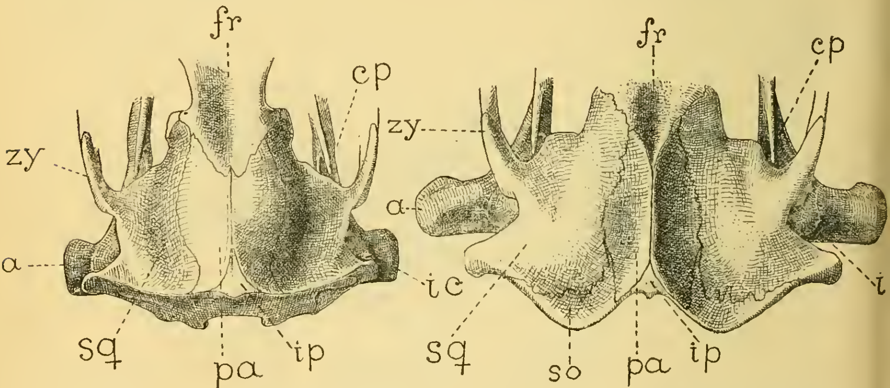
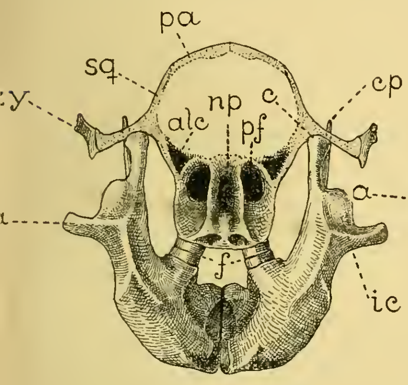


FIG. 51.—*Macrogeomys dolichocephalus*. FIG. 53.—*Platygeomys gymnurus*.

Posterior part of cranium from above, showing relations of mandible in place.

a Angular process of mandible.
cp Coronoid process of mandible.
ic Incisor capsule (covering root of lower incisor).
ip Interparietal.
fr Frontal.
pa Parietal.
so Supraoccipital.
sq Squamosal.
zy Zygoma.

its entire length, its anterior end being in front of the plane of the orbit. The action of this part of the masseter has drawn the zygomatic arch far outward and has pulled the anterior angle downward until the latter is further from the plane of the top of the skull than the posterior end of the arch. The angle is thus drawn down until it reaches four-fifths of the way from the plane of the top ot the skull to the plane of the molar alveolus, overreaching and overarching the maxillary or principal part of the masseter muscle, which operates beneath it (fig. 50, which should be contrasted with fig. 49 of *Macrogeomys dolichocephalus*). The insertion of the muscle has produced an equally extraordinary effect upon the shape of the under jaw. The sides of the jaw are not only spread widely apart in conformity with the great breadth of the skull, but in addition the fibers of the masseter that are inserted on the angular process have stimulated this process to push out sideways until it reaches off like a long arm at nearly a right angle to the axis of the skull (figs. 53 and 54, *a*).* The lengthening of this process was clearly necessitated in order to continue the effective action of the muscle. Furthermore, the segregation and specialization of the



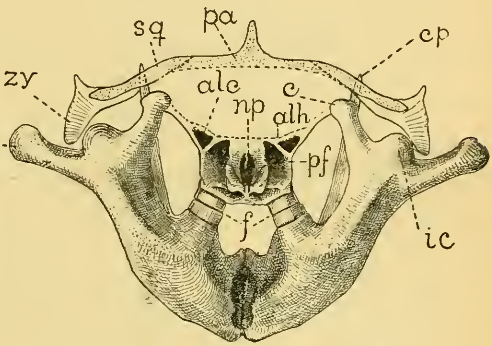


FIG. 52.—*Macrogeomys dolichocephalus.* FIG 54.—*Platygeomys gymnurus.*

Transverse vertical section of skull, with mandible in position, showing relations.

a Angular process of mandible.
alc Alisphenoid canal.
alh Horizontal arm of alisphenoid.
c Condyle of mandible.
cp Coronoid process of mandible.
f Angle of crowns of closed molars.
ic Incisor capsule (covering root of lower incisor).
np Narial passage.
pa Parietal.
pf Pterygoid fossa.
sq Squamosal.
zy Zygoma.

two parts of the masseter in the *platycephalic* series has resulted in the production of a long and well-defined horizontal shelf extending forward from the angle of the jaw to the base of the ascending ramus (fig. 50 *mss*). This shelf is totally wanting in *Macrogeomys dolichocephalus* and the other *dolichocephalic* forms in which the jugal part of the masseter is relatively unimportant and the principal movement of the jaw is fore and aft instead of transverse. The relations described may be seen to good advantage in the accompanying drawings (figs. 49–54).

Effect on the teeth.—While from the nature of the case it is clearly impossible to observe exactly what happens, either in the muscles or the teeth, during the act of mastication, it is at the same time permissible to draw certain inferences from the mechanical construction of the apparatus. In the case of the teeth, considered as the focus of the cutting machine, it has been already shown that two types exist, one

* In *M. dolichocephalus* the angle projects only 2½ mm. beyond the plane of the zygoma (fig. 52), while in *P gymnurus* it projects 10½ mm.

in which the crowns of the upper intermediary molars are broadly elliptical and bear two enamel plates (one on each face); the other in which the crowns are narrowly elliptical and bear only one enamel plate (which is on the anterior face). It has been shown further that the presence of two enamel plates is always correlated with an antero-posterior movement of the jaw, and that the presence of a single plate is always correlated with an obliquely transverse movement of the jaw. A careful study of the cutting blades in each instance shows that an antero-posterior movement is accompanied by a to-and-fro planing action in which two enamel blades are serviceable; and that a transversely oblique movement is accompanied by a lateral shearing action in which only a single blade can be used. In accordance with the well-known law that useful structures are preserved and useless structures suppressed, it is logical to infer that the direction of the dominant movement of the jaw has determined the presence or absence of the posterior enamel plate; and since the movement of the jaw is controlled by the masseter muscle, it is evident that the number of enamel plates on the upper intermediary molars may be traced back to the influence of this muscle.

In the course of the evolution of the two types just described it seems evident that as soon as the principal movement of the jaws in the line leading to *Macrogeomys dolichocephalus* came to be fore and aft it was settled that the form of the posterior part of the cranium should be narrow; that the angle of the under jaw should be shortly truncate; that the grinding teeth should be broadly elliptical, and that the posterior enamel plate of the upper series should be retained; and when the principal motion of the jaw in the ancestors of *Platygeomys gymnurus* came to be obliquely transverse, from that moment it was predetermined that the hinder part of the skull should be broadly expanded; that a long arm-like process should spring from the angle of the jaw; that the grinding teeth should be transversely flattened, and that the posterior enamel plate of the upper series should disappear.

CHAPTER IV.

SYSTEMATIC DESCRIPTIONS OF GENERA AND SPECIES.

Genus GEOMYS Rafinesque, 1817.

(Pls. 1, 7, 9, 12; pl. 15, figs. 11 and 12; pl. 17, fig. 3; pl. 18, fig. 1; pl. 19, fig. 3, and text fig. 55; maps 1 and 4.)

Type *Mus tuza* Ord, 1815, from Augusta, Georgia. (=*Geomys pinetis* Raf., 1817).

Geomys Rafinesque, Am. Monthly Magazine, II, No. I, Nov., 1817, 45. Type *G. pinetis* Raf. (=*Mus tuza* Ord, 1815), from pine barrens near Augusta, Ga.
Diplostoma Rafinesque, Ibid. 1817, 44-45.
Saccophorus Kuhl, Beiträge zur Zool., 1820, 65-66.
Pseudostoma Say, Long's Expd. to Rocky Mts., I, 1823, 406.
Ascomys Lichtenstein, Abh. Akad. Wiss. Berlin (1822), 1825, 20. fig. 2.

Dental characters.—Upper premolar with three enamel plates (the posterior absent). Upper pm decidedly longer than lower (in the other genera they are subequal); shaft of upper pm decidedly concave forward, except in a single species (*G. lutescens*). First and second upper molars with two enamel plates each, the posterior complete; posterior curvature of m^1 and anterior curvature of m_2 hardly apparent.

Last upper molar a single subcylindric or subtriangular prism without lateral sulcus on either side (and consequently without heel); outer enamel plate normally straight; inner and outer plates commonly subequal, or outer somewhat shorter, both reaching posterior face of tooth. Upper incisor strongly *bisulcate* (fig. 22^2 and 22^3; pl. 15, figs. 11 and 12).

Cranial characters.—Skull simple, without any very striking external characters. Orbitosphenoids small and narrow, not reaching alisphenoids (pl. 17, fig. 3); sphenoid fossæ correspondingly elongated, reaching forward to orbital plates of frontal; alisphenoids short posteriorly, ending on floor of brain case about on plane of front ends of audital bullæ; pterygoids large, always forming more than half of the palatopterygoid extensions; mesethmoid plate large, somewhat rectangular, much longer than high, and wholly superior to vomer (not dipping down between vomerine wings as in *Pappogeomys*); endoturbinals collectively forming a quadrate plate, the anterior border of which is parallel to the cribriform plate (pl. 19, fig. 3); first endoturbinal rounded and only slightly expanded anteriorly, its inferior border falling (as the os planum) in the front of the others and articulating with the anterior third of the internal vertical plate of the maxilla—the os planum thus extending anteriorly in front of the lower endoturbinal much further than the length of the latter.

In the elongated skulls of *Geomys bursarius* and *tuza* the lower part of the sphenoidal fissure, on the floor of the orbit, differs from its condition in any of the other groups (fig. 55). In all of the others a fenes-

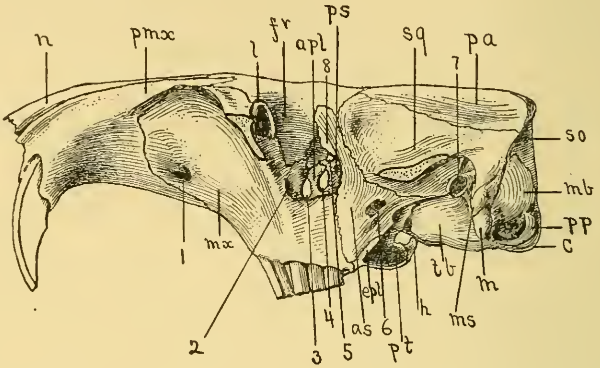


FIG. 55.—Side view of skull of *Geomys bursarius* from outside, zygomatic arch sawed off to show bottom of orbit. Animal a fully adult ♂, from Knoxville, Iowa. (This figure should be compared with the corresponding view of *Cratogeomys merriami*, fig. 4.)

1. Infraorbital foramen.
2. Posterior (orbital) opening of infraorbital canal.
3. Vacuity in front of presphenoid and ascending wing of palatine.
4. Vacuity in presphenoid, behind ascending wing of palatine.
5. Optic foramen (in orbitosphenoid bone).
6. Foramen rotundum and foramen ovale (which have here coalesced).
7. External auditory meatus.
8. Sphenoidal fissure (upper part).

apl. Ascending wing of vertical plate of palatine.
as. Alisphenoid.
c. Condyle of exoccipital.
epl. External pterygoid plate of palatine bone.
fr. Frontal.
h. Hamular process of pterygoid bone.
l. Lachrymal.
m. Mastoid process of mastoid bulla.
mb. Mastoid bulla.
ms. Mastoid process of squamosal.
mx. Maxilla.
n. Nasal.
pa. Parietal.
pmx. Premaxilla.
pp. Paroccipital process of exoccipital.
ps. Presphenoid.
pt. Pterygoid.
so. Supraoccipital.
sq. Squamosal.
tb. Tympanic or audital bulla.

trum (fig. 4,[6])* penetrates the interorbital septum, which at this point consists of the presphenoid only. In *Geomys bursarius* and *tuza* the basal part of the sphenoidal fissure is unusually broad, and the septum at

* In some cases, particularly in *Orthogeomys* and *Zygogeomys*, this fenestrum is subdivided into two or even three parts, but they all invariably penetrate the presphenoid; they are never in front of it.

its bottom, which here consists of both palatine and presphenoid, is perforated by two fenestra, which look completely through the skull from orbit to orbit. The posterior is the usual opening in the anterior part of the presphenoid (fig. 55,[4]); the other is in front of the presphenoid and is bounded anteriorly by a process from the maxilla, which here rises to join the frontal (fig. 55,[3]). Hence in *Geomys bursarius* there are three openings in the bottom of the orbital fossa, arranged seriatim, one in front of the other. The first is the posterior outlet of the infraorbital canal (fig. 55,[2]): the second is the vacuity here mentioned, which penetrates the skull in front of the presphenoid (fig. 55,[3]); the third is the usual fenestrum in the anterior part of the presphenoid (fig. 55,[4]). The opening in front of the presphenoid is completely surrounded by the maxilla and ascending wing of the palatine—the former bounding it in front, the latter behind—for the ascending wing of the vertical plate of the palatine (fig. 55, *apl*) here rises along the front of the presphenoid between the two fenestra in question and articulates with the maxilla, the orbital plate of the frontal, and the orbitosphenoid. (See also fig. 10.)

The condition here described has not been observed except in the elongate skulls of *Geomys bursarius*, *tuza*, and *personatus*, and is imperfectly developed in the latter. It reaches its highest development in *Geomys bursarius*, and does not occur in the closely related *G. lutescens*, which has a short skull. A condition simulating it sometimes exists in *Orthogeomys*, in which there are several (usually two or three) small perforations in the anterior part of the presphenoid, but the relations of the ascending wing of the palatine are not the same. Very young specimens of *Cratogeomys* resemble the adult of *Geomys* in the presence of a fenestrum in front of the presphenoid and ascending wing of the palatine, but the fenestrum disappears as the animal matures, a vestige of it remaining as a foramen (on each side), which opens from the floor of the orbit obliquely forward and downward into the narial passage.

The genus *Geomys*, even as here restricted, comprises three series or groups of species: (1) the *texensis-breviceps* series, (2) the *tuza* series, and (3) *Geomys busarius*.

(1) The *texensis-breviceps* series inhabits Texas, Louisiana, Arkansas, and the Great Plains, and includes eight species and subspecies, as follows: *arenarius*, *texensis*, *lutescens*, *breviceps*, *breviceps sagittalis*, *breviceps attwateri*, *personatus*, and *personatus fallax*. Most of these, particularly *arenarius*, *texensis*, and *breviceps*, are small generalized forms suggesting relationship with *Thomomys* and *Pappogeomys*. Indeed, these animals are very much alike in many ways and the skulls agree in general form, lightness, in the small rounded brain case, slender and nearly parallel zygomata, narrow pterygoids, and many other characters, though differing conspicuously in the teeth. It seems evident that they are but little removed from the trunk line of the group, and that both the *tuza* and the *bursarius* series are offshoots from the *brevi-*

ceps stem. *Geomys breviceps* seems to be the central or parent type from which three widely different species originated, *tuza* on the east, *bursarius* on the north, and *lutescens* on the west. To the eastward only a narrow gap separates the range of *breviceps* from that of *mobilensis* of the *tuza* series, which, though specifically distinct, was evidently derived from the *breviceps* stock. Still further east *mobilensis* passes in to*tuza*. On the west *breviceps* shades toward and probably will be found to intergrade with *lutescens*. On the north only a narrow hiatus separates it from *bursarius*, the most specialized type of the series. Specimens of *bursarius* from southern Missouri suggest that the gap between it and *breviceps* is not very wide; if continuity of range between the two forms is anywhere found this gap may be bridged even at the present time (see map 4).

(2) The *tuza* series inhabits the South Atlantic and Gulf States south of the Savannah River and east of the Mississippi (mah 4, A), and comprises three forms, *tuza*, *tuza mobilensis*, and *tuza floridanus*. They are locally known by the singularly inappropriate and misleading name 'Salamander.' The members of the *tuza* series agree among themselves and differ from the remaining forms of the genus *Geomys* in having longer and more naked tails, and in numerous cranial characters. The shape of the skull in pofile is decidly convex, the rostrum long and decurved, the nasals long and slender and constricted in the middle, giving them a somewhat hour-glass shape. The interparietal is permanently distinct from the supra-occipital and is normally much larger than in any of the other groups, though in *G. mobilensis* it is nearly obliterated in old age by the encroachment of the ridges that unite to form a sagittal crest.

The *tuza* group differs not only from *bursarius*, but from all other known members of the family, in the disproportionate length of the upper premolar in relation to the other molariform teeth. It is merely double the length of m^3. The lower premolar is much shorter, particularly in *floridanus*.

(3) *Geomys bursarius* inhabits the upper Mississippi Valley (map 4, B) and stands alone at the end ot the northern branch, just as *Geomys tuza* occupies the end of the eastern branch of the restricted genus *Geomys*. The skull is elongated and angular, the frontal compressed between the orbits, the palatopterygoids broadly lingulate, and the sagittal crest high; but the most important departure from its allies is found in the anterior part of the cranio-facial axis, and consists mainly in the broad articulation of the ascending wings of the palatine bones with the horizontal shelf of the orbitosphenoids, and in the presence of a fenestrum looking completely through the skull in front of the presphenoid. *G. bursarius* presents the extreme of differentiation occurring in the bisulcate series inhabiting the United States.

The following brief tabular statement of some of the cranial characters of the three members of the *tuza* group may facilitate the identification of specimens:

Differential cranial characters of the members of the tuza group.

	Mobilensis.	Tuza.	Floridanus.
Temporal impressions	United in a sagittal crest	Distant	Distant.
Frontal (interorbitally)	Very broad	Narrow	Narrow.
Ascending branches of premaxilla	Moderate	Moderate	Very broad and blunt.
Palatopterygoid	Narrow, sides parallel	Lingulate-cuneate	Lingulate cuneate.
Audital bullæ	Small	Small	Large.
Interparietal	Deeply notched posteriorly	Not notched	Not notched.

KEY TO SPECIES AND SUBSPECIES OF GEOMYS BY CRANIAL AND DENTAL CHARACTERS.

[Based on skulls of adult males only.]

(1) JUGAL *equal to or shorter than basioccipital* (measured from condyle).
- a^1 *Sagittal crest present.*
  - b^1 Zygomata strongly angular (standing out at right angles); jugal broadly rounded anteriorly.
    - Size large; audital bullæ normal .... *personatus*
    - Size medium; audital bullæ short and swollen (almost subglobular). *fallax*
  - b^2 Zygomata rounded; jugal narrow anteriorly; size small .... *sagittalis*
- a^2 *Sagittal crest absent.*
  - Temporal ridges prominent; squamosal arm of zygoma ending in a knob .... *arenarius*
  - Temporal ridges not prominent; squamosal arm of zygoma not ending in a knob .... *texensis*

(2) JUGAL *longer than basioccipital* (measured from condyle).
- c^1 *Sagittal crest strongly developed*—long and high; size largest ...... *bursarius*
- c^2 *Sagittal crest feebly developed or absent;* size medium or small.
  - d^1 Nasal bones hour-glass shaped; strongly constricted near middle.
    - e^1 Temporal impressions uniting in sagittal crest .... *mobilensis*
    - e^2 Temporal impressions not uniting in sagittal crest.
      - Audital bullæ small; not swollen; nasals broad posteriorly..... *tuza*
      - Audital bullæ large, swollen; nasals narrow posteriorly ... *floridanus*
  - d^2 Nasal bones not hour-glassed shaped; slightly or not constricted near middle.
    - f^1 Frontal strongly depressed interorbitally; zygomata broadly rounded; nasals very narrow posteriorly, notched behind. *breviceps*
    - f^2 Frontal slightly or not depressed; zygomata angular, strongly divergent anteriorly.
      - Temporal ridges prominent, divergent anteriorly; nasals abruptly narrow and convex posteriorly.......... *attwateri*
      - No temporal ridges; temporal impressions parallel or meeting in sagittal ridge; nasals truncate or emarginate posteriorly.......... *lutescens*

GEOMYS TUZA (Ord).

(Frontispiece and pl. 7, fig. 1; pl. 13, fig. 9; pl. 15, fig. 12.)

Mus tuza Ord, Guthrie's Geog., 2d Am. ed., II, 1815, 292 (based on Mitchill's "undescribed little quadruped of Georgia"—see *postea*).

Geomys pinetis Rafinesque, Am. Monthly Magazine, vol. II, No. 1, Nov., 1817, 45 (type of genus *Geomys*).

Undescribed little quadruped of Georgia, Mitchill, New York Medical Repository, V, 1802, 89. (Descr. orig. on which the name *Mus tuza* of Ord was based.)

Hamster of Georgia, Anderson, 2d Am. from 8th London ed. of Bewick's Hist. of Quadrupeds, 1848,* 326 (accompanied by figure with cheek pouches properly turned in).

Type locality.—Pine barrens near AUGUSTA, GEORGIA.†

Geographic distribution.—Pine barrens of Georgia (and probably northern Florida also), within the Austroriparian faunal area (map 4).

General characters.—Size medium or rather large; tail long and naked; feet moderately well haired; a small naked pad on end of nose.

Color.—Upper parts cinnamon brown, strongly tinged with fulvous in fresh pelage; only a faint trace of darker median dorsal stripe; under parts dull ochraceous buff; hairs of feet whitish.

Cranial characters.—Skull rather large and angular (Pl. 7, fig. 1), its upper surface convex in profile (due in part to the strongly decurved rostrum and in part to the absence of sagittal crest); zygomata divergent anteriorly, the maxillary root sloping strongly backward; temporal impressions never uniting in a sagittal ridge, but forming permanent temporal ribs, which in the males are elevated on both sides and separated by an interspace or sagittal area 3 to 4 mm. in width. In the females the interspace is broader and usually thickened so that it is flush with the top of the temporal impressions. Interparietal very large and broad. The frontal is narrow interorbitally; postorbital prominences marked; palatopterygoids lingulate-cuneate, the base slightly or not excavated on outer side; audital bullæ small, normal; basioccipital strongly wedge-shaped, truncate anteriorly.

Skulls of *G. tuza* may be distinguished from those of *mobilensis* by the presence of distant temporal ridges instead of a sagittal crest; by the narrow frontal (interorbitally); by the lingulate-cuneate (instead of narrow strap-shaped) palatopterygoids, and by the very large interparietal which is not notched behind (fig. 6 *e*). Skulls of *tuza* differ from those of *floridanus* in much narrower ascending branches of premaxilla, broader nasals posteriorly, more strongly wedge-shaped basioccipital, and much smaller audital bullæ. The relationship with *floridanus* is much closer than with *mobilensis*. The profile of the top of the skull is more convex than in either of the others.

Measurements.—*Average* of ten males from type locality (Hollywood, Georgia, 12 miles south of Augusta): Total length, 269; tail vertebræ, 89.5; hind foot, 34.4.

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* The copy cited by Coues (Monographs of N. Am. Rodentia, 1877, 615 footnote) has the same pagination, but a somewhat different title page (different publisher) and is not dated. The eighth London edition of Bewick was published in 1824. The only mammals described in the American reprint not in the original are the grizzly bear, hamster of Georgia, and mammoth.

†The type specimen was sent Dr. Mitchill from Augusta, Ga., in July, 1801, by Josiah Meigs, president of the University of Georgia. In the letter that accompanied the specimen Mr. Meigs said: "For the space of about 100 miles, between Savannah and Augusta, the land on each side of the road is almost covered by the heaps of loose earth raised by it."—New York Medical Repository, V, 1802, 89.

Average of nine females from same place: Total length, 249; tail vertebræ, 82; hind foot, 32.

For cranial measurements see Table C, p. 208.

Specimens examined.—Total number 32: twenty from type locality, Hollywood, 12 miles south of Augusta, Georgia; and twelve from Butler, Georgia, (latter not typical).

General remarks.—Specimens from Butler, near the western border of Georgia, are intermediate between *tuza* and *mobilensis.* In color they resemble the latter, while in cranial characters they are nearer the former.

It is an interesting fact that the first description of this species—and not a bad description either, considering it was written nearly a century ago—was from the pen of a member of Congress, the Hon. John Milledge, Representative from Georgia. It was published by Dr. Mitchill in the New York Medical Repository in 1802 (vol. v, p. 89), and runs as follows: "One of the little animals that burrows in the pine land, only known in Georgia, was caught by Mr. Stephen Pierce, living midway between Savannah and Augusta. Its body is of the length and thickness of a common-sized rat, and of the same color: the head between that of a rat and a mole, with small whiskers and short snout: the tail without hair, but shorter than that of a rat: the fore feet like those of a mole, with nails near an inch long: the hind feet like those of a rat, but the nails not of the same length, each foot having five claws: very sparkling small eyes: also short ears: teeth like a squirrel, and full as long. On both sides of the jaw, externally, are sacks or wallets, where it deposits its food, and each will contain as much as can be put in a large tablespoon. Little or no fur, and the hair of the length of a wood rat. The whole face of the pine country is covered with little mounds made by this animal, of the circumference of a peck, and from 6 to 8 inches high. It is by no means active, but remarkably fierce. No common wooden place of confinement can hold it long, as it gnaws its way out. It lives entirely on roots, and is very fond of the sweet potato, and often proves injurious to the planter by getting under his stacks. It appears to move nearer the surface in the spring and fall than at any other season. It is surprising, that though the work of this creature is seen throughout the country, in the region of the long-leaf pine, and in that region only, yet such is its skill in burrowing, and acuteness of hearing, that there is no animal in all our State so seldom caught or seen."

GEOMYS TUZA FLORIDANUS (Aud. and Bach.).

(Pl. 7, figs. 3 and 4; Pl. 10, fig. 1; Pl. 14, fig. 16.)

Pseudostoma floridana Aud. and Bach., Quadrupeds of North Am., Vol. III, 1854, 242–245.

Geomys tuza Goode (not Ord), Powell's Report Colorado River, 1875, 281–285 (habits).

Type locality.—St. Augustine, Florida.*

*Audubon and Bachman did not discriminate between the Georgia and Florida animals, but all of their Florida specimens came from St. Augustine.

General characters.—Similar to *G. tuza*, but much darker in color; fore feet larger; tail slightly more hairy; differs also in cranial characters.

Color.—Upper parts dull sooty-plumbeous, becoming cinnamon-drab on the sides; under parts plumbeous, more or less washed with buffy; an irregular white patch under chin and throat.

Cranial characters.—Skull long, with very angular zygomatic arches, much as in *tuza* and *mobilensis*. *G. floridanus* differs from *G. tuza* in broader and blunter ascending branches of premaxilla, narrower nasals posteriorly, somewhat broader jugals anteriorly, more rectangular (less strongly wedge-shaped) basioccipital, and much larger audital bullæ; from *mobilensis* in much larger audital bullæ, narrower frontal, less spreading and more depressed arches, much broader ascending branches of premaxilla, less flattened brain case, lingulate-cuneate instead of narrow palatopterygoids, and in the presence of temporal ridges instead of a sagittal ridge. The angular process of the mandible is much less deeply notched at base anteriorly. In *G. floridanus* the interspace between the two grooves of the upper incisor is broader than in either *tuza* or *mobilensis*, and the head of the jugal is more deeply mortised into the maxillary arm of the zygoma.

Specimens examined.—Total number 25, from the following localities in Florida: Chattahoochee, 2; Pomona, 4; Gainesville, 1; San Mateo, 6; Tarpon Springs, 12.

Measurements.—Average of three males from San Mateo, Florida (measured in flesh by Dr. W. L. Ralph): Total length, 288; tail vertebræ, 94; hind foot, 35.5. Average of three females from same locality: Total length, 235; tail vertebræ, 77; hind foot, 33. For cranial measurements see Table C, p. 208.

General remarks.—The foregoing description has been drawn up from specimens from San Mateo, Putnam County, Florida,* only 25 miles from St. Augustine, the type locality of the species. Specimens from further south on the peninsula are somewhat different.

The best and almost the only authentic account of the habits of this species is from the pen of the eminent director of the U. S. National Museum, Dr. G. Brown Goode, by whom it was contributed to Coues' monographic paper on the group, published in 1875.† Dr. Goode kept a number in confinement for several weeks and was thus enabled to make the following interesting observations on their habits. He says: "They may easily be confined in a wooden box, with sides 8 or 10 inches high, having dry sand 2 or 3 inches deep on the bottom. No cover is necessary; I have never seen one look up from the earth, and have

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*These specimens were kindly presented to me by Dr. W. L. Ralph, of Utica, New York, who collected them himself and measured them in the flesh.

†Abstract of results of a study of the genera *Geomys* and *Thomomys*. Powell's Expl. Colorado River, 4°, 1875, 215–285. Addendum B.—Notes on the "Salamander" of Florida, by G. Brown Goode, 281–285.

rarely known them to attempt to escape. They require no water, and no food except sweet potatoes. A single potato of moderate size will feed a salamander for three days.

"The senses of sight and hearing seem in them to be very dull. An object may be held within a short distance of their eyes without attracting their attention; but the moment one is touched, he turns with a jump, snapping fiercely, much to the detriment of fingers which may be near. If two are confined in the same cage, the one does not seem aware of the presence of the other, unless they accidentally come in contact. Their eyes are small, dull, and without expression. Their sense of smell I judge to be very delicate, from the manner in which they approach the hills of potatoes. Their motions are surprisingly quick and energetic, their activity never ceasing from morning to night.

"They are very pugnacious, and a rough-and-tumble combat between two vigorous males would seem terrific, if their size could be magnified a few diameters in the eye of the spectator. Every muscle of their compact, elastic, stout bodies is brought into action, and they plunge and bite with wonderful ferocity. A battle is usually followed by the death of one or both. I have examined them after death and found the whole anterior part of the body bruised almost to the consistency of paste, the bones of the legs crushed in four or five places. When two come together in the cage, their salutation is a plunge and a bite.

"I watched their burrowing with much interest. They dig by grubbing with the nose and a rapid shoveling with the long curved fore paws, assisted by the pushing of the hind feet, which remove the dirt from beneath the body and propel it back with great power a distance of 8 or 10 inches. When a small quantity of earth has accumulated in the rear of the miner, around he whirls with a vigorous flirt of the tail and joining fore paws before his nose, he transmutes himself into a sort of wheelbarrow, pushing the dirt before him to a convenient distance, and repeating the act until the accumulation is removed, then resuming his mining. Any root or twig which blocks his way is quickly divided by his sharp chisel-teeth. * * * The direction of the burrows may easily be traced by the loose hillocks of white sand which are thrown up along the line at intervals of 3 or 4 feet. These are the 'dumps' made by the burrower in throwing out his refuse accumulations. Each consist of about a peck of loose sand, and, by the casual observer, might easily be mistaken for an ant-hill. No opening is visible, but by digging under the hill a hole is found, the mouth of the adit to the main tunnel, which may be 3 feet below the surface if made in cold weather, but perhaps not more than 6 inches if in summer. One of the mounds is thrown up in a very few moments. I have seen 30 raised in a single night on the line of one tunnel; this would represent nearly 100 feet of tunneling. I have seen 150 in one continuous row raised in about two days; this would make between 400 and 500 feet of burrow completed in that short time, apparently by one little animal, an amount of work which may seem incredible to one who has not watched the restless movements of these animated plows, which are seemingly as well adapted for piercing the sand as birds are for cleaving the air. The burrows are about 2½ inches in diameter. * * * The nests are large chambers, 1 or 2 feet from the main tunnel, with which they are connected by side passages, which leave nearly at right angles. Here the miners lay up a supply of provisions and the chambers are often found to contain a half bushel of sweet potatoes cut up into chunks as large as peach stones, and of convenient size to be carried in the pockets. * * * In these side chambers the salamanders rear their young, building a nest of grass, pine needles, and live-oak leaves. I found them breeding in April."

Dr. Goode remarks that the name 'salamander,' by which the species is universally known in the South, "may allude to the safety enjoyed by these little animals in their subterranean abodes at the time of the devastating fires which sometimes consume the pine forests. After such a conflagration has passed over their heads, destroying every other kind of life, they are seen at work among the ashes, very good types of the salamander of fable."

Mr. Morris M. Green, who obtained specimens for the Division at Pomona, Putnam County, Florida, in June, 1889, furnished the following notes respecting their habits: "The hills of the 'salamander,' as the Florida *Geomys* is called, are abundant in the pine woods and clearings, on rather low and moist land. Their tunnels were from 4 to 24 inches below the surface; the hills were thrown up at intervals of from 2 to 6 feet, and contained about a peck of dirt each. The night and early morning seemed to be their favorite time for working. It is very easy to trap a 'salamander' when fresh mounds are found. By sweeping to one side the heaps of dirt, traces of the hole through which the earth was brought and its direction can be easily found. A minute's work with the spade will usually expose the tunnel lying to one side of the hill. Place a steel trap in the tunnel, and cover up the breach with a piece of pine bark or some palmetto 'fans.' If the breach is left open, the animals will carry dirt to shut out the light, and thus clog the trap, whereas if the opening is closed they will step in the trap and are caught. A break is often repaired within half an hour, or it may be left for nearly a day. In mending an opening it is astonishing how compactly the earth is packed; in one case an animal closed an opening so securely that the tunnel could not be found at all until another shaft was sunk in search of it.

"A 'salamander' caught in a trap is a picture of fury and spite, biting at everything within reach of its jaws, and sometimes breaking its front teeth in venting its rage on a trap.

"In the cheek pouches of one were some pieces of pine roots, and some grasses were found in the tunnels. The animals do serious injury to orange and pear trees by gnawing the roots. Sometimes the roots are gnawed off so completely that the tree can be pushed over with one hand. They also feed on sweet potatoes. But when an animal enters a garden or an orchard, and betrays itself by throwing up hills, there is no excuse for not ridding the place of it, as it may be easily caught in a steel trap. It is claimed that the 'salamander' works near the surface from September to March, retiring deeper in the ground during the hot season."

GEOMYS TUZA MOBILENSIS subsp. nov.

(Pl. 7, figs. 2, 5, and 6; pl. 10, fig. 2; pl. 14, fig. 15; text fig. 6, *f* and *g*.)

Type from MOBILE BAY, ALABAMA. No. $\frac{33988}{46023}$ ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected April 26, 1892, by Russell J. Thompson. (Original No. 50.)

Geographic distribution.—Southern Alabama and adjacent part of northwest Florida, within the Austroriparian zone (map 4).

General characters.—Similar to *G. tuza*, but somewhat smaller, and much darker in color; tail shorter, nearly naked; feet scant haired.

Color.—Upper parts dark, generally sepia or bistre, washed on sides of face and body with golden brown or ochraceous, intimately mixed with black-tipped hairs; top of head, between eyes and including ears, dusky, with an ill-defined dorsal band of the same color. Under parts dark plumbeous, faintly washed with dull pale fulvous. Hairs of feet whitish. More or less white about throat and pouches.

Cranial characters.—Skull very long and angular (pl. 7, fig. 2); frontal broad and high; top of skull in profile strongly convex; zygomatic arches broadly spreading, divergent anteriorly, and angular; brain case broad and flat; palatopterygoids narrow, their sides parallel; temporal impressions in adult males meeting in a low but well-developed sagittal ridge; interparietal deeply excavated posteriorly (trousers-shaped), reduced in advanced age by meeting of temporal ridges (fig. 6, *f* and *g*). *G. mobilensis* differs from *G. tuza* in the great breadth of the frontal interorbitally; the narrow palatopterygoids; the presence of a sagittal ridge in adult males, and the very different shape of the interpariteal (fig. 6). It differs from *floridanus* in much smaller audital bullæ, broader frontal, lower and more depressed brain case, more divergent zygomatic arches, narrower ascending branches of premaxilla and much narrower palatopterygoids. *G. mobilensis* differs from *G. breviceps*, its nearest neighbor on the west, in general form of the skull and in numerous details: in profile the top of the skull is strongly convex instead of concave; the zygomatic arches are more angular and more divergent anteriorly; the frontal is much broader interorbitally; the brain case flatter; the nasal bones broader and constricted in front of the middle; the angular process of the mandible deeply notched anteriorly.

Measurements (taken in flesh).—*Type* specimen: Total length, 260; tail vertebræ, 82; hind foot, 33.

Average of four males from type locality: Total length, 250; tail vertebræ 81; hind foot, 33.5.

Average of four females from same place: Total length, 229; tail vertebræ, 76; hind foot, 30.5.

For cranial measurements see Table C, p. 208.

Specimens examined.—Total number 23: 9 from Point Clear, Mobile Bay, Alabama, 2 from Brewton, Alabama, and 12 from Milton, Florida.

General remarks.—*Geomys mobilensis* is an inhabitant of the lowlands bordering the Gulf of Mexico east of Mobile Bay. How far its range extends to the east and north has not been ascertained. In size and coloration it seems to bear the same relation to its neighbor (*G. tuza*) of the adjacent pine barrens of Georgia that *G. breviceps* of the lowlands of Louisiana and Texas bears to its relative of the higher and drier ground further west (*G. lutescens*).

It seems a pity that such a strikingly marked animal as *mobilensis* must stand as a subspecies, but there is no reasonable doubt of its complete intergradation with *tuza* in western Georgia.

GEOMYS BURSARIUS (Shaw).

(Pl. 1; pl. 9, figs. 8 and 9; pl. 10, fig. 6; pl. 13, fig. 11; pl. 14, fig. 2; pl. 15, fig. 11; pl. 17, fig. 3; pl. 18, fig. 1; pl. 19, fig. 3; text fig. 55.)

Mus bursarius Shaw, Trans. Linnean Soc., v. 1800, 227-228, pl. 8; Genl. Zoology, Mammalia, Vol. II, pt. 1., 1801, 100-101, pl. 138.

? *Mus ludovicianus* Ord. Guthrie's Geography, 2d Am. ed., 1815, 292 (*Nomen nudum*).

Diplostoma fusca Rafinesque, Am. Monthly Magazine, Vol. II, No. I, Nov. 1817, 45.

Geomys cinerea Rafinesque, Am. Monthly Magazine, Vol. II, 1817, 45. (*Mus bursarius* renamed.)

Saccophorus bursarius Kuhl, Beiträge zur. Zool., 1820, 65.

Mus saccatus Mitchill, New York Medical Repository, Vol. VI, n. s., 1821, 249. (Type from Lake Superior, probably Minnesota.)

Pseudostoma bursarius Say, Long's Expd. to Rocky Mts., I, 1823, 406.

Ascomys canadensis Licht., Abh. Akad. Wiss. Berlin (1822), 1825, 20, fig. 2.

Geomys? bursarius Richardson, Fauna Boreali-Americana, I, 1859, 203.

Geomys canadensis LeConte, Proc. Acad. Nat. Sci., Phila., VI, 1852, 158.

Geomys oregonensis LeConte, Proc. Acad. Nat. Sci., Phila., VI, 1852, 160. (Locality erroneous.)

Type locality.—Unknown; somewhere in Upper Mississippi Valley.

Geographic distribution.—Upper Mississippi Valley from a short distance south of the Canadian boundary, in longitude 97° (Warren, Minnesota, and Grand Forks, North Dakota), southward to eastern Kansas (Neosho Falls), southeastern Missouri (Williamsville and Hunter), and southern Illinois (Belleville); east nearly to Lake Michigan (Winnebago and Fond du Lac, Wisconsin, and Cook County, Illinois); west in the Dakotas and Nebraska to the ninety-eighth or ninety-ninth meridian (Valley City and Hamlin, North Dakota; Burch, Mitchel, and Scotland, South Dakota; Niobrara, Ericson, and Kearney, Nebraska). The species belongs to the Upper Sonoran and Transition zones. See map 4, B.

General characters.—Size large; coloration dark; tail medium or rather long, scant haired, the terminal half nearly naked.

Color.—Dark liver brown or chestnut above and below, somewhat paler on the belly (belly very rarely whitish); fore feet white; hind feet soiled white; hairs of tail usually brown on basal part and white on terminal part.

Cranial characters.—Skull long, large, and angular (pl. 1); zygomata spreading, widely divergent anteriorly, angular; a well-developed sagittal crest; rostrum long and narrow for size of skull; frontal narrow and rounded interorbitally; palatopterygoids broadly lingulate, tapering posteriorly, not notched at base on outer side (pl. 14, fig. 2). The skull of *G. bursarius* does not require close comparison with any other species, though the young and females are sometimes difficult to distinguish from *lutescens*. The skull of the female differs from that of the male in much smaller size, shorter rostrum, broader interorbital region, fuller brain case, in the absence of distinct sagittal and lambdoidal crests, and in the less development of processes and ridges for muscular attachment. Skulls of *G. bursarius* differ from those of *lutescens* chiefly in greater length and angularity, the ratio of zygomatic breadth to basilar lenth of Hensel rarely exceeding 73 percent in adults; while in *lutescens* this ratio runs from 75 to 79. The brain case is higher posteriorly and the sagittal crest is much more highly developed. *G. bursarius* (in common with *lutescens*) differs from *personatus* notably in the angle of the anterior part of the zygomatic arch and in the length of the jugal. In both *bursarius* and *lutescens*, even in old age, the anterior root of the zygoma slopes back at a considerable angle; in *personatus* it stands out at nearly a right angle. In *bursarius* and *lutescens* the jugal is much longer than the basioccipital; in *personatus* it only equals the basioccipital.

Dental characters.—Face of upper incisors strongly bisulcate; small sulcus fine and close to inner edge of tooth; principal sulcus much larger and on or slightly external to median line; enamel face rounded externally and between sulci (fig. 22^2, and pl. 15, fig. 11). Molariform teeth much smaller than in the other sections of the genus; crown of last upper molar suborbicular, without heel.

Upper molariform series.—The upper premolar curves and slopes strongly forward and is concave anteriorly; the last molar curves strongly backward and is concave posteriorly. The intermediate molars curve both backward and outward; the first only slightly backward, the second strongly; both are concave externally; their roots divaricate, the first sloping forward, the second backward. (A second and greater point of divergence is between the premolar and first molar.) The premolar is nearly one-third longer than the last molar. The intermediate teeth are about as long as the premolar—sometimes longer.

Lower molariform series.—All the teeth are short compared with those of the upper series; premolar longest, largest, heaviest, and curves strongly forward; last molar smallest, shortest, and curves strongly backward; the intermediate teeth intermediate in length. Premolar strongly concave anteriorly and nearly as concave outward; m_1 slightly concave anteriorly, strongly concave outward, and somewhat twisted on its axis; m_2 strongly concave outward and faintly anteriorly, with a slight twist; m_3 strongly concave posteriorly and moderately so outwardly.

Average measurements of 26 specimens of both sexes from eastern North Dakota (measured by J. Alden Loring): Total, 270; tail vertebræ 80; hind foot, 35. Average of 6 males from same localities: Total, 296; tail vertebræ, 90; hind foot, 37. Average of 10 females: Total, 265; tail vertebræ, 78; hind foot, 34. Average total length of 20 males and 20 females from Elk River, Minnesota, measured in flesh by Vernon Bailey: Males, 284; females, 243. In both cases many of the specimens are not full grown, hence the measurements are toc small. Unfortunately no satisfactory series of measurements is available.*

For cranial measurements see Table A, p. 204.

General remarks.—Geomys bursarius is a well-marked species, easily distinguishable by color alone from all the other bisulcate forms. It is also the largest species inhabiting the United States, although varying considerably in size in different localities. The largest form inhabits the region about Knoxville, Iowa, where the males average a foot in length.

Geomys bursarius is of much greater economic consequence than all the other species combined, for the reason that its home is in the fertile prairie region of the Mississippi Valley from central Missouri northward, covering the whole State of Iowa, nearly the whole of Illinois, and the richest and most densely populated agricultural lands of eastern Kansas, eastern Nebraska, eastern South and North Dakota, Minnesota, and southern Wisconsin.

Specimens examined.—Total number 116, from the following localities: North Dakota: Portland, 18; Erie, 3; Casselton, 2; Buffalo, 2; Valley City, 3.

*Dr. C. E. McChesney, U. S. Army, in a paper on the Mammals of Fort Sisseton, Dakota, has recorded a valuable series of measurements of this species, all taken at that locality. While his measurements are not strictly commensurate with ours, and while many of his specimens were not full grown, his means are important, particularly as showing the average sexual difference. Reduced to millimeters his most important means are:

Mean of—	Head and body	Tail vertebræ.	Hind foot.
Thirty-three males, Fort Sisseton, South Dakota	214	79	35
Thirty-five females, Fort Sisseton, South Dakota	182	72.5	32
Sixty-eight specimens, both sexes	198	76	33

(Bull. U. S. Geol. and Geog. Survey, Terr. IV, No. 1, Feb., 1878, p. 213.)

South Dakota: Flandreau, 1; Fort Sisseton, 1; Travare, 2; Scotland, 1.

Minnesota: Ortonville, 2; Browns Valley, 1; Elk River, 39.

Iowa: Council Bluffs, 1; Knoxville, 16.

Nebraska: Niobrara, 3; Verdigris, 1; Columbus, 1; Ames, 1; Blair, 1; Norfolk, 2.

Kansas: Onaga, 3.

Missouri: Hunter, Carter County, 4; Williamsville, Wayne County, 8.

EARLY HISTORY OF GEOMYS BURSARIUS.

The early history of this gopher is somewhat obscure. It was originally described by Shaw in the year 1800 and was named *Mus bursarius.** The description is very brief and is as follows: "Ash-coloured rat, with short round nearly naked tail, pouched cheeks, and the claws of the forefeet very large, formed for burrowing in the ground." Shaw states further: "This quadruped was taken by some Indian hunters in the upper parts of interior Canada, and sent down to Quebec. It is now in the possession of Governor Prescot." The description is accompanied by a full-size engraving of the animal, with cheek pouches turned inside out and distended. The skin evidently was greatly overstuffed. No grooves are shown on the upper incisors.

The next year (1801) Shaw redescribed the same specimen as follows: "It is about the size of a brown or Norway rat, and is of a pale greyish-brown colour, rather lighter beneath; the length to the tail is about 9 inches, and that of the tail, which is but slightly covered with hair, about 2 inches: the legs are short; the fore feet strong, and well adapted for burrowing in the ground, having five claws, of which the three middle ones are very large and long; the interior much smaller, and the exterior very small, with a large tubercle or elbow beneath it. The claws on the hind feet are comparatively very small, but the two middle are larger than the rest, and the interior one is scarce visible: the teeth are extremely strong, particularly the lower pair, which are much longer than the upper: the ears are very small." (General Zoology, vol. II, part 1, Mammalia, 1801, pp. 100–101.) He gave a new engraving of the animal, stating that in the figure previously published (in the Transactions of the Linnean Society) "the claws on the fore feet are represented as only three in number, and are somewhat too long, weak, and curved. The engraving in the present plate is a more faithful representation, and is accompanied by an outline of the head, in its natural size, as viewed in front, in order to shew the teeth and cheek-pouches." This plate contains three figures: a side view, as in the earlier engraving; a front view, reduced, and a natural-size front view in outline. The cheek pouches are everted, as before, protruding from

*Transactions of the Linnean Society, London, vol. v, 1800, pp. 227–228; description read before the society June 4, 1799.

the sides of the face as great bursæ. Although the teeth are distinctly shown in these engravings, no trace of a groove is apparent, unless an incomplete dotted line near the middle of each upper incisor in the outline figure was intended to indicate it. The size of the incisors in this figure agrees exactly with the size of these teeth in specimens of *Thomomys talpoides* from Manitoba, and the size and shape of the fore feet and claws are as in *Thomomys*, thus differing widely from the same parts in *Geomys*, in which the teeth and claws are very much larger and heavier.

The color of the body (which he describes as "pale greyish-brown, rather lighter beneath"), the size and shape of the forefeet and claws, the size of the incisors, the absence of the deep median furrow so conspicuous in *Geomys* (which could hardly have been overlooked both in the description and figure), together with the statement that the animal came from the interior of Canada, all indicate that the species now known as *Thomomys talpoides* was the animal Shaw had before him.

The only point mentioned by Shaw in either of his descriptions of the type specimen of '*Mus bursarius*' that does not apply strictly to *Thomomys*, to the exclusion of *Geomys*, is the length of the animal, which he gives as 9 inches. This is easily explained on turning to the figure, which shows the specimen to be greatly overstuffed—a common error in taxidermy resulting from the exceedingly loose and distensible skins of these animals, which are nearly always stretched in taking off from the body.

Recapitulating, Shaw's description and figures seem to establish the following points:

(1) The type specimen of *Mus bursarius* came from the "upper parts of interior Canada," the home of *Thomomys*. No member of the genus *Geomys* reaches Canada, its northernmost known point being Warren, Minnesota.

(2) The type specimen of *Mus bursarius* was "ash coloured" or "pale greyish-brown, rather lighter beneath," exactly as in *Thomomys*. The color of the only species of *Geomys* inhabiting the Upper Mississippi Valley is dark chestnut or liver-brown, both above and below.

(3) The detailed description given by Shaw in his General Zoology makes no mention of grooves in the incisors, though these teeth are described with particularity. In *Geomys* the upper incisors are deeply furrowed; in *Thomomys* they are plane.

(4) Not one of the four figures of the type specimen of *Mus bursarius* published by Shaw shows any trace of the grooved incisors of *Geomys*, and two of these figures are front views, one natural size.

(5) The size of the teeth, fore feet, and claws in Shaw's natural-size figure agree with these parts in Manitoba specimens of *Thomomys* and are very much smaller than in *Geomys*.

From the above facts it would appear that the animal described by Shaw under the name *Mus bursarius* is the gray pocket gopher of Manitoba and the Dakotas (*Thomomys talpoides* of recent authors) and not the red pocket gopher of the Mississippi Valley (*Geomys bursarius* of recent authors). This view would necessitate a slight change in nomenclature: *Thomomys talpoides* Auct. would become *Thomomys bursarius* (Shaw), and *Geomys bursarius* Auct. would become either *Geomys fuscus* (Rafinesque) 1817, or *Geomys saccatus* (Mitchill) 1821.* Fortunately no change in the generic name would be required, since Rafinesque based his genus *Geomys* on *G. pinetis* [= *G. tuza*] of the pine barrens of Georgia.

Clear as the case seems to have been left by Shaw, it became shrouded in obscurity by the writings of subsequent authors.

In 1820 Heinrich Kuhl published his Beiträge zur Zoologie, in which he described the genus *Saccophorus*, basing it on the *Mus bursarius* of Shaw. He states that the specimen examined by him was formerly in Bullock's Museum, but then in Paris ("in Museo Bullokiano, nunc Parisiensi," p. 65), but does not intimate that it was Shaw's specimen. In the diagnosis of the genus he states that the upper incisors have two sulci, of which the external is broader and deeper, thus describing the condition in typical *Geomys*.

Lichtenstein, in a paper written in 1822, but not published until 1825, says: "When I was in London in the summer of 1819 I saw in the Bullock collection the specimen described by Shaw" (Überäussere Backentaschen an Nagethieren, Abh. K. Akad. Wiss. Berlin [for 1822], 1825, 14–15). He then goes on to describe another specimen, assumed to belong to the same species, which he says he had recently received from North America.

The first positive statement I have been able to find to the effect that Shaw's specimen had grooved incisors was made by Richardson more than a quarter of a century after the publication of Shaw's last description. Richardson states that the engraving of Shaw's *Mus bursarius* published in the Linnean Transactions was drawn by Maj. Davies,† and that "the specimen figured by Major Davies, in the Linnean Transactions, was of a pale gray colour, and 9½ inches long from the nose to the root of the tail, which measured 2½ inches. The belly was paler than the back, and the cheek-pouches were covered with very short pale hairs. Its superior incisors were deeply grooved in the middle, and more faintly close to their inner margins" (*Ibid.*, 203). As to the final disposition of this specimen he says: "The identical specimen

* *Diplostoma fusca* Rafinesque, Am. Monthly Mag. II, 1817, 45, is little more than a *nomen nudum*, the only specific description being "entirely brown, length 12 inches." But the generic diagnosis, though full of errors, leaves no doubt as to the animal; and the locality assigned, "Missouri Territory," is sufficiently exact in connection with the size and color of the species. If, however, this name is not considered available, the next in point of date seems to be *Mus saccatus* Mitchill, Medical Repository, vol. VI, 1821, 248–250; type "from the region bordering on Lake Superior," doubtless Minnesota, where the animal is abundant. The bisulcate upper incisors are described in detail by Mitchill.

† Fauna Boreali-Americana, 1829, 199.

described by Shaw, * * * on the dispersion of Mr. Bullock's collection, passed into the hands of M. Temminck" (*Ibid.*, p. 199).

That this particular specimen is now in the Leiden Museum is certain, for it is mentioned by Dr. F. A. Jentink, the able director of the Rijks Museum, in his *Catalogue Systématique des Mammifères*, XII, 1888, p. 93. In response to a letter of inquiry, Dr. Jentink has had the kindness to write me as follows: "On the underside of the stand [of the specimen above mentioned] I see the following words written with pencil: 'Mus bursarius, Cabinet Bullock, Londres.' So you may be sure of the fact that this specimen truly has been bought from Bullock's auction. As to the animal itself and its identity with Shaw's description, you may judge if I tell you that it has the cheek pouches turned inside out and distended, but not in the extraordinary way as represented in Shaw's figure 138, vol. II, p. 1. The incisors are deeply grooved. Shaw's figure represents, without doubt, an overstuffed specimen; meanwhile our specimen seems to be in excellent proportions and very well-preserved condition. Length of the animal, 9.8 inches, measured from the upper lip along the dorsal line of the body; tail about 2.8 inches. The color of our specimen is a desert color, more reddish toward head and hinder parts of the body."

In 1857 Baird made the following statement, evidently based partly on the remarks of Richardson, already quoted, and partly on an erroneous translation of the statements of Kuhl and Lichtenstein. Baird says: "The same skin referred to by Shaw was subsequently investigated by Kuhl, and then by Lichtenstein. It was for a time in the celebrated museum of Mr. Bullock, of London, and is said to have been purchased by Temminck at the sale of this collection, and is doubtless now in the Leyden Museum." (Mammals of North America, 1857, 376.) But Kuhl does not say that his specimen was the same as Shaw's, and Lichtenstein distinctly states that the animal described by him was not Shaw's specimen (which he says he saw in London in 1819), but one that he "received a short time ago with other North American mammals."

If it is true that the specimen described by Kuhl is really the same as that described by Shaw twenty years earlier, and afterwards mentioned by Lichtenstein as having been seen by him in London in 1819, it would be certain that no other animal than the furrowed-toothed pocket gopher of the Upper Mississippi Valley (*Geomys*) could be meant. But unfortunately Kuhl says nothing on this point, and it must be admitted that the conspicuous discrepancies between his description and Shaw's are hard to reconcile on the assumption that they refer to the same specimen. Shaw says the body of his animal as stuffed measured 9 inches, and the tail 2 inches. Kuhl says the body measured 7½ inches, and tail 2⅓ inches. Shaw described his animal as "ash-coloured," and "pale greyish-brown," while Kuhl says that his inclined to rufous ("rufescens")—the proper color for *Geomys*.

Is it not possible that Richardson, in translating the Latin of Kuhl or the German of Lichtenstein, fell into the same error as Baird? At all events it should not be forgotten that Richardson wrote nearly thirty years later than Shaw—an interval sufficiently long to allow additional specimens to reach England and also to favor slips of memory. It should be further remembered not only that Lichtenstein had a specimen additional to that described by Shaw, but also (and much more important) that there appears to be no ground for the assumption that Kuhl's description was taken from Shaw's specimen; in fact the marked discrepancies between them seem to prove the contrary, as pointed out above.

Shaw's and Richardson's descriptions are utterly irreconcilable on the assumption that they refer to the same specimen, but would be perfectly intelligible if it can be shown that a second specimen found its way into the Bullock collection between the years 1800 and 1819.

The matter is still further complicated by Richardson himself, who, writing in 1831, says: "We lately received several specimens of the *Mus bursarius* of Shaw (which is a true *Geomys*, with pouches opening internally) from the banks of the Saskatchewan." (Zoology of Beechey's Voyage of the Blossom, 1839, 9.) This statement shows that Richardson's ideas respecting the status and distribution of the several members of the group were badly confused, for it is now well known (as before stated) that no species of *Geomys* reaches the plains of the Saskatchewan; indeed the genus has not been found to enter Canada at all. The use of the generic name *Geomys* by Richardson, however, has no significance, since he applied the name to *Thomomys* as well as *Geomys*, and it is certain that his Saskatchewan animal is *Thomomys talpoides* Auct. His identification of the species with *Mus bursarius* of Shaw would be in accord with my belief that Shaw's animal could have been no other than the common *Thomomys* of Manitoba and the northern plains generally, except for his previous statement, already quoted from Fauna Boreali-Americana, that the Bullock specimen had grooved incisors and was the identical specimen described by Shaw. These conflicting statements by the same author I am utterly unable to reconcile.

GEOMYS LUTESCENS Merriam.

(Pl. 9, figs. 5 and 7; pl. 14, fig. 14.)

Geomys bursarius lutescens Merriam, N. Am. Fauna, No. 4, Oct. 8, 1890, 51.

Type locality.—Sand hills on Birdwood Creek, Lincoln County, Western Nebraska. (Type in U. S. National Museum.)

Geographic distribution.—The Upper Sonoran belt of the Great Plains from southwestern South Dakota southward to Colorado, Texas, covering the sand-hill region of western Nebraska, extreme eastern Wyoming (between the North Platte and Cheyenne rivers) western Kansas, eastern Colorado, western Oklahoma, and western Texas, ranging east to or a little beyond the ninety-ninth meridian (map 4, C).

General characters.—Size medium or rather large; coloration pale; tail moderate; scant haired; skull short.

Color.—Upper parts in winter drab, liberally mixed with black-tipped hairs along the median line, forming a distinct dorsal band from end of nose to rump; in summer pale buffy-ochraceous or very pale dull fulvous without dorsal band. Under parts buffy, usually white in the young and sometimes white in adults. Along the eastern and southern limits of its range the upper parts are decidedly more fulvous than in the typical animal.

Cranial characters.—Skull intermediate in size between *breviceps* and *bursarius;* zygomata broadly and squarely spreading, strongly divergent anteriorly; nasals normally elongate wedge-shaped, as in *bursarius*, but sometimes broadening in posterior third; temporal impressions normally uniting, at least posteriorly, in a low sagittal ridge (pl. 9, fig. 7), but sometimes remaining apart, separated by an interspace 1 to 3 mm. broad (pl. 9, fig. 5) [this form is commonest in the southwestern part of the range of the species]; interparietal varying from subquadrate in the young to subtriangular in adults, its size decreasing with age and the posterior suture becoming obliterated by ankylosis with the supraoccipital; palatopterygoids usually lingulate and tapering posteriorly as in *bursarius*, but somewhat narrower and sometimes strap-shaped.

Skulls of *Geomys lutescens* differ from those of *G. bursarius* chiefly in smaller size, greater relative breadth and flatness (the brain case as well as the rostrum being considerably shorter than in true *bursarius* from the Mississippi Valley), and in lacking the high sagittal crest of *bursarius.* Old skulls of *lutescens* have strongly spreading zygomatic arches which are very much broader anteriorly than posteriorly, and as a rule the premaxilla extends a little further back than in *bursarius.*

Skulls of *lutescens* bear a strong resemblance to those of *breviceps*, from which they differ in having the frontal region less depressed; the zygomatic arches more squarely spreading and more decidedly angular anteriorly; the nasal bones broader posteriorly; the ascending branches of the premaxilla longer and less blountly rounded posteriorly; the temporal impressions normally meeting posteriorly in a low sagittal ridge instead of remaining distant; the occiput more truncate (less bulging) posteriorly; the rostrum normally broader.

The cranial characters that distinguish *lutescens* from *texensis, arenarius*, and *personatus* are mentioned under the heads of these species.

Measurements.—Average of 28 specimens of both sexes from western Nebraska: Total length, 256; tail vertebræ, 77; hind foot, 32. Average of 12 males: Total length, 270.5; tail vertebræ, 84; hind foot, 33.5. Average of 10 females: Total length, 246; tail vertebræ, 72; hind foot, 31.5.

For cranial measurements, see Table A, p. 204.

Specimens examined.—Total number of typical or nearly typical specimens 118, from the following localities:

South Dakota: Pine Ridge Agency, 2; Rosebud Agency, 3.

Nebraska: Chadron, 1; Kennedy, 13; Valentine, 3; Ewing, 2; Oakdale, 2; Crawford, 1; Snake River, Cherry County, 1; Clarks Canyon, Cherry County, 7; Dismal River, Thomas County, 1; Niobrara River, Sheridan County, 1; near North Platte, Lincoln County, 4; Birdwood Creek, 1; Myrtle, 3; Sidney, 1; Calloway. 4· Kearney, 1.

Wyoming: Lusk, 3; Uva, 1.

Colorado: Las Animas, 6; Denver, 1; Pueblo, 4; Limon, 3; Burlington, 1; Chivington, 6.

Kansas: Trego County, 3.

Oklahoma: Woodward, 3.

Texas: Canadian, 5; Tascosa, 4; Newlin, 3; Childress, 12; Vernon, 9; Colorado, 3.

Number of non-typical specimens 18, from the following localities:

Kansas: Garden Plain, 4; Belle Plain, 5; Cairo, 6; Kiowa, 2; Ellis, 1.

General remarks.—*Geomys lutescens* is a pallid species inhabiting the arid plains west of the ninety-ninth meridian. Its characters are very constant throughout most of its range, and if it intergrades with *bursarius* it must do so in the narrow strip between the ninety-eighth and ninety-ninth meridians. In southeastern Kansas an aberrant form exists that seems to be an intergrade between the three types, *bursarius*, *lutescens* and *breviceps*, but a larger series of specimens than at present available is needed to prove it. This animal is smaller than *lutescens*, nearly as dark above as *bursarius*, and paler below than either. Some specimens indeed have the belly pure white, as in *texensis*. Specimens of this apparently intermediate form (mostly immature) have been examined from Cairo, Kiowa, Garden Plain, and Belle Plain, Kansas.

Mr. Vernon Bailey states that in western Nebraska, where typical *lutescens* is abundant, the light sandy soil is probably improved by their diggings, but that they do considerable damage in grain fields and to young trees on the tree claims.

GEOMYS BREVICEPS Baird.

(Pl. 9, fig. 6.)

Geomys breviceps Baird, Proc. Acad. Nat. Sci. Phila., VII, April, 1855, 335.

Type locality.—PRAIRIE MER ROUGE, MOREHOUSE PARISH, LOUISIANA.

Geographic distribution.—The alluvial lowlands of the Mississippi Valley and Gulf coast in southern Arkansas, Louisiana, and Texas, and the valley of the Arkansas River; north nearly to southern Kansas, and west to near the ninety-eighth meridian, where it is replaced by *G. lutescens*. It is therefore a member of the Austroriparian fauna (map 4 D).

General characters.—Size small; color very dark both above and below; tail of medium length, its distal half nearly naked.

Color.—Upper parts dark russet-brown, darkest along the middle of the back (but no trace of dorsal band in Louisiana specimens); nose and front of face to above eyes dusky, more or less tinged with russet; sides washed with pale fulvous; belly dark plumbeous, more or less obscured by pale buffy-fulvous tips to the hairs; feet and throat white; hairs on base of tail dusky (remainder of tail practically naked). The color of the back is hard to describe, and the term used ('russet-brown') is intended only as roughly indicating the general effect. The individual hairs are dark plumbeous, with a narrow subapical zone of dark fulvous, tipped with sooty.

Cranial characters.—Skull similar to *G. lutescens* in general appearance but smaller; zygomata broadly spreading; frontal flat, depressed; nasals narrow, emarginate posteriorly, their sides nearly parallel for posterior two-thirds, abruptly divergent anteriorly; ascending branches of premaxilla broad and bluntly rounded posteriorly; interparietal small, very irregular, and much cut up with tortuous windings of the sutures as in true 'Wormian' bones; temporal impressions never uniting in a sagittal crest but permanently distant, the interspace elevated, forming a broad convex band (3 to 5 mm. in width) along the top of the skull posteriorly; jugal longer than basioccipital, bluntly rounded anteriorly; occiput bulging behind lambdoid suture, but not so far as in *texensis*; pterygoids narrow, tapering posteriorly.

Skulls of *breviceps* may be distinguished from those of *lutescens* by the following characters (pl. 9, fig. 6): Size smaller; nasals narrower, shorter, and strongly emarginate posteriorly; ascending branches of premaxilla normally shorter and more bluntly rounded posteriorly; temporal impressions persistent, distant, the bone thickened between them; interparietal 'Wormian'-like; zygomata more rounded; interorbital region more depressed. Nevertheless, the cranial resemblances are striking in view of the dissimilarity of the animals in size and external appearance. Moreover, skulls of *breviceps* from the western part of its range have broader nasals; and skulls of *lutescens* from adjacent territory have a narrow sagittal area (resulting from permanently distant temporal impressions). It is probable, therefore, that the two forms will be found to intergrade.

Skulls of *breviceps* differ from those of *texensis* in larger size, much more spreading zygomata; longer and very much narrower nasals; broader, flatter, and more depressed frontal interorbitally; much longer jugal; smaller and more irregular interparietal; less bulging occiput; broader and more bluntly rounded ends to ascending branches of premaxilla. Viewed in profile, the skull of *breviceps* is flat and somewhat depressed or concave between the orbits; that of *texensis* is normally convex.

Average measurements of 40 specimens of both sexes from type locality (Mer Rouge, Louisiana): Total length, 219; tail vertebræ, 64; hind foot, 27. Average of 15 males from same place: Total length, 231; tail vertebræ, 70; hind foot, 28. Average of 23 females from same place: Total length 212; tail vertebræ, 61; hind foot, 26.5.

For cranial measurements see Table A, p. 205.

General remarks.—The type form of *Geomys breviceps* inhabits northern Louisiana, east of the Red River, the exact type locality being Prairie Mer Rouge in Morehouse Parish, near the northern boundary of the State and only a short distance west of the Mississippi River. The species as a whole is an inhabitant of the dark alluvial soils of the lowlands bordering the Lower Mississippi and its tributaries and the Gulf coast of Texas, whence it spreads westward nearly or quite to the ninety-eighth meridian. To the southward it reaches Nueces Bay. On the west it probably intergrades with *texensis* and *lutescens*. On the north there seems to be a hiatus between its range and that of *bursarius*; but if pocket gophers are ever found in northern Arkansas, southwestern Missouri, southeastern Kansas, or northeastern Indian Territory, they are likely to prove intergrades.

Departures from the type.—Specimens from extreme points in the range of the species differ much from the type. Two of these forms are here named as subspecies (*G. breviceps sagittalis* and *G. breviceps attwateri*). Others are regarded as slightly aberrant forms not meriting recognition by name; others still as intergrades. The following, contained in the Department of Agriculture collection, seem worthy of mention:

(1) A large dark form inhabiting the valley of the Arkansas River. The skulls point toward intergradation with the interior animal. Specimens from Tulsa and Fort Gibson, Indian Territory, and Fort Smith, Arkansas, resemble *breviceps* in coloration, while those from Ponca Agency, Indian Territory, are redder, shading strongly toward *lutescens*.

(2) A form from the valley of the Red River of the South, along the boundary between Texas and Indian Territory (specimens from Gainesville, Tex., and from Indian Territory opposite Arthur, Tex.). A small reddish form resembling *breviceps* externally, but with dark belly and a short tail. The skulls are more like *texensis* in general form (full brain case and narrow zygomata), and in the shortness and breadth of the nasals; but the ascending arms of the premaxilla are even shorter and more bluntly rounded posteriorly than in *breviceps*. The frontal and interparietal are intermediate between the two.* Regarded as an intergrade.

(3) A form from Shreveport, Louisiana. Much redder than true *breviceps*, resembling *texensis* in coloration of upper parts, but with dark belly. The skull differs from typical *breviceps* in more angular zygomata, broader nasals, and less depressed frontal. Regarded as a slight local departure from *breviceps*.

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* Skull No. 47590 ♂ ad. from Gainesville, Texas, is an excellent example of this form.

(4) A form from Galveston Bay, Texas (specimens from Clear Creek and Arcadia). A small, dark, highly-colored form with the head nearly black, and the throat and fore feet usually wholly or partly white, in sharp contrast with the dark of the surrounding parts. The skull differs from that of typical *breviceps* in smaller size, and in having shorter and broader nasals. Regarded as a subspecies and described under the name *sagittalis*. (Pl. 9, fig. 4.)

(5) A form from the coastal plane of Texas (specimens from Brenham, Milano, Hearne, Marquez, and Palestine.) Usually has a well-marked dark dorsal band, and the skulls differ from typical *breviceps* in having shorter and broader nasals. Skulls of old males from these localities are unusually short and have broadly spreading zygomata. The nasals are very broad posteriorly in comparison with true *breviceps*. Regarded as an aberrant form, perhaps shading toward *texensis* on one side and toward *attwateri* and *sagittalis* on the other.

(6) A form from the extreme southern limit of the range of the species on and near the Gulf coast of Texas. (Specimens from Rockport, Aransas County; Tallys Island, Aransas County, and near San Antonio.) A large dark form with a dark dorsal band in some pelages, and peculiar cranial characters: angular and strongly divergent zygomata, very broad ascending arms of premaxilla, and so on. Regarded as a subspecies, and described under the name *attwateri* (pl. 9, fig. 3).

Specimens examined.—Total number, 274, from the following localities:

Typical or nearly typical.—Mer Rouge, Morehouse Parish, Louisiana (type locality), 42; Pineville, Rapides Parish, Louisiana, 2; Provencal, Natchitoches Parish, Louisiana, 4; Shreveport, Caddo Parish, Louisiana, 8; Camden, Ouachita County, Arkansas, 1; Benton, Arkansas, 7; Fort Smith, Arkansas, 7; Fort Gibson, Indian Territory, 16; Tulsa, Indian Territory, 2.

Not typical.—Gainesville, Cook County, Texas, 5; Decatur, Texas, 1; Indian Territory, near mouth of Boggy River (opposite Arthur, Texas), 4; Ponca Agency, Oklahoma, 6; Oklahoma City, Oklahoma, 3. The following, all from Texas: Longview, 4; Mineola, 14; Terrell, 7; Troup, 1; Palestine, 5; Marquez, 5; Hearne, 9; Milano, 12; Brenham, 7; Victoria, 1; Inez, 3; Navidad River, 1; Houston, 9; Matagorda Bay, 9.

Subspecies sagittalis.—Mouth of Clear Creek, Galveston Bay, 4; Arcadia, Galveston Bay, 22.

Subspecies attwateri.—Rockport, Aransas County, 40; Tallys Island, Aransas County, 3; Calaveras, Wilson County, 3; San Antonio (18 miles south), Bexar County, 7.

Mr. Vernon Bailey, chief field naturalist of the Division, visited the type locality of *Geomys breviceps*, Prairie Mer Rouge, Morehouse Parish, Louisiana, in June, 1892, for the purpose of obtaining a series of duplicate types of the species. He found it common throughout the fields of the open country and along roads and fields in the woods of the flat land, except where flooded, but not in standing timber or on hilly land. He states: "They do not seem to be so common in cultivated land as in pastures and along fences and roadways. In one pasture of 20 acres we caught fifteen and one remained. They were more abundant at this point than elsewhere—probably twice as numerous to the area as they would average over the whole prairie. The damage done in the pasture by covering grass was trifling. This species does not seem to dig extensively, and the hills are small. Usually one or two are thrown up in a night. In one place, where a gopher had run his tunnel in a straight course, I counted sixteen hills in a line 6 rods long (measured). A hill of average size measured 24 by 15 inches in diameter and 5 inches in height. Probably the reason the gophers do not dig more extensively is that food is abundant and the soil compact. The greatest damage the farmers claim from gophers, or 'salamanders' as they are called here, is that they carry the tubers of the troublesome cocoa or nut grass from place to place, often bringing them from a roadside or waste place and storing a large quantity in their burrows in gardens or fields and leaving them to grow where they had been kept out with great difficulty. This cocoa grass is one of the worst plants with which the farmers are troubled and is very difficult to get rid of when once started in the land. Small tubers are borne along the roots, and these are carried by the gophers, though I have not found them in their pockets. The stomachs examined contained green vegetable matter. White clover seems to be a favorite food. Most of the specimens taken were moderately fat. In June the young were half grown to nearly full grown. Of 27 specimens which I examined. 12 were males and 15 females."*

Mr. C. L. Newman writes me that at Camden, Arkansas, this species (specimen received for identification) is abundant in sections of the Ouachita River Valley, where they are known almost exclusively as 'salamanders.' He says: "They seem to prefer old fields that have grown up in pine. I know of a place about a mile from Camden where the surface of about an acre of ground is mulched with loose earth brought from their burrows. Last year (1893) I caught twenty-three from about 6 acres of ground."

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* Mr. Vernon Bailey contributes the following notes on a specimen examined in the flesh at Mer Rouge, La., in June, 1892: "Size small; pelage very soft and silky; skin loose, as though much too large for the body; body soft and flabby; soles of feet, nose, and end of tail hairless, smooth, shining, and white when clean. Lips hairy over the edges, but roof of mouth not hairy all the way across, a narrow line of smooth skin extending along the median line to the incisors; eyes small for a *Geomys;* cornea relatively large, measuring 3 mm. across, nearly equaling diameter of ball; no apparent lid, eye opening 3.5 mm. by 2 mm. (normally), its long axis parallel to a line drawn from ear to tip of nose; color of eye appearing shiny black; ears consist of a circular rim 1 mm. high and about 5 mm. in diameter; opening of meatus 2 by 2.5 mm., slightly elongated vertically; mustache spreading forward and back; distance from eye to end of nose 21 mm.; from eye to center of ear, 17 mm."

GEOMYS BREVICEPS SAGITTALIS subsp. nov.

(Pl. 9, fig. 4.)

Type from CLEAR CREEK, GALVESTON BAY, TEXAS. No. $\frac{32936}{44957}$ ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected March 28, 1892, by William Lloyd. (Original number 1181.)

Geographic distribution.—Gulf coast of Texas about Galveston Bay.

General characters.—Similar to *breviceps*, but smaller and more highly colored; head very dark; throat and fore feet pure white in sharp contrast to dark of surrounding parts. The skull differs in having a distinct sagittal crest and in other particulars.

Color.—Upper parts rich, glossy, russet brown, strongly tinged with fulvous, becoming dusky along the middle of the back and head (but no distinct dorsal band); entire head and nose very dark, almost black, but washed in places with fulvous; inside of cheek pouches, chin, throat (breast also in some specimens), and fore legs pure white in sharp contrast. On the upper side of the fore legs the dark color of the sides reaches down about half way to the wrists and ends abruptly with a sharp line of demarkation. The under side of the fore legs is pure white to elbow. The belly varies from whitish, strongly washed with buffy ochraceous, to fulvous. The Arcadia specimens are not exactly like those from the mouth of Clear Creek.

Cranial characters (type specimen).—Skull similar to that of *breviceps* but smaller; zygomata more divergent anteriorly (in male); nasals shorter and broader posteriorly, bringing the constriction much nearer the middle; audital bullæ smaller; ascending branches of premaxilla narrower posteriorly; temporal impressions meeting in a well marked sagittal crest in male. In the female the temporal impressions never meet in a sagittal crest; the brain case is smoothly rounded, and the interparietal persists as a relatively large bone.

In the Arcadia males the temporal impressions do not meet in a sagittal crest as in the type.

Measurements (taken in flesh).—*Type:* Total length, 225; tail vertebræ, 70; hind foot, 27.

Average (of 5 males from Arcadia, Galveston County): Total length, 220; tail vertebræ, 64; hind foot, 26.

Average (of 15 females from same place): Total length, 196; tail vertebræ, 54; hind foot, 23.

For cranial measurements, see Table A, p. 205.

Specimens examined.—Total number 24: 4 from Clear Creek, Galveston Bay, and 20 from Arcadia, Galveston County, Texas.

General remarks.—To the northwestward *sagittallis* passes into the coastal plain form already mentioned under the head of *G. breviceps*. Old males of this form sometimes develop remarkably broad skulls. The broadest skull that I have seen in the restricted genus *Geomys* is an old male from Brenham, Washington County, Texas (No. 63612). It affords the following measurements and ratios: Basal length, 40;

basilar length of Hensel, 37; zygomatic breadth, 28.5. Ratio of zygomatic breadth to basal length, 71; to basilar length of Hensel, 77.

GEOMYS BREVICEPS ATTWATERI * subsp. nov.

(Pl. 9, fig. 3.)

Type from ROCKPORT, ARANSAS COUNTY, TEXAS. No. 51382 ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected November 18, 1892, by H. H. Keays. (Original No. 36.)

Geographic distribution.—Coastal plain and islands of Texas between Matagorda and Nueces bays; penetrates the interior to within a few miles of San Antonio. The south side of Nueces Bay is the home of another form (*G. personatus fallax*).

General characters.—Similar to *G. breviceps*, but larger and less dark in color; feet and basal third to half of tail moderately well haired for a *Geomys;* terminal half to two-thirds of tail nearly naked; zygomatic arches angular, strongly divergent anteriorly.

Color.—Upper parts russet brown, becoming dusky on the head and usually along the median part of the back; under parts varying from soiled whitish to buffy ochraceous. In some specimens the color of the upper parts is less fulvous than in others, and the dark dorsal band is variable; in some specimens it is absent, sometimes the head is nearly black from end of nose to occiput, the blackish area limited laterally by the eyes and ears, the sides of the face being russet in rather strong contrast. The type specimen is in this pelage, except on the hinder part of the back and rump where the more fulvous summer pelage remains, without trace of the dorsal band.

Cranial characters.—Skull similar to that of *breviceps*, but frontal less depressed interorbitally; zygomata less spreading, strongly divergent anteriorly, more angular, more depressed, the maxillary arm sloping strongly backward; ascending branches of premaxilla broader and usually more abruptly truncate posteriorly; nasals shorter and normally convex instead of emarginate posteriorly. The nasals are normally so narrow posteriorly, and the premaxillæ so broad, that in some cases the latter nearly meet behind the former (as in the type specimen, pl. 9, fig. 3). Normal skulls of *attwateri* differ markedly from those of *fallax* in the form of the zygomata, the maxillary arms sloping strongly backward instead of standing out at right angle, and the outer sides being strongly divergent instead of nearly parallel. The nasals are narrower and contracted posteriorly, the ascending arms of the premaxilla broader, and the audital bullæ less swollen. In the series of fifty-two skulls of *Geomys breviceps attwateri* now before me, three depart from the normal in general outline, as seen from above, and resemble *fallax* in the form of the anterior part of the zygomatic arches, which stand out squarely from the cranial axis and have the antero-external angles

* Named in honor of Mr. H. P. Attwater, of San Antonio, Texas, who collected nearly all of the specimens.

broadly rounded. In other respects they are typical *attwateri.* All are very old males, collected at Rockport by Mr. Attwater (original Nos. 102, 118 and 119). They now belong to the American Museum of Natural History in New York.

Measurements (taken in flesh).—*Type:* Total length, 250; tail vertebræ, 85; hind foot, 30.5.

Average of 10 males from type locality: Total length, 255; tail vertebræ, 80; hind foot, 30.

Average of 7 females from type locality: Total length, 220; tail vertebræ, 68; hind foot, 28.

For cranial measurements see Table A, p. 205.

Specimens examined.—Total number 53, from the following localities on or near the Gulf coast of Texas: Rockport, Aransas County (type locality), 40; Tallys Island, Aransas County, 3; Calaveras, Wilson County, 3; San Antonio (18 miles south), Bexar County, 7.

General remarks.—*Geomys breviceps attwateri* is a medium-sized species closely resembling its near neighbor *G. fallax* in color, though somewhat darker, and with the hind foot shorter. The resemblance to *G. breviceps* is much closer in the plumbeous russet pelage than in the fulvous pelage.

Mr. H. P. Attwater has kindly contributed the following memorandum respecting the habits of this gopher at Rockport, Texas: "As soon as the warm weather sets in, from about May to September, very few gophers are observed working. The soil is sandy, and at all times damp, dampness known as 'natural subirrigation.' In the hot weather the dampness does not come as near the surface as in the cooler months. I have thought that perhaps the gophers travel deeper in summer, but now think the chief reason why they do not throw up hills in summer, as they do in fall and winter, is that during the summer months the soil is so full of roots, suckers, bulbs, etc., that they do not have far to go before finding all they can eat, and that the reason they work so much after the summer months are over is because they are hunting around to find some bulb or root which was their favorite food in summer, and which they commenced to find about the month of May, and was over with in September. The animals are very abundant all over the peninsulas in Aransas County, wherever the soil is sandy. There is hardly a foot of land that has not been 'plowed' several times over by gophers, and I believe the fertility of some sections has been greatly improved by them, by bringing the poorer soil up to the top. I have noticed that the richer the land the richer the gophers. Of course they do considerable damage to vegetable crops, especially to young fruit trees and cuttings just rooting. The samples sent you of mulberry trees cut by gophers were from the Faulkners' ranch, on St. Charles peninsula, in the eastern part of the county. Mr. Samuel Walker, the manager of the ranch, told me that he killed over two hundred and fifty gophers in his young pear orchard between the 1st of

March and April 15, 1893. This orchard was set out where sweet potatoes had grown the year before, and they came up again and covered the ground, and I think the potatoes attracted the gophers in the first place more than the pear trees."

GEOMYS TEXENSIS sp. nov.

(Pl. 9, fig. 2; pl. 13, fig. 12.)

Type from MASON, MASON COUNTY, TEXAS. No. $\frac{1690}{2259}$ ♀ ad. Merriam collection. Collected by Rev. Ira B. Henry, December 17, 1885.

Geographic distribution.—Mason County, central Texas, and probably thence southerly to the Rio Grande; limits of range unknown (map 4, E).

General characters.—One of the smallest known species; tail short; terminal third nearly naked.

Color.—Upper parts liver-brown, finely mixed with black-tipped hairs, much as in *G. bursarius*. Under parts and feet white. The hairs of the belly are plumbeous at base in the type and other winter specimens; in summer specimens they are white throughout. Throat suffused with pale buffy fulvous, forming a complete collar. In some specimens this collar is interrupted along the median line. The color of the upper parts is darker in winter than in summer, as usual in the genus. There is no trace of a dark dorsal band in adults, but in the young the black-tipped hairs are sometimes concentrated along the middle of the back, forming an ill defined dark streak.

Cranial characters.—Skull small (smallest of the known species), smooth; zygomata only moderately spreading and normally but slightly divergent anteriorly; nasals short, rather broad and convex or truncate behind; ascending branches of premaxilla long, normally passing plane of lacrymals, usually straight on inner edge behind nasals and attenuate on outer edge; temporal impressions not forming distinct ridges and not uniting in a sagittal crest, usually separated by interspace 1–3 mm. broad in adults; jugal short (shorter than basioccipital); interparietal broader than long, normally oval or elliptical and projecting posteriorly behind plane of lambdoid suture; occiput bulging posteriorly more than in any other United States species (resembling *Pappogeomys bulleri* and some species of *Thomomys*).

Skulls of *texensis* differ conspicuously from those of *G. arenarius* in the following points: Nasal branches of premaxilla longer and more pointed posteriorly; jugal more slender; no distinct knob at end of squamosal arm of zygoma; no distinct temporal ridges; interparietal projecting posteriorly behind plane of lambdoid suture; occiput more bulging posteriorly; mandible less heavy. *G. texensis* differs from *G. breviceps* in the shape of the nasal bones which are usually short, very broad posteriorly, with the sides nearly parallel. In *G. breviceps* they are usually longer, strongly wedge shaped, very narrow posteriorly, with the anterior third abruptly broader and flaring. In *texensis* the nasal branches of the premaxilla reach or pass the plane of the orbital fossa and are pointed; in *breviceps* they usually fall short of this plane and are bluntly rounded. In *texensis* the jugal is shorter than the *basioccipital*; in *breviceps* it is longer. In *breviceps* the outer angle of the zygomatic arch is evenly rounded; in *texensis* it is angular and abruptly flattened (or even excavated) on its infero-external face, beginning at the angle and extending posteriorly under the jugal (as seen from the side). The inflated mastoids and audital bullæ are larger in *breviceps*, in which species the mastoids are conspicuously broader than in *texensis*, the exposed part, viewed from behind, being as broad as high, while in *texensis* the breadth is only about half the height. But the range of individual variation is so great that much confidence can not be placed on this character.* In *breviceps* the frontal is flatter and depressed interorbitally, forming a slight concavity in the plane of the upper side of the skull when seen in profile; in *texensis* the profile is convex at this point.

Skulls of *Geomys texensis* differ from those of *G. bursarius*, in addition to their much smaller size, in shorter rostrum and brain case, less prominent ridges and processes for muscular attachments, absence of sagittal and lambdoidal crests at all ages; much larger interparietal; much larger audital bullæ (which are inflated and rounded antero-laterally instead of flattened), and in the greater length of the ascending branches of the premaxilla posteriorly. The skull as a whole is not only much smaller than that of *bursarius*, but is relatively thin and smooth, like that of *Thomomys*. The arch of the brain case is low, but not so flat as in *breviceps*, and the temporal impressions never meet along the median line.

Measurements.—Type specimen: Total length, 203 (measured in flesh); hind foot, 28 (in dry skin moistened to straighten the toes). Tail not measured in flesh, but short; about 60 in dry skin. Average total length of 28 specimens from type locality measured in flesh, 210.

For cranial measurements see Table B, p. 206.

Specimens examined.—Total number 31, from the following localities in Texas: Mason, Mason County (type locality), 28; Laredo, 1; Sycamore Tree (on Rio Grande), 1; Del Rio (on Rio Grande), 1.

General remarks.—*Geomys texensis* is a small white-bellied species inhabiting central Texas. Its back is chestnut-brown or liver-brown, much as in the large dark-bellied *G. bursarius*, with which it requires no comparison. It is the smallest species in the United States, about equaling *Pappogeomys bulleri* of Mexico. The only bisulcate species of approximately the same size are *G. breviceps* of Louisiana and its subspecies *sagittalis* of the Gulf coast of Texas, and *G. arenarius* of the Upper Rio Grande Valley in extreme western Texas and south-cen-

* The actual size of the mastoid is often hidden by the thin outer edge of the exoccipital which overlies its inner border, and which is not always alike on the two sides. Hence it sometimes happens that the exposed part of the mastoid is narrow on one side and broad on the other.

tral New Mexico, with all of which it may intergrade, although it differs widely from them all in color and cranial characters, as elsewhere shown. On the north, in Oklahoma and southern Kansas, it probably intergrades with *G. lutescens*.

Three specimens of a small *Geomys* from as many points in the Rio Grande Valley (Laredo, Del Rio, and Sycamore Creek) are provisionally referred to the present species. The Laredo specimen lacks the skull and its upper parts are more drab than usual. The specimens from Del Rio and the mouth of Sycamore Creek are too immature for positive identification. They differ from the young of *texensis* from the type locality in having longer tails, somewhat darker backs, and in lacking the chestnut tint on the sides. Their skulls seem to be intermediate between *texensis* and *arenarius*. Mr. William Lloyd, who collected the Sycamore Creek specimen, states that the species is rare there and was found only in a belt of fine sand along the Rio Grande. He found a species, presumably the same, on chalky soil near Comstock. Mr. Vernon Bailey collected the Del Rio specimen in the river bottom, where the species was rather rare.

GEOMYS ARENARIUS sp. nov.

(Pl. 9, fig. 1; pl. 13, fig. 13.)

Type from EL PASO, TEXAS. No. $\frac{18117}{25015}$ ♂ ad. U. S. National Museum, Department of Agriculture collection. Collected December 13, 1889, by Vernon Bailey (Original No. 798).

Geographic distribution.—Valley of the Upper Rio Grande, from El Paso, in extreme western Texas, and Juarez, Chihuahua (on the Mexican side of the river opposite El Paso), north to Las Cruces, New Mexico, and west to Deming, in the same state (map 4, G). It will probably be found to follow the valley somewhat further in both directions, and to the east may intergrade with *texensis*. So far as now known its range seems to be separated by a broad interval from that of the species inhabiting central and southern Texas, the westernmost records of which are Del Rio and Comstock, in the Rio Grande Valley. Curiously enough the intervening region is inhabited by a widely different Pocket Gopher, one belonging to the unisulcate series, namely, *Cratogeomys castanops*. The ranges of all the other bisulcate species, except *tuza*, are either directly continuous or contiguous. In faunal position *G. arenarius* belongs to the upper edge of the Lower Sonoran Zone.

General characters.—Size medium; tail rather long and unusually well haired, except near tip; coloration pale.

Color.—Upper parts drab-brown, finely mixed with black-tipped hairs; under parts and feet white. In some specimens the color of the sides encroaches on the belly and is only partly masked by the white tips of the hairs.

Cranial characters.—Skull resembling *Thomomys talpoides;* size rather small (intermediate between *texensis* and *breviceps*); zygomata normally narrow and nearly parallel (in one ♂ from El Paso, No. 58340, they are exceptionally divergent anteriorly); no sagittal crest at any age; temporal ridges prominent, distant, and nearly parallel or slightly divergent anteriorly, usually separated by a flat or concave interspace 4 to 5 mm wide, as in *Thomomys talpoides;* squamosal arm of zygoma ending in a prominent knob over middle of jugal (diagnostic of the species); jugal short (shorter than basioccipital); interparietal rather large, normally (but not always) broader than long, usually subquadrangular or with the corners rounded anteriorly, truncate posteriorly on plane of lambdoid suture; occiput bulging posteriorly, but not so far as in *texensis;* palatopterygoids normally abruptly narrow, their sides nearly parallel (but form somewhat variable); mandible heavy for size of skull. The females differ from the males in having shorter nasals, larger parietals, and less prominent temporal ridges. As a rule the interspace is somewhat thickened and the ridge is evident from the outer side only.

The skull of *G. arenarius* differs from that of *texensis* in the following characters: Jugal heavier and broader; temporal ridges much more prominent and distant; a prominent knob at distal end of squamosal arm of zygoma; top of skull flatter; frontal broader and flatter interorbitally; interparietal truncate posteriorly on plane of lambdoid suture; occiput less bulging. It differs from *lutescens* in much smaller size, narrower and more parallel zygomata; shorter jugal; in the presence of well-developed distant temporal ridges, and of a prominent knob at distal end of squamosal arm of zygoma; shorter and somewhat narrower nasals, and shorter ends of ascending arms of premaxilla behind the nasals.

Measurements (taken in flesh).—Type specimen (♂ ad.): Total length 258; tail vertebræ, 88; hind foot, 33. Average of 8 males from type locality: Total length, 260; tail vertebræ, 83; hind foot, 32. Average of 24 females* from type locality: Total length, 250; tail vertebræ, 78; hind foot, 32.

For cranial measurements see Table B, p. 207.

Specimens examined.—Total number 43, from the following localities: Juarez, Mexico, 3; El Paso, Texas, 30; Deming, New Mexico, 3; Las Cruces New Mexico, 7.

General remarks.—In color and external appearance *Geomys arenarius* closely resembles the typical form of *G. lutescens* (from western Nebraska and eastern Wyoming), differing chiefly in smaller size and in greater length and hairiness of tail. From its nearest ally in central Texas (*G. texensis*) it differs both in color and proportions, having the upper parts pale drab instead of reddish brown, and the tail long and hairy instead of short and nearly naked. In cranial characters it may be distinguished from all other species by the presence of distant tem-

*Some of the specimens recorded as females are very large and were probably males; hence the averages here given for females are probably too great.

poral ridges or ribs, which are nearly parallel, in connection with the development of a prominent knob at the distal end of the squamosal arm of the zygoma.

This fine species was discovered by my assistant, Mr. Vernon Bailey, at El Paso, Texas, in December, 1889, and was obtained by him at Deming, New Mexico, also. Mr. J. Alden Loring, who was sent to the Upper Rio Grande Valley to work out its range, secured a large series from Las Cruces, New Mexico, and Juarez, Chihuahua, Mexico, as well as at the type locality, El Paso, Texas. Mr. Loring says: "They are not very common on the Mexican side of the river, but extremely so on American soil, where they seem to thrive and grow fat. The places they most prefer are railroad embankments and irrigation ditches, where they were found both in sand and wet, dark clayey soil. Two were seen on February 5 just as they protruded their heads from their holes. Their faces were covered with dirt, and as soon as they had shaken it off they saw me and quickly dodged back. When these Gophers were caught I noticed that they walked with the claws of the front feet partially doubled under, which did not allow the sole of the foot to touch the ground."

GEOMYS PERSONATUS True.

(Pl. 12, fig. 4; pl. 13, fig. 14; pl. 14, fig. 4.)

Geomys personatus True, Proc. U. S. National Museum, XI (for 1888), Jan. 5, 1889, 159–160.

Type locality.—PADRE ISLAND, TEXAS.

Geographic distribution.—The Tamaulipan fauna of Texas, comprising Padre Island and the adjacent mainland southwesterly to Carrizo on the Rio Grande (map 4, F).

General characters.—Size large; coloration pale; tail long, scant-haired on proximal half and nearly naked on distal half.

Color.—Upper parts pale drab (darker in winter from more liberal admixture of dark-tipped hairs); middle of face from nose to above eyes inclining to dusky. Under parts white, sometimes obscurely clouded, from the presence of irregular patches of hairs with plumbeous bases, the hairs on other parts of the belly white to roots. Tail hairs white, but too far apart to give color to the nearly naked tail.

Cranial characters.—Skull large, heavy, with well-developed processes and ridges and a high sagittal crest (pl. 12, fig. 4); zygomata standing out at right angle to axis of skull; jugal bluntly and broadly rounded anteriorly, and short, not longer than basioccipital (measured from condyle); nasals long and narrow, anterior third spreading; frontal narrow interorbitally, the orbital borders rounded; basioccipital with sides parallel, or nearly parallel. In profile the top of the skull (including the sagittal crest) is nearly a straight line.

Adult skulls of *Geomys personatus* may be easily distinguished from those of *bursarius* and *lutescens* by the squareness of the zygomatic arches anteriorly, the shortness of the jugal bone anteriorly, with corresponding production of the maxillary arm of the zygoma. The greatest length of the jugal in *personatus* is only equal to the length of the basioccipital bone (measured from the condyle). In both *bursarius* and *lutescens* the jugal is much longer than the basioccipital. In *personatus* the skull as a whole is relatively as well as actually longer, and narrower across the zygomatic arches, than that of *lutescens*, from which it differs further in the following particulars: zygomatic breadth usually less than distance from foramen magnum to incisive foramina (the contrary being usually true in *lutescens*); ascending branches of premaxilla extending much further posteriorly; zygomatic arches relatively long, only moderately spreading anteriorly (except in extreme age), but standing out at right angle to longitudinal axis of skull; orbital fossæ elongated antero-posteriorly instead of subtriangular; length of frontal along median line usually equal to length of nasals (commonly shorter in *lutescens*); audital bullæ longer, with outer side flattened; inflated mastoid smaller. Skulls of *personatus* average longer in proportion to the zygomatic breadth than those of any other known bisulcate species, except the Mexican *Zygogeomys trichopus* (the ratio of zygomatic breadth to basilar length ranging from 68 to 72 percent), though in this respect they differ but slightly from *Geomys bursarius*.

Measurements.—Of 13 specimens (of both sexes) from type locality (Padre Island): Total length, 399; tail vertebræ, 103; hind foot, 37. Average of 4 males: Total length, 315; tail vertebræ, 111; hind foot, 40. Average of 9 females: Total length, 293; tail vertebræ 100; hind foot, 36.

For cranial measurements see Table B, p. 206.

Specimens examined.—Total number 33, from the following localities on or near the Gulf coast of Texas: Padre Island (type locality), 15; near Santa Rosa, 8; Sauz Rancho, 6; Carrizo, 3.

Number of subspecies *fallax* 22, as follows: Nueces Bay and River (south side), 6; Corpus Christi, 15; Las Mottes, 1.

Departures from the type.—The type locality of *Geomys personatus* is Padre Island. Fairly typical specimens are at hand from points on the mainland west of the southern part of this island, namely, Santa Rosa and the Arroyo Colorado (Sauz Rancho), and also from Carrizo on the Rio Grande, though the latter depart somewhat from the type. Singularly enough, specimens from the lower Nueces River and Bay, and from Corpus Christi and Las Mottes, differ decidedly from the typical animal in smaller size, darker color, and in important cranial characters. The skull is much smaller, more abruptly truncate posteriorly, with more spreading zygomatic arches, and much more globular audital bullæ (pl. 12, fig. 3). This form is here separated sub-specifically under the name *Geomys personatus fallax* (see p. 144). Intergradation between *personatus* and *fallax* probably occurs in the narrow strip between Santa

Rosa and Corpus Christi Bay, since the single specimen from Las Mottes, a few miles south of Nueces Bay, is somewhat larger than the Nueces Bay and Corpus Christi specimens.

Some of the specimens from Santa Rosa are fairly typical *personatus*, though all have more swollen audital and mastoid bullæ. One adult skull (No. 42,860) from the Arroyo Colorado (Sauz Rancho, about 50 miles north of Brownsville) has a very narrow rostrum, narrow zygomata, projecting occiput, very much swollen mastoid and audital bullæ (the latter almost subglobular) and abnormally short and narrow jugal. Five other skulls from the same locality are young and apparently less extreme. The adult skull may be regarded as abnormal, or as pointing to the differentiation of an incipient race.

General remarks.—*Geomys personatus* resembles *G. lutescens* in summer pelage more closely than any other form. The typical animal may be distinguished from *lutescens* at all seasons by larger size, longer feet and tail, by important cranial characters (just described in detail), and by the white of the under parts. In summer specimens of *G. lutescens* the belly is sometimes pale, but rarely white except in the very young. The color of the upper parts in summer pelage differs but little in the two species, being drab in both, with the nose and middle of the face, as far back as the eyes, inclining to dusky; but in winter and early spring the two differ notably, the dusky face markings of *lutescens* extending posteriorly over the head and back to the rump, forming a distinct dorsal stripe. In this pelage, also, the under parts are much darker, the fur being dark plumbeous, tipped with drab. While *personatus* is the larger of the two animals, the claws of the fore feet are equally large (and relatively larger) in *lutescens*. In some specimens of *personatus* the claws are remarkably long and slender—the result, doubtless, of the unresisting character of the sand in which the animals live.

The geographic distribution of *Geomys personatus* (including subspecies *fallax*) appears to coincide with the limits of the arid tropical area of Texas—an area recognized and defined by me in 1892,* and subsequently named the *Tamaulipan fauna* by Allen.† The range of the species has been ascertained to terminate abruptly both on the north and on the west, specimens from a few miles north of Corpus Christi Bay, and from Laredo on the Rio Grande, belonging to different species.

Mr. William Lloyd, who collected the specimens, states that *G. personatus* is abundant in a patch of fine sandy soil above Carrizo, but was not found elsewhere in the neighborhood. He states further that in traveling north from the mouth of the Rio Grande it was first met on entering the great sand belt on the north side of the Arroyo Colorado (at El Sauz). It continued throughout this sand belt, becoming more abundant to the northward. On Padre Island he found the animals living in colonies, perhaps a mile or more apart, and common from the

* Presidential Address, Proc. Biol. Soc., Washington, April, 1892, p. 33.

† Bull. Am. Museum Nat. Hist., New York, Vol. iv, Jan., 1893, 241-242.

north end to the center of the island, but not within 20 miles of the south end. Mr. Lloyd says: "Their habits are in some respects peculiar, owing perhaps to the soft sand that caves in on them, or to fear of the coyotes, or for both reasons; they fill up their tunnels for a yard or two almost immediately after they throw out the dirt. They can not go very deep in the flats or they would reach water; in fact, the water filled some of the tunnels for about a foot until they curved upward. Not more than one is ever found in a hole."

GEOMYS PERSONATUS FALLAX subsp. nov.

(Pl. 12 fig. 3.)

Type from south side of NUECES BAY, TEXAS. No. $\frac{32031}{43845}$ ♂ ad. Collected November 30, 1891; by William Lloyd. (Original No. 949.)

Geographic distribution.—South shore of Nueces Bay and lower Nueces River, Texas; further south passing into *G. personatus*.

General characters.—Similar in external appearance to *G. personatus* of Padre Island, but much smaller (only about half the bulk of that species); somewhat darker; tail shorter and nearly naked.

Color.—Upper parts drab-brown, darker in winter; paler and more fulvous in summer; nose and face between eyes dusky; sometimes an ill-defined dusky band along the middle of the back. Under parts usually marbled with pure white and patches of dark hair (the white hair being white to roots).

Cranial characters.—Skull similar to that of *personatus*, but very much smaller (pl. 12, fig. 3). The zygomata stand out squarely at right angles to axis of cranium and are widely spreading, their outer sides nearly parallel; the temporal impressions meet in the males in a well-marked sagittal crest; in the females they remain apart, separated by an interspace about 3 millimeters wide; nasals rather broad and blunt posteriorly; jugals short (not longer than basioccipital); mastoid and audital bullæ swollen, the latter short and rounded; palatopterygoids narrow, their sides nearly parallel. Skulls of *fallax* differ from those of *personatus* in very much smaller size, shorter (and usually blunter) ascending arms of premaxilla, more squarely truncate occiput (lambdoid crest less convex posteriorly), and in much shorter and more swollen audital bullæ.

Geomys personatus fallax differs markedly from *G. attwateri* (which it approaches in size) in the form of the zygomata, the maxillary arm standing out at right angle instead of sloping strongly backward, and the outer sides of the arches being nearly parallel instead of strongly divergent anteriorly. It differs further in having more globular audital bullæ, broader nasals, narrower ascending branches of the premaxilla, and in the males a well-developed sagittal crest instead of permanent temporal ridges.

Measurements.—Type specimen: Total length, 250; tail vertebræ, 80; hind foot, 35. Average of 9 males from south side of Nueces Bay: Total length, 263; tail vertebræ, 87; hind foot, 34. Average of 10 females from same locality: Total length, 236; tail vertebræ, 75; hind foot, 31.

For cranial measurements see Table B, p. 206.

Specimens examined.—Total number 32, from the following localities on or near Nueces Bay, Texas: Nueces Bay, 4; Nueces River, 10 miles from mouth, 2; Corpus Christi 15; Las Mottes, 1.

General remarks.—*Geomys fallax* is a miniature of *G. personatus*, both in external appearance and in the general form of the skull. It is hardly more than half the bulk and weight of *personatus*, from which it differs further in somewhat darker coloration and in cranial details. The geographic range of the typical form is remarkably restricted, being limited, so far as known, to the south side of the lower Nueces River and Bay.

In his notes on mammals observed in southeastern Texas, Mr. William Lloyd states that this species "is abundant in all soils, although it prefers the black loam. On Nueces Bay they burrow in the sand close to the water's edge, but are most at home on the highest point attainable. I have seen an unbroken line of hills extending from 70 to 100 yards across patches of early pease and onions. They cause havoc among the sweet potatoes, coming above ground to eat them in the daytime. I shot a marsh hawk that was flying off with a gopher which had been thus engaged. While driving along the road cats may be seen frequently a mile from the house intently watching the gophers' holes. The gophers are known to be great pests to fruit and other trees; in more than a dozen instances near the bay I have seen the huisachi (*Acacia farnesiana*) leveled by their work in chewing the rootlets and digging the earth away from the roots."

Genus PAPPOGEOMYS * nob.

(Pl. 11, fig. 1; and text figs. 56, 57 and 58.)

Type *Geomys bulleri* Thomas, from TALPA, MASCOTA, JALISCO.

Dental characters.—Upper premolar with three enamel plates, the posterior absent; m^1 and m^2 with two enamel plates each, as in *Geomys*. Last upper molar an imperfectly double prism; a single sulcus on outer side, behind which the crown is narrowed, forming a moderately well-defined heel; outer enamel plate bent slightly outward near its anterior end. Upper incisor unisulcate, the sulcus median and deep (no trace of minor sulcus; see fig. 21[4]).

Cranial characters.—Skull small, short, rather smoothly rounded; a broad sagittal area (no sagittal crest at any age, pl. 11, fig. 1); zygomata slender, rather broadly and squarely spreading, without trace of angular expansion; occiput bulging posteriorly; palatopterygoids little

**Pappogeomys*, from πάππος, grandfather, + *Geomys*, in reference to the apparent antiquity of the type.

more than vertical lamellæ, slightly everted inferiorly; orbital plates of frontal separated inferiorly by full breadth of cribriform plate as in *Thomomys;* orbitosphenoids broad, articulating firmly with alisphenoids and sending a tongue upward to nearly fill the upper part of the sphenoidal fissure; mesethmoid a nearly vertical plate much higher than long, its inferior edge dipping down between wings of vomer posteriorly; endoturbinals as in *Platygeomys*, the first sharply triangular and the os planum trimmed closely in front of the others.

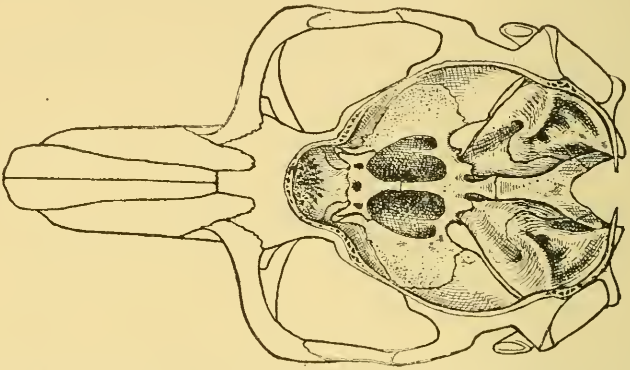

FIG. 56.—*Pappogeomys bulleri.* Vault of cranium sawed off, showing floor of brain case. (For key see fig. 9).

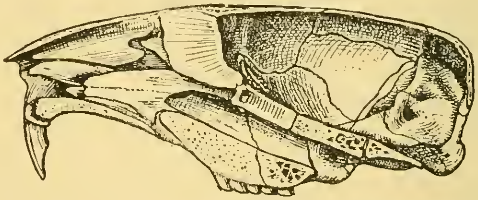

FIG. 57.—*Pappogeomys bulleri.* Vertical longitudinal section of skull, mesethmoid and vomer in place. (For key see fig. 7).

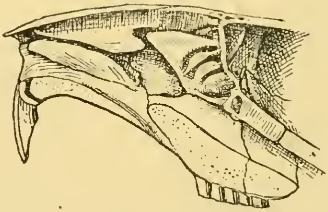

FIG. 58.—*Pappogeomys bulleri.* Mesethmoid and vomer removed to show endoturbinals. (For key see fig. 10).

External characters.—Size small; pelage soft; form *Thomomine.*

General remarks.—*Pappogeomys* holds an interesting position with eference to the trunk line of the *Geomyidæ.* In dental characters it combines the molariform enamel pattern of *Geomys* with the unisulcate incisors of *Cratogeomys* and *Platygeomys;* and in cranial characters it exhibits striking resemblances to both *Geomys* and *Thomomys* on the one hand, and to *Cratogeomys* on the other. The endoturbinals are not widely different from the *Geomys* type, while the orbitosphenoids depart entirely from *Geomys* and surpass *Cratogeomys* in the extent of their development and articulations. They cut off and shorten the sphenoid fossæ, which in *Geomys* reach forward to the orbital plates of the frontal (pl. 17, fig. 3). The shape of the mesethmoid plate is unique. The form of the skull as a whole is very like the simpler forms of *Thomomys* and *Geomys*—as *texensis* and *arenarius*—and the permanently distant orbital plates of the frontal is a decidedly Thomomine character.

The resemblances to *Geomys* and *Thomomys* do not indicate that *Pappogeomys* has descended from either of these genera, but that it occupies a place near the trunk line and below the point from which they branched off. On the other hand, the resemblances to *Cratogeomys* and *Platygeomys* are prophetic, indicating a position near the base of the great branch that afterward gave rise to these more specialized types.

KEY TO SPECIES OF PAPPOGEOMYS.

Mastoids small, truncate above .... *bulleri.*
Mastoids large, rounded above .... *albinasus.*

PAPPOGEOMYS BULLERI (Thomas).

(Pl. 11, fig. 1; pl. 13, fig. 15; pl. 14, fig. 11.)

Geomys bulleri Thomas, Annals and Magazine Nat. Hist., 6 series, Vol. x, August, 1892, p. 196.
Geomys nelsoni Merriam, Proc. Biol. Soc., Washington, VII, September 29, 1892, 164–165.

Type locality.—Near TALPA, WEST SLOPE OF SIERRA DE MASCOTA, JALISCO, MEXICO (altitude, 8,500 feet). Type in British Museum.

Geographic distribution.—Lower slopes of Sierra Nevada de Colima and Sierra de Mascota, Jalisco, Mexico (map 3[1]).

*General characters.**—Size smallest of the known unisulcate species, of which it is a generalized type; skull small and smooth, resembling *Thomomys;* tail naked; a naked pad on end of nose, partly inclosed in a pale patch.

Color.—Upper parts rich rusty chestnut; underparts paler. An immature but full-grown specimen (No. 33585) is dusky in color, and one in the molt has the anterior parts chestnut and the posterior dusky.

Cranial characters.—The skull of *Pappogeomys bulleri* is small and smoothly rounded, with broadly distant and rather feeble temporal ridges. The maxillary arms of the zygomata stand out at right angles

* The following description is based wholly on specimens from the north slope of the Sierra Nevada de Jalisco. They are larger than Thomas's type and only specimen of *G. bulleri,* and may prove subspecifically separable, in which case the name *nelsoni* will be available.

to the axis of the skull; the zygomata are slender, rather widely spreading, without trace of expanded angle, and their outer sides are nearly parallel (sometimes broader posteriorly than anteriorly). The occiput bulges far behind the lambdoid suture and is smoothly rounded (except in old males, in which it is less inflated and is marked by a median vertical ridge). In all of these respects it agrees with the closely related *P. albinasus* and differs from all other known Mexican species. The frontal is broad and rather flat interorbitally; the nasals narrow and truncate posteriorly; the ascending branches of the premaxilla short, bluntly rounded posteriorly, and barely reaching plane of orbits. The pterygoids are parallel lamellæ, their inferior edges slightly everted—a transition step in the development of the horizontal shelf of *Cratogeomys* from the simple lamella of *Thomomys*. The hamular processes articulate directly with the audital bullæ. *P. bulleri* differs from the nearly related *P. albinasus* in smaller size, smaller mastoids (which are truncate above instead of rounded), narrower rostrum, narrower and longer nasals, narrower ascending branches of premaxilla, and much shorter angular process of mandible.

Dental characters.—Upper incisors narrow, with a single median furrow; molariform series only slightly heavier than in *G. texensis;* last upper molar with a large heel, which equals or exceeds the anterior prism in antero-posterior diameter.

Measurements.—Average of 2 males from north slope of Sierra Nevada de Colima, Jalisco (measured in flesh): Total length, 236; tail vertebræ, 81.5; hind foot, 33. Average of 4 females from same locality: Total length, 215.5; tail vertebræ, 72.5; hind foot, 30.*

For cranial measurements see Table F, p. 214.

Specimens examined.—Six, all from the north slope of the Sierra Nevada de Jalisco, Mexico.

General remarks.—This species was described almost simultaneously by Mr. Oldfield Thomas and myself, but his description has priority of publication by about a month. Hence his name, *bulleri*, has precedence over my *nelsoni*. Mr. Nelson states that the species "was found only in some fields at the upper ranch at the foot of the main north slope of the Sierra Nevada de Colima, Jalisco, in the upper border of the lower pine belt, at about 6,500 feet altitude, where it was common, and was found in company with the large species, *Geomys gymnurus*."

Pappogeomys bulleri greatly resembles the bisulcate *Geomys texensis*, from which its dental characters distinguish it at a glance. It is evident that both *bulleri* and *texensis* have undergone but little modifica-

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* In my original description of *G. nelsoni*, the measurements were taken "from dry skin of type [♂], slightly overstuffed," the field measurements not having been received (Proc. Biol. Soc., Washington, VII, Sept. 29, 1892, 164.) The measurements as published were: Total length, 250; tail vertebræ, 80; hind foot, 30. The flesh measurements of the same specimen are: Total length, 238; tail vertebræ, 83; hind foot, 33. Mr. Thomas' measurements of his type specimen of *bulleri* are: Head and body, 135; tail, 63; hind feet, with claw, 27.6.

tion since they left the main trunk line of the group, and that both branched off from points not very remote from the place where *Thomomys* left the same stock.

PAPPOGEOMYS ALBINASUS sp. nov.

Type from GUADALAJARA, STATE OF JALISCO, MEXICO. No. $\frac{34138}{46215}$ ♀ ad. U. S National Museum, Department of Agriculture collection. Collected at Atemajac, a suburb of Guadalajara, May 21, 1892, by E. W. Nelson (Original No. 2654).

Geographic distribution.—The plain of Guadalajara; limits of range unknown. Mr. Nelson states: "This species occurs very sparingly on the open plain about Guadalajara, and diggings of a small gopher, probably the same species, were seen near Ahualulco, some 35 miles farther west. The range in altitude of these localities lies between 4,000 and 5,100 feet."

General characters.—Size small; naked nasal pad well developed; tail naked. Animal similar to *P. bulleri* of Thomas, but somewhat larger; nasal pad and white patch above it more elongated; color paler; whiskers finer and less conspicuous.

Color.—Uniform pale plumbeous above and below, irregularly washed with pale chestnut, palest below; a small dark patch around each ear; an elongated white patch on nose inclosing nasal pad and reaching posteriorly nearly to plane of eyes.

Cranial characters.—Skull small, smoothly rounded like *Thomomys;* zygomatic arches parallel, slender, angle not expanded; temporal impressions widely distant; zygomatic breadth slightly exceeding greatest breadth of cranium posteriorly. Skull similar to that of *P. bulleri*, but differing in larger size; much larger mastoids, which are rounded above instead of truncate; broader muzzle; shorter and broader nasals; broader ascending branches of premaxilla, and more elongated angular processes of mandible.

Measurements in flesh.—Type specimen ♀ ad. Total length, 226; tail vertebræ, 68; hind foot, 31.

For cranial measurements see Table F, p. 214.

General remarks.—The only known species requiring comparison with *P. albinasus* is the related *P. bulleri* of Thomas, a smaller and much more highly colored animal, differing in the cranial characters above pointed out. Future investigations may show that the ranges of the two meet, and that the animals intergrade, in which case *albinasus* will become a subspecies of *bulleri*.

Unfortunately, only a single specimen of *Pappogeomys albinasus* is at hand. But since its type locality, Guadalajara, is an attractive and accessible locality. It is probable that a large series of specimens will be obtained in the near future.

Genus CRATOGEOMYS * nob.

(Pl. 2; pl. 10, fig. 5; pl. 12, figs. 1 and 2; pl. 13, figs. 4–8, and 17; pl. 14, figs. 6 and 7; pl. 15, figs. 6 and 9; pl. 17, fig. 5; pl. 18, fig. 4; pl. 19, fig. 6.)

Type *Geomys merriami* Thomas, from the VALLEY OF MEXICO (pl. 2).

Dental characters.—Upper premolar with three enamel plates (the posterior absent), its shaft strongly convex forward; upper and lower premolars subequal in length. First and second upper molars with one enamel plate each (posterior absent); posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 strong.

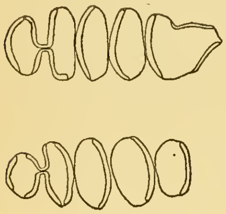

FIG. 59.—*Cratogeomys merriami.* Crowns of molariform teeth: *a*, upper; *b*, lower.

Last upper molar an imperfectly double prism; a deep sulcus on outer side; no sulcus on inner side; crown of tooth normally broader than long, variable in form, usually more or less obcordate or subtriangular; inner and outer enamel plates variable; inner plate normally at least two-thirds as long as anterior plate, obliquely transverse, normally covering posterior face of tooth.

Upper incisor with a single sulcus, median or slightly on inner side, and usually rather open (fig. 21[1], 21[3], and pl. 15, fig. 9).

Cranial characters.—Skull large and massive; zygomata heavy and rather broadly spreading; orbitosphenoids short and broad, articulating with alisphenoids anteriorly; mesethmoid a half crescent, its apex pointing to presphenoid; endoturbinals together forming a compact plate, strongly convex below, straight above, its anterior border sloping strongly backward without any extension of the os planum in front of the folds (pl. 19, fig. 6); first endoturbinal moderately expanded and elongated; second, third, and fourth subequal; vomerine edge of os planum curving down below plane of roof of narial passage; floccular fossa circumscribed and separated from internal auditory meatus by a distinct ridge; ridge separating inner from superior face of petrous sharp and incurved, and sometimes rising high posteriorly (pl. 17, fig. 5, and pl. 18, fig. 4).

The following additional characters, of more or less weight, are introduced with special reference to antithesis with *Platygeomys:* † Breadth of cranium posteriorly (above mastoids) much less than zygomatic breadth; breadth of occipital plane not more than twice its height; lambdoid crest broadly convex posteriorly; squamosal expansion chiefly toward the median line (in *C. merriami* in advanced age they completely cover and conceal the parietals, above which they meet in a median crest); mandible longer than broad (including incisors); angular process

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* *Cratogeomys*, from κράτος, strong, powerful, + *Geomys*, in reference to the great size and strength of the animals.

† Many of the characters already given in the generic diagnosis are also in strong contrast to those of *Platygeomys*.

of mandible short, nearly sessile, truncated externally, and forming a shelf completely around the base of the outer side of the incisor knob; squamosal arm of zygoma covering nearly or quite two-thirds of jugal, which latter fills but a narrow gap in zygomatic arch (except in one species, *C. fulvescens*, in which the jugal is abnormally short posteriorly, its anterior relations being normal); free part of upper edge of jugal half or less than half the length of basioccipital on median line; paroccipital processes relatively light; incisors heavy in contrast to those of *Platygeomys* (except in *fulvescens* and *castanops*); antero-posterior diameter of incisors greater than transverse (except in *fulvescens* and *castanops*); enamel face of lower incisors forming a conspicuous bead on outer side of tooth, behind which the tooth is strongly beveled, the transverse diameter being much greater through the enamel face than posteriorly (except in *fulvescens* and *castanops*).

In *Cratogeomys* a marked depression extends obliquely across the squamosals from the root of the zygoma to the occiput near the median line. In the *gymnurus* series no such depression exists, but, on the contrary, a distinct bulge or elevation occupies this part of the skull.

Cratogeomys splits naturally into two sections: The *merriami* series, comprising *merriami*, *perotensis*, *estor*, *oreocetes*, and *peregrinus;* and the *castanops* series, comprising *castanops* and *fulvescens*. In the *merriami* series the top of the skull seen in profile is a nearly straight line; the zygomata are not strongly decurved, and the outer angle is only moderately expanded. In the *castanops* series the top of the skull is decidedly convex, the zygomata are strongly decurved, and the outer angle is broadly expanded. Numerous other cranial differences exist, and it is probable that the *castanops* series will be eventually separated, at least subgenerically, from *Cratogeomys* proper.

KEY TO SPECIES OF CRATOGEOMYS.

(1) BASIOCCIPITAL *rectangular, its sides parallel*

Rostrum and brain case long .... *castanops*

Rostrum short; brain case broad .... *goldmani*

(2) BASIOCCIPITAL *truncate wedge-shaped* (sides approximating anteriorly).

a^1 *Sagittal crest well developed.*

b^1 Lower incisor strongly beveled on outer side .... *merriami*

b^2 Lower incisor not beveled on outer side.

c^1 Top of skull strongly convex in profile .... *fulvescens*

c^2 Top of skull nearly flat in profile.

Nasals normal (rather long and narrow) .... *perotensis*

Nasals short, narrow posteriorly and broad anteriorly .... *estor*

a^2 *No sagittal crest.**

Outer face of upper incisor strongly beveled .... *oreocetes*

Outer face of upper incisor not beveled .... *peregrinus*

* The only specimens seen of *oreocetes* and *peregrinus* are females; it is possible that the old males may have a crest.

CRATOGEOMYS MERRIAMI (Thomas).

(Pl. 2; pl. 10, fig. 5; pl. 13, fig. 4; pl 14, fig. 7; pl. 15, figs. 6 and 9; pl. 17, fig. 5; pl. 18, fig. 4; pl. 19, fig. 6).

Geomys merriami Thomas, Annals & Magazine Nat. Hist., Ser. 6, Vol. XII, October, 1893, 271-273. (Type in British Museum.)

Type from "southern Mexico"—probably the VALLEY OF MEXICO.

Geographic distribution.—South end of Valley of Mexico and adjacent mountain slopes from just below the lower edge of the lower pine belt up to an altitude of 10,000 or 11,000 feet; east to Atlixco (Puebla), north to Irolo (Hidalgo), and west to Lerma, in Toluca Valley (map 4, I).

General characters.—Size largest of the genus *Cratogeomys;* tail and hind feet moderately haired but not so well covered as in *C. fulvescens;* skull massive; incisors huge.

Color.—Upper parts dull chestnut brown, mixed with black-tipped hairs, varying to glossy slate black; underparts similar but paler; the rusty specimens have a dark patch around and behind each ear, which is not apparent in the slate-black ones.

Cranial characters.—Skull large and massive, the zygomatic arches widely spreading anteriorly and rapidly narrowing posteriorly (pl. 2); incisor teeth larger and heavier than in any known Mexican species, not excepting *Platygeomys gymnurus;* antero-posterior diameter of incisors much greater than transverse; lower incisors with a strongly marked bevel on the outer side immediately behind the enamel; behind the bevel the tooth is abruptly narrower; outer edge of enamel forming a conspicuous bead. In adult males the squamosals completely cover the parietals and meet in a median crest above the sagittal crest proper. The mandible of the Lerma skull (No. 50110) is longer and narrower across the angular processes than that of specimens from the slopes of the Valley of Mexico. Skulls from Irolo differ from the typical form of the Valley of Mexico in having the mastoids considerably larger and fuller posteriorly, occupying more of the occipital plane. The audital bullæ also are somewhat more swollen. The mastoids do not extend out so far laterally as in typical *merriami;* the postpalatal pits are not so deep; the coronoid processes of the mandible are more spreading (directed more strongly outward), and the heel of the last upper molar is shorter. The Irolo skulls agree with typical *merriami* and differ from the Atlixco specimens in having the frontal reach further forward along the median line than on the sides. Skulls from Atlixco differ from typical *merriami* in the following particulars: The nasals extend further back, reaching or passing plane of fronto-maxillary suture; the frontal reaches as far forward laterally as on median line (in *merriami* it reaches much further forward on median line); as a rule the coronoid processes of mandible are lower and more abruptly curved backward, with the coronoid notch correspondingly narrower.

The massiveness of the incisor teeth in true *merriami* is much more extreme than in any of the other species, and is coördinated, as already pointed out, with a much greater development of the squamosal and of the various prominences and ridges for muscular attachment.

Variations in pelage.—*Cratogeomys merriami* exhibits both the melanistic and chestnut color phases, and also intermediate pelages. In four adult specimens from Tlalpam, three are dark brown, faintly washed with fawn color or very pale fulvous; the fourth is bright chestnut or reddish-brown on the rump and sides, while the newer hair of the back is intimately mixed with blackish. One specimen from Amecameca has a white spot above the tail, as in the Irolo specimens.

All of the three specimens from Irolo have an irregular white patch at the base of the tail above, and one has a small irregular patch on the rump and another on the belly between the hind legs.

In the Irolo specimens the tail is less hairy and the hind feet more hairy than usual, and the hairs of the hind feet are white.

One of the eight specimens from Atlixco has the white spot at the base of the tail, though not so large as in the Irolo and Las Vigas specimens. The hind foot is scant haired in the Atlixco specimens, which peculiarity is probably seasonal, since the Atlixco specimens were collected in July, while those from Irolo were collected in March. The tails are less hairy than usual in the Irolo and Atlixco specimens.

Measurements (taken in flesh).—Average of 11 males from the south end of the Valley of Mexico and adjacent slopes (Amecameca, Tlalpam, Ajusco, Salazar, Huitzilac, and Lerma): Total length, 380; tail vertebræ, 112; hind foot, 50. Average of 7 females from same localities: Total length, 344; tail vertebræ, 105; hind foot, 46.

For cranial measurements see Table D, p. 210.

Specimens examined.—Total number 31, from the following localities: State of Mexico, Tlalpam, 4; Amecameca, 9; Ajusco, 2; Salazar, 1; Lerma, 1; State of Morelos, Huitzilac, 3; State of Hidalgo, Irolo, 3; State of Puebla, Atlixco, 8.

General remarks.—Mr. Nelson states that this large and powerful species is common in the south end of the Valley of Mexico, where it inhabits the soft soil of the bordering slopes and ranges on the west, south, and east sides of the southern two-thirds of the basin. Owing to the hard rock and clayey character of the middle and northern parts of the valley it does not occur there. On the west side it ranges up to the summit of the Sierra de Las Cruces (where he secured a specimen at an altitude of 11,000 feet near Salazar), and thence down the west slope into the border of the valley of Toluca, where a specimen was taken at Lerma. South of the Valley of Mexico it ranges up over the Sierra de Ajusco to an altitude of 10,000 feet, and across to Huitzilac on the south slope within the borders of the state of Morelos. On the east side of the valley it ascends the basal slopes of Mounts Popocatapetl and Iztaccihuatl. On the southeast slope of Popocatapetl it occurs at Tochimilco and on the adjacent plain about Atlixco, Puebla. It was also found at Irolo, Hidalgo, at the extreme north end of the Sierra

Nevada de Iztaccihuatl. Wherever found in agricultural land it is very destructive to corn, wheat, and other crops.

CRATOGEOMYS PEROTENSIS sp. nov.

(Pl. 8, fig. 6.)

Type from Cofre de Perote, Vera Cruz (altitude 9,500 feet). No. 54299 ♀ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected May 28, 1893, by E. W. Nelson. (Original No., 4889.)

Geographic distribution.—*Cratogeomys perotensis* inhabits the west and higher slopes of the Cofre de Perote, which are wooded, and probably descends to the northward to meet the range of *C. estor*. Mr. Nelson's specimens were obtained at the altitudes of 9,500 and 12,000 feet (map 4).

General characters.—Size rather large (smaller than *merriami* but larger than *estor*); no naked nose pad; hind feet and tail rather well haired.

Color.—Upper parts dark russet fulvous, everywhere finely mixed with black-tipped hairs; a small dusky patch behind each ear; an irregular white patch at base of tail in some specimens (in eight out of thirteen); under parts dark plumbeous, more or less washed with fulvous; hind feet usually dark proximally and white distally, but sometimes all white (and not always symmetrical on the two feet). Not one of the thirteen specimens is in the slaty-plumbeous pelage so common in *C. merriami*. This species has the tail more hairy than in the others of the *merriami* series, and in a number of specimens it is irregularly blotched with dusky and white, a peculiarity not observed in any other species.

Cranial characters.—Unfortunately the male of *perotensis* is unknown,* all of the thirteen specimens collected by Mr. Nelson on the Cofre de Perote being females. The skull of the female, however, furnishes excellent characters. It agrees with *merriami* in general form, in having the profile of the top of the skull a nearly straight line (not convex as in *fulvescens* and *castanops*) and in having a well developed sagittal crest. Whether or not the squamosals completely overlap the parietal in the adult male, as they do in *merriami*, is not known, but they probably do. Aside from its much smaller size, the skull of the ♀ *perotensis* may be distinguished at a glance from that of *merriami*, and from all other known species of *Cratogeomys*, by the slenderness of the jugal anteriorly. The jugal is not at all enlarged anteriorly, and is deeply mortised into the maxillary arm of the zygoma (see pl. 13, fig. 5).

* Unless one of the specimens obtained near Las Vigas (No. 54311) belongs to this species instead of *estor*. It is an immature male, too young to place the identity beyond question, but has the characters a young male *perotensis* would be expected to possess. The skull as a whole is larger than the adult female of *perotensis* (and hence considerably larger than *estor*); the rostrum and nasals are longer; the jugal is broader anteriorly, and the squamosals have already crept up over part of the parietals and would undoubtedly meet in advanced age.

In some instances the squamosal arm of the zygoma reaches so far forward and the maxillary arm so far backward that the two nearly meet above the jugal. The nasals end on or near the plane of the front of the zygoma, and the ascending branches of the premaxilla reach back past the plane of the lachrymals, thus leaving a long median projection of the frontal between the hinder ends of the premaxillaries. Skulls of *perotensis* may be distinguished from those of *estor* (from the lower northeast slopes of the same mountain) by larger size, much greater length of rostrum and nasals, slenderness of jugal anteriorly, greater length of sagittal crest, and by the form of the frontal between the orbits, which is broadly rounded instead of flat.

Measurements (taken in flesh).—Type: Total length 300; tail vertebræ 79; hind foot 40.

Average measurements of twelve females from type locality: Total length 310; tail vertebræ 88; hind foot 41.5.

For cranial measurements see Table D, p. 210.

Specimens examined.—Thirteen, all from Cofre de Perote, Vera Cruz.

CRATOGEOMYS ESTOR sp. nov.

(Pl. 8, figs. 4 and 5.)

Type from LAS VIGAS, VERA CRUZ (altitude 8,000 feet). No. 54308 ♂ ad. U. S. Nat. Museum, Department of Agriculture collection. Collected June 12, 1893, by E. W. Nelson. (Original No. 5005.)

Geographic distribution.—The pine-covered hills and flats forming the extreme northeastern foothills of the Cofre de Perote, and also the belt of pine forest connecting the timber of the mountain with the wooded hills of the north. Its range is chiefly east and north of that of *perotensis*. *C. estor* thus reaches the extreme eastern edge of the table-land. Mr. Nelson's specimens were obtained at an altitude of about 8,000 feet (map 4, K).

General characters.—Size medium (smaller than *perotensis*); naked nasal pad small or absent; hind feet and tail rather well haired, as in *perotensis*.

Color.—Upper parts dark russet fulvous, everywhere finely mixed with black-tipped hairs; a small dusky patch behind each ear; an irregular white patch at base of tail above (on all ten specimens) and sometimes one below also; under parts dark plumbeous, more or less washed with fulvous; hairs of hind feet whitish, usually to ankle. Not one of the ten specimens is in the melanistic or slaty-plumbeous pelage so common in *merriami*.

Cranial characters.—Skull similar to that of *perotensis* in general form and profile, the top of the skull a nearly straight line—not strongly convex as in *fulvescens* and *castanops*. Contrasted with *perotensis* (the only species with which it requires comparison) *C. estor* differs in the following characters: Size smaller (♂ of *estor* about equaling ♀ of *perotensis*); rostrum much shorter; nasals shorter and broader anteriorly; jugal broader anteriorly and less deeply embeded between forks of maxillary arm of zygoma; frontal broader interorbitally on top of skull, and flat instead of broadly rounded; sagittal crest shorter anteriorly and perhaps not present in the female. The female with distant temporal impressions (No. 54306) figured on pl. 8, fig. 4, is not fully adult; in advanced age the sagittal area is probably nearly or quite obliterated by union of the temporal ridges.

Measurements (taken in flesh).—Type (♂ ad.): Total length 315; tail vertebræ 94; hind foot 41.

Average measurements of four males from type locality: Total length 313; tail vertebræ 89; hind foot 42.

Average measurements of four females from same place: Total length 277; tail vertebræ 75; hind foot 37.

For cranial measurements see Table D, p. 210.

Specimens examined.—Ten, all from Las Vigas, Vera Cruz.

General remarks.—*C. estor* resembles *C. perotensis* so closely in color and external characters that the two are practically indistinguishable except in size, *estor* being decidedly the smaller. In cranial characters, however, they are quite distinct, as pointed out above.

Mr. Nelson states that wherever the pine forests are cleared away and the ground cultivated within the range of this species, the animal multiplies rapidly and becomes exceedingly destructive to crops.

CRATOGEOMYS OREOCETES sp. nov.

(Pl. 8, figs. 1 and 2.)

Type from MOUNT POPOCATAPETL, MEXICO (altitude, 11,000 feet). No. 57963 ♀ yg. ad. U. S. National Museum, Department of Agriculture collection. Collected January 7, 1894, by E. W. Nelson and E. A. Goldman. (Original No. 47.)

Geographic distribution.—The boreal higher slopes of Mount Popocatapetl, above the range of *Cratogeomys merriami* (above 11,000 feet altitude.)

General characters.—Incisor sulcus broadly open and wholly on inner side; size rather large; pelage soft; nasal pad small; hind feet and tail sparsely haired.

Color (of type specimen).—Dusky, darkest on head and along median part of back; tips of hairs washed with pale brown; a golden brown patch under each eye; forefeet dusky; hind feet white. Apparently the specimen is just beginning the change from the plumbeous to the brown pelage.

Cranial characters.—Zygomatic arches narrow, their sides nearly parallel; anterior angle moderately expanded (about as in *Heterogeomys hispidus*); temporal ridges strongly developed; nasals wedge-shaped, not inflated anteriorly, ending posteriorly in front of plane of anterior face of zygoma; ascending branches of premaxilla just reaching plane of orbit, not divaricating behind nasals; frontal flat (orbital edge rounded), rather broad interorbitally and posteriorly, reaching forward between premaxillæ much further than laterally; supraorbital prominences not strongly developed; temporal ridges anterior to interparietal straight, inclosing an elongated wedge-shaped interspace (but very different from the interspace between the strongly curved ridges of *H. hispidus*); interparietal elongated antero-posteriorly, very much longer than broad; jugal long and large, forming an important part of arch; lambdoid crest strongly and evenly convex posteriorly; occipital plane flat, sloping slightly forward from below upward; posterior ends of palatals excavated laterally; pterygoids narrow lingulæ with parallel sides, as in *C. merriami;* audital bullæ relatively short and swollen, more subglobular than in *H. hispidus;* brain case rising abruptly from posterior roots of zygomata, much as in *hispidus* (not flatly rounded as in the *merriami* group and in *peregrinus*). Under jaw short and rather narrow, as in *hispidus;* angular processes short.

Dental characters.—Face of upper incisors unisulcate, the groove wholly on inner side and broadly open, as in *merriami*—not narrow and deep as in *H. hispidus* and *M. heterodus;* breadth of enamel face of upper incisor slightly greater than antero-posterior diameter of tooth; outer side of tooth strongly beveled immediately behind enamel, as in the lower incisor of *merriami.* Lower incisor narrow, the transverse diameter less than the antero-posterior. Crown of last upper molar much broader than long; no distinct heel; the inner side convex, the outer side emarginate and longer. The curvature of the prism of this tooth is much less than in the *merriami* series and less than in *H. hispidus.*

The premolar is the longest tooth and is slightly convex anteriorly; m^1 and m^2 are hardly shorter and are subequal (or m^2 may be slightly the shorter); both are strongly convex anteriorly; m^3 is more than two-thirds the length of m^2 and is only moderately convex anteriorly.

Measurements (taken in flesh).—Type specimen: Total length, 318; tail vertebræ, 92; hind foot, 43.

For cranial measurements see Table D, p. 211.

General remarks.—*Cretogeomys oreocetes* does not require close comparison with any known species. From its nearest neighbor of the lower slopes of the same mountain (*C. merriami*) it differs conspicuously in smaller size, narrower zygomata, shorter and more globular audital bullæ, and in the presence of strongly developed temporal ridges.

From *C. peregrinus*, which inhabits the corresponding boreal slopes of the neighboring mountain, the lofty Iztaccihuatl, it may be distinguished by its narrower and higher cranium, by the beveled outer face of the upper incisor, the convex (instead of notched) inner border of crown of last upper molar, and other characters mentioned under that species.

The measurements of the skull of *C. oreocetes* (see table D) show that the posterior breadth of the cranium is nearly equal to the zygomatic breadth. This is due to the narrowness of the zygomatic arches—not to any unusual breadth of the cranium posteriorly.

CRATOGEOMYS PEREGRINUS sp. nov.

(Pl. 8, fig. 3.)

Type from Mount Iztaccihuatl, Mexico (altitude 11,500 feet). No. 57964 ♀ old. U. S. National Museum, Department of Agriculture collection. Collected January 9, 1894, by E. W. Nelson and E. A. Goldman. (Original No. 50.)

Geographic distribution.—The boreal higher slopes of Mount Iztaccihuatl, above the range of *Cratogeomys merriami* (above 11,500 feet altitude).

General characters.—Size medium or rather large; hind foot and tail scant haired; nasal pad small; forefoot large (with claws nearly equaling hind foot with claws). Color peculiar.

Color (of type and only specimen).—Steel gray from the intimate admixture of dusky and whitish hairs; under parts paler than upper; throat, sides of face, and fore feet darker. The hairs of the hind foot are whitish; of the tail dusky.

Cranial characters.—The skull of the type, a very old female, has the posterior part of the cranium very flat and broad, and the zygomata broad and bowed outward, suggesting *Platygeomys fumosus*. In other respects the resemblances are more in the direction of *Cratogeomys merriami*, with a few characters pointing toward *Heterogeomys*. The zygomatic arches are widely spreading, not divergent anteriorly but broadest across the middle (breadth anteriorly slightly less than greatest breadth of squamosals posteriorly); the anterior roots stand out at nearly a right angle; the antero-external angle is moderately expanded and sharply angular when seen from the side; rounded as seen from above. The jugal is rather large and forms an important part of the arch as in *C. merriami*. The muzzle and nasals are short, the latter broad anteriorly and truncated posteriorly about on the plane of the anterior face of the zygomata. The ascending branches of the premaxilla are broad and blunt posteriorly, barely reach the plane of the orbits, and do not approximate or divaricate behind the nasals. The frontal reaches furthest forward along the median line; the suture at base of maxillary root of zygoma (on top of skull) is nearly a straight line. There is no sagittal crest, but the temporal ridges approximate immediately in front of the interparietal, from which point they divaricate in both directions; anteriorly they slope slightly outward in nearly a straight line to a point about opposite the posterior part of the postorbital prominences of the frontal where they become less distinct and curve abruptly outward. The interspace is an elongated wedge, as in *C. oreocetes*, and is not depressed below the level of the temporal ridges, a result perhaps of the extreme age of the animal. In shape it differs widely from that of the genus *Heterogeomys*. The great breadth of the cranium posteriorly is due to lateral expansion of the squamosals, as in *Platygeomys*. The greatest breadth across squamosals (over mastoids) is slightly greater than the zygomatic breadth anteriorly. The interparietal is not covered by the parietals and is elongated antero-posteriorly. The plane of the occiput is moderately smooth and slopes forward; it is low and broad, the breadth being about two-and-a-half times the height. The mastoid bullæ are much as in *merriami*, except that the inferior border is shorter and the inner side is armed with a short blunt spine projecting inward and slightly backward. (This may be abnormal, but the points are symmetrical on the two sides.) The audital bullæ are rather short and tumid (much as in *oreocetes*) and the anterior projection which abuts against the basisphenoid is sharply set off by a deep notch on the upper side. The palatopterygoids are lingulate, slightly broader than in *merriami*, the sides nearly parallel; mandible short and narrow, resembling that of *oreocetes*, from which it differs in having the angular processes even shorter and the coronoids more hooked.

Dental characters.—Upper incisors with a single very broad and open groove (broader even than in *oreocetes*), its deepest point on the inner side of the median line; breadth of enamel face greater than antero-posterior diameter of tooth. Lower incisors narrow, the breadth of the enamel face being considerably less than the antero-posterior diameter of tooth. Crown of last upper molar not distinctly heeled, its inner border about half the length of outer and deeply notched; outer side broadly concave.

Measurements (taken in flesh).—Type specimen: Total length, 304; tail vertebræ, 87; hind foot, 42.

For cranial measurements see Table D, p. 211.

CRATOGEOMYS CASTANOPS (Baird).

(Pl. 12, fig. 1; pl. 13, fig. 17; pl. 14, fig. 6.)

Pseudostoma castanops Baird, Report Stansbury's Exp'd. to Great Salt Lake, June 1852, 313. (Type from near Bents Fort, Colorado.)

Geomys castanops Baird, Mammals of North America, 1857, 381–386.

Geomys clarkii Baird, Proc. Acad. Nat. Sci., Phila., VII, 1855, 332. (Type from Presidio Del Norte, on the Rio Grande, Chihuahua, Mexico.)

Type locality: "Prairie road to Bents Fort," near the present town of LAS ANIMAS, COLORADO, on the Arkansas River. (Type in U. S. National Museum.)

Geographic distribution.—Isolated areas on the Great Plains from the Arkansas River in Colorado, southward through eastern New Mexico (west to Albuquerque), and western Texas to Santa Rosalia, Chihuahua, and Jaral, Coahuila (map 4, II).

General characters.—Size, medium; coloration, yellowish-brown; tail of medium length; rather scant haired.

Color.—Upper parts yellowish brown or buffy ochraceous tinged with yellowish, more or less mixed with black-tipped hairs, which are much more numerous in winter pelage; under parts buffy.

Cranial characters.—Skull very broad and heavy; zygomatic arches widely spreading anteriorly and strongly decurved; profile of skull convex on top; end of maxillary root of zygoma greatly expanded, forming a broad plate, into which the enlarged head of the jugal is received; *sides of basioccipital parallel*. *C. castanops* differs from *C. fulvescens* in having the basioccipital narrow, its sides excavated and parallel; the nasals and nasal branches of the premaxilla more produced posteriorly; the latter cutting the plane of the orbits, and in lacking the thickened sockets of the upper incisors.

Measurements (taken in flesh.)—An adult male from Las Animas, Colorado (practically type locality): Total length, 295; tail vertebræ, 95; hind foot, 37.

Average of 3 females from same locality: Total length, 256; tail vertebræ, 77; hind foot, 33.

For cranial measurements see Table D, p. 211.

Specimens examined.—Total number 43, from the following localities: Olney, Colorado, 2; Las Animas, Colorado (type locality), 6; Chico Springs, New Mexico, 2; Albuquerque, New Mexico, 3; Eddy, New Mexico, 3; Sierra Blanca, Texas, 1; Marfa, Texas, 3; Eagle Pass, Texas, 13; Samalayuca, Chihuahua, Mexico, 2; Gallego, Chihuahua, Mexico, 2; Santa Rosalia, Chihuahua, Mexico, 4; and Jaral, Coahuila, Mexico, 5.

General remarks.—Coues has already shown that *clarkii* can not be distinguished from *castanops*, and the examination of a much larger series than heretofore available confirms this determination. The peculiar line of demarkation in the type specimen* described by Baird as separating the color of the head and neck from that of the rest of the upper parts, is now well known as the molt line (which progresses from before backward); and the alleged differences in the feet and skull do not hold good in the ample series (forty-three specimens) now at hand. The species presents considerable geographic variation in size (mostly sporadic), as usual in members of the family having an extensive range. The only notable departure from the type observed in the present series is in two specimens from Chico Springs, N. Mex. These specimens are smaller than the type form, brighter and more 'yellowish-chestnut' in color, and the fore feet, hind feet, and tail are distinctly blackish. The tail furthermore is well covered with hair for its entire length.

Mr. Vernon Bailey tells me that *Cratogeomys castanops* is a very injurious species to orchards and nurseries. Along Onion Creek, 30 miles southwest of Marfa, in Presidio County, Texas, he found them eating the roots of fruit trees where "two or three soon spoil an orchard if left in it; the owners did not know how to get rid of them."

CRATOGEOMYS CASTANOPS GOLDMANI subsp. nov.

Type from CAÑITAS, ZACATECAS, MEXICO. No. 57965 ♀ yg. ad. U. S. National Museum, Department of Agriculture collection. Collected December 24, 1893, by E. A. Goldman. (Original No. 286.)

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* The type specimen, formerly in the Patent Office, is now in the National Museum, but is in very poor condition, having been exposed to the light for nearly forty years, as a result of which it is so faded that no trace of the original color remains.

General characters.—Similar to *C. castanops* in size and external appearance, but differing in cranial characters. Tail and hind feet rather well haired for a Pocket Gopher.

Color.—Upper parts dull buffy-ochraceous, moderately mixed with black-tipped hairs; under parts paler.

Cranial characters.—Unfortunately all of the five specimens at hand of this form are females. Compared with females of *C. castanops* the skulls differ in being broader, shorter, and flatter, with less decurved zygomata, and decidedly shorter and broader nasal bones. The shortening is chiefly in the rostrum; the broadening chiefly in the brain case. The basioccipital averages longer and somewhat larger and its sides are less truly parallel, being a little broader posteriorly than anteriorly. The plane of the occiput is narrow and much elongated transversely. The coronoid process of the mandible is long, depressed, and reaches far back.

Measurements (taken in flesh).—Type: Total length, 270; tail vertebræ, 90; hind foot, 35.

Average measurements of three females from type locality: Total length, 257; tail vertebræ, 83; hind foot, 34.3.

For cranial measurements see Table D, p. 211.

Specimens examined.—Total number 5, all from Cañitas, Zacatecas.

CRATOGEOMYS FULVESCENS sp. nov.

(Pl. 12, fig. 2.)

Type from CHALCHICOMULA, STATE OF PUEBLA, MEXICO. No. 58168 ♂ ad. U. S. National Museum, Department of Agriculture collection. Collected January 15, 1894, by E. W. Nelson and E. A. Goldman. (Original No. 5651.)

Geographic distribution.—The basin-like plain of eastern Puebla, Mexico, from Esperanza north to Perote and west to the northeast base of Mount Malinche in Tlaxcala (map 4, J).

General characters.—Upper incisors unisulcate; forefeet shorter than hind feet. Similar in general appearance to *C. castanops*, but larger; color darker; tail rather longer, darker, and slightly more hairy.

Color.—Upper parts grizzled yellowish-brown, liberally mixed with dark-tipped hairs; under parts buffy-fulvous or ochraceous-buff. Compared with *castanops* the general color is darker, owing to more bountiful admixture of dark-tipped hairs.

Cranial characters.—Skull rather massive; zygomata squarely spreading, angles broadly expanded; alveoli of upper incisors thickened; profile of top of skull very convex; rostrum decurved anteriorly.

The fronto-maxillary suture is peculiar, its anterior end usually reaching or nearly reaching the plane of the front of the zygoma—in all the allied species the frontal ends about opposite the middle of the anterior root of the zygoma.

The height of the roof of the cranium above the palate, and of the brain case above the posterior roots of the zygomata, are much greater than in any other member of the genus, and the breadth of the skull posteriorly is much less.

Contrasted with *C. castanops* the skull of *fulvescens* differs in the following particulars: size larger; rostrum broader; sockets of upper incisors thicker, bulging externally; nasals and ascending branches of premaxilla shorter posteriorly, the former hardly reaching plane of front of zygoma, the latter not reaching plane of orbits; basioccipital much broader and wedge-shaped, as usual in the genus (in *castanops* the basioccipital is narrower and its sides are parallel, see pl. 12, figs. 1[a] and 2[a]).

Measurements (taken in flesh).—Type specimen (♂): Total length, 318; tail vertebræ, 102; hind foot, 43.5.

Average of three males from type locality: Total length, 327; tail vertebræ, 105; hind foot, 43.

Average of six females from type locality: Total length, 302; tail vertebræ, 97; hind foot, 39.6.

For cranial measurements see Table D, p. 211.

Specimens examined.—Total number 11, from the following localities: Chalchicomula, Puebla, 9; Perote, Vera Cruz, 2.

General remarks.—*C. fulvescens* does not require close comparison with any known species except *C. castanops*, which it resembles in the grizzled yellowish-brown color of its upper parts. It is more fulvous than *castanops*, from which it differs further in larger size and in the cranial characters above pointed out. Specimens from Perote are more yellowish and less fulvous than those from Chalchicomula.

Mr. Nelson states that this species inhabits the sandy open plain from an altitude of 8,000 feet in the lower parts of the basin up to 9,000 feet on the west slope of Mount Orizaba. He states further: "In this district its range is almost identical with that of *Dipodomys phillipsi*. Like the latter species it follows up the cultivated land into the lower border of the pine forest on Mount Orizaba, and is common also about the northeast base of Mount Malinche. These gophers are particularly numerous in cultivated ground, and are very destructive to corn and grain of all kinds."

Genus PLATYGEOMYS * nob.

(Pl. 3; pl. 10, fig. 8; pl. 13, figs. 1–3; pl. 14, fig. 9; pl. 15, fig. 7; pl. 17, fig. 4; pl. 18, fig. 5; pl. 19, fig. 7.)

Type Geomys gymnurus Merriam, from ZAPOTLAN, JALISCO, MEXICO.

Dental characters.—Upper premolar with three enamel plates (the posterior absent), its shaft nearly straight. First and second upper molars with one enamel plate each (posterior absent).

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* *Platygeomys*, from πλατύς, broad, wide, + *Geomys*, with reference to the great breadth of the cranium.

Third upper molar an incomplete double prism, the outer side abruptly narrowed behind the anterior prism; axis of heel antero-posterior; inner enamel plate normally less than two-thirds as long as anterior plate; not covering posterior face of tooth; outer plate normally as long as inner and usually reaching posterior edge of heel.

Upper incisor strongly *unisulcate*, the sulcus median or slightly on inner side (fig. 21[2]).

Cranial characters.—Skull large, heavy, and flat; hinder part of cranium extraordinarily broad and flat, the great breadth due chiefly to lateral expansion of the squamosals, which not only project as a thin shelf beyond the brain case, increasing the size of the glenoid fossa both anteriorly and posteriorly, but also completely arch over and conceal the postglenoid notch, curving with only a shallow concavity from the posterior angle of the zygomatic arch to and beyond the extreme tip of the transversely elongated mastoid; zygomatic arches massive, broadly spreading anteriorly, the antero-external angle expanded vertically into a triangular plate between the strongly produced and decurved external angle and the evenly rounded orbit (the resulting plate made up in part of the distal end of the maxillary arm of the arch, and in part of the anterior end of the jugal, which is usually expanded); jugal normally large and broad, forming an important part of the arch; pterygoids vertical lamellæ with inferior border everted; orbitosphenoids larger than in *Cratogeomys* but not normally articulating with alisphenoid; mesethmoid a little more than a half crescent, its anterior border strongly rounded above (pl. 18, fig. 5); endoturbinals together forming an elongated oblique plate which is sharply pointed antero-superiorly, owing to the elongation of the upper endoturbinals (pl. 19, fig. 7); no extension of os planum in front of lower endoturbinals and no curving down of vomerine edge of os planum below plane of roof of narial passage; floccular fossa ill defined and not separated from internal auditory meatus by a distinct ridge; ridge separating superior from inner surface of petrous only feebly developed (pl. 17, fig. 4; and pl. 18, fig. 5).

In addition to the above-described generic characters, most of which are in strong contrast to those of *Cratogeomys*, the following points are selected with special reference to antithesis with *Cratogeomys* (which see): Breadth of cranium posteriorly (above mastoids) equal to or greater than greatest zygomatic breadth; breadth of occipital plane at least two and a half times its height; lambdoid crest sinuous, presenting three posterior concavities; squamosal expansion chiefly away from median line—not covering inner part of parietals; mandible very much broader than long* (including incisors); angular processes of mandible

* The extraordinary breadth of the mandible across the angular processes is not due alone to the great length of these processes, but in part to their position. They are higher and more nearly on a level with the incisor protuberance than in any other form, and the jaw as a whole is flatter.

extraordinarily long and spreading, reaching out so far laterally that the knob over root of incisor is midway between condyle and end of angular process (pl. 3); squamosal arm of zygoma covering about half (in *fumosus* more than half) of upper edge of jugal, which latter enters broadly into formation of zygomatic arch; free part of upper edge of jugal equal to length of basioccipital on median line (except in *fumosus*); paroccipital processes large and expanded, forming recurved flanges; incisors slender in contrast to those of the *merriami* series; antero-posterior and transverse diameters of incisors subequal; enamel face of lower incisors forming an inconspicuous bead on outer side of tooth, behind which the tooth is not beveled, the transverse diameter through the enamel face being inappreciably greater than posteriorly.

KEY TO SPECIES OF PLATYGEOMYS.

1[a] *Zygomatic arches parallel or bowed outward in the middle* .... *fumosus.*
1[b] *Zygomatic arches strongly divergent anteriorly*:
  Jugal only slightly expanded anteriory .... *planiceps.*
  Jugal broadly expanded anteriorly:
    Nasals strongly wedge-shaped; narrow posteriorly; reaching plane of zygoma .... *gymnurus.*
    Nasals not wedge-shaped; broad posteriorly; not reaching plane ot zygoma .... *tylorhinus.*

PLATYGEOMYS GYMNURUS Merriam.

(Pl. 3; pl. 10, fig. 8; pl. 13, fig. 2; pl. 15, fig. 7; pl. 17, fig. 4; pl. 18, fig. 5; pl. 19, fig. 7.)

Geomys gymnurus Merriam, Proc. Biol. Soc. Washington, VII, Sept. 29, 1892, 166-167.

Type locality.—ZAPOTLAN, JALISCO, MEXICO. (Type in U. S. National Museum.)

Geographic distribution.—Valley of Zapotlan and adjacent slopes of the Sierra Nevada de Colima, Jalisco, and the volcano of Colima down to the upper edge of the plain of Colima, Mexico.

General characters.—Size very large; a naked pad on end of nose; tail naked; feet sparsely haired; hinder part of cranium extraordinarily broad.

Color.—Upper parts dark reddish-brown or chestnut, varying to sooty plumbeous or slate-black, slightly paler below. The rusty specimens have a dusky patch about each ear and a larger one on the nose. The depth of the chestnut seems to increase with the age of the hair, specimens in the molt having the new hair very dark and only washed on the tips with chestnut. The hairs of the hind feet are scattered and nearly colorless. The young are glossy slate-black, with the sides and rump conspicuously sprinkled with whitish bristles.

Cranial characters.—The skull of *Platygeomys gymnurus* differs from all others of the family (except the related *P. tylorhinus* and *planiceps* here described) in the extraordinary breadth and flatness of the hinder part of the brain case, the result of lateral expansion of the squamosals, which completely arch over and conceal the postglenoid notch, curving with a shallow concavity from the posterior angle of the zygomatic arch to the extreme tips of the transverely elongated mastoids, which they overreach. The breadth of the cranium here equals or exceeds the greatest zygomatic breadth. Correlated with this unprecedented breadth of the posterior part of the cranium is an even more extreme lateral extension of the angular processes of the mandible. The zygomatic arches are widely spreading anteriorly, with broadly expanded subtriangular outer angles. The jugals are large, broadly expanded anteriorly, enter largely into the outer wall of the orbital fossa, and, as a rule, terminate anteriorly in a straight edge, which articulates with the lower third of the ascending or maxillary arm of the zygoma without being mortised into it as usual in the group; still the front of the jugal rests on a strong shelf of the maxillary arm, and is commonly overtopped by a short spicule. The exposed part of the upper edge of the jugal forming part of the outer wall of the orbital fossa is usually, though not always, as long as the basioccipital (on median line), and as a rule the posterior half of the jugal is overlapped by the squamosal arm of the zygoma. The fronto-maxillary suture is straight or slightly convex outward, while its continuation as the premaxillo-maxillary suture (on top of the skull) is strongly concave inward, the result being that the suture at the base of the maxillary arm of the zygoma, taken as a whole, is shaped like the letter S somewhat drawn out. In *tylorhinus* and *planiceps* it is broadly and uniformly convex inward. The nasals end posteriorly on or a little behind the anterior plane of the zygoma, and are strongly wedge-shaped and much narrower posteriorly than in *tylorhinus*. The nasal branches of the premaxilla may or may not reach the plane of the orbits; they approximate slightly behind the nasals.

The occipital plane is exceedingly broken and irregular; the lambdoid crest overhangs it as a sinuous ledge throughout its entire length; the greatly enlarged paroccipital processes stand out like broad flanges from the exoccipitals, projecting strongly outward and backward, forming, in conjunction with the middle part of the lambdoid crest, a remarkable basin-shaped inclosure, outside of which, and far anterior to the great paroccipital flanges, are the transversely-elongated mastoids (pl. 15, fig. 7). In striking contrast is the smoothly planed-off occiput of *Heterogeomys hispidus* (pl. 15, fig. 4).

The shape of the lambdoid crest is peculiar; it is deeply sinuous, with three concavities directed forward (of which the median is deep, the lateral shallow), and two strong convexities directed backward; at each end it terminates in a club-shaped knob directed outward. Looking at the skull from above there is nothing to indicate the limits of the brain case, the broad squamosals being convex upward behind the zygomata, without trace of the lateral depression that marks off the brain case in *Cratogeomys* and most other members of the family.

Measurements (taken in flesh).—Average of three males from type locality (Zapotlan, Mexico): Total length, 352.6; tail vertebræ, 105.3; hind foot, 53.3. Average of three females from same place: Total length, 341; tail vertebræ, 91; hind foot, 49.6.

For cranial measurements see Table E, p. 212.

Specimens examined.—Total number, 10, from the following localities in Jalisco, Mexico: Zapotlan, 7; Sierra Nevada de Colima, 3.

General remarks.—*Platygeomys gymnurus* may be regarded as the type (for it is the largest and most extreme in cranial peculiarities) of a remarkable series of Pocket Gophers inhabiting southern Mexico from the Sierra Nevada de Colima of Jalisco eastward to the north slope of the Volcan Toluca in the State of Mexico, and Tula in Hidalgo. Externally these animals differ so little from the larger species of *Cratogeomys* as to be distinguished with difficulty, but in cranial characters they may be told at a glance. The number of recognizable forms now known is four, of which one (*fumosus*) is very distinct from the others; the remaining three are closely related (*gymnurus*, *tylorhinus*, and *planiceps*) and two of them (*tylorhinus* and *planiceps*) may be found to intergrade when specimens are obtained from intermediate localities along the line of their distribution, in which event the latter must be reduced to subspecific rank. Still another form that might be deemed worthy of separation is the Patzcuaro animal mentioned under the head of *P. tylorhinus.*

All the members of the *gymnurus* series have the upper parts more or less plentifully sprinkled with long, slender, bristle-like hairs which protrude far beyond the ordinary fur. In *fumosus* these hairs are very conspicuous, owing to the marked contrast of their whitish color with the blackish-slate of the body; the same is true of the young in *gymnurus*, but in the adult they harmonize so well with the prevailing reddish-brown or chestnut tints that they may be easily overlooked. They are most abundant in the Patzcuaro specimens of *tylorhinus.*

Mr. Nelson states that the range of *Platygeomys gymnurus*, so far as determined by him, is limited to the valley of Zapotlan and slopes of the Sierra Nevada de Colima and base of the adjacent volcano of Colima, and the immediate vicinity. On the north slope of the Sierra Nevada de Colima he found them up to an altitude of 11,000 feet, among the firs and alders, where a specimen was secured. Thence to the base of the mountain they are rather common on open grassy slopes, and range out over all of the adjacent valley of Zapotlan. In this latter district they were usually found in fields, where they do much damage to corn and wheat. Zapotlan Valley has an altitude of about 4,500 feet, and is an open basin-like plain just below the pines and oaks of the mountains. On the extreme upper border of the plain of Colima, near the southwest base of the volcano, at an altitude of about 3,500 feet, he saw numerous diggings of a gopher, which was probably this species.

PLATYGEOMYS TYLORHINUS sp. nov.

(Pl. 13, fig. 1.)

Type from TULA, HIDALGO, MEXICO. No. 51883 ♂ ad. U. S. National Museum, Department of Agriculture collection. Collected March 13, 1893, by E. W. Nelson. (Original No. 4442.)

Geographic distribution.—Tula, Hidalgo, and thence southwesterly along the north slope of the Sierra Madre to the vicinity of Patzcuaro, Michoacan.

General characters.—Size, large; tail nearly naked; a naked pad on end of nose; coloration dark. Similar to *P. gymnurus*, but smaller, with shorter and more hairy hind feet, which are distinctly white in contrast to dark of ankles and legs; skull remarkably broad and flat, as in *P. gymnurus*, but lighter and differing further in important characters.

Color.—Upper parts chestnut or liver-brown, as in *Geomys bursarius;* under parts similar but slightly paler, the plumbeous showing through in places; legs and ankles concolor with body; hind feet white in contrast.

Cranial characters.—Skulls of *P. tylorhinus* differ from those of *P. gymnurus* in smaller size, narrower rostrum, and shorter nasals, which do not reach plane of zygomatic arches. The most conspicuous difference is in the shape of the nasals: instead of being wedge-shaped, as in *gymnurus*, they are much broader posteriorly and abruptly truncated behind, and the premaxillæ do not approximate behind them. The skull as a whole is much less massive and the maxillary arm of the zygoma less thickened than in *gymnurus*. The jugal is enlarged throughout and expanded anteriorly into a broad plate which abuts against the sides of the maxillary part of the zygomatic arch, which latter is hardly excavated to receive it, sending out a small shelf below and a short spicule above, much as in *gymnurus*. The suture at the base of maxillary root of zygoma is broadly convex inward; in *gymnurus* it is shaped like a drawn-out S. As usual, the skull of the female is much smaller than that of the male, and the jugal is narrower.

Measurements (taken in flesh).—Type specimen, ♂ ad.: Total length, 345; tail vertebræ, 100; hind foot, 45. Average of two ♀ specimens from type locality: Total length, 298; tail vertebræ, 91.5; hind foot, 39.5.

For cranial measurements see Table E, p. 212.

Specimens examined.—Total number 9, from the following localities in Mexico: Tula, in Hidalgo, 4; Patzcuaro, in Michoacan, 5.

General remarks.—Specimens from Patzcuaro, State of Michoacan, are intermediate in size and form of nasals between *gymnurus* and typical *tylorhinus* from Tula, but exceed the latter in the expansion of the jugal and whiteness of the hind feet. The hind feet are more hairy, and the ankles are dark plumbeous instead of chestnut, causing the white to stand out in stronger contrast. Skulls of the Patzcuaro animal differ further from those from Tula in having smaller and shorter pterygoid lamellæ (as seen from the side), leaving more space between their posterior edge and the audital bullæ. The posterior ends of the palatals are smaller, thicker, and have the outer edge straighter. In the Tula skulls the palatals are thinner and broader, with the outer edge irregularly sinuous. In the Patzcuaro animal the jugals are conspicuously broader anteriorly than in those from Tula, but as in the latter they are much less expanded in the female than in the male.

There is an average difference in external characters by which the Patzcuaro specimens may be distinguished from specimens from Tula and the Volcano of Toluca. They are darker and richer in color (the chestnut being more ferruginous), and the head is mainly slate-black, more or less faintly washed with rusty. This color does not cover the head uniformly but is disposed in a tolerably regular pattern from which there is little variation in the series of specimens at hand. The slate-black covers the muzzle, reaching back along the median line as far as the plane of the eyes, and sends a broad arm backward on each side to the shoulders, inclosing the eye and ear. The chestnut of the back comes forward over the top of the head to about the plane of the eyes, and on the sides of the face below the eyes to and sometimes including the cheeks. Possibly there is something seasonal in this pelage; all of the Patzcuaro specimens were collected at the same time—the latter half of July.

Mr. Nelson contributes the following information respecting the local distribution of *P. tylorhinus:* "I found this species common along the north slope of the mountains about Lake Patzcuaro and thence to the vicinity of Lake Cuitzeo, in Michoacan. All of this district lies in the zone immediately below the pines (from about 5,500 to 6,800 feet altitude), and is largely cultivated to wheat and corn. The gophers are particularly numerous in the fields, where they do considerable damage to crops. They range up into the lower border of the forest where *Zygogeomys trichopus* is found. Beyond Lake Cuitzeo no work was done to the northeast until Tula, Hidalgo, was reached. There these animals were found in small numbers at an altitude of about 6,000 feet, in the vicinity of the town. They were only noted about the borders of small basin-like sinks, where the land was under cultivation. Not being numerous here their depredations in the grainfields were of little moment. The district from Lake Cuitzeo to Patzcuaro has a cool climate, with abundant rains during the summer months. Tula lies in a much more arid and warmer zone."

PLATYGEOMYS PLANICEPS sp. nov.

(Pl. 13, fig. 3; pl. 14, fig. 9.)

?*Ascomys mexicanus*, Licht., Brants Muizen, 1827, 27-31 (in part).

Type from north slope VOLCAN TOLUCA, MEXICO. No. 55906 ♂ U. S. National Museum, Department of Agriculture, collection. Collected September 12, 1893, by E. W. Nelson. (Original No. 5466.)

Geographic distribution.—Northern and eastern slopes of the volcano of Toluca and adjacent part of the valley to the city of Toluca, from an altitude of 8,600 feet up to the vicinity of timber line.

General characters.—Similar to *P. tylorhinus*, from which it differs inappreciably in external appearance except in the greater length of the tail. Upper incisors unisulcate; skull broad and flat; size large; tail nearly naked; a naked pad on end of nose; forefeet with claws shorter than hind.

Color.—Upper parts chestnut, as in *tylorhinus* from Tula; under parts similar but paler, the plumbeous basal fur showing through in places; legs and ankles concolor with body; hairs of hind feet whitish, but scant. Nose below eyes blackish; a large blackish spot around each ear. One specimen is dark plumbeous, washed with chestnut, and has the head markings described under the Patzcuaro specimens of *tylorhinus.*

Cranial characters.—Skull similar to that of *tylorhinus*, from which it differs chiefly in the form of the jugal bone, which is narrow throughout or very slightly expanded anteriorly—not broadly expanded as in *tylorhinus.* It differs further from *tylorhinus* in having the nasals less squarely truncate posteriorly (and ending about on plane of middle of maxillary root of zygoma); the ascending branches of premaxilla rounded posteriorly and ending near anterior plane of orbits—not passing nasals so far as in *tylorhinus;* the cranium very broad and flat; occipital plane more than two and a half times as broad as high. The rostrum is narrow, but not narrower than in some specimens of *tylorhinus* from Tula.

Measurements (taken in flesh).—Type specimen ♂: Total length, 372; tail vertebræ, 121; hind foot, 46. Average of two females from type locality: Total length, 336.5; tail vertebræ, 100; hind foot, 43.

For cranial measurements see Table E, p. 212.

Specimens examined.—Three, all from the north slope of the Volcan de Toluca, State of Mexico.

General remarks.—This animal may prove to intergrade with *tylorhinus* of Tula, in which case it must be reduced to subspecific rank. The number of specimens at hand (only three) is not sufficient to determine the constancy of the characters that distinguish it from *tylorhinus.* The chief differences, as above stated, are the longer tail and narrower jugal. The jugal is always narrower in females than in males, and two of the three specimens are females. The male (type specimen), while full grown, is not old, and its jugal may be abnormally slender, though there is nothing about the skull to suggest this belief. In the light of the present material no course seems open but to recognize the animal as a distinct species. It may be remarked, however, that it is the poorest species described in the present paper.

Respecting its local distribution Mr. Nelson states: "On the slopes of the Volcano of Toluca this species is not very numerous, but is found scattered in small numbers continuously from the base of the mountain up to the vicinity of timber line, usually in open parts of the pine forest and in small grassy parks. It is more common in the valley of Toluca, where it inhabits fields and grassy meadows and is very destructive to crops."

PLATYGEOMYS FUMOSUS Merriam.

(Pl. 11, fig. 4, and pl. 14, fig. 8.)

Geomys fumosus Merriam, Proc. Biol. Soc. Washington, VII, September 29, 1892, 165-166.

Type locality.—COLIMA CITY, MEXICO. (Type in U. S. National Museum.)

Geographic distribution.—Plain of Colima, Mexico. (Altitude 1,500 to 2,000 feet.)

General characters.—Size medium, about equalling *Geomys bursarius* (smaller than the other species of *Platygeomys*); pelage rather soft, sparingly mixed with long whitish bristles, which are most abundant on the rump; tail and hind feet nearly naked; nasal pad not strongly developed; color very dark.

Color.—Upper parts everywhere plumbeous slate or dark sooty-brown, faintly washed in places, particularly along the sides, with pale reddish-brown; color of upper parts fading in worn pelage to pale dull liver brown, usually in irregular patches; underparts scant haired, pale plumbeous, sometimes indistinctly washed with pale brownish. A young specimen, about half grown (No. 34186 ♂), is rich slate black above, conspicuously lined with whitish bristly hairs, which are most abundant on the rump, and more so on the sides than along the middle of the back. There is also a faint brownish tinge on the sides of the neck. The scant hairs of the belly are very pale plumbeous or even soiled whitish.

Cranial characters.—Skulls of *Platygeomys fumosus* agree with those of the other members of the *gymnurus* group in the extreme breadth of the hinder part of the cranium, due to the expansion of the squamosals beyond the parieties of the brain case, and in the great lateral production of the angle of the mandible. *P. fumosus* departs from the *gymnurus* series markedly in the form of the zygomatic arches, which, when looked at from above, are rounded instead of sharply angular anteriorly, and have the sides nearly parallel or bowed outward, so that they are broadest across the middle instead of anteriorly. In *gymnurus* they are usually widely divergent anteriorly. *P. fumosus* differs further from the other members of the *gymnurus* series in greater interorbital breadth of frontals; strongly wedge-shaped nasals; more elongated postpalatal pits (which reach the plane of front of last molars), and in having the anterior end of jugal more deeply embedded between the terminal forks of the maxillary arm of the zygoma.

The jugals are but slightly (sometimes not at all) expanded anteriorly, in which respect the species agrees with *P. planiceps*, from the Volcano of Toluca. It differs from the latter greatly in the extent to which the jugal enters into the formation of the zygomatic arch; the jugal being so far overlapped by the maxillary and squamosal roots of the arch that its free upper border is short—less than half the length of the basioccipital in median line. It differs from *planiceps* further in broader rostrum, less spreading and more strongly decurved zygomata, and shorter and broader ascending arms of the premaxilla, which are bluntly rounded off opposite the middle of the maxillary root of the zygoma.

Measurements.—Average of seven males from type locality: Total length, 287.5; tail vertebræ, 82.2; hind foot, 42. Average of three females from type locality: Total length, 277; tail vertebræ, 75.3; hind foot, 39.6.

For cranial measurements see Table E, p. 213.

Specimens examined.—Total number, eleven; all from Colima City, Colima, Mexico.

General remarks.—*Platygeomys fumosus* belongs to the *gymnurus* series, of which it is the smallest species yet described. It differs markedly from the other members of the series in having the zygomatic arches rounded and nearly parallel instead of sharply angular and strongly diverging anteriorly; and differs further in having the sides and rump beset with whitish bristles that protrude far beyond the fur.

The original description of this species was faulty in several respects and is here corrected. The material collected by Mr. Nelson since the original description was published has thrown a flood of light not only on the affinities of this species but also on the whole group. It is now clear that *fumosus* is not related in any way to *hispidus*, authentic skulls of which are now available for the first time.

Mr. Nelson found this species limited in distribution. His notes state that it was rather numerous in damp saline flats overgrown with cocoanut palms, wild fig trees, mesquites, and acacias, in the valley of the Colima River near the city of Colima. In the vicinity of Armeria, at an altitude of about 200 feet, a few hills were seen but none of the animals were caught. Thence up the course of the Armeria river, on the plain of Colima the hills became more and more numerous, especially between the altitudes of 800 and 2,500 feet. The animals seem to live in isolated and limited colonies, between which, in apparently equally favorable ground they occur singly and rarely. One colony of considerable size occupies an open grassy area in the limestone belt between Colima and the volcano; others were seen along the sandy border of the Armeria river bottom in a growth of low bushes, and in some thick thorny woods on a dry bench bordering the Colima river a few miles below the city.

Genus ORTHOGEOMYS* nob.

(Pl. 19, figs. 1 and 2; text figs. 60–64; map 3[5].)

Type Geomys scalops Thomas, from TEHUANTEPEC, MEXICO.

Dental characters.—Upper premolar with three or four enamel plates, the posterior when present restricted to inner fourth; † m^1 and m^2 with two enamel plates each. Third upper molar with an elongated heel and deep outer sulcus; inner sulcus variable; both inner and outer enamel plates normally reaching posterior end of heel, the inner plate usually covering the posterior half of the inner side of the tooth, leaving a broad cement band in front of it (fig. 34, [7], [8], and [9]). In *O. scalops* the outer plate is often divided, presenting an anomalous condition in the family (fig. 62). Posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 strongly developed. Shaft of upper pm straight.

Upper incisor *unisulcate*, the sulcus widely open and slightly on inner side, but sometimes reaching middle.

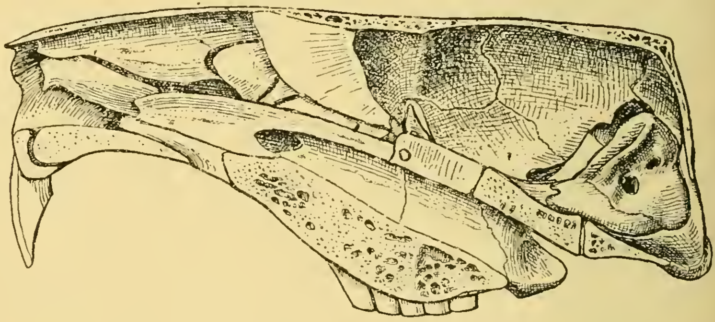


FIG. 60.—*Orthogeomys scalops*. Longitudinal vertical median section of skull, mesethmoid and vome in place. (For key see fig. 7.)

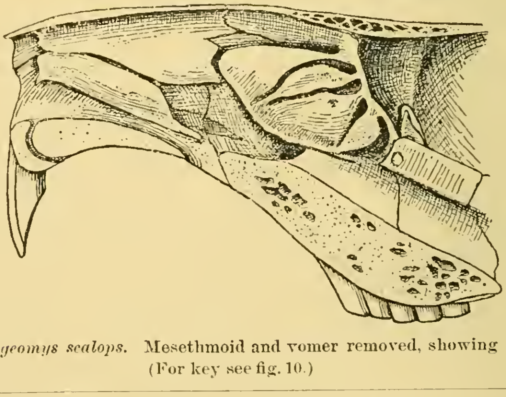


FIG. 61.—*Orthogeomys scalops*. Mesethmoid and vomer removed, showing endoturbinals. (For key see fig. 10.)

* *Orthogeomys*, from ὀρθός, straight, + *Geomys*, in reference to the unusual shap of the skull.

†The posterior plate is present in both upper premolars of the type and only know specimen of *O. latifrons*, but is altogether absent, or present as a very narrow stri on one side only, in *O. scalops* and *O. nelsoni*.

Skull as a whole much elongated; frontal extraordinarily broad and flat, much broader than muzzle, with sides nearly parallel (not excavated or concave laterally between the orbits, fig. 17[4]); orbital plates of frontal not meeting inferiorly behind cribriform, but broadly separated by orbitosphenoids, as in *Pappogeomys* and *Thomomys*. Zygomata narrow or only moderately spreading. Brain case subcylindric, as seen from above, in continuation of the general form of the frontal and muzzle. Angle of mandible short. Orbitosphenoids rather large, articulating with the anterior part of the alisphenoids and sending a tongue upward, partly filling the upper part of the sphenoidal fissure (fig. 60). Mesethmoid a half crescent, as in *Cratogeomys;* endoturbinals as a whole quadrangular, the anterior border essentially parallel to cribriform plate; first endoturbinal only slightly expanded and rounded anteriorly, as in *Geomys;* third endoturbinal larger and much broader than second—a unique condition in the family (fig. 61). The palatopterygoids are long and narrow, and of nearly equal breadth throughout; the basal third or less, is palatine; the distal two-thirds or more, pterygoid. The foramen rotundum and foramen ovale are nearer together than usual, and sometimes merge into a single large opening which communicates directly with the alisphenoid canal.

FIG. 62.—*Orthogeomys scalops*. Last upper molar. *b*, divided outer enamel plate.

External characters.—Size large; pelage very coarse, hispid or setose; nasal pad present or absent.

Cranial characters.—The chief cranial characters that distinguish *Orthogeomys* from the other genera having essentially the same enamel pattern of the molariform series (*Heterogeomys* and *Macrogeomys*)* are the great breadth of the frontal interorbitally, absence of interorbital constriction, absence of conspicuous postorbital prominences or ridges, large size and extended relations of orbitosphenoids, peculiar form of endoturbinals, and shape of the palatopterygoids. The great length and narrowness of the cranium as a whole is matched by *Macrogeomys dolichocephalus*, but the nearly uniform breadth of the upper part of the skull and the form of the zygomata and palatopterygoids are very different. The posterior position of the lateral enamel plates of m^3, both of which normally reach the end of the heel, is a distinctive character.

KEY TO SPECIES OF ORTHOGEOMYS.

Pelage setose; muzzle short .... *latifrons*.
Pelage not setose; muzzle long:
  Frontal inflated on orbital margin anteriorly; m^3 normal—
    Nasals broad posteriorly .... *grandis*.
    Nasals narrow posteriorly .... *nelsoni*.
  Frontal inflation slight or absent; m^3 with outer enamel plate divided .. *scalops*

*It has been stated in the preceding footnote that the upper premolar of *Orthogeomys* normally has only three enamel plates, while in *Heterogeomys* and *Macrogeomys* four are always present. Hence the enamel pattern can hardly be said to be the same.

ORTHOGEOMYS SCALOPS (Thomas).

(Pl. 19, figs. 1 and 2, and text figs. 60–62.)

Geomys scalops Thomas, Annals and Mag. Nat. Hist., 6th series, XIII, May, 1894, 437–438.

Type from TEHUANTEPEC, MEXICO. (Type in British Museum).

Geographic distribution.—Extreme southern Mexico, in State of Oaxaca, and probably adjacent part of Chiapas.

Mr. Nelson states that on the pine-covered slopes of the Cerro San Felipe, a few miles north of the city of Oaxaca, he found the diggings of this gopher extending upward from an altitude of about 7,000 feet to the summit (altitude about 10,500 feet), always in pine or oak timber or in the small openings that occur in the forest.

General characters.—Size rather large; pelage hispid; naked nasal pad large (measuring 20 mm. in length in fresh specimen); tail naked; hind feet naked, except for a few scattered colorless hairs; ear opening surrounded by a broad, thickened rim.

Color.—Type specimen in worn, faded pelage: "Smoky-brown, tending rather toward rufous (very near 'Prout's brown' of Ridgway)."—Thomas. An adult specimen from Cerro San Felipe, Oaxaca, collected June 21, 1894, by E. W. Nelson, is in good pelage and is dark seal-brown (almost black in places) with an evident gloss.

Cranial characters.—Skull of adult ♀ very long and narrow; frontal very broad interorbitally, not constricted in front of postorbital processes; zygomata little spreading, flattened, elongated antero-posteriorly, the outer sides parallel; occipital plane sloping forward; paroccipital flanges turned backward, but not reaching plane of occipital condyles; palatopterygoids narrow, of nearly uniform breadth throughout, the pterygoids forming distal two-thirds, but not reaching base of notch (see pl. 19, fig. 2). Inferiorly the premaxilla reaches far behind the incisive foramina. Contrasted with *latifrons*, which it greatly resembles, *scalops* differs in having the rostrum much longer, the nasals broader, more arched anteriorly, and longer, and the jugal broader anteriorly. The resemblances and differences are such as to at once suggest sexual variation—the skull of *O. latifrons* differing from that of *scalops* in the way that female skulls usually differ from males in the *Geomyidæ*—smaller size, shorter rostrum, and narrower jugals. But, unfortunately for this hypothesis, the specimen of *scalops* is an adult female, as shown both by the collector's label and by the conspicuous teats on the dry skin. Furthermore, the grooving of the upper incisors is very different and the external characters are marked.

Since the above was written I have received nine additional specimens of *O. scalops* from Mr. Nelson, all collected in the Cerro San Felipe, near the city of Oaxaca, during the last week of August and 1st of September, 1894. Two of these are adult males. Their skulls differ from those of the female in slightly larger size; more spreading and somewhat heavier zygomata, which divaricate anteriorly instead of being parallel; in a more decided tendency to inflation of the anterior part of the border of the frontal; the development of a long sagittal ridge, and of much larger paroccipital processes, which reach backward behind the plane of the condyles.

Male skulls of *scalops* from Cerro San Felipe, Oaxaca, differ from males of *nelsoni* from Totontepec and Mount Zempoaltepec, Oaxaca in the following characters: Size smaller, muzzle much narrower, the narrowness especially marked in the ascending branches of the premaxilla; nasals decidedly broader posteriorly and less evenly acuminate, spreading more abruptly in front of the middle; zygomatic arches more slender and more divergent anteriorly; frontal inflation less pronounced; paroccipital processes much larger and directed more strongly backward, exceeding the plane of the condyles; occipital plane less flattened, and marked by three ridges, a median ridge and two lateral; palatopterygoids shorter; groove of upper incisors narrower.

Dental characters.—Molars as in the genus. Upper incisors with a single deep and rather broad furrow wholly on inner side; outer side strongly convex. In *latifrons* the groove is relatively shallow and median, or nearly so. The outer enamel plate of the last upper molar is usually divided, making four instead of three plates for this tooth, a condition not observed elsewhere in the family (fig. 62).

Measurements.—Type specimen (measured by Thomas from dry skin): Head and body, 270; tail, 95; hind foot, 45.2 (without claw, 40).

Average of two males from Cerro San Felipe, Oaxaca (measured in flesh): Total length, 369; tail vertebræ, 103.5; hind foot, 50.*

Average of eight females from same place: Total length, 360; tail vertebræ, 109; hind foot, 50.

Cranial measurements.—Type specimen (measured by Thomas): Basal length, 63; basilar length of Hensel, 56.7; greatest zygomatic breadth, 40.8; nasals, length 26, greatest breadth, 8; least breadth of muzzle above maxillo-premaxillary suture, 15; interorbital breadth, 14.2; between tips of postorbital processes, 16.2; postglenoid breadth, 26.7; greatest squamosal breadth, 39; basion to occipital crest, 18.4; between tips of paroccipital processes, 27.5; palate from gnathion, 47; diastema, 24.5. Upper molar series on crowns, 12.6; breadth of m^1, 4; least height of muzzle on diastema, 12.

For other cranial measurements see Table F, p. 214.

Specimens examined.—Total number 13: 10 from Cerro San Felipe, Oaxaca, Mexico; 3 from mountains 15 miles west of city of Oaxaca.

General remarks.—*Orthogeomys scalops* seems to be more closely related to *O. grandis* than to *O. nelsoni.*

ORTHOGEOMYS GRANDIS (Thomas).

(Text fig. 63.)

Geomys grandis Thomas, Annals and Magazine Nat. Hist., 6 ser., XII, October, 1893, pp. 270-271.

Type locality.—Dueñas Guatemala. (Type in British Museum).

*A larger series of males would undoubtedly result in larger average measurements, as neither of our specimens are very old.

Geographic distribution.—"Common all over the highlands [of Guatemala], and traces of their presence are to be met with almost everywhere in the neighborhood of Dueñas."—Biologia Centrali-Americana, Mammalia, 1880, 160.

General characters.—Size very large; upper incisors deeply unisulcate, the sulcus on inner side and widely open; tail naked; fore and hind feet "very thinly haired, the few scattered bristles whitish;" pelage coarse. The following quotation is from Mr. Thomas's description of the type specimen:

Color.—"Smoky chocolate brown throughout, except on the muzzle, cheeks, and chin, where the hairs are white or pale whitish brown. A few white hairs scattered over the back."

Cranial characters.—"Skull large and heavily built. Ascending processes of premaxillaries surpassing the nasals by about a quarter of an inch; the space between them behind the nasals less than the breadth of one of them. Interorbital space broad, as broad as the muzzle, its edges anteriorly rounded and inflated in a manner quite unique. Zygomata not very widely expanded in proportion to the size of the skull.

"Incisors pale yellow or whitish, in marked contrast to the deep orange found in the allied species. Their single groove deep and very widely open, so that its greatest width on the cutting edge amounts to 2 mm.; in position the bottom of the groove is internal, the breadth of the inner portion of the tooth being about 43 to 45 percent of the whole; owing, however, to the great breadth of the groove itself, it considerably overlaps the median line, but the above percentage is taken strictly from the bottom of the groove. Molar teeth large."*

Measurements of type specimen (from dry skin).—Head and body, 320; tail, 135; hind foot, with claw, 57; without claw, 50; longest foreclaw, 23. For cranial measurements see Table F, (p. 214).

General remarks.—This animal, though long known from Guatemala, had been confounded with *hispidus* until recently separated by Mr. Thomas, who, struck by its larger size and some other external differences, removed the skull from one of Mr. Salvin's original Dueñas specimens and discovered the remarkable cranial peculiarities above mentioned.

ORTHOGEOMYS NELSONI sp. nov.

(Text fig. 63.)

Type from MT. ZEMPOALTEPEC, OAXACA, MEXICO. (Altitude 8,000 feet.) No. 66751 ♂ ad. U. S. National Museum, Department of Agriculture Collection. Collected July 8, 1894, by E. W. Nelson and E. A. Goldman. Original No. 6376.

Geographic distribution.—Mt. Zempoaltepec in the State of Oaxaca, Mexico, and the adjacent region, including Comaltepec and Totontepec.

General characters.—Size, largest of the known species of the family, slightly exceeding *O. grandis* of Guatemala, which it closely resembles, differing chiefly in the fronto-nasal region of the skull. Ears larger than in any other member of the family; naked nasal pad large; tail naked except at base.

* Annals and Magazine Nat. Hist., XII, October, 1893, 270–271.

Color.—Uniform dull dark-brown; hardly paler below.

Cranial characters.—Skull large, long, and heavy, resembling both *scalops* and *grandis*, but differing from both in the shape of the nasal bones, which are *very much narrower posteriorly*. Mr. Oldfield Thomas has had the kindness to compare his type of *grandis* with the type and other skulls of *nelsoni* sent him for the purpose, and has taken the trouble to give me a sketch of the fronto-nasal region of *grandis*, with a number of detailed measurements which show the differences between the two forms. In addition to the striking narrowness of the nasals posteriorly, *nelsoni* differs from *grandis* further in the following points: the ascending arms of the premaxilla reach much further backward, cutting the plane of the orbit; the articular face of the maxillary root of the zygoma (on top of the skull) is much longer, measuring 11.5 instead of 8.7 mm.; the frontal is both narrower and shorter between the nasal branches of the premaxilla; the muzzle is narrower, the frontal broader, and the frontal inflations are more anterior and less extreme. The mandible differs, not only from *grandis*, but from all known members of the family in the absence of the capsular inflation over the root of the incisor, between the condyle and angular process. It is entirely wanting in the type, and only faintly apparent in the adult female from the same locality. It is larger, but still abnormally small, in an old male from near *Totontepec* (No. 66753). The skull of the latter specimen is the largest I have seen of the species and the jugal is broader anteriorly than in the specimens from Mount Zempoaltepec.

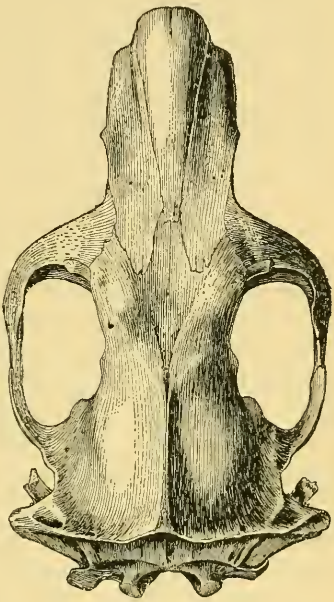


FIG. 63.—*Orthogeomys nelsoni* ♂ type (natural size). From Mount Zempoaltepec, Oaxaca, Mexico.

Skulls of *O. nelsoni* differ from those of *O. scalops* in larger size, much broader muzzle, heavier zygomata, longer nasals, which are much narrower posteriorly and truly cuneate in form; much broader ascending branches of premaxilla; broader and decidedly more inflated frontal; U-shaped, instead of V-shaped postglenoid notch; flatter occipital plane, with less backward extension of the paroccipital processes.

Measurements.—Type specimen, an adult ♂ from Mount Zempoaltepec: total length, 397; tail, 123; hind foot, 53. Another male, from near Totontepec, is even larger: total length, 435; tail, 140; hind foot, 55. An adult female from Mount Zempoaltepec measures: total length, 380; tail, 118; hind foot, 52.

For cranial measurements see Table F, p. 214.

Specimens examined.—Five, all from the State of Oaxaca, southern Mexico: Mount Zempoaltepec, 2; near Totontepec, 2; Comaltepec, 1.

General remarks.—In color the specimens of *O. nelsoni* differ materially from Mr. Thomas's description of *grandis*. They are in worn pelage, and are very dark-brown, but the muzzle and cheeks are not paler. In fresh pelage they would probably resemble *O. scalops* in being rich seal-brown, almost black. The feet are evidently more hairy than those of *grandis*, and the ears are larger than in any other member of the family, measuring about 5 mm. in height in the dry skin.

ORTHOGEOMYS LATIFRONS sp. nov.

(Pl. 11, figs. 5 and 6; text fig. 64.)

Type from GUATEMALA. Exact locality unknown. No.——. U. S. National Museum (No. 2 World's Fair exhibit of Guatemala).

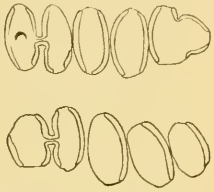
General characters.—Size medium (rather small for the tropical American species); incisor groove median or nearly so; tail long and absolutely naked; hind feet naked, except a few scattering hairs; forefeet scant haired; nasal pad small or absent; pelage hispid, scant and unusually long, unlike any known species of the family. The individual hairs are bristles, very much coarser and longer than those of *Geomys hispidus*. There is no under fur. The belly is so sparsely haired that the bare skin shows through.

Color.—Everywhere uniform dull sooty-brown.

Cranial characters—Unfortunately the skull of the type and only known specimen of this remarkable animal is defective, the entire occipital region and the audital bullæ being absent. The anterior part of the skull is perfect, including all of the teeth and one of the zygomatic arches. The upper surface of the cranium is remarkably smooth and free from lateral indentations or projections, and is of almost uniform breadth. Seen from above, the muzzle, frontal, and brain case pass into one another without interruption or constriction, the frontal being a trifle wider than the muzzle and the cylindrical brain case a trifle broader than the frontal. There is only a faint attempt at a postorbital prominence, and it is below the level of the top of the skull and is made up of the alisphenoid and squamosal. The muzzle is short. The zygomata are narrow and slender, without any enlargement or expansion at any point; they are broader posteriorly than anteriorly, and the maxillary arm slopes strongly backward. The jugal is small and slender and the arch is incomplete without it. The palatopterygoids are broken off. The ascending branches of the premaxilla slightly surpass the plane of the orbits. Inferiorly the premaxilla slightly passes the posterior end of the incisive foramina. The nasals are small, short, and narrow, but slightly broader anteriorly than posteriorly, and without trace of inflation. The angles of the mandible are short and flat. Unfortunately the palatopterygoids and audital bullæ are broken off, along with the whole of the occipital region, hence additional important characters may exist that are not apparent in the single specimen at hand.

Dental characters.—The single groove of the upper incisors is median, open, and rather shallow, and the face of the tooth slopes toward it from both sides. It thus differs widely from the deep and abrupt groove of *G. scalops*, which is wholly on the inner side. The face of the incisors is orange; in *scalops* it is pale yellowish or straw-color. The long axes of the crowns of the individual molars are not quite transverse, but slope slightly backward toward the median line. In most species they slope forward. The heel of the last upper molar is short, but is sharply circumscribed. In addition to the usual deep sulcus on the outer side, the inner side is abruptly narrowed (figs. 34[7] and 64). The enamel plates are peculiar: *Inner enamel plate* covering considerably more than half of inner side of tooth, its anterior end bent outward at nearly a right angle; its posterior end curved toward the median line and reaching the hindermost part of the heel; *outer enamel plate* covering about five-sixths of the outer side of the tooth, its anterior third bent outward at right angles, its posterior half sloping strongly backward to the end of the heel, forming nearly a right angle with the middle part and thus making two sharp angles instead of one—a unique condition. The posterior interspace is very narrow and is on the median line of the tooth behind. The inner interspace is twice as broad as the posterior.

a



b

FIG. 64.—*Orthogeomys latifrons* (type). Crowns of molariform teeth: *a* upper; *b* lower.

Measurements (from dry skin, not overstuffed).—Total length, 320; head and body, 235; tail. 100; hind foot with claw, 44; hind foot without claw, 39.

General remarks.—Externally *Orthogeomys latifrons* may be distinguished from all other known members of the *Geomyidæ* by the character of the pelage, which is setose, the individual hairs being long bristles. In cranial characters it closely resembles *O. scalops*, but differs in the much shorter muzzle and nasals (which latter are not at all inflated anteriorly), and narrower jugal. The upper incisors are very unlike. In *latifrons* the face is orange, the groove median, or nearly median, and relatively shallow, and both sides slope similarly into it. In *scalops* the face is pale yellowish or straw color, the groove wholly on the inner side and deep and abrupt, and the outer side is strongly (roundly) convex.

Genus HETEROGEOMYS * nob.

(Pl. 4; pl. 14, fig. 12; pl. 15, fig. 2; pl. 17, fig. 1; pl. 18, fig. 3; pl. 19, fig. 5; text figs. 65 and 66; map 3[4].)

Type Geomys hispidus LeConte, from near JALAPA, VERA CRUZ, MEXICO.

Dental characters.—Upper premolar with four enamel plates, the posterior restricted to inner or lingual half. Upper and lower premolars

* *Heterogeomys*, from ἕτερος, different, + *Geomys*.

subequal in length. First and second upper molars with two enamel plates each, the posterior complete. Third upper molar a double prism; crown much longer than broad; posterior loop or heel strongly developed; outer sulcus deep; inner sulcus slight; inner enamel plate covering half or more than half of inner side of tooth and falling short of hinder end of heel; outer enamel plate very long, covering the whole of the outer side of the tooth behind the anterior cement band, and curving inward posteriorly to the median line of the tooth. At the lateral sulcus the outer enamel band bends outward at right angles. Posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 slight. Shaft of upper pm straight or faintly convex forward. Upper incisor unisulcate, the sulcus wholly on inner side of median line and sometimes on inner third; deep and abrupt (fig. 20^2).

Cranial characters.—Skull as a whole high and narrow; frontal broad and flat; its sides biconcave interorbitally; distance between orbits much greater than length of basioccipital on median line; temporal impressions anteriorly defining a marked frontal shield (fig. 17^2); orbital plate of frontal usually perforated by a foramen above apex of sphenoidal fissure; zygomatic arches variable, outer sides nearly parallel, antero-external angle sharp and moderately expanded; inferior surface of palatopterygoids cuneate-lingulate, long and slender, the palatal arms much elongated, the pterygoid part small and terminal; postpalatal pits deep; nasals much arched anteriorly to support the large nasal callosity; occipital plane but little more than twice as broad as high, very flat, sloping strongly forward from below upward, squamosal part very high above mastoid bullæ; orbitosphenoids shield-shaped, rather narrow and long, not articulating with alisphenoids;* upper part of optic foramen disappearing in advanced life (pl. 17, fig. 1); endoturbinals peculiar, the first greatly expanded, its anterior face vertical or slightly emarginate (pl. 19, fig. 5). Mesethmoid rather small and strongly convex anteriorly (pl. 18, fig. 3). Squamosal expansion slight; fronto-maxillary suture reaching orbit in front of lachrymal (instead of behind, as usual). Mandible short and compact; angular processes short.

KEY TO SPECIES OF HETEROGEOMYS.

Zygomata broadly spreading, divergent anteriorly; nasals short .... *torridus.*
Zygomata not broadly spreading and not divergent anteriorly; nasals rather long .... *hispidus.*

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*In immature skulls of *Heterogeomys* the orbitosphenoid seems to articulate anteriorly with the maxilla as well as the frontal, but careful examination shows it to be separated by the narrow descending arm of the frontal. In rare cases, irregular absorption of the exceedingly thin plate may permit the orbitosphenoid to reach the maxilla.

HETEROGEOMYS HISPIDUS (LeConte).

(Pl. 4; text fig. 65; pl. 13, fig. 20; pl. 14, fig. 12; pl. 15, fig. 4.)

Geomys hispidus LeConte, Proc. Acad. Nat. Sci., Phila., V, September, 1852, 158.

Type locality.—Near Jalapa, Vera Cruz,* Mexico. (Type in Acad. Nat. Sciences, Phila.)

Geographic distribution.—The 'Tierra Templada,' or middle belt, along the basal slope of the table-land, in the State of Vera Cruz, Mexico, between the altitudes of 4,000 and 4,500 feet. Mr. Nelson found the species common about Jalapa and Jico, and in less abundance from near the city of Orizaba north to Huatusco. The U. S. National Museum contains a specimen from Necostla (near Orizaba).

General characters.—Size large; upper incisors deeply unisulcate, the sulcus wholly on inner side; tail naked; a large naked pad on end of nose; forefeet with claws shorter than hind; pelage harsh and stiff, unlike any other species known to occur in Mexico except *torridus.*

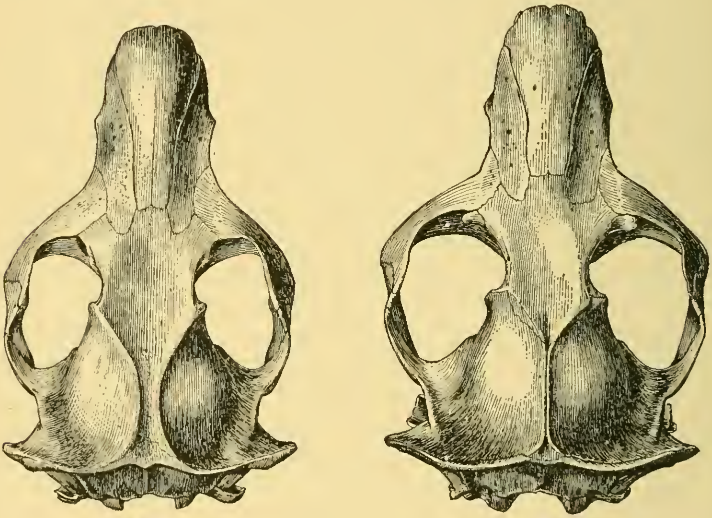
Color.—Upper parts everywhere uniform dark seal-brown;† hardly paler below.

Cranial characters.—Skull as a whole high and narrow; frontal very broad and flat, depressed and biconcave interorbitally, concave both longitudinally and transversely; distance between orbits much greater than length of basioccipital on median line; temporal impressions forming elevated semicircular ridges separated in both sexes by a distinct interval, and extending from postorbital prominences to outer angles of interparietal, anteriorly defining a marked frontal shield, and posteriorly inclosing a broad interparietal; zygomatic arches narrow, the maxillary arms sloping strongly backward, outer sides nearly parallel (sometimes broadest across the middle instead of anteriorly), antero-external angle sharp and moderately expanded, but not in the usual way; angle not produced downward; expansion oval in shape and encroaching on orbital fossa, which is correspondingly narrowed at this point; inferior surface of palatine bones greatly elongated posteriorly, forming, on either side of the postpalatal notch, narrow lingulate extensions which are terminated by short and narrow pterygoids; postpalatal pits deep; ascending branches of premaxilla broad and bluntly rounded posteriorly; premaxilla extending far enough posteriorly to inclose incisive foramina; nasals inflated anteriorly and then contracted at nares; anterior nares larger than in the other groups; occipital plane a little more than twice as broad as high, very flat (free

*The type specimen was collected by Mr. Pease in 1847 on the road followed by Scott's army "between Vera Cruz and the City of Mexico," which road passes through Jalapa. Mr. Nelson found the species abundant about Jalapa, which is in the 'Tierra Templada,' about halfway down the slope from the table-land to the coastal plain. He ascertained further that the species does not occur on the table-land, which is inhabited by other genera.

†This color may be otherwise described as very dark plumbeous, faintly tinged with purple.

from the projections and irregularities common to other forms), sloping strongly forward from below upward; brain case larger, more clearly defined, and higher above posterior root of zygoma than in any other group; squamosal expansion minimum, neither extending out far laterally nor increasing length of glenoid fossa anteriorly—the usual shelf-like projection into the orbito-temporal fossa from the posterior root of the zygoma being nearly obsolete; fronto-maxillary suture reaching orbit in front of lachrymal (instead of behind it as usual). This arrangement broadens the frontal anteriorly, shortening and apparently weakening the attachment of the maxillary root of the zygoma. Mandible short and compact, little spreading posteriorly; angular process short; prominence over root of incisor low and flattened posteriorly; condylar process long and only slightly sloping inward.



(65.) (66.)

FIG. 65.—*Heterogeomys hispidus.* Jico, Vera Cruz, Mexico. (Nat. size.)
FIG. 66.—*Heterogeomys torridus.* Motzorongo, Vera Cruz, Mexico. (Nat. size.)

Dental characters.—Front face of incisors perfectly flat, not rounded off on edges as in *Geomys*, *Platygeomys*, and *Zygogeomys.* Upper incisors deeply unisulcate, the groove narrow and wholly on inner side. Lower incisors without bevel or groove on outer face. Molars larger, heavier, and less flattened antero-posteriorly than in *Geomys* or *Zygogeomys;* crown of last upper molar elongated posteriorly and abruptly narrowed behind lateral sulcus, the crown of posterior prism longer than anterior, to which it forms a distinct heel. Isthmus connecting anterior and posterior lobes of upper premolar decidedly on inner side of tooth.

Measurements (taken in flesh).—Average of two males from near type locality (Jico, 7 miles south of Jalapa, Vera Cruz): Total length, 345;

tail vertebræ, 92.5; hind foot, 53. Average of three females from same place: Total length, 310.6; tail vertebræ, 85.3; hind foot, 47.3.*

For cranial measurements see Table F, p. 215.

Specimens examined.—Total number 9, from the following localities in the State of Vera Cruz, Mexico: Jico, 6; Huatusco, 1; Necostla, 1; locality unknown, 1.

General remarks.—Through the courtesy of Mr. Witmer Stone and other officers of the Academy of Natural Sciences of Philadelphia, the type specimen of *Geomys hispidus* has been sent me for examination. In size, character of pelage, and all other respects except color, it agrees almost exactly with Mr. Nelson's specimens. The color, which LeConte described as "reddish-brown" and Baird as "reddish-brown or dull chestnut," was probably the result of museum exposure, the skin being mounted and exposed to the light. It was collected by Mr. Pease in 1847, during the march of Scott's army from Vera Cruz to the City of Mexico, and consequently had been in the collection five years before it was described by LeConte. The fading has continued, the specimen now being much paler than when seen by Baird in 1855.

In view of the large number of species of Pocket Gophers now known to inhabit southern Mexico, it is exceedingly gratifying to be able to settle the status of *hispidus* by actual comparison of the type specimen with the series collected by Mr. Nelson at or very near the original type locality. The skull of the type specimen has never been removed, and the cranial characters of the species have remained unrecorded until the present time. The series of skulls obtained by Mr. Nelson therefore were examined with unusual interest and the result was a complete surprise. They show not only that the animal is a strongly marked species, but that it is generically distinct from *Geomys*, as already pointed out.

The naked nasal pad is more largely developed in this species than in any of the others, and its large size is clearly correlated with the inflated nasal bones. For this reason it shows to unusual advantage in the type specimen, which is mounted with the skull inside, the arched nasals keeping it stretched in its natural relations. In this specimen it measures 12.5 mm. in length by 10 in breadth.

Mr. Nelson states that *H. hispidus* is confined to the district suitable to the cultivation of coffee and sugar cane and is said to be very injurious to cane plantations.

HETEROGEOMYS TORRIDUS sp. nov.

(Pl. 15, fig. 2; pl. 17, fig. 1; pl. 18, fig. 3; pl. 19, fig. 5; text fig., 66.)

Type from CHICHICAXTLE, VERA CRUZ. No. 63629 ♀ ad., U. S. National Museum, Department of Agriculture collection. Collected February 15, 1894, by E. W. Nelson. (Original number, 5850.)

Geographic distribution.—Lowlands of Vera Cruz, from Chichicaxtle

* The measurements of the feet of the mounted type specimen as taken by me now, nearly half a century after its capture, are: Forefoot from basal pad to tip of longest claw, 42.5; hind foot from heel to tip of longest claw, 45.5.

and Motzorongo to Catemaco, and thence into Guatemala; penetrating the interior to Reyes, Oaxaca, and Guatemala City, Guatemala.

Mr. Nelson first observed this species on the way from Mirador to the coast, from an altitude of about 1,500 feet near Santa Maria, down to the border of the sand hills along the coast at Antigua. The next point where it was noted was on the route from the city of Cordoba to the hacienda of Motzorongo. At an altitude of 800 feet at this latter place it was again found in abundance. The easternmost locality at which it was obtained by Mr. Nelson is Catemaco, in the district of Tuxtlas. He afterwards secured it at Reyes, in northern Oaxaca, at an altitude of 6,700 feet. The range of the species is strictly tropical.

General characters.—Similar to *H. hispidus.* Size large; tail naked; naked nasal pad large; hind feet nearly naked; fore feet scant haired.

Color.—Everywhere dark seal-brown, only slightly paler below; in worn pelage chocolate brown.

Cranial characters.—Skull large, heavy and rather broad, resembling that of *H. hispidus*, from which it differs in the following particulars: Pituitary fossa deeper and (usually?) perforate; zygomata much more squarely spreading anteriorly (the maxillary arm standing out at more nearly a right angle instead of sloping strongly backward); temporal impressions uniting posteriorly in old of both sexes, but not rising in a sagittal crest; audital bullæ smaller, narrower anteriorly, and not sending up a point or ridge toward hamular process of pterygoid; ascending arms of premaxilla averaging broader and shorter posteriorly. The skull of the male differs from that of the female in larger size and greater angularity. The zygomata reach out much further sideways, are much broader anteriorly than across the middle, and the outer angle stands out prominently (in the female it turns downward). The jugal is considerably larger and broader anteriorly in the male.

Measurements (taken in flesh).—Type specimen (♀ ad. from Chichicaxtle): Total length, 323; tail vertebræ, 88; hind foot, 52.

Average of four adult males from Motzorongo: Total length, 348; tail vertebræ, 96.5; hind foot, 49.2.

Average of ten adult females from Motzorongo: Total length, 317; tail vertebræ, 81.5; hind foot, 45.5. The ♀ from Reyes, Oaxaca, is decidedly larger, measuring: total length, 332; tail, 98; hind foot, 49.5.

The mounted specimen in the World's Fair exhibit from Guatemala, which is considerably overstuffed, now measures: Total length, 380; tail vertebræ, 85; hind foot, 46. It is a female.

For cranial measurements see Table F, p. 215.

Specimens examined.—Total number 27: 2 from Guatemala; 1 from Reyes, Oaxaca, and 24 from the following localities in Vera Cruz, Mexico: Chichicaxtle (type locality), 1; Motzorongo, 22; Catemaco, 1.

General remarks.—*Heterogeomys torridus* differs but little externally from true *hispidus*. Even in color the type specimen, which is in worn pelage, except on the head, is only a shade paler than specimens of *his-*

pidus in worn pelage. The differences in cranial characters, however, are marked and constant. Still it is quite possible that intergrades may be found in the exceedingly narrow belt separating the two forms. It should be observed that the type specimen has a hind foot 4 mm. longer than the largest female from Motzorongo, and that the skull, also, is larger. The type is a very old individual.

Two specimens of a *Heterogeomys* from Guatemala, belonging to the U. S. National Museum collection, are here referred to the present species. One of these, a young adult (No. $\frac{9019}{22550}$) was collected many years ago near Guatemala City by Dr. Van Patten; the other was recently presented to the Museum by the Guatemala Commissioners to the World's Fair. The exact locality where it was obtained is unknown. It is an old female, and the temporal impressions meet over the middle part of the sagittal suture (which is obliterated, as in all adults of the species). The specimen obtained by Dr. Van Patten (probably also a female) is younger, and the temporal impressions are still distant. The two Guatemala skulls differ from those from Vera Cruz in having the postorbital prominence obsolete or nearly so.

Mr. Nelson states that in Vera Cruz this species is one of the most injurious of the genus to the agriculturist. At Catemaco he found it in small numbers among the dry hills and plains on the western border of the lake, but in the forest on the eastern shore it swarms in countless numbers. At one point the ground was fairly honeycombed with their tunnels, so that he sank to the knee at nearly every step.

Hetergeomys torridus becomes sexually mature at a remarkably early age. Several of the young females were mothers, and one in particular, though hardly half grown, has long pendant teats that have evidently been nursed. This specimen (No. 63640) is still in the woolly pelage of the very young, and its skull, barely half the size of the adult, has not yet attained the mature form. The animal could hardly be more than three months old. Its measurements in the flesh are: Total length, 259; tail vertebræ, 71; hind foot, 43.

Genus MACROGEOMYS[*] nob.

(Pl 5; pl. 11, figs. 2 and 3; pl. 13, figs. 18, 19, 22, and 23; pl. 14, figs. 3 and 10.)

Type Geomys heterodus Peters, from Costa Rica.

Dental characters.—Upper premolar with four enamel plates, the posterior restricted to inner third; m^1 and m^2 with two enamel plates each. Last upper molar with an elongated heel and deep outer sulcus; inner emargination variable (slight in *heterodus;* deep in *dolichocephalus*); inner enamel plate covering half to two-thirds of inner side of the tooth, its posterior end nearly reaching hinder end of heel. *Outer enamel plate* variable, the posterior limb double the length of the anterior. In *M. heterodus* it covers half; in *dolichocephalus* and *costari-*

[*] *Macrogeomys*, from μακρὸς, large, great, + *Geomys*, in reference to the large size of the animals.

censis, three-fourths of the outer side of the tooth. The posterior loop or heel is greatly developed, attaining the maximum size known in the family (about half or more than half the length of the tooth and narrow, the constriction about half the breadth of the anterior prism).

Posterior curvature of m^1 and m^2 and anterior curvature of m_1 and m_2 strongly developed. Shaft of both upper and lower premolar strongly convex forward and very large and heavy.

Upper incisor *unisulcate*, the sulcus wholly on inner third of face, narrow and deep; face of tooth flat on both sides of sulcus (fig. 20[1], and pl. 15, fig. 8).

Cranial characters.—Frontal broad, flat, depressed or concave along the median line, deeply excavated laterally between the orbits, the notch immediately succeeded by a strongly developed postorbital process (much larger than in any other member of the family, fig. 17[3]). Palatopterygoids broad, short, and truncated posteriorly, the horizontal part composed almost wholly of the palatal, the pterygoid simply capping the end and abruptly upturned at right angles (fig. 11[5]). Nasals moderately convex, slightly or not inflated. Brain case rising high above posterior root of zygoma. Unfortunately there are no skulls of *Macrogeomys* in the Department collection; hence I have been unable to make sections to expose the mesethmoid and turbinals.

The lambdoid crest is straight or slightly convex posteriorly (not sinuous as in *Platygeomys*) and the occipital plane is flat and slopes strongly forward, as in *Heterogeomys*.

External characters.—Size large; naked nasal pad well developed; tail naked; pelage soft, almost silky, and with a tendency to become wavy; color pattern unique, bicolor: muzzle and sides of rump abruptly whitish; rest of upper parts dark chocolate or sepia in marked contrast. (The color pattern of the adult *M. costaricensis* and *cherriei* is unknown.)

General remarks.—*Macrogeomys* requires comparison with only two genera, *Heterogeomys* and *Orthogeomys*, from both of which it may be distinguished at a glance, whether viewed from above or below. The most striking points of difference are the remarkably short and broad palatopterygoids and the strongly developed postorbital processes.

KEY TO SPECIES OF MACROGEOMYS.

Audital bulla normal, outer side not flattened.
  Skull short and broad; zygomata divergent anteriorly .... *heterodus*.
  Skull long and narrow; zygomata parallel .... *dolichocephalus*.
Audital bulla peculiar, the outer side flattened and disk-shaped.
  Jugal normal, entering largely into zygoma .... *cherriei*.
  Jugal small, the zygoma complete above without it .... *costaricensis*

MACROGEOMYS HETERODUS (Peters).

(Pl. 11, fig. 2; pl. 14, fig. 3).

Geomys heterodus Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin (1864), 1865, 177. (Translation of original description appended to present article, p. 189.)

Type locality.—COSTA RICA. Exact locality unknown.

Geographic distribution.—The Irazu range and perhaps other parts of Costa Rica.

General characters.—Size large; face of upper incisors deeply unisulcate, the sulcus narrow and wholly on inner side of median line; enamel face of incisors orange; naked nasal pad large; tail absolutely naked; hind feet naked, with a few stiff hairs about the toes; fore feet nearly naked (shorter than hind); pelage moderately coarse, but not hispid as in *G. hispidus*; no external ears. Coloration peculiar, the muzzle and sides, including sides of rump, being conspicuously paler than rest of upper parts.

Color.—Upper parts uniform sepia or hair brown; muzzle, under parts, and sides all round abruptly much paler, the pale color (a soiled gray) reaching higher on the sides of rump than elsewhere and including base of tail.

Cranial characters.—Skull large, heavy, and rather short; zygomata broadly spreading, their sides divergent anteriorly, maxillary arms sloping backward less strongly than in *dolichocephalus;* antero-external angle well marked, moderately expanded; jugal large and broad, its upper surface not covered by squamosal and maxillary arms; frontal broad and flat, concave along the median line between the orbits and deeply notched on the sides immediately in front of the large postorbital processes, which latter are capped by the apex of the alisphenoid and overlapped posteriorly by the anterior edge of the squamosal. Nasals broadly wedge-shaped and not inflated. The ascending branches of the premaxilla slightly exceed the plane of the orbits. Inferiorly the premaxilla reaches but does not inclose the posterior end of the incisive foramina. The zygomatic breadth is considerably greater than the greatest squamosal or mastoid breadth. The occipital plane is flat (except a vertical median ridge) and slopes moderately forward; the lambdoid crest is straight, slightly incurved near median line. The palatopterygoids are broadly U-shaped and shortly truncate posteriorly, the pterygoids abruptly upturned at right angles to the palatals. The basioccipital has the sides parallel for the anterior half and is broadly wedge-shaped posteriorly. Audital and mastoid bullæ normal. The enamel face of the upper incisors is flat, with the sulcus deep, rather narrow, and wholly on inner side. Traces of the fine inner sulcus may also be seen in the only specimen at hand. The heel of the last upper molar is narrow, much elongated, and slopes strongly outward.

Macrogeomys heterodus differs from *M. dolichocephalus*, the only known species with which it requires comparison, in the very different form of the skull as a whole, it being much shorter and broader, and in the following details: Jugal broadest anteriorly and not covered by squamosal and maxillary arms of zygoma; zygomata divergent anteriorly (instead of parallel); nasals shorter and not inflated; orbital borders of frontal not inflated anteriorly; muzzle and diastema much shorter; palatopterygoids less broad at base; occipital plane broader and lower;

mastoid bullæ narrower vertically. Mandible much shorter. Heel of last upper molar longer and narrower, the outer enamel plate reaching little more than halfway from sulcus to end of heel; in *dolichocephalus* it reaches all the way.

Measurements.—Peters recorded no measurements for his type specimen, but Dr. Matschie has kindly measured it for me and finds the total length 325 mm. He states that the tail is defective. The specimen in the U. S. National Museum, from the Irazu Mountains, which is the subject of the foregoing description (a well-made dry skin), affords the following measurements: Total length, 325; head and body, 280; tail, 65; hind foot with claw, 45; hind foot without claw, 41.

For cranial measurements see Table F, p. 215.

General remarks.—The only species known to me with which *heterodus* needs comparison is *dolichocephalus*, which agrees with it in the abrupt paleness of the muzzle and sides of the rump. But *heterodus* differs from *dolichocephalus* in having the entire under parts and lower sides of the same pale color as the muzzle and sides of the rump. It differs further (in the specimens at hand) in the tint of the upper parts, which is sepia or hair brown instead of chocolate brown, and in the cranial characters above pointed out.

Unfortunately, Peters's description of his *G. heterodus* from Costa Rica is brief and unaccompanied by measurements, cranial characters, or exact locality (see next page). That his animal is the same as *hispidus* of LeConte (from Vera Cruz), as assumed by Coues and Alston, is exceedingly improbable on geographic grounds (in view of the remarkably restricted ranges of all the tropical American species now known) and impossible in view of the wide difference in coloration. Peters described *heterodus* as *bicolor*, the upper parts "dark brown," the muzzle, rump, and underparts "brownish gray or white." *Hispidus* is *concolor* and uniformly dark. Fortunately the type of Peters's *heterodus* is extant. It is still in the Berlin Museum, and Dr. Paul Matschie of that museum has had the kindness to send me additional notes, accompanied by full cranial measurements, which suffice to place its identity beyond question.

Through the courtesy of Mr. F. W. True, Curator of Mammals in the United States National Museum, I have been able to examine several specimens of the *Geomyidæ* from Costa Rica and Guatemala. Among those from Costa Rica is one which agrees in every way with Peters's original description of *heterodus*, and also with the additional particulars concerning Peters's type specimen kindly furnished me by Dr. Matschie. This specimen was recently presented to the museum by the Costa Rica Government through its commissioners to the World's Columbian Exposition at Chicago in 1893. It consists of a well-prepared skin, from which Mr. True has kindly had the skull extracted. It is the only specimen of *heterodus* I have seen, and is the subject of the foregoing description. Mr. George K. Cherrie, of the Costa Rica

National Museum, in response to a letter of inquiry, contributes the following important statement respecting this specimen: "It is No. 313 of the collection of the 'Museo Nacional,' an adult male; was collected October 15, 1890, near Rancho Redondo, a point on the Irazu range between the volcanoes Irazu and Barba, at an altitude of about 1,400 meters. The specimen was purchased from a 'peon' and mounted by myself. October is the last month of the rainy season, and the month in which it rains hardest. I might also add that the species is abundant in the locality given above."

Peters's original description of *heterodus* is as follows: "Our museum has received through Dr. Hoffmann and Dr. v. Frantzius the skin with the perfect skull of a new species of *Geomys* from Costa Rica, whereby the geographical distribution of this genus in Central America is established. This species agrees best with *G. mexicanus* Licht. in size, proportion of the limbs, nakedness of the tail, and the nature of its hairy covering, which latter, however, appears to be somewhat shorter and stiffer. The color is dark brown except on the belly, rump, and muzzle, which are brownish gray or white. It is, however, readily distinguished by the position of the deep longitudinal groove of the upper incisors, which does not run along the middle but between the inner and middle thirds of the teeth, for which reason I propose to name the species *Geomys heterodus*." (Monatsber. K. Preuss. Akad. Wiss., Berlin, 1864, 177.)

Dr. Paul Matschie has kindly sent me the following cranial measurements of Peters's type specimen of *heterodus*, which is in the Berlin Museum (No. 2864):

Greatest basal length (condyle to front of premaxilla), 61; basal length (basion to gnathion), 58; basilar length of Hensel (basion to alveolus of incisor), 51.2; greatest breadth across squamosals, 38; least breadth between postglenoid notches, 27.5; least interorbital breadth, 11; breadth across postorbital processes, 15.25; height of cranium above palate, 24; height above basion, 17; length of upper molar series on alveoli, 14; length of diastema, 22.5; length of single mandible (condyle to front of jaw between incisors), 44; breadth across angular processes, 40; distance from condyle to end of angular process, 13; breadth of muzzle just in front of zygoma, 15.

MACROGEOMYS DOLICHOCEPHALUS sp. nov.

(Pl. 5; pl. 10, fig. 7; pl. 13, fig. 19.)

Type from San Jose, Costa Rica. No. $\frac{8627}{36295}$ ♂ ad. Collected January, 1866, by José C. Zeledon.

Geographic distribution.—Vicinity of San Jose, Costa Rica. Range unknown.

General characters.—Size large. Animal similar to *M. heterodus;* face of upper incisors deeply unisulcate, the sulcus narrow and wholly on inner side of median line (pl. 15, fig. 8); enamel face of incisors orange;

naked nasal pad large;* tail absolutely naked; hind feet naked, with a few stiff hairs about the toes; fore feet nearly naked (shorter than hind); pelage moderately coarse, but not hispid as in *Heterogeomys hispidus;* no external ears. Coloration peculiar, the muzzle and sides of rump conspicuously paler than rest of upper parts, as in *heterodus.*

Color.—Upper parts dull chocolate brown, except muzzle and lower part of rump, which are buffy in conspicuous contrast, but without line of demarkation. (The buffy of the rump surrounds the base of the tail and reaches further anteriorly on the sides than along the middle of the back.) Under parts similar to back but paler, without line of demarkation; wrists and ankles pale. No dark patch around ears.

Cranial characters.—The skull of *Macrogeomys dolichocephalus*, in addition to the generic characters which associate it with *M. heterodus*, is remarkable for its length and narrowness, the zygomatic breadth in an old male (the type specimen) being only 58 percent of the total length (from condyle to point of premaxilla), and the greatest squamosal or mastoid breadth only 57 percent. The opposite extreme is found in the genus *Platygeomys*, in which the corresponding ratios in *P. gymnurus* are 71 and 75.

The zygomata are not only very narrow, but present the appearance of having been drawn out while in a plastic condition. The maxillary arms slope strongly backward and are broadly rounded off without trace of angle or of angular expansion at the usual place, though there is a slight expansion about the middle of the outer side of the arch, encroaching on the orbito-temporal fossa, which it constricts in the middle opposite the large postorbital processes—a step toward the differentiation of these two fossæ from one another. The jugal is broad, short anteriorly, narrower at both ends than in the middle, and is overlapped by the maxillary and squamosal arms of the zygoma, which nearly or quite meet above it. The frontal is grooved medially between the orbits and is somewhat inflated along the margin of the orbits behind the lachrymal bones, in this respect resembling *O grandis* of Thomas, though the inflation is much less extreme. The sides of the frontal are deeply notched immediately in front of the large postorbital processes. The nasals are wedge-shaped as in *heterodus*, but longer and slightly inflated anteriorly; they are broadest near junction of middle and anterior thirds (in the ♂ only). The ascending branches of the premaxilla barely reach the plane of the orbits. Inferiorly the premaxilla reaches the posterior end of, but does not inclose, the incisive foramina, as in *heterodus.* The zygomatic breadth is only a trifle greater than the mastoid breadth. The occipital plane is flat, high, and slopes strongly forward; the lambdoid crest is slightly convex posteriorly. The palatopterygoids are very broad and

* In an alcoholic specimen (No. 1466 U. S. National Museum) the nasal pad or callosity is broad and rather short, not reaching posteriorly behind plane of upper incisors.

short. [In the male skull the pterygoids are broken off; in the female they are abruptly upturned, as in *heterodus*.] The basioccipital has the sides parallel in the anterior half and is broadly wedge-shaped posteriorly. The height of the cranium above the palate is unusually great, and the zygomata do not descend below a plane drawn midway of the height of the skull. The audital bullæ are normal and rather short, plump, and well rounded anteriorly. The brain case seen from above is subcylindric in shape, in which respect it resembles *Orthogeomys*. The nasals end in front of the plane of the zygomatic arches, while the premaxillæ reach the plane of the orbits, causing an unusual elongation of the median part of the frontal in order to articulate with the nasals. The mandible is long and narrow. The enamel face of the upper incisors is flat, the sulcus deep, narrow, and wholly on inner side (fig. 20[1]).

A young female of *M. dolichocephalus* (No. 36820) differs from the old male above described (36295) in the following particulars: The skull as a whole is very much smaller (see table of cranial measurements); nasals very much shorter, flatter, and broadest anteriorly (instead of at junction of middle and anterior thirds); temporal impressions distant (interspace 3 to 4 mm broad); brain case less cylindrical (owing in part to greater depth of constriction running obliquely upward from posterior root of zygoma to occiput, and in part to a slight bulging upward of the middle of the brain case); basioccipital narrower. The top of the skull in profile is not a straight line, the brain case presenting a slight convexity behind the orbits, while the interparietal and occipital crest fall below the plane of the upper surface as a whole. In both sexes the anterior part of the nasals is strongly decurved.

M. dolichocephalus differs markedly from *M. heterodus*, the only species with which it requires comparison, in the general form of the cranium, which is narrow and greatly elongated; in the narrow, drawn-out zygomata, without trace of angular projection or expansion; in the narrower jugal, which is covered above by the anterior and posterior arms of the arch, which meet or nearly meet above it; in having the zygomata parallel (instead of divergent anteriorly); the nasals longer and somewhat inflated anteriorly; the muzzle and diastema much longer; the palatopterygoids broader at base; the occipital plane higher and less broad; the mastoid bullæ much higher vertically; and the mandible much longer.

Measurements (of type specimen, ♂ ad., from dry skin): Total length, about 380 (approximate, as the tail was not wired and is shrunken); head and body, 310; tail, about 75 (approximate only); hind foot, 48; without claw, 45.

Measurement of a young female from Costa Rica, preserved in alcohol (No. $\frac{14666}{36820}$ ♀ yg. ad., U. S. National Museum, collected by José C. Zeledon and received in October, 1884): Total length, 310; tail, 74; hind foot, with claw, 49; without claw, 43; forefoot, with claw, 45; without claw, 33.

For cranial measurements see Table F, p. 215.

General remarks.—Externally *Macrogeomys dolichocephalus* resembles *M. heterodus* in the peculiar paleness of the muzzle and sides of the rump (in strong contrast to the color of the rest of the upper parts), but differs from *heterodus* in not having the lower part of the sides and belly of the same pale tint. On the other hand, the pale color of the rump reaches a little further forward on the dorsal surface. There is a slight difference also in the tint of the upper parts, the color being dull chocolate brown in *dolichocephalus*, while it is sepia or hair brown in *heterodus*. The important cranial differences have been pointed out.

The alcoholic specimen already mentioned (No. 14666) is a female, and although not fully adult, has borne young, as shown by the large pendent nipples. The teats are: pectoral $\frac{1}{1}$, inguinal $\frac{2}{2}=\frac{3}{3}$, as usual in the group. The pectoral pair are situated on the sides immediately behind the fore legs. The inguinal pairs are not *on* the belly at all, but on the *inner side of the thighs* just below and outside of the belly.

The great callosity at the hinder edge of the wrist is made up of two large tubercles resembling kernels of corn placed side by side and covered by common integument.

MACROGEOMYS COSTARICENSIS sp. nov.

(Pl. 11, fig. 3; pl. 13, fig. 23; pl. 14, fig. 10.)

Type from PACUARE, COSTA RICA. No. $\frac{12914}{22551}$ juv. U. S. National Museum. Collected in 1876 by Juan Cooper. (Original No. 96.)

General characters.—Upper incisors with a single deep sulcus wholly on inner side; pelage in type specimen (immature) short and silky, suggesting the fine crinkled pelage of *Didelphis murina;* tail and hind feet naked; a conspicuous naked pad on end of nose.

Color.—Upper parts uniform dark-brown, *not* paler on nose and rump; underparts abruptly whitish. The type and only known specimen has a large symmetrical white spot on top of the head, occupying about three-fourths of the area bounded by the eyes and ears.*

Cranial characters (of immature skull, pl. 11, fig. 3).—Similar in a general way to an immature ♀ skull of *M. dolichocephalus* (No. 36820), from which it differs in the following particulars: Nasals very much broader throughout, particularly posteriorly; space between posterior ends of ascending arms of premaxilla about twice as broad; zygomata standing out more squarely, nearly at right angles to axis of skull, with anterior angle abruptly rounded; jugal narrower; palatopterygoids shorter and broader; basioccipital very much broader and wedge-shaped, its inferior surface not excavated by audital bullæ; audital

*The white crown patch of *costaricensis* was at first believed to be abnormal, alling in the same category with the irregular white blotches frequently found on the throat and sometimes at the base of the tail, in various species of pocket gophers. But the fact that the spot is bilaterally symmetrical, and is repeated in the only specimen known of a closely allied species, *cherriei*, points to its permanence, at least as a mark of the young.

bulla peculiar, compressed, the outer side strongly flattened; more smoothly rounded, somewhat disk-shaped, and separated from the mastoid bulla inferiorly by a distinct groove. The only other known species of the family having a similar audital bulla is *Macrogeomys cherriei* of Allen. Both are known from single specimens only, and both are too young to show all of the characters of the adult. Their specific distinctness will be apparent at a glance at the accompanying cut (fig. 67) showing the differences in the jugals. The palatopterygoids also are different. The palatopterygoids of *M. costaricensis* are shown on pl. 14, fig. 10, but the figure is inaccurate; in the specimen they are shorter and broader, more nearly as in fig. 3 of the same plate. The pterygoids of *cherriei* are broken, but the remaining base shows that they are considerably more slender.

In *M. costaricensis* the jugal is much shorter than the basioccipital (measured from condyle) and is wholly inferior, the maxillary and squamosal roots of the zygoma meeting above it and on its inner side, so that when viewed from the inner side it appears only as a narrow edge with the apex upward (fig. 67, [4]). In position and relations, therefore, it resembles *Zygogeomys trichopus*, though considerably broader than in that species.

FIG. 67.—Zygomatic arches of *Macrogeomys costaricensis* (3 and 4), and *M. cherriei* (1 and 2). 1 and 3 outer side; 2 and 4 inner side.

Measurements.—Type specimen (probably not more than two-thirds grown) from dry skin: Total length, 330; tail (apparently stretched), 100 from point assumed to be over first caudal vertebra, 80 from apparent base; hind foot, 37 (without claw, 33).

For cranial measurements see Table F, p. 215.

General remarks.—This singular species, for the privilege of describing which I am indebted to the courtesy of Mr. F. W. True, Curator of Mammals in the U. S. National Museum, is represented in the collection by an immature specimen only. At first it was supposed to be the young of *M. dolichocephalus*, but comparison of its skull with that of *dolichocephalus* shows numerous points of specific difference, as above mentioned. While the peculiar texture of its pelage may be due in part to immaturity, this explanation fails when applied to the cranial characters which, as described above, are numerous and striking and of such a nature that most of them would be accentuated by age. In external appearance the animal bears a striking resemblance to the young type of *Macrogeomys cherriei.*

MACROGEOMYS CHERRIEI (Allen)

(Pl. 15, fig. 1.)

Geomys cherriei Allen, Bull. Am. Mus. Nat. Hist., V, 337–338, Dec. 16, 1893.

Type from SANTA CLARA, COSTA RICA. No. 664 ♂ im. Museo Nacional de Costa Rica. Collected in October, 1892, by George K. Cherrie.

General characters.—Naked nasal pad large; tail and hind feet naked. Similar to *Macrogeomys costaricensis* in size and coloration, including the white head patch, but differing in important cranial characters.

Color (of type, juv.).—Upper parts very dark plumbeous or sooty brown; under parts abruptly paler, with distinct line of demarkation; top of head between eyes and ears pure white.

Cranial characters (from skull of type, but little more than half grown, pl. 15, fig. 1).—The skull of *M. cherriei* agrees with *Heterogeomys hispidus* in general form, in the widely-separated temporal impressions; the broad and flat frontal, depressed between the orbits; the flat forward-sloping occipital plane; the form of the zygomata; the inflated nasals, and the short and compact under jaw, with short angular processes. But it is so young that one must be cautious in placing much stress on characters that vary with age. It differs from *H. hispidus* and agrees with *M. costaricensis* in the convexity of the anterior part of the roof of the brain case;* in the peculiarly flattened and smoothly rounded audital bullæ, which are separated from the mastoid bullæ by a distinct inferior transverse groove; and in the long heel of the last upper molar. It differs from *costaricensis* in the size, form, and relations of the jugal (as shown in fig. 67), in narrower palatopterygoid lingulæ, and in a narrower gap behind the nasals (between posterior ends of ascending branches of premaxilla). The jugal is large and long, and nearly half of its upper edge enters into the orbital fossa; it is not covered anteriorly by the maxillary arm of the zygoma, and its total length is greater than that of the basioccipital (measured from condyle). In *M. costaricensis* the jugal is much shorter than the basioccipital (measured from condyle), and is completely covered by the maxillary and squamosal arms of the zygoma, which meet above it (fig. 67). It differs further from *costaricensis* in the shape of the horizontal part of the zygomatic arch, which is not strongly convex upward, and lacks the constriction tending toward the separation of the orbital from the temporal fossa. The large orbito-temporal fossæ are broadest across the middle—just where they are narrowest in *costaricensis*.

Measurements.—Hind foot, with claws, 39 mm. (in dry skin). No measurements were recorded from the flesh, and the specimen is far from full grown.

For cranial measurements see Table F, p. 215.

General remarks.—Through the courtesy of Dr. J. A. Allen, Curator of Mammals in the American Museum of Natural History of New

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* It is probable that the saddle-shaped frontal of *costaricensis* and *cherriei* is the result of immaturity, since a young skull of *G. trichopus* (No. 50104) shows the same peculiarity, though in less degree.

York, I have been able to examine the only specimen known of this species. It belongs to the Museo Nacional de Costa-Rica, and was loaned Dr. Allen by Mr. George K. Cherrie, who collected it at Santa Clara, Costa Rica, in October, 1892. It is a male, and, like the type of *costaricensis*, is immature. It resembles the latter in having a large pure-white patch on top of the head,* in the large size of the naked nasal pad or callosity, and in the nakedness of the tail and feet. The hind feet are absolutely naked; the forefeet are naked except for the presence of a few long hairs about the toes. The color of the upper parts is somewhat darker than in *costaricensis*. The specimen is so young that some hesitancy is felt in its generic assignment. It may be a *Heterogeomys* instead of a *Macrogeomys*, though this is exceedingly improbable.

Genus ZYGOGEOMYS† nob.

(Pl. 6; pl. 13, fig. 24; pl. 14, fig. 1; pl. 15, fig. 10; pl. 17, fig. 2; pl. 18, fig. 2; pl. 19, fig. 4.)

Type Zygogeomys trichopus sp. nov., from NAHUATZIN, MICHOACAN, MEXICO.

Generic characters.—Upper premolar with four enamel plates, the posterior restricted to lingual third; upper and lower premolars subequal in length; shaft of upper premolar slightly convex forward.

First and second upper molars with two enamel plates each, the posterior failing on outer side. Third upper molar an incomplete double prism; crown much longer than broad; heel well developed, broad, narrowed on outer side only; sulcus on middle of outer side; absent on inner side. *Inner enamel plate* covering two-thirds to three-fourths of inner side of tooth, straight, reaching end of heel posteriorly; *outer enamel plate* covering about half or a little less than half of outer side of tooth, its anterior half bent strongly outward. Interspaces broadly open, the posterior broadest, directed backward, and often forming a sort of everted lip (fig. 27[5]).

Upper incisors bisulcate; principal sulcus on inner side of median line; minor sulcus on inner convexity (see fig. 22[1] and pl. 15, fig. 10).

Cranial characters.‡—Cranium as a whole long and narrow, the zygomata not widely spreading, slender, antero-external angle rounded and not expanded; zygomatic arch normally complete without jugal, the

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* The white crown patch of *cherriei* and *costaricensis* was at first believed to be abnormal. But the fact that the spot is bilaterally symmetrical, and is repeated in the only specimen known of *Macrogeomys costaricensis*, which is likewise young, suggests its possible permanence, at least as a mark of immaturity.

† *Zygogeomys*, with reference to the unique character of the zygomata.

‡ Owing to the extreme difficulty of discriminating generic from specific characters in animals presenting such extraordinary cranial variations as the Mexican *Geomyidæ*, it is thought best in descriptions of genera, of which only a single species is known, to record all of the characters that seem entitled to more than specific weight. The generic diagnosis here given, therefore, errs on the side of fullness. The future discovery of additional species will promptly reduce the number of characters.

maxillary and squamosal arms coming in contact above it; jugal rudimentary, inferior and chiefly external; rostrum long and narrow; temporal impressions meeting in a short but well-developed sagittal crest; palatine bones contracted at base of pterygoids; pterygoids vertical lamellæ as in *Thomomys*, meeting or nearly meeting in median line behind palate. Premaxilla not inclosing incisive foramina, which is bordered posteriorly by the maxilla.

Mandible rather long and slender, much as in *Geomys bursarius;* orbitosphenoids relatively larger than in any other genus of the family, closing the upper part of the sphenoidal fissure (except a foramen at apex) and ankylosed broadly with the alisphenoid (pl. 17, fig. 2), as in some species of *Thomomys;* sphenoid fossæ correspondingly shortened, reaching only halfway from horizontal part of alisphenoid to base of cribriform plate; mesethmoid quadrangular, much longer than high (pl. 18, fig. 2); endoturbinals collectively subquadrate, but with antero-superior corner rather sharply elongated, projecting into posterior emargination of nasoturbinal; the os planum spreading forward in front of fourth endoturbinal about as far as length of latter (pl. 19, fig. 4).

General remarks.—*Zygogeomys* presents the unique combination of distinctly bisulcate incisors with remarkably short sphenoid fossæ and a type of zygomatic arch heretofore unknown in the whole order Rodentia. It presents further an exceptional degree of coossification of the component elements of the skull. The occipitals, parietals, frontal, ethmoid, squamosals, alisphenoids, maxilla, palatines, and pterygoids are ankylosed together; and the basisphenoid, presphenoid, and orbitosphenoids are ankylosed together. Furthermore, the two resulting complex masses are firmly united by ankylosis of the orbitosphenoids with the alisphenoids. The coossification is sometimes carried even further by the fusion of the anterior and posterior arms of the zygoma, and the union of the premaxilla with the maxilla and nasals. The sutures that remain open are between the basioccipital and basisphenoid; between the frontal on the one hand and the nasals, premaxillaries, and maxillary root of the zygoma on the other; between the maxilla and frontal anteriorly, and maxilla and alisphenoid posteriorly. The result of these extensive ankyloses is that in old age all of the bones of the cranium except the mandible are inseparably bound together—if not directly in every case, then in a roundabout manner. *Zygogeomys* thus occupies an anomalous position in the family.

ZYGOGEOMYS TRICHOPUS sp. nov.

(Pl. 6; pl. 13, fig. 24; pl. 14, fig. 1; pl. 15, fig. 10.)

Type from NAHUATZIN, MICHOACAN, MEXICO. No. 50107 ♂ ad., U. S. National Museum, Department of Agriculture collection. Collected October 11, 1892, by E. W. Nelson (original No. 3571).

Geographic distribution.—The Sierra Madre of Michoacan, from Patzcuaro to Nahuatzin; strictly limited to the pine zone, between the altitudes of 6,800 and 9,500 feet (map 3[5]).

General characters.—Size large; tail rather long, entirely naked from base; a conspicuous naked pad at end of nose; fore feet and claws shorter than hind; upper surfaces of both fore and hind feet densely covered with hair, completely hiding the skin; color very dark. Cranial characters marked; maxillary and squamosal arms of zygoma meeting above the jugal, which is greatly reduced.

Color.—Upper parts varying from dark slate to rich seal-brown, glossy, and finely mixed with a very thin wash of ferruginous, especially on the sides; underparts dark plumbeous washed with fulvous; upper surfaces of hind feet slate-gray, sometimes varying to white; an irregular patch of white on throat. Some specimens lack the ferruginous wash and are glossy slate-black. Some have an almost metallic luster.

*Cranial characters.**—Skull, as a whole, long and narrow; zygomatic arches contracted, slender, not expanded at antero-external angle; complete without jugal, which is much reduced in size, the maxillary and squamosal arms meeting above it†; rostrum and nasals long and narrow; temporal impressions meeting in a short but well-developed sagittal crest; palatine bones contracted at base of pterygoids; pterygoids vertical lamellæ as in *Thomomys;* occipital plane nearly vertical, about twice as broad as high; mastoid bullæ fuller and more rounded posteriorly than in *Geomys;* audital bullæ of moderate size, similar to those of *Geomys bursarius;* premaxilla ending below at middle of incisive foramina (instead of surrounding them, as usual in the family); postpalatal pits rather narrow, elongated and shallow, reaching anterior plane of last molar; mandible rather long and slender, much as in *Geomys bursarius;* angular processes moderate; condylar process rather short; coronoid process long, its tip overhanging front of condyle.

Measurements (taken in flesh).—Type specimen, ♂ ad.: Total length, 346; tail vertebræ, 115; hind foot, 46. Average of three adult males from type locality: Total length, 342.6; tail vertebræ, 111; hind foot, 45.8. Average of seven females from type locality: Total length, 322.7; tail vertebræ, 105.8; hind foot, 42.8.

For cranial measurements see Table C, p. 209.

Specimens examined.—Total number 12, from the following localities in Michoacan, Mexico: Nahuatzin, 10; Patzcuaro, 2.

General remarks.—Mr. Nelson found these remarkable animals pretty generally distributed over the wooded mountain slopes except where the timber is dense. They are most numerous about the borders of small grassy parks and in the more open parts of the forest. In places where the land has been cleared in these mountains they infest the culti-

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* Owing to the circumstance that only a single species of this remarkable genus is known, it is unsafe to attempt to discriminate sharply between generic and specific characters. For this reason many of the characters given in the generic description are here repeated.

† In some specimens the union is not quite complete.

vated fields and do considerable damage to the corn, wheat, and potatoes of the Indian farmers.

Genus THOMOMYS Max Wied, 1839.

(Text figs. 31^5, 32^b, and 68-71.)

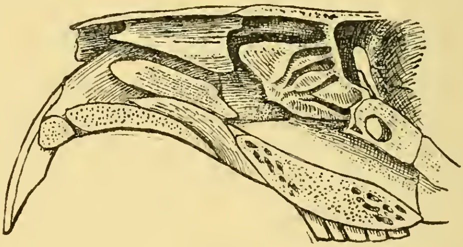
Type *Thomomys rufescens* Max Wied. Type locality unknown.

Thomomys Max Wied, Nova Acta Acad. Caes. Leop.-Carol. Vol. XIX, pt. I., 1839, 377-384.

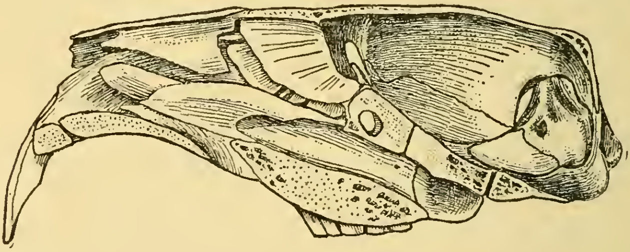
Upper and lower molars, including m^3, with two enamel plates each, one anterior and one posterior (figs. 31^5 and 32^b). Upper incisor with sulcus normally very small and close to inner edge of tooth (fig. 23, p. 72), or absent. In a few species it is relatively large and deep, as in *T. monticola* of Allen.

Orbital plates of frontal not meeting inferiorly behind cribriform plate of ethmoid, but broadly separated by orbitosphenoids (fig. 71, *fro*).

FIGS. 68-71.—*Thomomys bulbivorus.* ♀ Salem, Oregon.



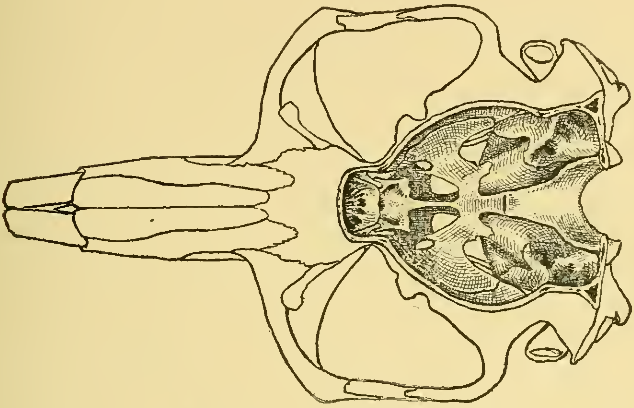
68. Vertical longitudinal section of front of skull, showing turbinated bones. For key see fig. 10.



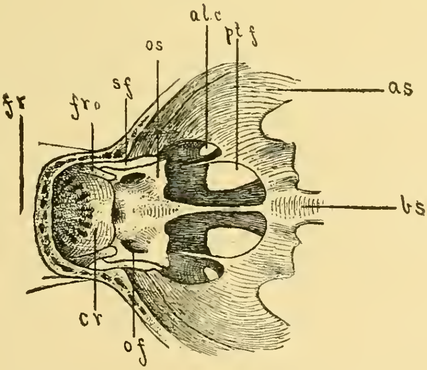
69. Vertical longitudinal median section of skull, mesethmoid and vomer in place. For key see fig. 7.

The accompanying cuts (figs. 68-71) show the relations of the several bones forming the floor of the brain case, and also those of the nasal chamber, in *Thomomys bulbivorus* of Richardson. In this species the incisors project much further forward than usual. The various species differ considerably in important cranial characters, as will be shown in a special paper on the species of *Thomomys.* The geographic distribution of the group as a whole is shown on map 1, A.

Externally *Thomomys* differs from all the other genera of the *Geomyidæ* in the relatively small size of the fore feet. In this respect, and in the faint sulcation of the incisors, the presence of two enamel plates on each of the molars, above and below, and in numerous cranial characters it is much less highly specialized than most members of the family.



70. *Thomomys bulbivorus*, from Salem, Oregon. Skull from above; vault of cranium sawed off to show floor of brain case. For key see fig. 9.



71. Anterior part of floor of brain case. much enlarged. (Same specimen as fig. 70.)
alc Anterior opening of alisphenoid canal.
as Alisphenoid bone.
bs Basisphenoid.
cr Cribriform plate of ethmoid.
fr Frontal.
fro Orbital or descending plate of frontal. It should be observed that this plate does not meet its fellow inferiorly behind the cribriform plate as in most of the other genera.
of Optic foramen.
os Orbitosphenoid.
ptf Pterygoid fossa.
sf Upper part of sphenoidal fissure.

APPENDIX.

(A) Status of Geomys mexicanus Auct.

The earliest description that I have seen of any member of the family *Geomyidæ* was published by Fernandez in 1651, and relates to a Mexican animal called by him the Tucan or Indian mole.* Nearly a century and a half later Kerr bestowed the name *Sorex mexicanus* upon Fernandez's Tucan without having seen a specimen (Kerr, Animal Kingdom, 1792, 207–208). It is not surprising that Kerr followed Fernandez and Buffon in placing the animal among the moles,† misled by its projecting incisors and habit of throwing up little mounds of earth along the course of its subterranean galleries.

The animal seems to have been first referred to the genus *Geomys* by LeConte in 1852 (Proc. Phila. Acad. Nat. Sciences, 1852, p. 160).

In 1827 Lichtenstein described, under the name *Ascomys mexicanus*, three specimens of pocket gophers collected by Deppe on the tableland of Mexico, but the exact locality whence they came is unknown (Brants Muizen, 1827, 27–31). The specimens differed greatly among themselves in color, as originally described by Lichtenstein, and their cranial measurements, kindly furnished me by Dr. Matschie, show that they belong to at least two different genera. The case as it stands, therefore, seems to be as follows: Lichtenstien's *mexicanus* is composite ‡

*Following is a translation of the original description: "On the Tucan, or a certain kind of Indian mole. Chap. XXIV. [The Tucan] is apparently a species of mole 9 inches in length, and equaling the humerus of man in size; it is fleshy, fat, and furnished with such short legs that it almost touches the ground with its belly; hair, fulvous; tail, short; claws and nails, long; snout, murine; ears, small and round; front [teeth], two above and same in number below, considerably exserted and curved inward; [the other teeth], though much smaller, are very strong. When fat the flesh is edible, of pleasant taste, but causes stupor. * * *."—(Francisco Fernandez, Historiæ Animalium et Mineralium Novæ Hispaniæ, Liber I, 1651, pp.7–8.)

†All the American moles were at that time placed with the shrews in the genus *Sorex*, the genera *Scalops*, *Scapanus*, and *Condylura* not having been proposed until sometime later.

‡From the cranial measurements kindly furnished me by Dr. Matschie, and now for the first time published, it is evident that one of Lichtenstein's specimens was a *Platygeomys* closely related to, if not identical with, the animal here described as *P. planiceps*.

and is preoccupied by *mexicanus* of Kerr (1792). The latter is unidentifiable, the vague description applying equally well to several species. It being clearly impossible to use the name *mexicanus*, it should be dropped from the group.

Cranial measurements of two of Lichtenstein's type specimens of Ascomys mexicanus.

[Measured by Dr. Paul Matschie.]

	1558.	1559.
Greatest basal length (condyle to front of premaxilla)	....	55
Basal length (basion to gnathion)	....	52
Basilar length of Hensel (basion to alveolus of incisor)	....	48
Greatest zygomatic breadth	....	35.5
Greatest breadth posteriorly across squamosals	....	40
Least breadth between postglenoid notches	....	28
Least interorbital breadth	....	9.5
Height of cranium above palate	....	20
Height of cranium above basion	....	17
Length of upper molar series on alveoli	14.5	13
Length of diastema	25.5	21
Length of single mandible without teeth	42.5	36
Breadth across angular processes	54	37
Distance from condyle to end of angular process	20	16
Breadth across muzzle just in front of zygoma	13	11

(B.) Tables of Average Measurements of the Various Species.

Average measurements of the species of Geomys.

[All measurements are in millimeters and from fresh specimens.]

Name of species.	Locality.	Number of specimens.			Total length.		Tail vertebræ.		Hind foot.	
		Total.	♂	♀	♂	♀	♂	♀	♂	♀
G. bursarius	Southeastern North Dakota	16	6	10	296	265	90	78	37	34
	Elk River, Minnesota	40	20	20	284	243	.....	.....	.....	.....
	Hunter and Williamsville, Missouri	12	4	8	256	223	74	63	33	30
G. lutescens	Western Nebraska*	22	12	10	270	246	84	72	33.5	31.5
	Childress, Texas	10	4	6	257	228	81.5	68	30	28
G. breviceps	Mer Rouge, Louisiana*	38	15	23	231	213	70	61	28	26.5
	Benton, Arkansas	7	4	3	243	206	74	66.3	29	27
	Fort Gibson, Indian Territory	14	5	9	233	209	68.2	61.7	27.8	26.3
	Mineola, Texas	14	6	8	220.5	193.2	67.8	57.2	26.3	24.1
	Melano, Texas	11	5	6	216.2	206	63.8	60.3	26.4	24.5
G. sagittalis	Galveston Bay, Texas*	20	5	15	220	196	64	54	26	23
	Houston, Texas	9	5	4	226	208	64	57	25	24
G. attwateri	Rockport, Aransas County, Texas*	17	10	7	255	220	80	68	30	28
G. texensis	Mason, Texas*	28	....	....	(†)	.....	.....	.....	.....	.....
G. arenarius	El Paso, Texas*	32	8	24	260	‡250	83	‡78	32	‡32
G. personatus	Padre Island, Texas*	13	4	9	315	293	111	100	40	36
G. fallax	South side Nueces Bay, Corpus Christi, Texas*	13	9	10	263	236	87	75	34	31
G. tuza	Augusta, Georgia*	19	10	9	269	249	89.5	82	34.4	32
	Butler, Georgia§	10	5	5	257	241	82	74	33.8	30.6
G. mobilensis	Mobile Bay, Alabama*	8	4	4	250	229	81	76	33.6	30.5
G. floridanus	San Mateo, Florida	6	3	3	288	235	94	77	35.5	33

* *Type locality.*
† Average of 28 specimens of both sexes: total length, 210; hind foot, 28.
‡ Some of the specimens of *arenarius* recorded as females are very large and were probably males; hence the averages here given for females are probably too great.
§ The specimens from Butler, Ga., are clearly intermediate between *tuza* and *mobilensis*.

Average measurements of the species of Cratogeomys.

[All measurements are in millimeters and from fresh specimens.]

Name of species.	Locality.	Number of specimens.			Total length.		Tail vertebræ.		Hind foot.	
		Total.	♂	♀	♂	♀	♂	♀	♂	♀
C. merriami	Valley of Mexico, Mexico	18	11	7	380	344	113	105	50	46
	Atlixco, Mexico	7	4	3	328	289	94.5	85	47	43.5
	Irolo, Hidalgo, Mexico	3	....	3	.....	324	......	91	......	42.6
C. perotensis	Cofre de Perote, Mexico	12	....	12	.....	310	......	88	......	41.5
C. estor	Las Vigas, Mexico	8	4	4	313	277	89	75	42	37
C. oreocetes	Mount Popocatapetl, Mexico	1	....	1	.....	318	......	92	......	43
C. peregrinus	Mount Iztaccihuatl, Mexico	1	....	1	.....	304	......	87	......	42
C. castanops	Las Animas, Colorado	4	1	3	295	256	95	77	37	33
	Albuquerque, New Mexico	3	....	3	.....	259	......	77	......	34
	Eagle Pass, Texas	....	....	....	.....	.....	......	......	......	......
C. castanops goldmani	Cañitas, Zacatecas, Mexico	3	....	3	.....	257	......	82.7	......	34.3
C. fulvescens	Chalchicomula, Puebla, Mexico	9	3	6	327	302	105	97	43	39.6

Average measurements of the species of Platygeomys, Orthogeomys, Heterogeomys, Pappogeomys, and Zygogeomys.

[All measurements are in millimeters and from fresh specimens.]

Name of species.	Locality.	Number of specimens.			Total length.		Tail vertebræ.		Hind foot.	
		Total.	♂	♀	♂	♀	♂	♀	♂	♀
Platygeomys gymnurus.	Zapotlan, Jalisco, Mexico	6	3	3	353	341	105	93	53.5	49.5
	Sierra Nevada de Colima, Jalisco, Mexico.	2	....	2	......	322	......	85	......	49
P. tylorhinus	Tula, Hidalgo, Mexico	3	1	2	345	298	100	91.5	45	39.5
	Patzcuaro, Michoacan, Mexico.	5	3	2	348	331.5	101.5	91.5	49.5	45.5
P. planiceps	N. slope Volc. Toluca, Mexico, Mexico.	3	1	2	372	336.5	121	100	46	43
P. fumosus	Colima City, Mexico	10	7	3	287.5	277	82	75	42	39 5
Orthogeomys scalops	Cerro San Felipe, Oaxaca, Mexico.	10	2	8	369	360	103.5	109	50	50
Orthogeomys nelsoni	Mount Zempoaltepec, Oaxaca, Mexico.	3	2	1	416	380	131	118	54	52
Heterogeomys hispidus.	Jico, Vera Cruz, Mexico	5	2	3	345	311	92	85	53	47
H. torridus	Motzorongo, Vera Cruz, Mexico.	14	4	10	348	317	96.5	81.5	49	45.5
	Chichicaxtle, Vera Cruz (type), Mexico.	1	....	1	......	323	......	88	......	52
Pappogeomys bulleri	Sierra Nevada de Colima, Jalisco, Mexico.	6	2	4	236	216	81	72	33	30
Pappogeomys albinasus.	Guadalajara, Jalisco	1	....	1	......	226	......	68	......	31
Zygogeomys trichopus	Nahuatzin, Michoacan	10	3	7	343	323	111	106	46	43

(C.) Tables of Cranial Measurements.

Table A.—*Cranial measurements of Geomys bursarius, lutescens, breviceps, sagittalis, and attwateri.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to gnathion).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals.	Breadth at postglenoid notch.	Interorbital breadth.	Height of cranium above palate.	Height of cranium above basion.	Upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible without teeth.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		Geomys bursarius.																		
																		Per ct.	*Per ct.*	*Per ct.*
49185	♂ ad....	Portland, North Dakota	60	57	53.5	36	31.5	22	6.5	20	16	9.5	24.5	40	38	14	11	63.1	55.2	35
2766*	♂ old...	Knoxville, Iowa	59.5	57	53	37.5	34	23.5	7	21	17.5	10	24	40	41.5	15	11	65.8	59.6	36.8
2625*	♂ ad....	.....do	59	57	52.5	36	33	21	7	20	16	10	22.5	39.5	37	14	11	63.1	57.9	35
2772*	♂ ad....	.....do	59	56.5	52	37.5	34.5	22	7	21	17	10	24	40	39.5	15	11	66.3	61	37.1
2624*	♂ ad....	.....do	58	55.5	51	38	33.5	23.5	7.5	20.5	17	9.5	23	39.5	40	15	12	......	......	......
4119*	♂ ad....	Ortonville, Minnesota	58	55	51	36	32	22.5	7	20	16	10	23	39.5	37	14.5	10.5	......	......	......
2621*	♂ ad....	Knoxville, Iowa	54.5	51.5	48	33.5	30.5	20.5	6.5	18	16	9.5	22	36	33.5	11.5	10.5	......	......	......
2925*	♂ ad....	Elk River, Minnesota	53.5	51	47	32	28.5	19.5	6.5	19	15	9.5	21.5	36	34	12.5	10.5	......	......	......
2930*	♂ ad....	.....do	53.5	51.5	47.5	32	29	19	6.5	18.5	15.5	9	21.5	36.5	32	11.5	10	......	......	......
2024*	♀ ad....	Knoxville, Iowa	50	47	43	30	29	21	7	17.5	14.5	8.5	19	33.5	30	11	10	......	......	......
2623*	♀ ad....	.....do	48	45.5	42.5	28	27	19	6	17.5	14	9	18.5	33	27.5	10	10	......	......	......
2768*	♀ ad....	.....do	47	44.5	41	28.5	26	19	7	16.5	13.5	8.5	16.5	32	28	10.5	9	......	......	......
2771*	♀ ad....	.....do	45	42.5	39.5	27.5	26	19	6.5	16.5	13.5	8	18	30	29	10	9	......	......	......
		Geomys lutescens.																		
25471	♂ ad....	Cherry County, Nebraska	50	48.5	44	32.5	27.5	20.5	7	18	13.5	8.5	19.5	33.5	32	12	10.5	67	56.6	37.1
25634	♂ ad....	Chadron, Nebraska	47	44.5	40.5	32	27	20.5	7	17.5	13	9	18	32	29.5	10.5	10.5	71.9	60.6	39.3
25472	♂ ad....	Myrtle, Nebraska	49	47	42	33	27.5	20	6.5	18	15	8.5	18	32.5	31	11.5	10.5	70	58.5	38.3
23799	♂ ad....	Cherry County, Nebraska	48	46	42	31	28	20	6.5	18	13.5	9	17.5	33.5	29	10.5	11	67.3	60.8	39.1
25640	♂ ad....	Kennedy, Nebraska	46	43	39	31	26	19.5	6	16	13	9.5	15.5	30	31	10	10	......	......	......
48468	♀ ad....	Calloway, Nebraska	47.5	45	41	30.5	26.5	19.5	7	17	13.5	9	17	31.5	29.5	10.5	10.5	......	......	......
56088	♂ ad....	Crawford, Nebraska	47	44.5	40.5	30	26	19	7	16.5	13	8.5	17	31.5	29	10	10	......	......	......
25643	♂ ad....	Valentine, Nebraska	47	45	41	30	27.5	19.5	7	17	13.5	8.5	17	31.5	29	10	10	......	......	......
48467	♀ ad....	Calloway, Nebraask	46	44	39.5	30.5	27	20	7	17	13.5	8.5	16.5	30	30	10.5	10.5	......	......	......

47374	♀ ad....	Las Animas, Colorado	45	43	39	30	27	20	6.5	16.5	13.5	8	16.5	31	28	10.5	9.5	......	......	......
23595	♀ ad....	Cherry County, Nebraska (*type*)	45.5	43	39	28.5	26.5	19	7	17	13	9	16.5	30.5	27	10	11	......	......	......
		Geomys breviceps.																		
46664	♂ ad....	Mer Rouge, Louisiana	46	44	40.5	28.5	25.5	19	7	15.5	12.5	9.5	16.5	31	29	10	8.5	64.7	57.9	35.2
46673	♂ ad....	....do	46	43.5	40	29.5	28	19.5	7	16	13	9.5	16.5	31	30	10	10	67.8	64.3	36.7
46356	♂ ad....	....do	44.5	42.5	39	29	25	19	6.5	15.5	12.5	9	16	35	29	10	9.5	68.2	58.8	36.4
46663	♂ ad....	....do	43.5	42	38	28.5	25	19	6.5	15.5	12	9	16	29	29.5	10	9	67.8	59.5	36.9
46661	♂ ad....	....do	43.5	41.5	37.5	27	23	19	7	15.5	12	8.5	15.5	29	28	10	9	......	......	......
46665	♂ ad....	....do	42.5	40	36.5	27	23.5	18	7	15	12	8.5	15.5	28.5	27	9	8.5	......	......	......
46666	♂ ad....	....do	42	40	36.5	26.5	24	18	6	15	12.5	8.5	15	28	26	8.5	8.5	......	......	......
46363	♂ ad....	....do	42	40	36.5	27	24	18.5	7	15.5	12	8	15	28.5	27.5	9.5	9	......	......	......
46659	♀ ad....	....do	40.5	38	35	26	23	18	6.5	14.5	12	8	14	27	23	8	8	......	......	......
46657	♀ ad....	....do	39.5	37	34	24	22.5	17.5	6.5	14	11	8.5	13	26.5	24	8	8.5	......	......	......
46682	♂ old...	Fort Gibson, Indian Territory	44.5	42	38	28.5	24.5	18	6.5	16	12.5	8.5	16	30	28.5	10	9	......	......	......
		Geomys sagittalis.																		
44957	♂ ad....	Galveston Bay, Texas (*type*)	41	39	36	27.5	23.5	18.5	6	16	12.5	8.5	15.5	28.5	27	8	9	70.5	60.2	41
		Geomys attwateri.																		
119†	♂ old...	Rockport, Texas	49.5	47	43.5	33.5	29	21	7	18.5	14.5	9	20	34.5	35.5	13.5	10	71.2	61.7	39.3
100†	♂ old...	....do	49	47	43.5	31.5	27	21	6.5	18	13.5	8.5	19	34	33	12	10	67.8	57.5	38.3
44392	♂ ad....	Tallys Island, Texas	44	42	38.5	28.5	25	18.5	7	16.5	13	8.5	17	30	28	10	10	67.8	59.5	39.2
44321	♂ ad....	Rockport, Texas	44	......	......	[28]	25.5	18.5	6.5	16	13	9	16	30.5	27	10	9	......	......	......
51382	♂ ad....	Rockport, Texas (*type*)	42.5	40.5	38	27.5	24	18	7	16	12.5	8	16	30	27	10	9	67.8	59.2	39.5
44316	♀ ad....	Matagorda, Texas	40	38	35	25	22.5	18	6	14.5	12	8	14.5	28	......	8	8.5	65.7	59.2	38.1
51497	♀ ad....	Rockport, Texas	38	36	33.5	24.5	21.5	18	7	14.5	11.5	8	13	......	......	......	9	68.0	59.8	40.2
44222	♀ ad....	Matagorda, Texas	40	38	35	26.5	23.5	18.5	6.5	15	12	8	14.5	25.5	......	9	8.5	......	......	......
44317	♀ ad....	....do	39.5	38	35	25	22.5	18	6	15	11.5	8	15	27.5	25	9	9	......	......	......

* Merriam collection. † Collection of H. P. Attwater.

TABLE B.—*Cranial measurements of Geomys personatus, fallax, texensis, and arenarius.*

[All measurements are in millimeters. Museum numbers refer to U. S National Museum unless contrary is stated.]

Museum No.	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		Geomys personatus.																*Perct.*	*Perct.*	*Perct.*
43294	♂ ad....	Padre Island, Texas	56	53.5	49.5	36	33	24.5	7	20	16	11.5	21	38.5	36	14	12	67.2	61.6	37.3
43432	♂ ad....	......do	56	53.5	49	35.5	33	24	6.5	19.5	15	10	21	38.5	34	13	10.5	66.3	61.6	36.4
43434	♂ ad....	......do	54	51.5	47	34.5	32.5	23	6	18.5	15.5	11.5	19	37	34.5	13.5	11	66.9	63.1	35.9
43430	♂ yg. ad	......do	53.5	51	47	33	30.5	23	6.5	18.5	15	10.5	18.5	37	33	12.5	11	64.7	59.8	36.2
43436	♀ ad....	......do	53	50	46	31.5	29	21	7	18.5	14.5	10	19	35.5	36.5	12	10.5	......	......	......
43429	♀ ad....	......do	51	48.5	45	31.5	28	22	7.5	18.5	15	10.5	18	35	31.5	12	11	......	......	......
43438	♀ ad....	......do	51.5	49	45.5	31.5	28.5	21.5	7.5	18.5	15	10	18.5	35	32	12.5	10.5	......	......	......
43433	♀ ad....	......do	51	48.5	44.5	31	29	22.5	7.5	18	14	10	18	34	31	11.5	11.5	......	......	......
43435	♀ ad....	......do	49	46.5	42	31.5	30	22	6.5	17.5	14.5	11	16.5	34.5	......	12	10.5	......	......	......
		Geomys fallax.																		
43840	♂ ad....	South side Nueces Bay, Texas	46	43.5	40	28	27	20	6	17	13.5	9	16	32	30	10.5	9	64.3	62	39
43845	♂ ad....	......do (type)	45.5	43.5	39.5	30	27.5	20	6.5	16.5	14	8.5	17	31	31.5	11.5	8.5	68.9	63.3	37.9
43259	♂ ad....	......do	45	42	39	27.5	25.5	19.5	6.5	16.5	13.5	9	16	30	28	10	9	65.4	60.7	39.2
43843	♂ ad....	......do	45	42	39	27.5	27	20.5	6	16	13	9	15.5	31	30	11	8.5	65.4	64.2	38
43262	♂ yg. ad	......do	45	42.5	39	27.5	26	20.5	6.5	17	13	9	15.5	30	28	10.5	9	......	......	......
43842	♀ ad....	......do	42	39.5	36	26	24	19.5	7	16	13.5	8.5	15	29	26	9	8.5	......	......	......
43841	♀ ad....	......do	42	39.5	36	25	24.5	19.5	6.5	16	13	8.5	14.5	28.5	25.5	9.5	8.5	......	......	......
43292	♀ ad....	......do	41.5	39.5	36	26.5	24.5	20	6.5	16	13	8.5	14.5	28.5	28	10	9	......	......	......
43844	♀ ad....	......do	40.5	38.5	35	25	23.5	18	6.5	15.5	12.5	8	14	28	26	9.5	8.5	......	......	......
43293	♀ ad....	......do	40.5	38	35	25	23	18.5	6	15.5	12.5	8.5	13.5	27	25.5	9.5	8.5	......	......	......
		Geomys texensis.																		
4161*	♂ ad....	Mason, Texas	42.5	40.5	37	27	24.5	19	6.5	16	12	8	15.5	......	......	......	9.5	66.6	60.4	39.5
4164*	♂ ad....	......do	39.5	37.5	34	24	22	17.5	5.5	14.5	12	8	14	26	26	9	8.5	59.2	54.3	38.6

2415*	♂ ad	......do	39.5	37.5	34	24.5	22	17.5	6.5	14.5	12	8	14	......	......	......	8.5	65.3	58.6	38.6
4163*	♂ ad	......do	39.5	37	34	23.5	21	17	6	14.5	11.5	8	13.5	26	24.5	7.5	8.5	63.5	56.7	39.1
2694*	♀ ad	......do	38	35.5	32	22.5	22	17.5	7	14.5	11.5	7.5	12.5	25.5	23	8	8	......	......	......
4172*	♂ ad	......do	39	37	33	25	22	17.5	6.5	15	11	8.5	12.5	26	26	8.5	9	......	......	......
2259*	♀ ad	......do (type)	37.5	35	32	23	20.5	17	6	14	11.5	7.5	12.5	25	24	7.5	8	......	......	......
		Geomys arenarius.																		
25015	♂ ad	El Paso, Texas (type)	43	40.5	37	27	23.5	18.5	7	16	12	8	15	28.5	26.5	9	9	66.6	58	39.5
58340	♂ old	......do	42.5	40.5	37	28	24.5	18.5	6.5	15.5	12	8	15	28	28	9.5	9.5	69.1	60.4	35.8
58334	♂ yg. ad	......do	42	40	36.5	25.5	23.5	19	7	15.5	12	8	14.5	28	24.5	9	9	63.7	58.7	38.7
23787	♂ ad	......do	42	39.5	36	25.5	23.5	18	6	15.5	11.5	7.5	14.5	28.5	27	9	8.5	64.5	59.4	39.2
58339	♂ ad	......do	41.5	39	35.5	25	24.5	19	6.5	15	12	8.5	13.5	28	27	9	9	......	......	......
24973	♀ old	......do	41	38.5	35	26	23	17.5	6.5	15.5	10.5	7.5	14.5	27	26.5	9	9	......	......	......
58337	♀ ad	......do	41	39	35	25.5	24	18	6	15.5	11.5	8	14	27	26	9	9	......	......	......
55013	♀ ad	......do	40.5	38	35	25.5	23	18	6	15	11.5	8	13	27	25	9	9	......	......	......
25016	♀ ad	......do	40	37.5	34	24	23	18	6.5	15	11	8	13	27	26	9	8.5	......	......	......

* Merriam collection.

TABLE C.—*Cranial measurements of Geomys tuza, floridanus, mobilensis, and Zygogeomys trichopus.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series of alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		Geomys tuza.																Per ct.	Per ct.	Per ct.
58591	♂ ad	Augusta, Georgia	52.5	50	46	32	28	21	6.5	18.5	13.5	10.5	20.5	37	33.5	12	10	64	56	37
58593	♂ ad	do	52.5	49.5	46	31	28	21	7	19	13	10	20	37	34	12	10	62.6	56.5	38.3
58639	♂ ad	do	51	48	44.5	31.5	26.5	20	7	18.5	13	10	19.5	35	31	11.5	9	65.6	55.2	38.5
63842	♂ ad	do	50	47	44	31.5	26.5	20	7	18	13.5	10	19	35	32	12	10	67	56.4	38.3
58643	♂ ad	do	50	47.5	43.5	29.5	26	19	6.5	17.5	12.5	9.5	19	34	31	11.5	9.5	......	......	......
63844	♂ ad	do	50	47	44	29.5	26	19.5	6	18	13	10	19.5	35	30.5	11	9.5	......	......	......
58594	♂ ad	do	50	47	44	30	26	19.5	7	18	13	10	19.5	35	30	11.5	10	......	......	......
58642	♀ ad	do	47	44	40.5	27	24	19.5	6	16.5	12.5	9.5	17.5	32	27.5	10	9	61.3	54.5	37.5
58595	♀ ad	do	46	43	40	26.5	24	20	6.5	16.5	12.5	9.5	16.5	32.5	27	10	9	......	......	......
58640	♀ ad	do	46	43	39.5	27	24.5	19.5	6.5	17	12.5	10	16	32	27.5	10	9.5	......	......	......
58646	♀ ad	do	44	41	38	27	24	19.5	6.5	16.5	12.5	9.5	15.5	31	25	9.5	8.5	......	......	......
58644	♀ ad	do	44	41.5	37.5	27	24	19	6.5	15.5	12	9.5	15.5	30	27.5	9.5	8.5	......	......	......
58641	♀ ad	do	43	41	38	25,5	23	18.5	6.5	15.5	12	9	15	30	25	9	8.5	......	......	......
		G. tuza floridanus.																		
6514*	♂ ad	San Mateo, Florida	53.5	51	47	31.5	27	20.5	7.5	18	14	10.5	20.5	38	34.5	13	13	61.7	52.9	35.2
6511*	♂ ad	do	52.5	49.5	46.5	31	28	21	7	18	14	11	20.5	37.5	32.5	11.5	10.5	62.6	56.5	36.3
6512*	♂ ad	do	50.5	48	44.5	31	27.5	20	7.5	18	13.5	10.5	21	36.5	32.5	12	10.5	64.5	57.3	37.5
24131	♂ ad	Pomona, Fla	51	49	45	31	27.5	18.5	7	18.5	14	11	20	35	32.5	12	10	63.2	56.1	37.7
51510	♂ ad	Gainesville, Fla	48.5	45.5	42	29	24.5	19	7	17	13	9.5	20	34	30.5	11	9.5	......	......	......
24128	♀ ad	Pomona, Fla	45.5	43	40	27	25	19	7	16.5	13	9.5	17.5	32	28.5	10.5	9	62.8	58.1	38.3
24130	♀	do	42.5	40	37	26.5	23.5	18	7	16.5	13	9.5	15.5	29.5	27.5	9.5	9	......	......	......
		G. tuza mobilensis.																		
46023	♂ ad	Mobile Bay, Alabama (*type*)	52.5	50	46	33.5	27.5	20.5	9.5	18	13.5	11	22	38	34	12	10	67	55	36
46024	♂ ad	do	51	48.5	45	32	26	19	8	17	13.5	9.5	21	36	32	11	9	65.9	53.5	35

46019	♀ ad	do	44.5	42	39.5	27.5	23	18	7.5	16.5	12.5	9	17.5	31	......	8.5	8.5	61.8	51.6	37
46021	♀ ad	do	44	42	38.5	28	24	19	8	16.5	12.5	10	17	32	28.5	9.5	9	66.6	57.1	39.2
46017	♀ ad	do	43.5	41	38	25.5	22.5	18.5	7	16	12.5	9	16.5	31	26	9	8.5	62.2	54.9	39
		Zygogeomys trichopus.																		
50106	♂ ad	Nahuatzin, Michoacan, Mexico	61	58.5	54	39	35.5	25	9.5	20	17.5	11.5	24.5	42	40	15.5	11.5	66.6	62	34.1
50100	♂ ad	do	61	58	53.5	38.5	35	25	8.5	21	18	12	23	40	42.5	15	11.5	66.3	60.3	36.2
50107	♂ ad	do (*type*)	60	56.5	53	37	33.5	25	8	21	18	11	24	40	40	14.5	11.5	65.4	59.2	37.1
50099	♂ ad	do	59.5	56	52	38.5	33.5	25	8	21	18	12	23	39	40	15	11.5	68.7	59.8	37.5
50105[a]	♀ ad	do	57	53.5	49.5	35.5	33.5	25	8.5	20.5	16.5	11.5	22	37.5	35	14	11.5	66.3	62.6	38.3
50108	♀ ad	do	56.5	53.5	49	36	33	25	8	20	17.5	11	21	37.5	37	13.5	10.5	......	......	......
50103	♀ ad	do	56	53.5	49.5	35.5	34	25.5	8	20	17	11.5	22	37	38	14	10.5	......	......	......
50101	♀ ad	do	55	52	48	37	32.5	24.5	8	20	16	10.5	21.5	37	36.5	13	11	......	......	......
50102	♀ ad	do	52.5	49.5	46	34.5	30	23	8	20	15.5	11.5	18.5	35	34	12	10.5	......	......	......
47187	♀ ad	Patzcuaro, Michoacan, Mexico	50	46.5	43	30.5	29	21	8	18.5	15	11.5	18	33	32	11.5	10	......	......	......

[a] Merriam collection.

TABLE D.—*Cranial measurements of the species of Cratogeomys.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla)	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Ratios to basal length. Greatest squamosal breadth.	Ratios to basal length. Height of cranium above palate.
		C. merriami.																*Per ct.*	*Per ct.*	*Per ct.*
57970	♂ old	Amecameca, Mexico (giant)	74.5	70.5	64	49	48.5	33.5	9.5	28.5	21	15.5	28.5	52	53	21	17	69.5	68.7	40.4
50110	♂ ad.	Lerma, Mexico	70	66.5	61	47	42	31	9	25	18.5	13	29	47	48.5	17.5	15.5	70.6	63.4	37.5
50112	♂ ad.	Tlalpam, Mexico	68	64.5	58.5	42.5	39	29	8	25.5	19.5	13.5	26.5	45	46.5	17	15.5	65.8	60.4	39.5
51447	♂ ad.	Amecameca, Mexico	67.5	64.5	58.5	45	41.5	30	8.5	27	19.5	13.5	26	46	47	17.5	14.5	69.7	64.3	41.8
51446	♂ ad.	......do	67	63	57	45.5	41	31	8.5	26.5	19.5	14	26	45	51	18.5	15	72.1	65	42
51158	♂ ad.	Huitzilac, Mexico	67	64	58.5	44.5	43.5	31.5	9	24.5	19	13.5	25.5	44	50	18.5	14.5	......	......	......
50113	♂ ad.	Tlalpam, Mexico	65.5	62	57	44.5	39.5	31	8.5	24.5	18.5	12.5	26	46	48	17	14.5	......	......	......
55347	♂ ad.	Atlixco, Mexico	64	60	54.5	45	43.5	31	9	25	18	12	25.5	45	51	19.5	15	......	......	......
55346	♂ ad.	......do	63	60	54.5	42.5	42	29	9	24	18	12.5	24.5	44	47	17	14	......	......	......
50109	♂ yg. ad.	Salazar, Mexico	61.5	58	53.5	40	39	29	8	23	17	12.5	24	41	43	15.5	14	......	......	......
50114	♀ ad.	Tlalpam, Mexico	60.5	57.5	52.5	41	37	26	7.5	23.5	18	12.5	23	41	43.5	16	13.5	71.3	64.3	40.8
53494	♀ ad.	Irolo, Mexico	60	56.5	51	40.5	38	31	8	23	17	12	22	40	42	15	14.5	......	......	......
53496	♀ ad.	......do	59.5	56.5	51	40.5	37.5	30.5	9	23.5	17.5	12	22	40	42	14.5	13.5	......	......	......
53495	♀ ad.	......do	59.5	......	......	39.5	38	29.5	7.5	23	17	12	22.5	39.5	41	15	13	......	......	......
55351	♀ ad.	Atlixco, Mexico	57.5	54	49	38	35	26	9	22.5	16.5	11.5	21.5	39	42	15	13	......	......	......
55350	♀ ad.	......do	54	51	46.5	35	33	24	8.5	21	15	11.5	19.5	36.5	40	15	12.5	......	......	......
		C. perotensis.																		
54295	♀ ad.	Cofre de Perote, Mexico	58.5	55	50.5	39.5	36	27	7.5	22.5	16.5	12	21	40.5	40.5	15.5	12	71.7	65.3	40.9
54296	♀ ad.	......do	58.5	55	51	39	35	28.5	7.5	22.5	17	12	23	40	41	15	12	70.9	63.6	40.9
54291	♀ ad.	......do	57	54	49.5	38	34.5	25.5	7.5	22.5	17.5	11.5	21	39	40	14	11.5	70.3	63.8	41.6
54299	♀ ad.	Cofre de Perote, Mexico (*type*)	56.5	54	49.5	38	34	26.5	7	22	17	10.5	21.5	39	42	15.5	11.5	......	......	......
54289	♀ yg. ad.	Cofre de Perote, Mexico	54.5	51.5	47	37	33	25	7.5	21.5	16.5	11	20.5	37.5	37.5	12.5	11.5	......	......	......
		C. estor.																		
54308	♂ ad.	Las Vigas, Vera Cruz, Mexico (*type*)	55	52	47.5	38	33.5	26	8	20.5	16	11	20	37	38.5	13.5	12	73	64.4	39.4

54305	♂	Las Vigas, Vera Cruz	55.5	52	48	38.5	34	26	7.5	21	15.5	11	21	37	37.5	13.5	12	74	65.3	40.3
54307	♂	do	54.5	52	47.5	38	33.5	26.5	7.5	20.5	15.5	11	20	37.5	38.5	13.5	12.5	73	64.4	39.4
		C. oreocetes (type).																		
57963	♀ yg.ad.	Mount Popocatapetl, Mexico	54.5	51	47	32.5	32	24	8	20	15	10.5	20	36	34	13	12.5	63.7	62.7	39.3
		C. peregrinus (type).																		
57964	♀ old	Mount Ixtaccihuatl, Mexico	55.5	52	47.5	35	34.5	27.5	7.5	21.5	15	11.5	20	37	35	13	12	65.3	66.3	41.3
		C. castanops.																		
47368	♂ ad.	Las Animas, Colorado	54	51	46.5	38	30.5	23	7	20.5	15.5	10.5	21	36.5	38	14	11	74.5	59.8	40.1
47364	♀ ad.	do	50	47	43	32.5	28	22	7	19.5	14.5	9.5	19.5	33.5	32.5	12.5	10	69.1	59.5	41.5
47363	♀ ad.	do	47.5	44	41	31	27	21.5	7.5	18.5	14	10	18	32	31	11.5	10	70.4	61.3	42
47365	♀ ad.	do	47.5	44.5	40.5	30	26.5	21	6.5	18	13.5	10	18	31.5	31	11	10	......	......	......
25108	♂ ad.	Marfa, Texas	56	53	49	37.5	33.5	22	7	21.5	15.5	9.5	22	38	38	14.5	10.5	......	......	......
51048	♂ ad.	Jaral, Mexico	56.5	53.5	49	......	32.5	24	7.5	20.5	15.5	10.5	22.5	38	......	14	12	......	......	......
51049	♂ yg.ad.	do	53.5	50.5	47	34	30	22.5	7	20	15	10	21.5	36	36	12.5	11.5	......	......	......
		C. castanops goldmani.																		
57968	♀	Cañitas, Zacatecas, Mexico	49	46	42.5	32	27.5	21.5	7.5	18.5	13.5	9	18.5	32.5	33	11.5	10.5	69.5	59.7	40.2
57965	♀	Cañitas, Zacatecas, Mexico (*type*)	47.5	44.5	41	32.5	29	21	7.5	18	13	9.5	18.5	31	33	12	10.5	73	65.1	40.4
		C. fulvescens.																		
58168	♂ ad.	Chalchicomula, Puebla, Mexico (*type*)	58	55	50.5	40	34	26	7.5	22.5	17	12	22	38	40	14	12.5	72.7	61.8	40.9
58166	♂ yg.ad.	Chalchicomula, Puebla	56	52	48	38.5	33.5	25	8	22	17	12	21	38.5	41	14.5	13	74	64.4	42.3
53497	♀ ad.	do	54.5	51	47	35.5	30	22.5	7.5	22	16.5	11	20	36.5	36	13	12	69.6	58.8	40.1
53498	♀ ad.	do	54	51	47	35.5	30.5	24	6.5	20.5	15.5	10.5	20	36.5	36.5	12	11.5	......	......	......
58169	♀ ad.	do	52	49	45	34	29.5	23	7	21	16	10	19	35	33	12.5	11	......	......	......

TABLE E.—*Cranial measurements of the species of Platygeomys.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number.	Sex and age.	Locality.	Greatest basal length (condyle to front of premaxilla).	Basal length (basion to front of premaxilla).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals (over mastoids).	Breadth at postglenoid notch.	Breadth across postorbital processes.	Interorbital breadth.	Greatest height of cranium above palate.	Greatest height of cranium above inferior lip of foramen magnum.	Length of upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible.	Greatest breadth of mandible across angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratio to basal length. Zygomatic breadth.	Ratio to basal length. Greatest squamosal breadth.	Ratio to basal length. Greatest height of cranium above palate.
		P. gymnurus.																	*Per ct*	*Per ct*	*Per ct*
45614	♂ ad	Zapotlan, Jalisco, Mexico (*type*)	66	62.5	57.5	45	48	34	......	10	24	20	14	26	43	57.5	21	15	72	76.8	38.4
45611	♂ ad	Zapotlan, Mexico	66	62	57	47	49.5	35.5	......	9.5	23	19	14.5	25	45	63	23.5	15	75.8	79.8	37
45610	♂ ad	do	65.5	62	57.5	46.5	47	33	......	10	24	19	14	25.5	42	56	20	15	75	75.8	38.7
46214	♂ ad	do	65	61	56	44.5	47	34	......	10	23	18	14.5	24	41.5	57	20.5	15.5	72.9	77	37.7
45609	♂ ad	do	64	60	56	46	46.5	33	......	10	23.5	18.5	14	23.5	42	57	20	15	......	......	......
45613	♂ yg. ad	do	62.5	59	54.5	44	44.5	30.5	......	9	23	17.5	14	23	41	56	19.5	15	......	......	......
45615	♀ ad	Sierra Nevada de Colima, Jalisco	62.5	58.5	53.5	43.5	44.5	32	......	9.5	23	18.5	14.5	22	41.5	49	19	14.5	69.6	74.3	39.3
45616	♀ ad	do	60	57	53	42	42.5	31	......	9.5	22	18	13	22.5	42	52	20	14	......	......	......
		P. tylorhinus.																			
51883	♂ ad	Tula, Hidalgo, Mexico (*type*)	61.5	58	54.5	43	44	31	......	8	23.5	18.5	12	24.5	42	52	18.5	12.5	88.6	69.9	38.2
51881	♀ ad	Tula Hidalgo	53	50	47	36	36.5	27	......	7.5	21	15.5	12.5	19	35	42	15	11	88.6	67.9	39.6
51884	♀ im	do	51	48	45	33.5	36	26	......	7.5	20	14.5	10.5	20	34	40.5	13.5	10.5	88.2	65.6	39.2
47183	♂ ad	Patzcuaro, Michoacan, Mexico	66	62	57	46	46	32.5	......	9	24.5	19.5	13	25	44	55	19	16	74.2	74.2	39.5
47182	♂ ad	do	64.5	60	56	42	44	31	......	9	23.5	17	13	24	43	48	18.5	14	70	73.3	39.1
47181	♀ ad	do	61	56.5	52.5	42	44	32	......	8	23	18.5	12	23	40	51	17.5	12.5	74.3	77.8	40.7
47185	♀ ad	do	60.5	56.5	53	41.5	44	32	......	7.5	22.5	18	12.5	23	40	50	17	13	......	......	......
47184	♂ yg. ad	do	59	55	52	40	40.5	28.5	......	7.5	23	16.5	12	23	40	46	17	12	72.7	73.6	41.8
		P. planiceps.																			
55906	♂ ad	Volcan Toluca, Mexico (*type*)	63	59	55	42.5	43.5	30	......	8	22.5	17.5	13	24	41	51	18	13	72	73.7	38.1
55907	♀ ad	Volcan Toluca, Mexico	56	52.5	49	38	39.5	28	......	7.5	21	16	12	21	36	46	16	12	72.3	75.2	40

		P. fumosus.																				
45211	♂ ad	Colima City, Mexico	59	55.5	51	38.5	38.5	30	......	9.5	21	16	13	22	38	46	15.5	13.5	69.3	69.4	37.8
45207	♂ ad	Colima City, Mexico (*type*)	56	53	48.5	39	37.5	29.5	......	8.5	20	15.5	12.5	20.5	37	46.5	15.5	13	73.5	70.7	37.7
45213	♂ ad	Colima City, Mexico	54.5	51	47	38.5	36	28.5	......	8.5	20.5	15	12	20.5	37	45	15.5	12.5	75.4	70.5	40.1
45208	♂ ad	do	53.5	50	46.5	37	36	28.5	......	8.5	19	15.5	12	19.5	35.5	44	14.5	12.5	74	72	38
45212	♀ ad	do	52	49.5	45.5	36	36	29	......	8.5	20	15	12	19	35.5	43	14	12.5	72.7	72.7	40.4
45214	♀ ad	do	52	49	45	35.5	34.5	27.5	......	8	19.5	14.5	11.5	19	35.5	40.5	14	11.5	72.4	70.4	39.8
45205	♀ yg. ad	do	51.5	49	44.5	35.5	33.5	28	......	8	19	13.5	11.5	18.5	34.5	41.5	14	12.5	72.4	68.3	38.8

TABLE F.—*Cranial measurements of the species of Pappogeomys, Orthogeomys, Macrogeomys, and Heterogeomys.*

[All measurements are in millimeters. Museum numbers refer to U. S. National Museum unless contrary is stated.]

Museum number.	Sex and age.	Locality.	Greatest basal length (condyle to gnathion).	Basal length (basion to gnathion).	Basilar length of Hensel.	Zygomatic breadth.	Greatest breadth across squamosals.	Breadth at postglenoid notch	Breadth between postorbital processes.	Interorbital breadth.	Height of cranium above palate.	Height of cranium above basion.	Upper molar series on alveoli.	Length of diastema.	Greatest length of single half of mandible without incisor.	Greatest breath of mandible between angular processes.	Distance from condyle to angular process.	Breadth of muzzle at root of zygoma.	Ratios to basal length. Zygomatic breadth.	Greatest squamosal breadth.	Height of cranium above palate.
		Pappogeomys bulleri.																			
																			Per ct	*Per ct*	*Per ct*
45622	♂ ad ...	Sierra Nevada de Colima, Jalisco, Mexico.*	40	38	35	25.5	24	19.5	......	7	16	12.5	9	14	28	26.5	9	8.5	67.1	63.1	42.1
45619	♀ ad....	.....do..........	39	36.5	33.5	25	23	19	......	8	15.5	12	9	13.5	27	26	9	8	65.7	60	44.3
45623	♀	.....do..........	37.5	35	32	23	21	18.5	......	7	15.5	12	8.5	13.5	25	24	8	8	65.7	60	44.3
		Pappogeomys albinasus.																			
46215	♀ ad....	Guadalajara, Jalisco (*type*)..	39.5	36.5	33	25.5	23.5	20.5	......	7.5	15	12	9.5	12.5	25	26.5	9	9	69.8	64.3	41
		Orthogeomys scalops.																			
67029	♂	Cerro San Felipe, Oaxaca...	67.5	64	59.5	42	40	27	16.5	14	25.5	19.5	14	25	45	43.5	16	14	65.6	62.5	39.8
67030	♂	.....do..........	67	63	57.5	41.5	42	28.5	18.5	15	26.5	20.5	13	26	46.5	42.5	16	14	65.8	66.6	42
65973	♀	.....do..........	67	63.5	58	37	40	27.5	17	15	25.5	19.5	14.5	25	45.5	43.5	16	13	58.2	62.9	40.1
67033	♀	.....do..........	66	62	57	38	41	28	18	15	26	20	14	24.5	44.5	40.5	15.5	14.5	......	......	......
67026	♀	.....do..........	64.5	60.5	55.5	37.5	40	29	18.5	16	25	19	14	23	43.5	38	14.5	14.5	......	......	......
79.1.6.2.†	....	Tehuantepec (*type*)‡	......	63	56.7	40.8	39	26.7	16.2	14.2	......	18.4	......	24.5	......	......	......	15	......	......	......
		Orthogeomys grandis.																			
65.5.18.65.†	ad	Dueñas, Guatemala (*type*)‡..	72	68	62	43.8	44.2	30	16	15	29	20.5	16.5	25.5	51	49	19.6	16.2	64.4	65	42.6
		Orthogeomys nelsoni.																			
66753	♂	Near Totontepec, Oaxaca ...	75	70	64	45	44	29.5	18	17	28.5	22	15	28	51	48.5	17	17.5	64.2	62.8	40.7
66751	♂	Mount Zempoaltepec, Oaxaca, Mexico (*type*).	73	70	64	44	42.5	30.5	18	16	28	21.5	15	28.5	50	47	17	16	62.8	60.7	40

66752	♀	....do	68	63.5	58	39	39.5	28	17	14	24.5	19.5	14	25.5	46.5	40	16	15	61.4	62.2	38.5
		Macrogeomys heterodus.																			
2864¶	....	Costa Rica (*type*)§	61	58	51.2	......	38	27.5	15.25	11	24	17	14	22.5	44	40	13	15	......	65.5	41.3
W. F. 3	♂ ad	Irazu Range, Costa Rica	64	60	55	42.5	40	30	18	10	25.5	19.5	15	24	45	44	17	15	70.8	66.6	42.5
		Macrogeomys dolichocephalus.																			
36295	[♂ ad]	San Jose, Costa Rica (*type*)	69	65	60	40.5	39.5	29	17	9.5	26.5	19	15.5	27.5	48.5	42	17	15.5	62.3	60.7	40.7
36820	♀ im	....do	56	52	48	33	33	24.5	16	9.5	23	17	13	20.5	38.5	36	14	13.5	63.4	63.4	44.2
		Macrogeomys costaricensis.																			
22551	im	Pacuare, Costa Rica (*type*)	52	48.5	44.5	33	29.5	23	15.5	9	21.5	16	13	20	37	35	12.5	14	68	60.8	44.3
		M. cherriei.																			
C. R. N. M. 664	im	Santa Clara, Costa Rica (*type*).	51	47.5	44	34	30	23.5	15	9.5	21.5	16	12	20	37	(?34)	12.5	13	71.5	63.1	45.2
		Heterogeomys hispidus.																			
55016	♂	Jico, Vera Cruz, Mexico	......	......	......	45	42.5	30.5	14.5	11	25.5	19.5	14	......	42	48.5	18	......	......	......	......
55343	♂	....do	61	57.5	53	38	39.5	28.5	15	11.5	24.5	17	13.5	22	40	43.5	16	14	66	69.6	42.6
55060	....	....do	......	......	......	37.5	......	29.5	14.5	11.5	24.5	......	13.5	22	39.5	......	......	13	......	......	......
55017	♀	....do	58	55	51	37	37.5	28	15	10	23.5	17.5	14	20.5	38.5	40	15	12.5	67.2	68.1	42.7
55018	♀	....do	......	......	......	36	37	28	15	11.5	23.5	17	13.5	......	38	41	15.5	......	......	......	......
		Heterogeomys torridus.																			
63629	♀ ad	Chichicaxtle, Vera Cruz, Mexico (*type*).	60.5	57	52.5	41	39	28	15.5	11	23	18	13.5	21	41	46.5	17.5	15	71.9	68.4	40
63645	♂ ad	Motzorongo, Vera Cruz	60.5	57	52	41.5	40.5	30	14	11	23.5	18	13.5	21.5	40	45	16.5	15	72.8	71	41
63632	♂ ad	....do	63.5	60	55.5	43.5	41	30	15.5	10.5	25	19.5	14.5	23	42	46	18	15	72.5	68.3	40.1
63635	♀	....do	57	54	50	38.5	38	29	13.5	11	23.5	18	13	21	38	42	16	12.5	71.2	70.3	33.3
63651	♀	....do	57	54	50	37	36	28	13.5	10.5	23	18	13	20.5	38.5	42	15.5	13.5	68.5	66.6	33.3

* Type of *Geomys nelsoni* Merriam. † British Museum. ‡ Measured by Oldfield Thomas. ¶ Berlin Museum. § Measured by Dr. Paul Matschie.

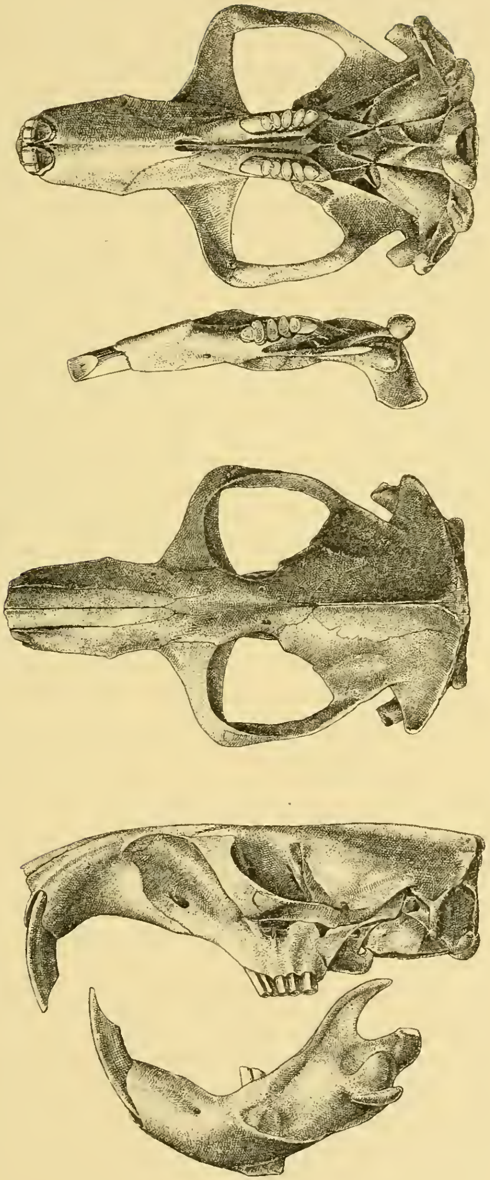
INDEX.

[Names of genera and species are in heavy type.]

PLATE 1.

(All natural size.)

Geomys bursarius (Shaw). Knoxville, Iowa.
(No. 2772 ♂ ad. Merriam collection.)



Benj Mortimer del. Nat. size B Meisel, phot.

GEOMYS BURSARIUS (Shaw)

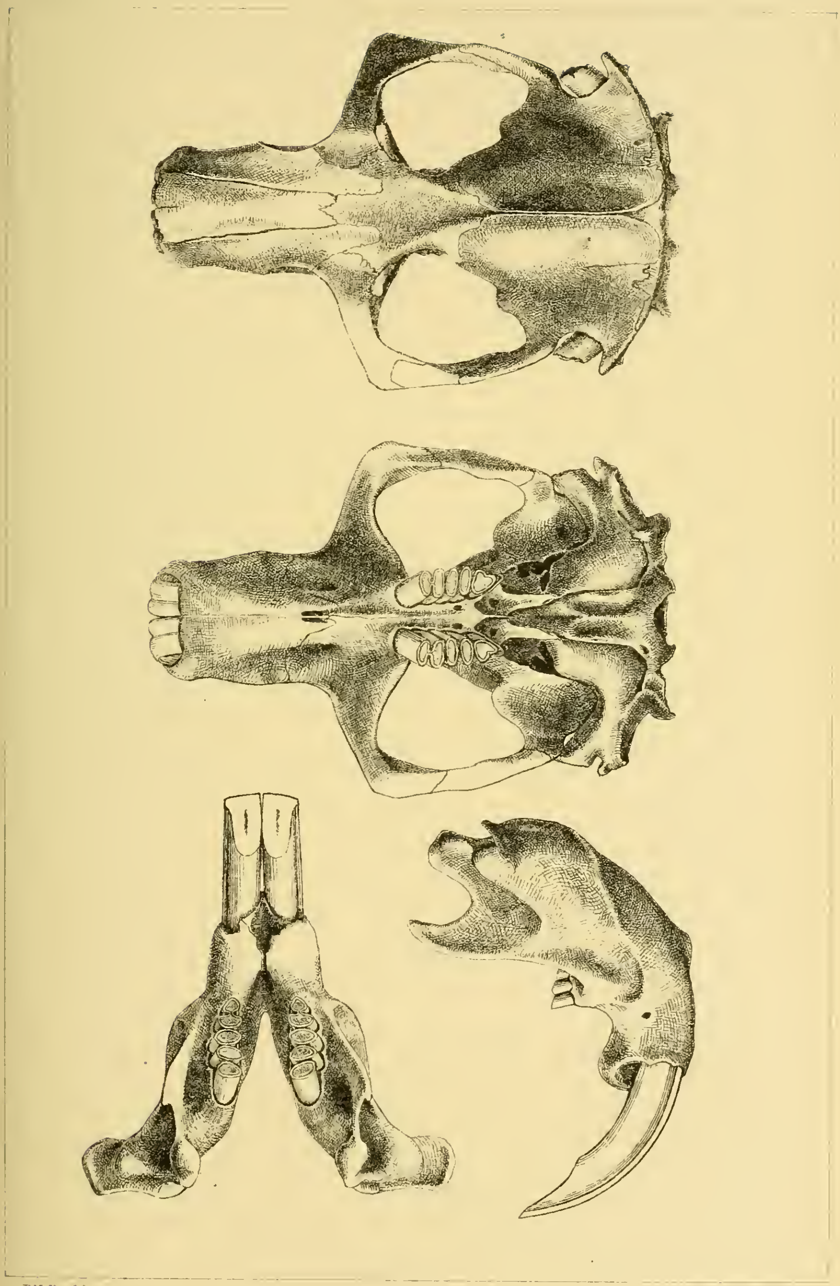
Knoxville, Iowa.

No. 2772. ♂ ad.

PLATE 2.

(All natural size.)

Cratogeomys merriami (Thomas). Lerma, Mexico.
(No. 50110 ♂ ad. U. S. Nat. Mus.)



F. Muller, del. Nat size B. Meisel photo

GEOMYS MERRIAMI Thomas

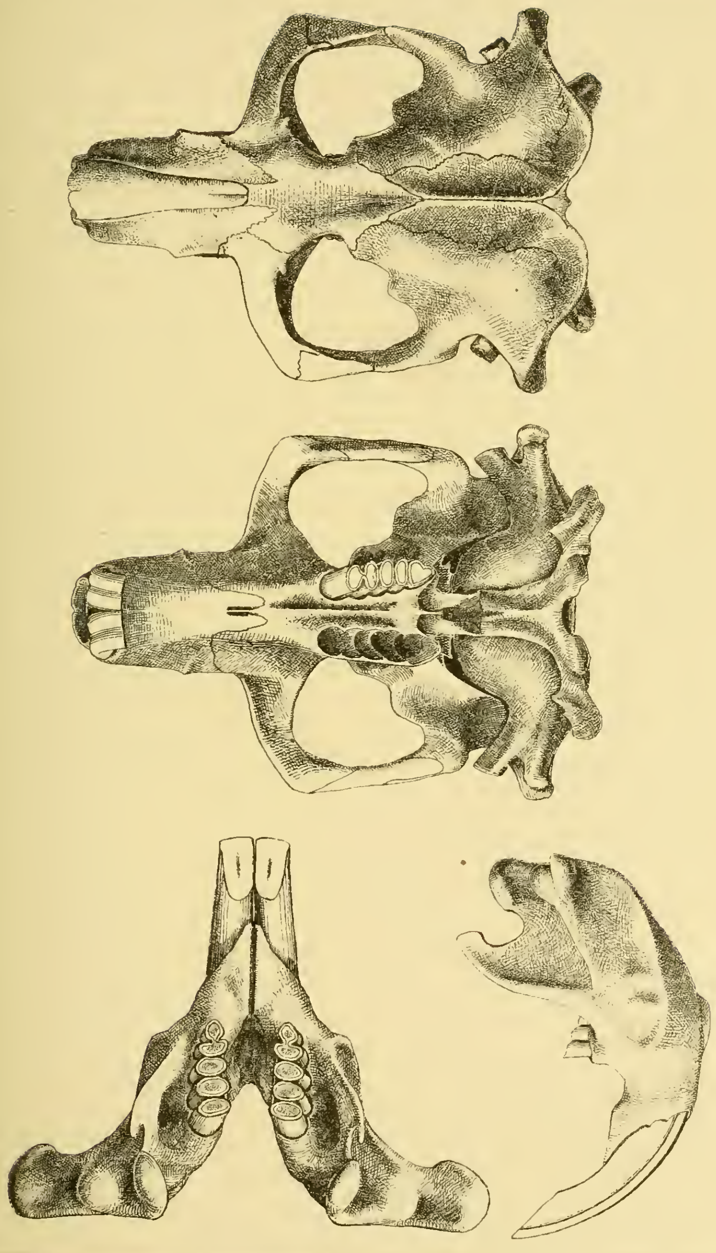
Lerma, Mexico.

No. 50110, ♂ ad

PLATE 3.

(All natural size.)

Platygeomys gymnurus Merriam. Zapotlan, Jalisco, Mexico. (No. 45611 ♂ ad. U. S. Nat. Mus.)



F. Muller, del. Nat. size B Meisel, lith.

GEOMYS GYMNURUS Merriam

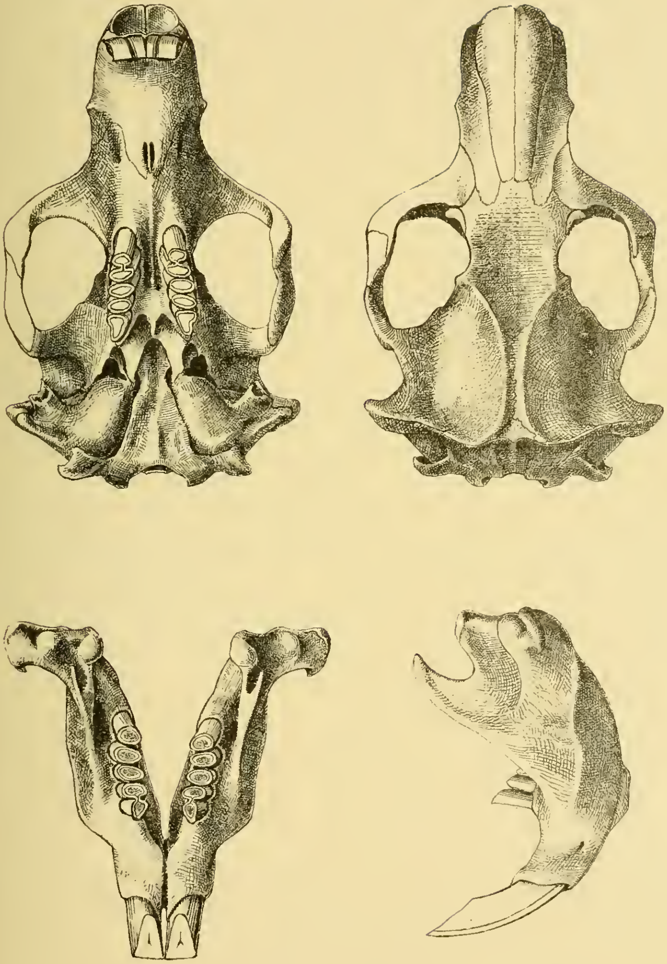
Zapotlan, Mexico.

No. 45611. ♂ ad.

PLATE 4.

(All natural size.)

Heterogeomys hispidus (LeConte). Jico, Vera Cruz, Mexico.
(No. 55343 U. S. Nat. Mus.)



F. Muller, del. Nat. size B. Meisel, [illegible]

GEOMYS HISPIDUS. Le Conte

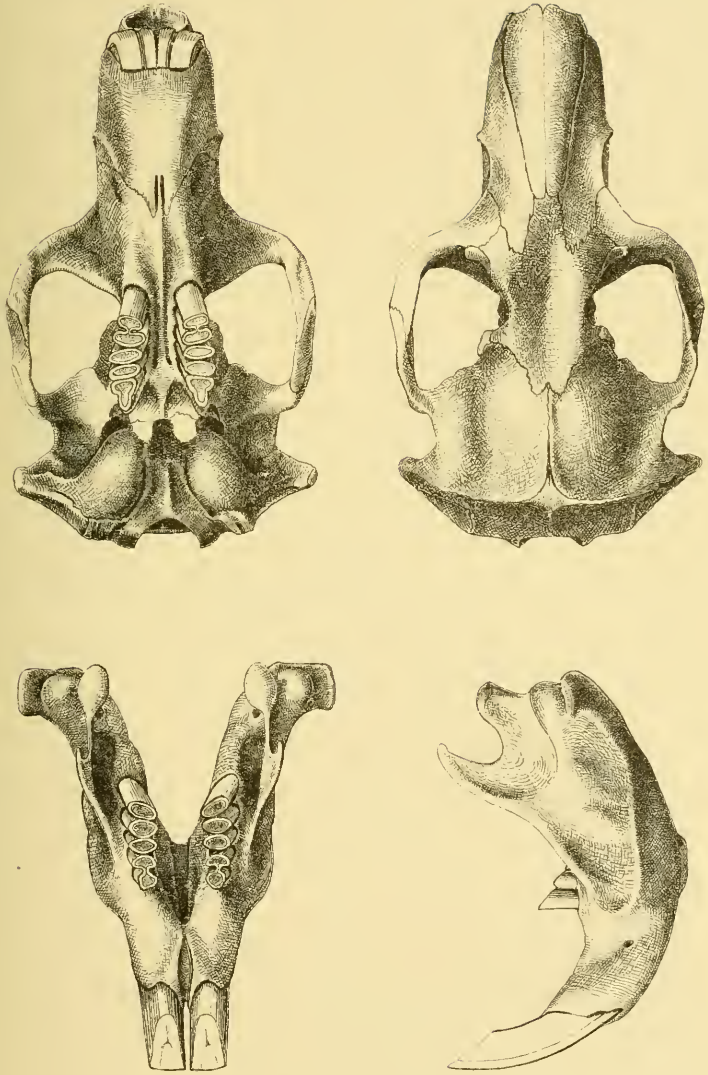
Jico, Vera Cruz, Mexico.

No. 55343. ♂ ad.

PLATE 5.

(All natural size.)

Macrogeomys dolichocephalus sp. nov. San Jose, Costa Rica.
(No. 36295 ♂ ad., U. S. Nat. Mus.)



F Muller, del. B Meisel

GEOMYS DOLICHOCEPHALUS sp. nov.

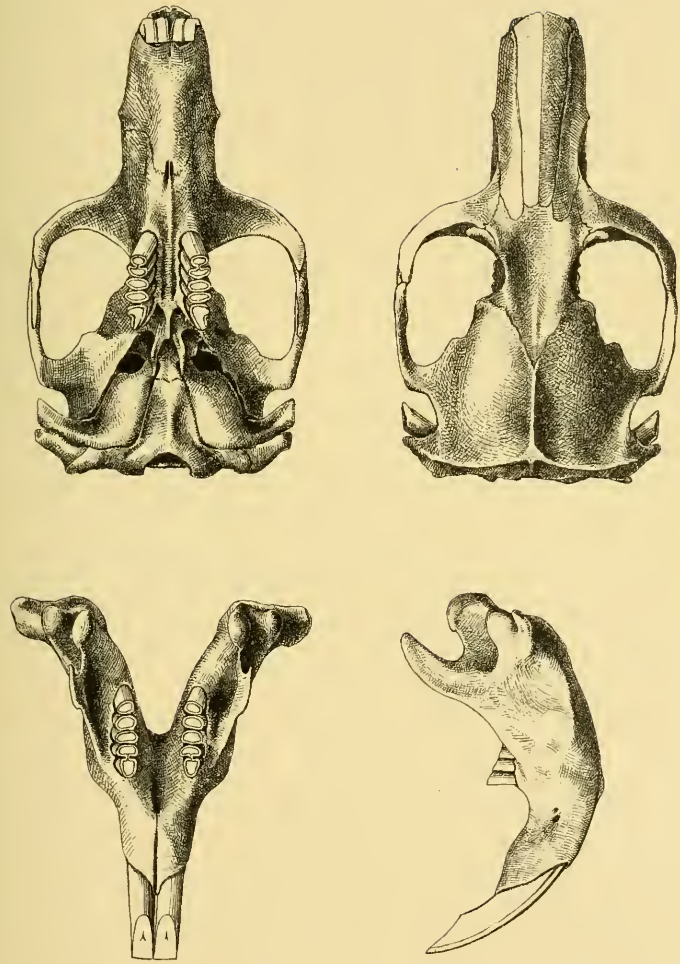
San José, Costa Rica.

No 36295.

PLATE 6.

(All natural size.)

Zygogeomys trichopus sp. nov. Nahuatzin, Michoacan, Mexico. (No. 50107 ♂ ad., U. S. Nat. Mus.)



F. Muller, del. Nat. size B. Meisel, photo.

GEOMYS TRICHOPUS Merriam

Nahuazin, Michoacan, Mexico.

No. 50107. ♂ ad.

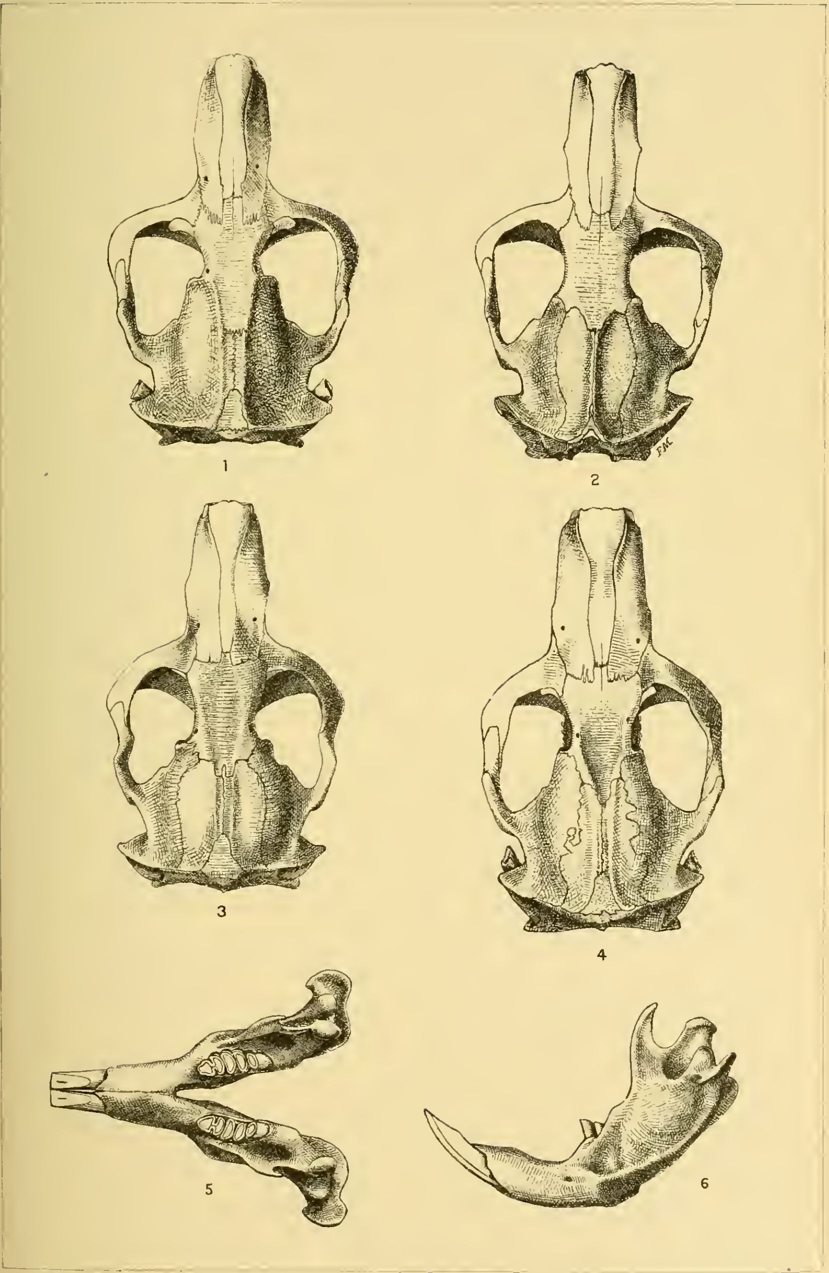
PLATE 7.

(All natural size.)

1. *Geomys tuza* (Ord) ♂ ad. Augusta, Ga. (Type locality).
   (No. 58639 U. S. Nat. Mus.)

2, 5, 6. *G. tuza mobilensis* ♂ ad. Mobile Bay, Alabama. (Type locality).
   (No. 46024 U. S. Nat. Mus.)

3 and 4. *G. tuza floridanus* ♂ ad. San Mateo, Fla.
   (No. 6512 ♂ ad. and 6514 ♂ old, Merriam collection.)



F. Muller, del. Nat. size B. Meisel, photo lith.

1. GEOMYS TUZA ♂ 2, 5 & 6. G. MOBILENSIS ♂ 3 & 4. G. TUZA FLORIDANUS ♂

PLATE 8.

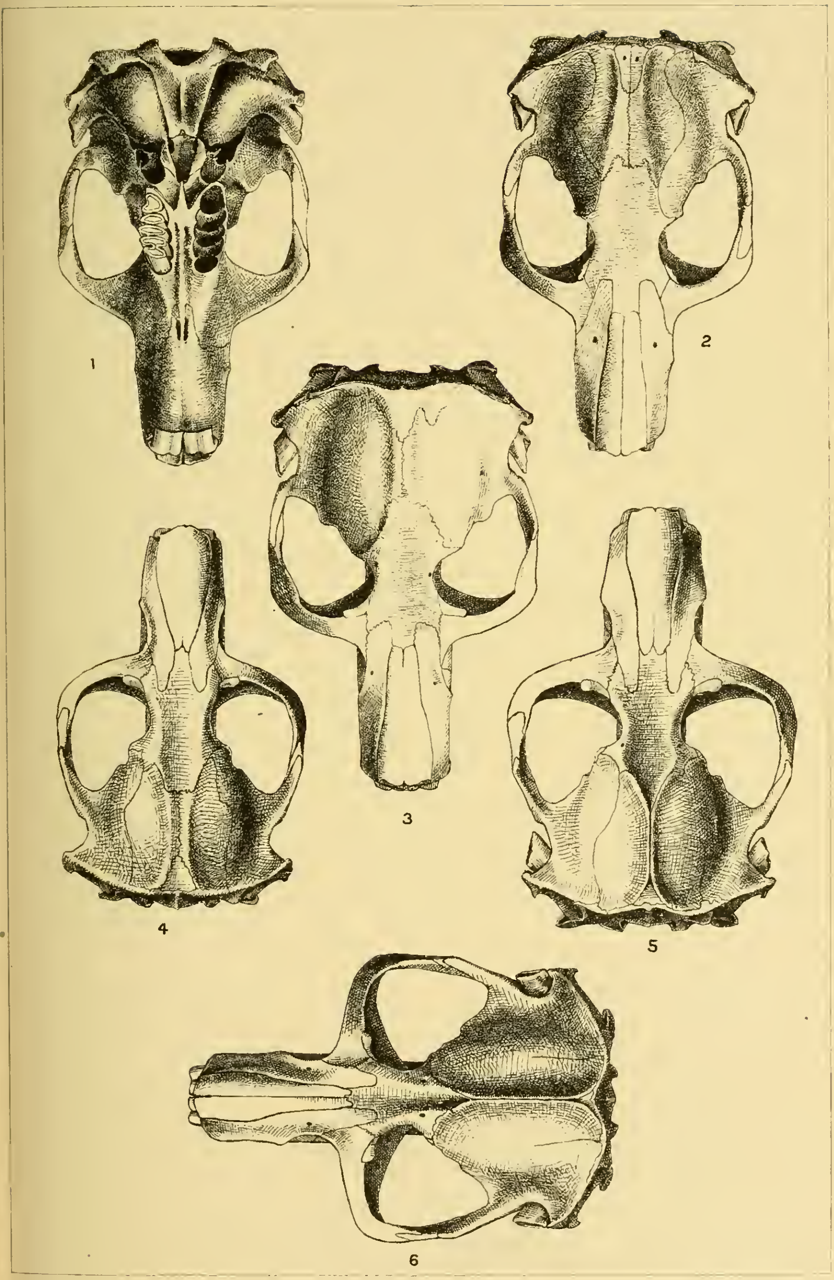
(All natural size.)

1 & 2. *Cratogeomys oreocetes* sp. nov. ♀ ad. Mount Popocatapetl, Mexico. *Type.* (No. 57963 U. S. Nat. Mus.)

3. *C. peregrinus* sp. nov. ♀ ad. Mount Iztaccihuatl, Mexico. *Type.* (No. 57964 U. S. Nat. Mus.)

4 & 5. *C. estor* sp. nov. Las Vigas, Vera Cruz, Mexico. (4 = No. 54306 ♀ ad. and 5 = 54308 ♂ ad. U. S. Nat. Mus.)

6. *C. perotensis* sp. nov. ♀ ad. Cofre de Perote, Vera Cruz, Mexico. (No. 54299 U. S. Nat. Mus.)



E. Muller, del. Nat. size B. Meisel, photo. lith.

1 & 2 ♀ ad. GEOMYS OREOCETES 3 ♀ ad. G. PEREGRINUS
4 ♀ & 5 ♂ G. ESTOR 6 ♀ ad. G. PEROTENSIS

PLATE 9.

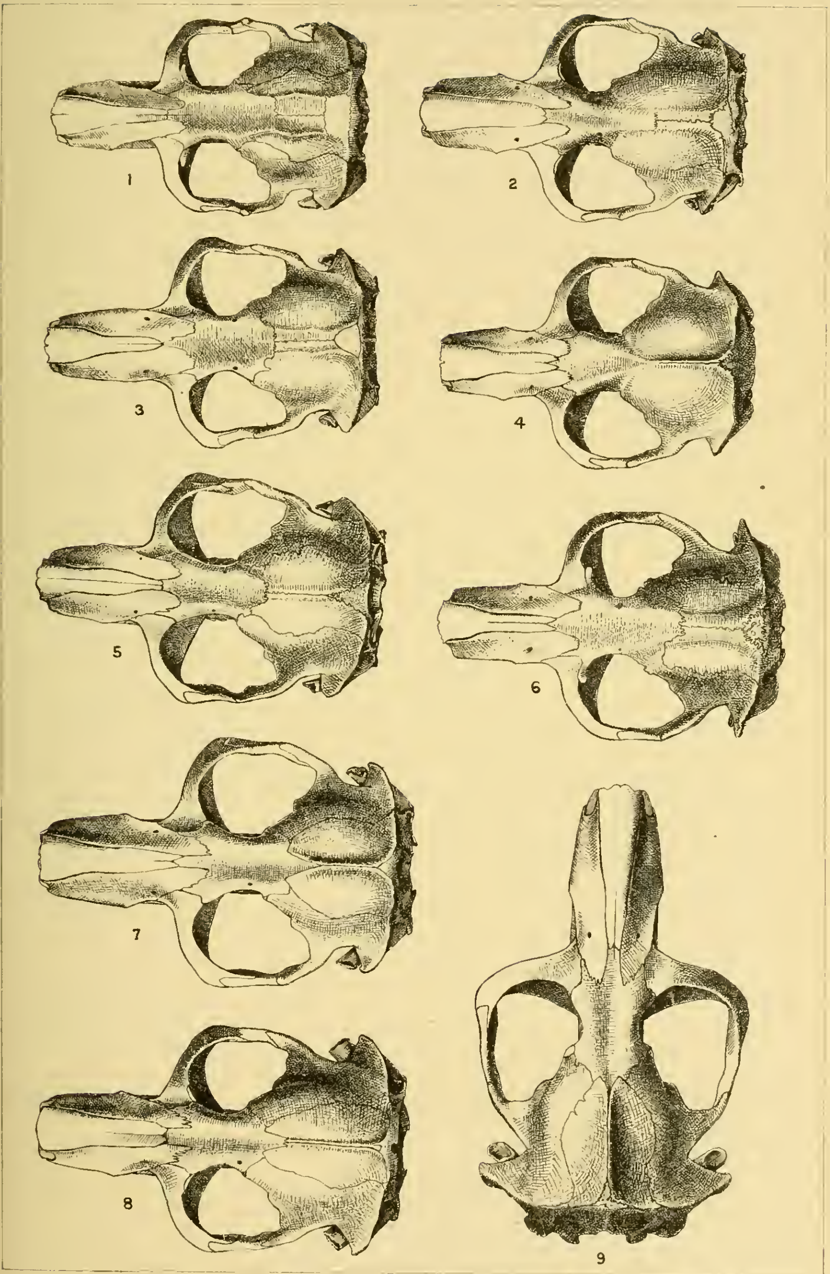
(All natural size.)

1. *Geomys arenarius* ♂ ad. El Paso, Texas.
   (No. 58339 U. S. Nat. Mus.)
2. *G. texensis* ♂ Mason, Texas.
   (No. 4161 Merriam collection.)
3. *G. attwateri* ♂ ad. Rockport, Aransas County, Texas.
   (No. 51382 U. S. Nat. Mus.)
4. *G. sagittalis* ♂ ad. Galveston Bay, Texas.
   (No. 44957 U. S. Nat. Mus.)

5 & 7. *G. lutescens* ♂ ad. Cherry County, Nebraska.
   (5 = 25640 ♂ yg. ad.; 7 = 25471 ♂ old, U. S. Nat. Mus.)

6. *G. breviceps* ♂ ad. Mer Rouge, Louisiana.
   (No. 46673 U. S. Nat. Mus.)

8. *G. bursarius* ♀ ad. Knoxville, Iowa.
   (No. 2024 Merriam collection.)
9. *G. bursarius* ♂ ad. Knoxville, Iowa.
   (No. 2625 Merriam collection.)



F. Muller, del. Nat. size B. Meisel, photo lith.

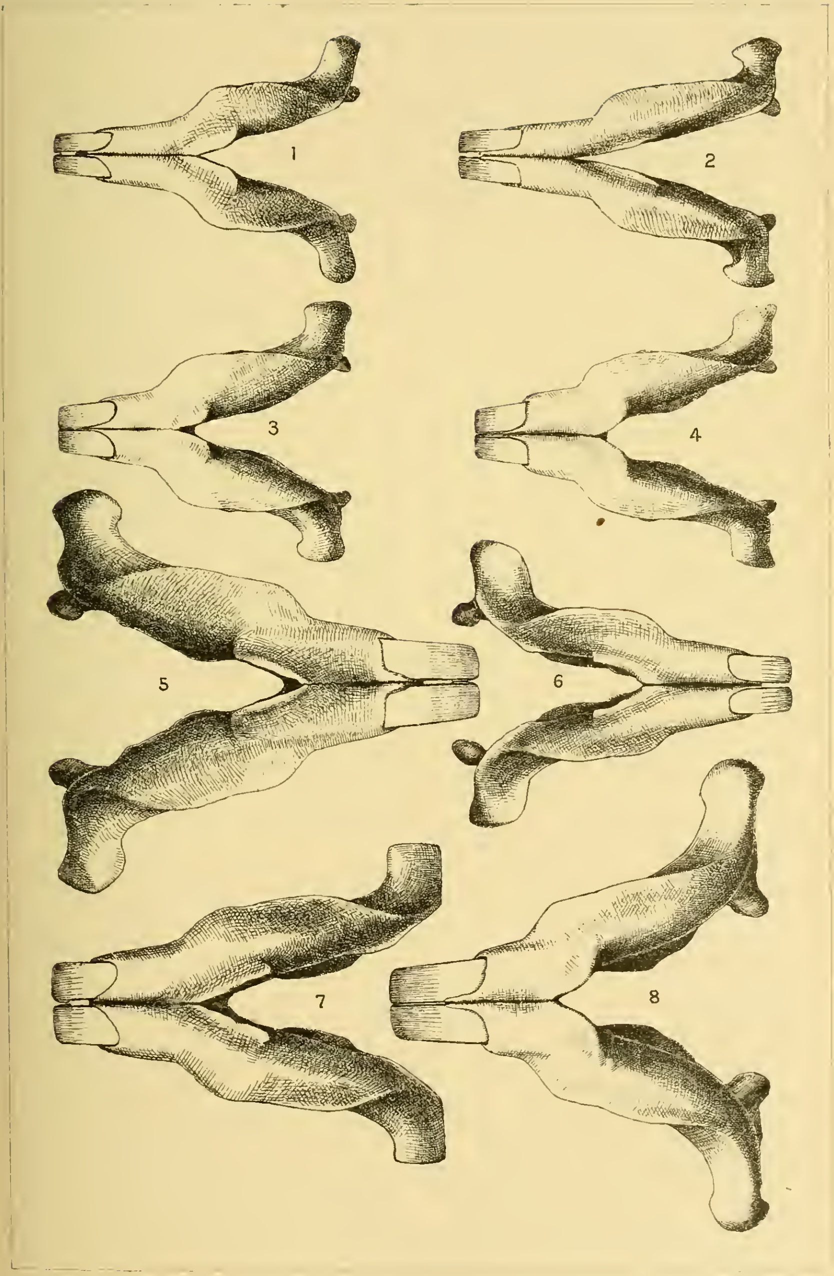
1. GEOMYS ARENARIUS ♂ ad. 2. G. TEXENSIS ♂ ad. 3. G. ATTWATERI ♂ ad. 4. G. SAGITTALIS ♂ ad.
5 & 7. G. LUTESCENS ♂ ad. 6. G. BREVICEPS ♂ ad. 8 ♀ ad. 9 ♂ ad. G. BURSARIUS

PLATE 10.

Under side of mandible.

(All natural size.)

1. *Geomys tuza floridanus* (Bachman). San Mateo, Florida.
   (No. 6511 ♂ Merriam collection.)
2. *G. tuza mobilensis* sp. nov. Mobile Bay, Alabama.
   (No. 46023 ♂ U. S. Nat. Mus.)
3. *Cratogeomys oreocetes* sp. nov. Mount Popocatapetl, Mexico.
   (No. 57963 ♀ U. S. Nat. Mus.)
4. *C. peregrinus* sp. nov. Mount Iztaccihuatl, Mexico.
   (No. 57964 ♀ U. S. Nat. Mus.)
5. *C. merriami* (Thomas). Amecameca, Mexico.
   (No. 57970 ♂ U. S. Nat. Mus.)
6. *Geomys bursarius* (Shaw). Knoxville, Iowa.
   (No. 2772 ♂ Merriam collection.)
7. *Macrogeomys dolichocephalus* sp. nov. San Jose, Costa Rica.
   (No. 36295 ♂ U. S. Nat. Mus.)
8. *Platygeomys gymnurus* Merriam. Zapotlan, Jalisco, Mexico.
   (No. 45611 ♂ U. S. Nat. Mus.)



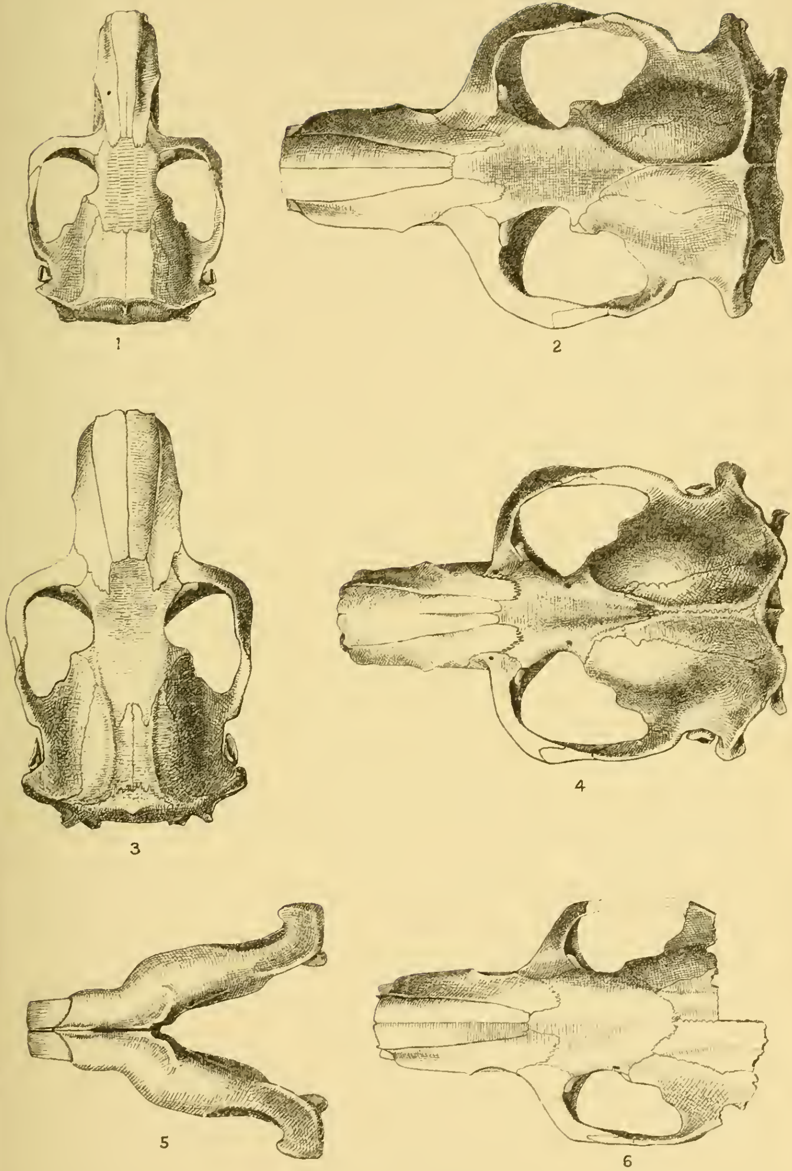
F. Muller, del. Nat. size

1 GEOMYS TUZA FLORIDANUS ♂ 2 G. MOBILENSIS ♂ 3. G. OREOCETES ♀ 4. G. PEREGRINUS ♀
5. G. MERRIAMI ♂ 6. G. BURSARIUS ♂ 7. G. DOLICHOCEPHALUS ♂ 8. G. GYMNURUS ♂

PLATE 11.

(All natural size.)

1. *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Jalisco, Mexico. (No. 45622 ♂ U. S. Nat. Mus.)
2. *Macrogeomys heterodus* (Peters). Costa Rica, Mexico. (No. ——— ♂ U. S. Nat. Mus.)
3. *Heterogeomys costaricensis* sp. nov. Pacuare, Costa Rica. (No. 22551, sex ?, U. S. Nat. Mus.) *Type.*
4. *Platygeomys fumosus* Merriam. Colima City, Mexico. (No. 45211 ♂ U. S. Nat. Mus.)
5. *Orthogeomys latifrons* sp. nov. Guatemala. (No. ———, sex ?, U. S. Nat. Mus.) *Type.*
6. *O. latifrons* (under side of mandible of same skull as 5.)



F. Muller, del.

Nat. size.

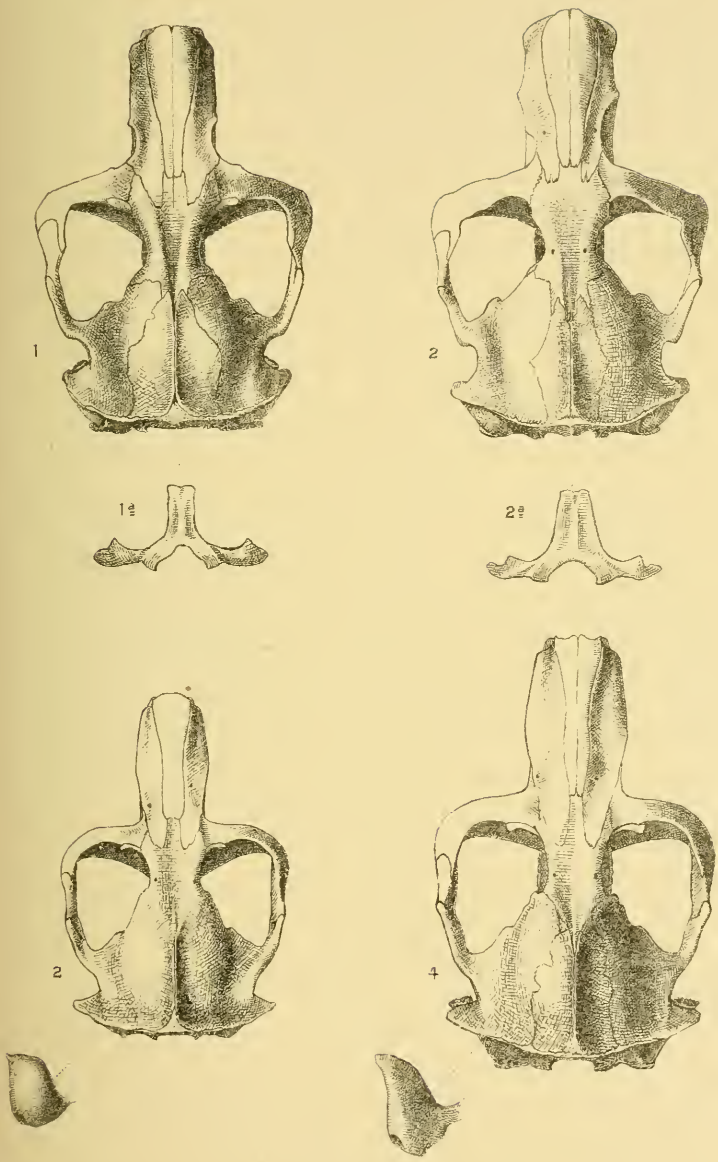
B. Meisel ...

1. GEOMYS BULLERI · 2. G. HETERODUS ♂ 3. G. COSTARICENSIS
4. G. FUMOSUS ♂ 5 & 6. G. LATIFRONS

PLATE 12.

(All natural size.)

1. *Cratogeomys castanops* (Baird). Las Animas, Colorado. (Type locality.)
   (No. 47368 ♂ U. S. Nat. Mus.)
   1^a. Basioccipital of same specimen.
2. *Cratogeomys fulvescens* sp. nov. Chalchicomula, Mexico. (Type locality.)
   (No. 53498 ♂ U. S. Nat. Mus.)
   2^a. Basioccipital of same specimen.
3. *Geomys personatus fallax* subsp. nov. Corpus Christi, Texas. *Type.*
   (No. 43845 ♂ ad. U. S. Nat. Mus.)
   3^a. Left audital bulla of same skull.
4. *Geomys personatus* True. Padre Island, Texas. (Type locality.)
   (No. 43294 ♂ U. S. Nat. Mus.)
   4^a. Left audital bulla of same skull.



F. Muller del.

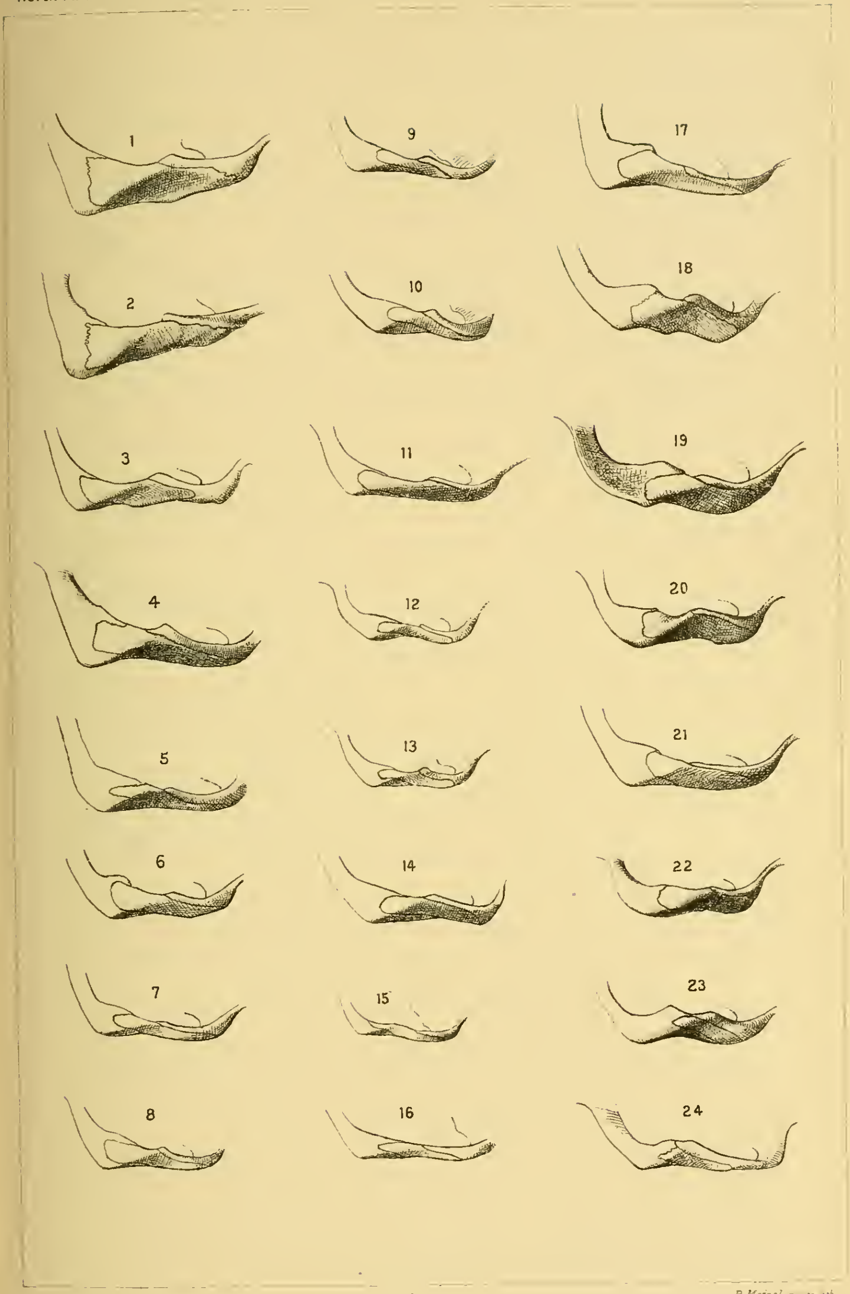
1. GEOMYS CASTANOPS 2. G. FULVESCENS
3. G. PERSONATUS FALLAX 4. G. PERSONATUS

PLATE 13.

Left zygoma, showing variations in jugal bone.

(All natural size.)

1. *Platygeomys tylorhinus* sp. nov. Patzcuaro, Mexico. (No. 47183 ♂ U. S. Nat. Mus.)
2. *P. gymnurus* Merriam. Zapotlan, Mexico. (No. 45611 ♂ U. S. Nat. Mus.)
3. *P. planiceps* sp. nov. Tula, Hidalgo, Mexico. (No. 55906 ♂ U. S. Nat. Mus.)
4. *Cratogeomys merriami* (Thomas). Lerma, Mexico. (No. 50110 ♂ U. S. Nat. Mus.)
5. *C. perotensis* sp. nov. Cofre de Perote, Mexico. (No. 54295 ♀ U. S. Nat. Mus.)
6. *C. estor* sp. nov. Las Vigas. Mexico. (No. 54308 ♂ U. S. Nat. Mus.)
7. *C. estor* sp. nov. Las Vigas, Mexico. (No. 54306 ♀ U. S. Nat. Mus.)
8. *C. oreocetes* sp. nov. Mount Popocatapetl, Mexico. (No. 57963 ♀ U. S. Nat. Mus.)
9. *Geomys tuza* (Ord). Augusta, Georgia. (No. 63842 ♂ U. S. Nat. Mus.)
10. *G. tuza floridanus* (Aud. and Bach.). San Mateo, Florida. (No. 6514 ♂ Merriam collection.)
11. *G. bursarius* (Shaw). Knoxville, Iowa. (No. 2624 ♂ Merriam collection.)
12. *G. texensis* sp. nov. Mason, Texas. (No. 4161 ♂ Merriam collection.)
13. *G. arenarius* sp. nov. El Paso, Texas. (No. 25015 ♂ U. S. Nat. Mus.)
14. *G. personatus* True. Padre Island., Texas. (No. 43294 ♂ U. S. Nat. Mus.)
15. *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Mexico. (No. 45618 ♀ U. S. Nat. Mus.)
16. *Orthogeomys latifrons* sp. nov. Guatemala. *Type.* (No. ——— U. S. Nat. Mus)
17. *Cratogeomys castanops* (Baird). Las Animas, Colorado. (No. 47368 ♂ U. S. Nat. Mus.)
18. *Macrogeomys heterodus* (Peters). Costa Rica. (No. ——— U. S. Nat. Mus.)
19. *Macrogeomys dolichocephalus* sp. nov. San Jose, Costa Rica. (No. 36295 ♂ U. S. Nat. Mus.)
20. *Heterogeomys hispidus* (LeConte). Jico, Vera Cruz, Mexico. (No. 55343 ♂ U. S. Nat. Mus.)
21. *Heterogeomys torridus* sp. nov. Guatemala. (No. ——— ♂ U. S. Nat. Mus.)
22. *Macrogeomys cherriei* (Allen). Santa Clara, Costa Rica. (No. 664 im. Costa Rica Nat. Museum.)
23. *Macrogeomys costaricensis* sp. nov. Pacuare, Costa Rica. (No. 22551 im. U. S. Nat. Mus.)
24. *Zygogeomys trichopus* sp. nov. Nahuatzin, Michoacan, Mexico. (No. 50107 ♂ U. S. Nat. Mus.)



F Muller, del. Nat. size B Meisel,

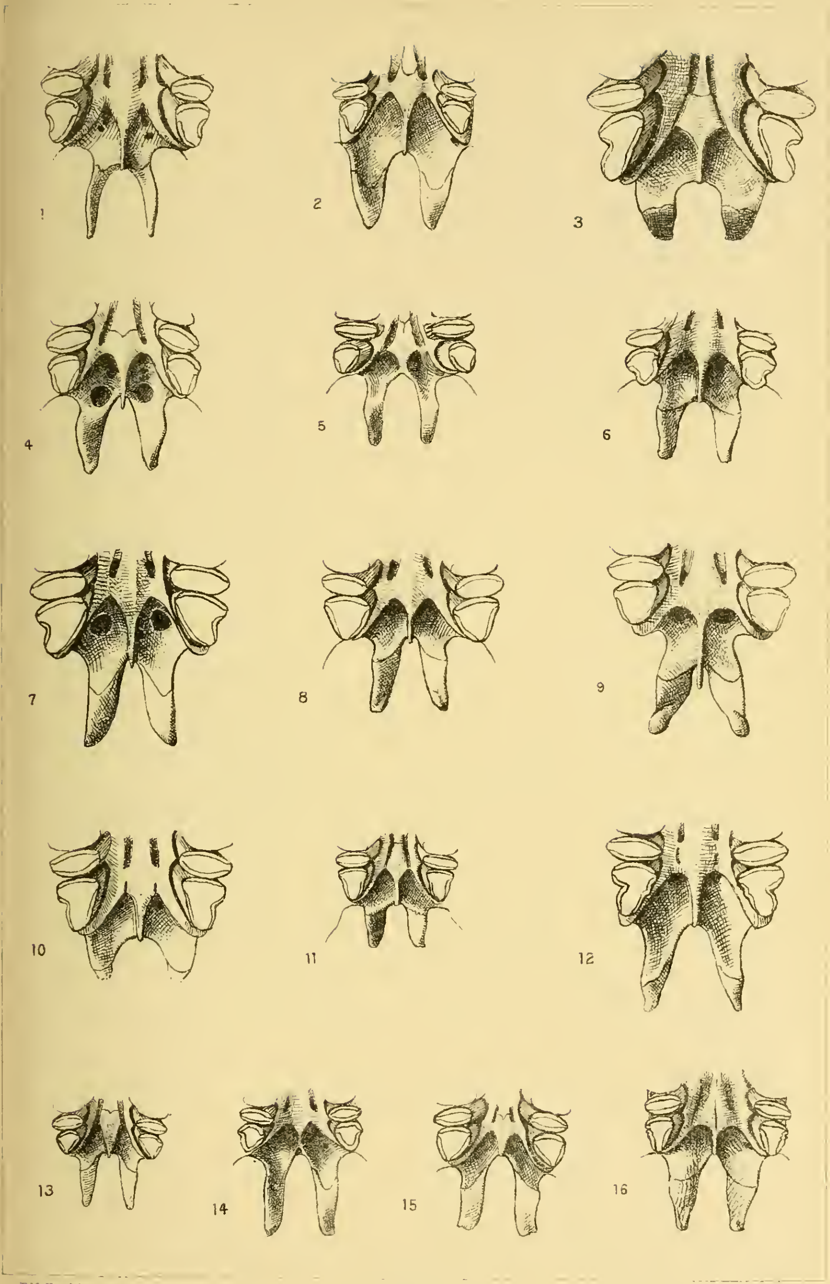
1. GEOMYS TYLORHINUS ♂
2. GYMNURUS ♂
3. PLANICEPS ♂
4. MERRIAMI ♂
5. PEROTENSIS ♀
6. ESTOR ♂
7. ESTOR ♀
8. OREOCETES ♀
9. TUZA ♂
10. TUZA FLORIDANUS ♂
11. BURSARIUS ♂
12. TEXENSIS ♂
13. ARENARIUS ♂
14. PERSONATUS ♂
15. BULLERI ♀
16. LATIFRONS
17. CASTANOPS ♂
18. HETERODUS ♂
19. DOLICHOCEPHALUS ♂
20. HISPIDUS ♂
21. HISPIDUS (form)
22. CHERRIEI
23. COSTARICENSIS
24. TRICHOPUS ♂

PLATE 14.

Posterior molars and palatopterygoids.

(All double natural size.)

1. *Zygogeomys trichopus* sp. nov. Nahuatzin, Michoacan, Mexico. (No. 50107 ♂ U. S. Nat. Mus.)
2. *Geomys bursarius* (Shaw). Knoxville, Iowa. (No. 2624 ♂ Merriam collection.)
3. *Macrogeomys heterodus* (Peters). Costa Rica. (No. —— U. S. Nat. Mus.)
4. *Geomys personatus* True. Padre Island, Texas. (No. 43294 ♂ U. S. Nat. Mus.)
5. *Geomys personatus fallax* subsp. nov. Corpus Christi, Texas. (No. 43292 ♀ U. S. Nat. Mus.)
6. *Cratogeomys castanops* (Baird). Las Animas, Colorado. (No. 47368 ♂ U. S. Nat. Mus.)
7. *Cratogeomys merriami* (Thomas). Lerma, Mexico. (No. 50110 ♂ U. S. Nat. Mus.)
8. *Platygeomys fumosus* Merriam. Colima, Mexico. (No. 45213 ♂ U. S. Nat. Mus.)
9. *Platygeomys planiceps* sp. nov. Volcan Toluca, Mexico. (No. 55906 ♂ U. S. Nat. Mus.)
10. *Macrogeomys costaricensis* sp. nov. Costa Rica. *Type.* (No. 22551 U. S. Nat. Mus.)
11. *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Jalisco, Mexico. (No. 45618 ♀ U. S. Nat. Mus.)
12. *Heterogeomys hispidus* (LeConte). Jico, Vera Cruz, Mexico. (No. 55017 ♀ U. S. Nat. Mus.)
13. *Geomys texensis* sp. nov. Mason, Texas. (No. 4168 ♀ Merriam Collection.)
14. *Geomys lutescens* Merriam. Woodward, Oklahoma. (No. 48566 ♂ U. S. Nat. Mus.)
15. *Geomys tuza mobilensis* sp. nov. Mobile Bay, Alabama. (No. 46025 ♂ U. S. Nat. Mus.)
16. *Geomys tuza floridanus* (Aud. and Bach.). San Mateo, Florida. (No. 6511 ♂ Merriam Collection.)



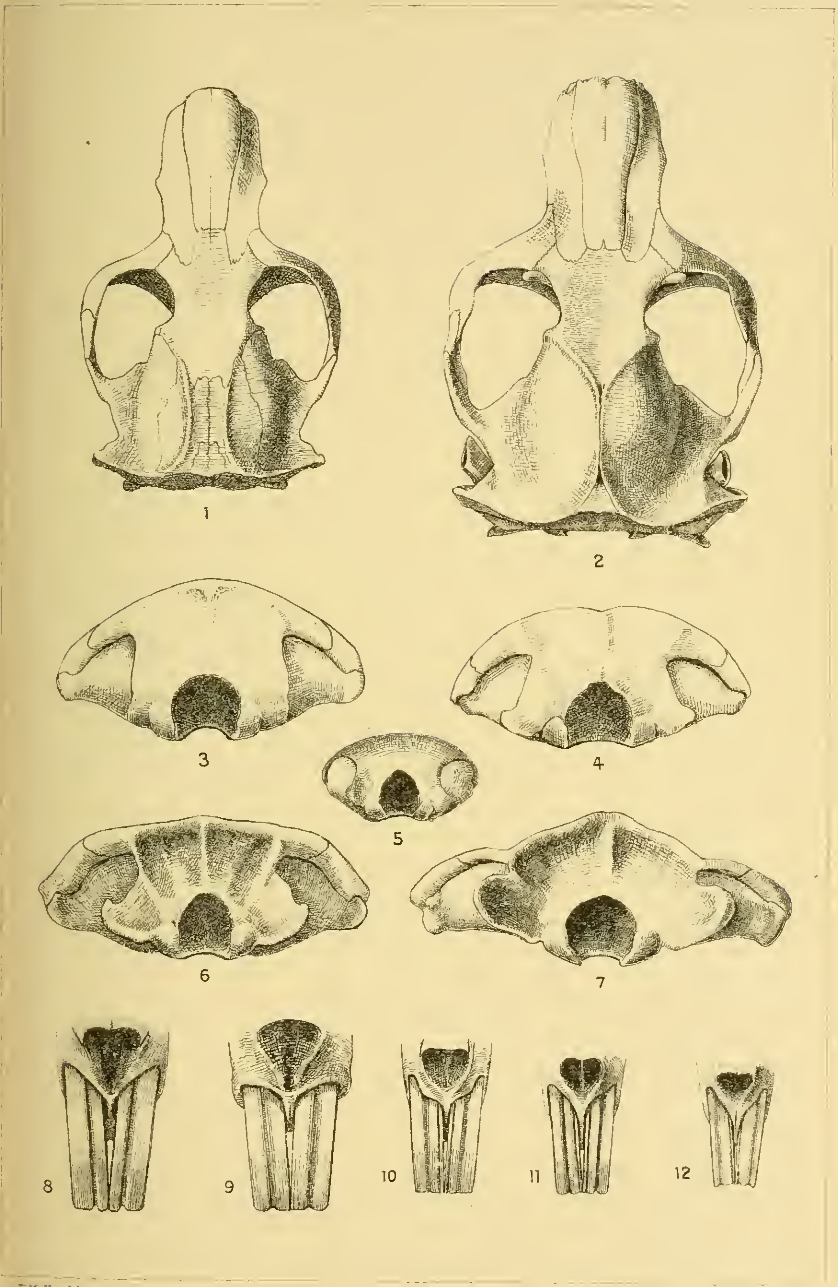
F. Muller, del. Double nat. size B. Meisel

1. GEOMYS TRICHOPUS nob.
2. BURSARIUS (Shaw)
3. HETERODUS Peters
4. PERSONATUS True
5. PERSONATUS FALLAX nob.
6. CASTANOPS Baird
7. MERRIAMI Thomas
8. FUMOSUS Merriam
9. G. PLANICEPS nob.
10. COSTARICENSIS nob.
11. BULLERI Thomas
12. HISPIDUS Le Conte
13. TEXENSIS nob.
14. LUTESCENS Merriam
15. MOBILENSIS nob.
16. TUZA FLORIDANUS (Bachman)

PLATE 15.

(All natural size.)

1. *Macrogeomys cherriei* (Allen). Santa Clara, Costa Rica. (No. 664 im Museo Nacional de Costa Rica). *Type.*
2. *Heterogeomys torridus* sp. nov. Chichicaxtle, Vera Cruz, Mexico. (No. 63629 ♀ ad. U. S. Nat. Mus.). *Type.*
3. Occiput of *Macrogeomys dolichocephalus* sp. nov. San Jose, Costa Rica. (No. 36295 ♂ ad. U. S. Nat. Mus.). *Type.*
4. Occiput of *Heterogeomys hispidus* (LeConte). Jico, Vera Cruz, Mexico. (No. 55343 ♂ ad. U. S. Nat. Mus.)
5. Occiput of *Pappogeomys bulleri* (Thomas). Sierra Nevada de Colima, Jalisco, Mexico. (No. 45618 ♀ yg. ad. U. S. Nat. Mus.)
6. Occiput of *Cratogeomys merriami* (Thomas). Lerma, Mexico. (No. 50110 ♂ ad. U. S. Nat. Mus.)
7. Occiput of *Platygeomys gymnurus* Merriam. Zapotlan, Jalisco, Mexico. (No. 45611 ♂ ad. U. Nat. Mus.)
8. Upper incisors of *Macrogeomys dolichocephalus.*
9. Upper incisors of *Cratogeomys merriami.*
10. Upper incisors of *Zygogeomys trichopus.*
11. Upper incisors of *Geomys bursarius.*
12. Upper incisors of *Geomys tuza.*



F. Muller, del. Nat. size B Meisel, photo lith.

1. GEOMYS CHERRIEI 2. G. TORRIDUS 3 & 8. G. DOLICHOCEPHALUS
4. G. HISPIDUS 5. G. BULLERI 6 & 9. G. MERRIAMI 7. G. GYMNURUS
10. G. TRICHOPUS 11. G. BURSARIUS 12. G. TUZA.

PLATE 16.

1 and 2. *Heterogeomys torridus* juv. Motzorongo, Mexico (No. 63643 U. S. National Museum).

Molariform teeth, showing deciduous premolars in situ; also unworn m 3, and immature pattern of crowns in m 1 and 2.

1. Left upper series.
2. Left lower series.

1*x*. Permanent upper premolar, uncovered to show unworn enamel crown.

a, Permanent premolar not yet in place; *b*, deciduous premolar; *c*, third upper molar; *d*, third lower molar.

3, 4, and 9. *Geomys bursarius* juv. Elk River, Minn. (No. 4909 Merriam coll.)

Molariform teeth, showing deciduous premolars in situ; also unworn m 3, and immature pattern of crowns in m 1 and 2.

3. Left upper series.
4. Left lower series.

4*x*. Transverse section of m_2 about three-fourths down, showing that the tooth is a single prism below, and that the enamel is confined to its posterior border.

9. Left lower series from outer side, showing relations of permanent and deciduous premolar, bilophiodont crown of m_3, and forms of m_1 and m_2 (which show the manner in which the change occurs from the double prism above to the single prism below).

a, Permanent premolar not yet in place; *b*, deciduous premolar; *c*, third upper molar; *d*, third lower molar.

5, 6, and 7. *Heterogeomys torridus* juv. (same specimen as in fig. 1).

Right upper premolar, showing unworn enamel cap and relations of enamel and cement. The cement bands are shaded.

5. Outer side of tooth.
6. Inner side.
7. Posterior face.

a, Outer cement band of anterior prism; *b*, postero-external cement band of posterior prism; *c*, inner cement band of posterior prism; *d*, inner cement band of anterior prism; *e*, lower end of enamel, showing position of enamel organ.

8. *Macrogeomys heterodus* ad.

Right upper premolar, showing relation of cement bands (unshaded) to enamel (shaded) in [illegible]ature tooth after the enamel cap [shown in figs. 5, 6, and 7] has w[illegible] [illegible]ff.

10 and 11. *Zygogeomys trichopus* juv. Nahuatzin, Mexico (No. 50104 U. S. Nat. Mus.).

Crowns of molariform series showing permanent enamel pattern and 'osteodentine' islands.

10. Left upper series.
11. Left lower series.

12 and 13. *Heterogeomys hispidus* ad. Motzorongo, Mexico.

Right upper premolar, after the enamel cap of the young tooth has worn off, showing permanent enamel pattern.

12. Outer side of the tooth (should be compared with 5, which shows same side of same tooth before the wearing down of the enamel cap begins).
13. Crown of same tooth.

a. Outer cement band of anterior prism.
b. Postero-external cement band of posterior prism.
Shaded bands show the enamel.

14–17. *Cratogeomys castanops* juv. Las Animas, Colorado.

14 and 15. A very young individual, but older than Nos. 1 and 4. The deciduous premolars have been shed, but the enamel caps of the permanent premolars (*a*) and the last true molars (m^3c and m_3d) have not yet worn down far enough to show the enamel pattern of the adult tooth (which may be seen in figs. 16 and 17). The crown of the last lower molar (*d*) is still a double prism.

16 and 17. Another immature individual of the same species, but enough older than 14 and 15 to show the permanent form and enamel pattern of the adult teeth.

18 and 19. *Geomys bursarius* im. Elk River, Minnesota.

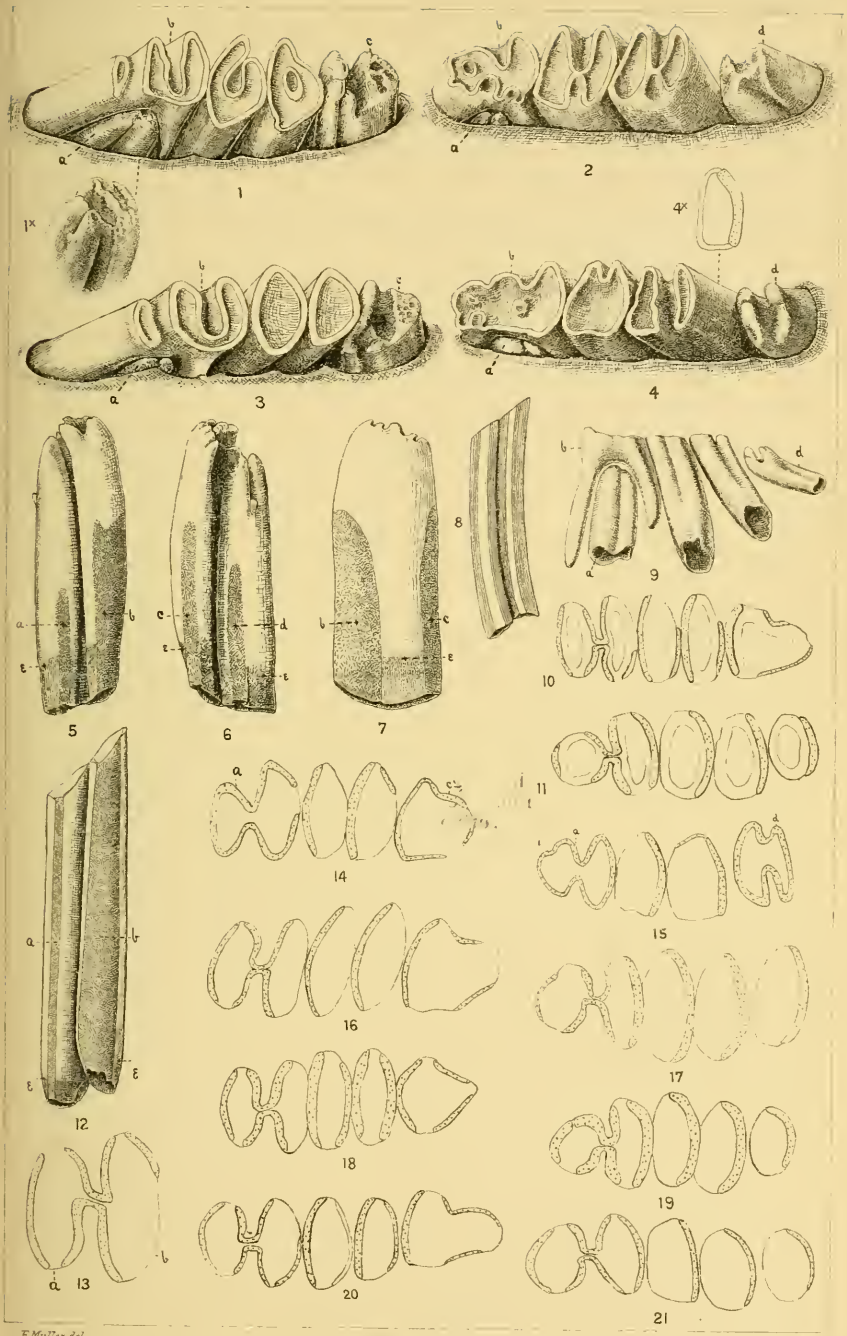
Crowns of molariform series showing permanent enamel pattern.

18. Left upper series.
19. Left lower series.

20 and 21. *Macrogeomys cherriei* im. Santa Clara, Costa Rica. *Type*.

Crowns of molariform series showing permanent enamel pattern.

20. Left upper series.
21. Left lower series.



F. Muller del. — Much enlarged — B. Meisel photo lith.

1, 2, 5, 6, 7, 12 & 13. HETEROGEOMYS HISPIDUS 3, 4, 9, 18 & 19. GEOMYS BURSARIUS
8. HETEROGEOMYS HETERODUS 10 & 11. ZYGOGEOMYS TRICHOPUS
14, 15, 16 & 17 CRATOGEOMYS CASTANOPS 20 & 21. HETEROGEOMYS CHERRIEI

PLATE 17.

(All natural size.)

Skulls seen from above; vault of cranium cut away, showing floor o brain case.

1. *Heterogeomys torridus.* Motzorongo, Vera Cruz, Mexico
2. *Zygogeomys trichopus.* Nahuatzin, Michoacan, Mexico.
3. *Geomys bursarius.* Portland, North Dakota.
4. *Platygeomys gymnurus.* Zapotlan, Jalisco, Mexico.
5. *Cratogeomys merriami.* Amecameca, Valley of Mexico.

Key to pl. 17.

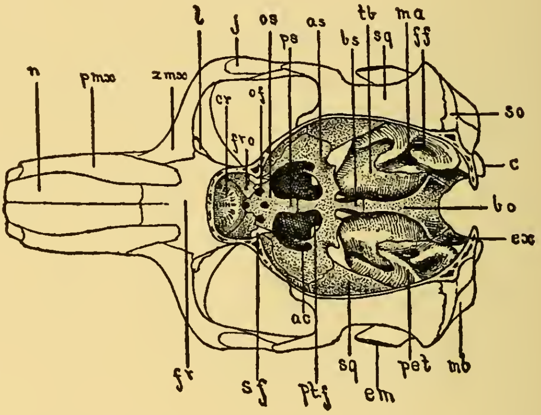
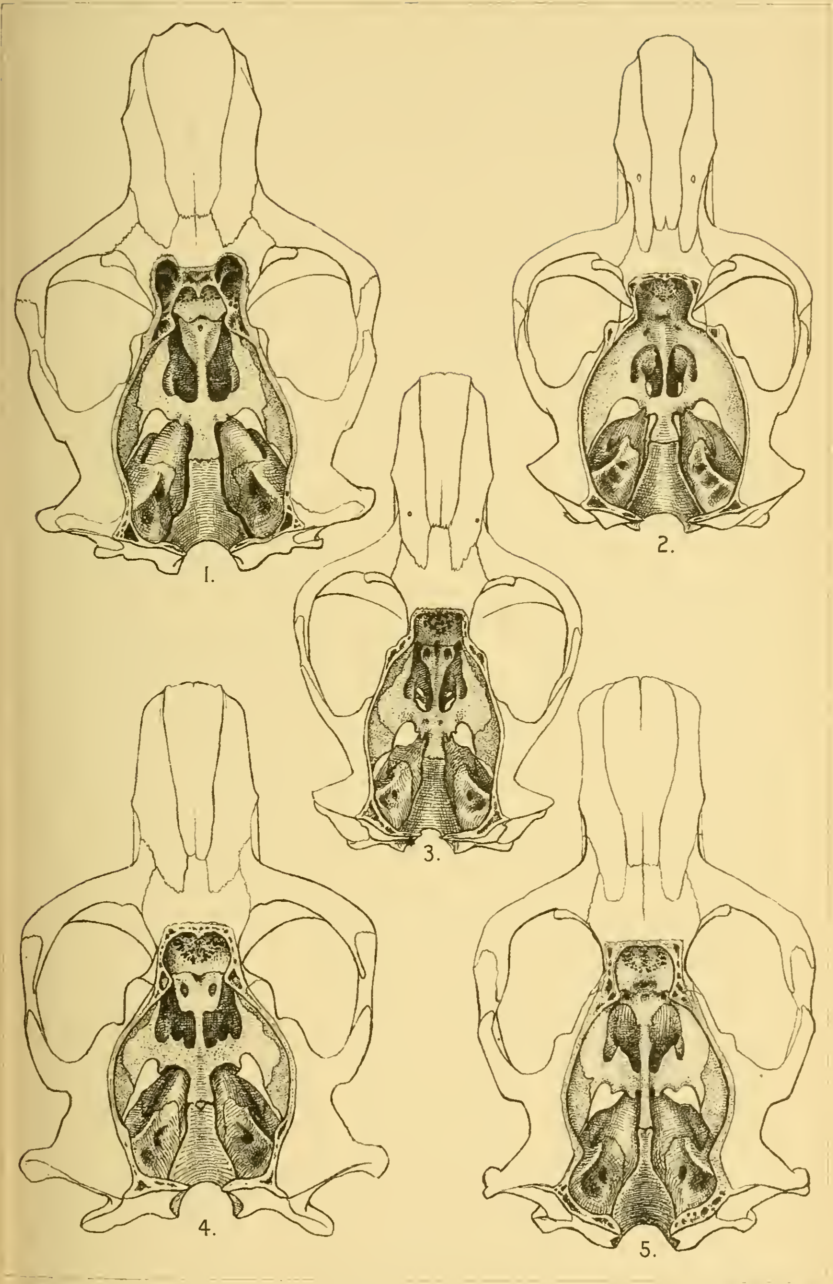


FIG. 9.—Young skull of *Cratogeomys merriami*, vault of cranium cut to show floor of brain case.

ac Anterior opening of alisphenoid can
as Alisphenoid bone.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
cr Cribriform plate of ethmoid.
em External auditory meatus.
ex Exoccipital.
ff Floccular fossa.
fr Frontal.
fro Descending or orbital plate of frontal (the animal is so young that the plates of the two sides have not yet united below).
j Jugal.
l Lachrymal.
ma Meatus auditorius internus.
mb Mastoid bulla.
n Nasal.
of Optic foramen.
os Orbitosphenoid.
pet Petrous part of periotic.
pmx Ascending arm of premaxilla.
ps Presphenoid.
ptf Spheno-pterygoid fossa.
sf Apex of sphenoidal fissure.
so Supraoccipital.
sq Squamosal.
tb Superior face of tympanic or audital bull
zmx Zygomatic root of maxilla.



F. Muller del. B. Meisel, photo.

1. HETEROGEOMYS TORRIDUS sp. nov. 2. ZYGOGEOMYS TRICHOPUS sp. nov.
3. GEOMYS BURSARIUS (Shaw) 4. PLATYGEOMYS GYMNURUS (Merriam)
5 CRATOGEOMYS MERRIAMI (Thomas)

PLATE 18.

(All natural size.)

Vertical median longitudinal section of skull (mesethmoid and right half of vomer in place).

1. *Geomys bursarius* ♂. Knoxville, Iowa.
2. *Zygogeomys trichopus* ♀. Nahuatzin, Michoacan, Mexico.
3. *Heterogeomys torridus* ♂. yg. ad. Motzorongo, Vera Cruz, Mexico
4. *Cratogeomys merriami* ♂. Tlalpam, Valley of Mexico.
5. *Platygeomys gymnurus* ♂. Zapotlan, Jalisco, Mexico.

Key to pl. 18.

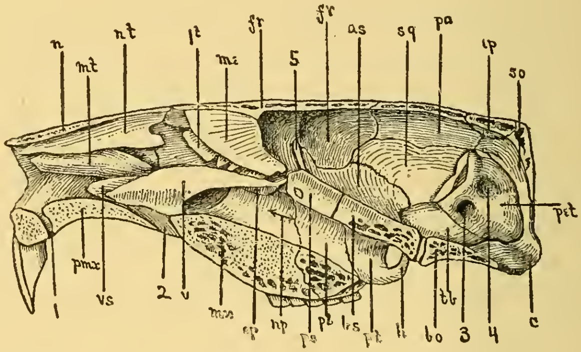
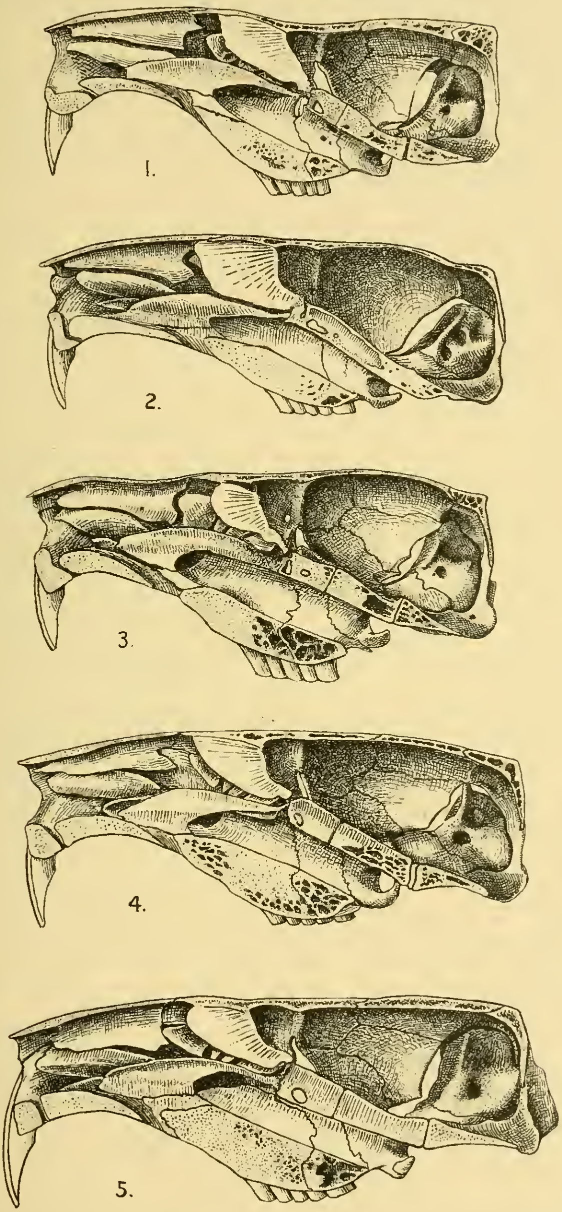


FIG. 7.—Longitudinal vertical median section of skull of *Cratogeomys merriami*, showing interior of brain case and nasal chamber. Vomer and mesethmoid in place.

1 Anterior palatine foramen.
2 Incisive foramen.
3 Meatus auditorius internus.
4 Floccular fossa.
5 Upper part of sphenoidal fissure.
as Alisphenoid.
bo Basioccipital.
bs Basisphenoid.
c Condyle of exoccipital.
fr Frontal.
h Hamular process of pterygoid.
ip Interparietal.
me Mesethmoid plate.
mt Maxillo-turbinal.
mx Maxilla.
n Nasal.
nt Naso-turbinal.
op Lower border of os planum.
pa Parietal.
pet Petrous part of periotic capsule.
pl Palatine.
pmx Premaxilla.
ps Presphenoid.
pt Pterygoid.
so Supraoccipital.
sq Squamosal.
tb Tympanic bulla. (antero-superior part, which alone appears within the brain case.)
v Vomer.
vs Vomerine sheath of maxilla.
1t First endoturbinal (Below and somewhat behind it the anterior ends of the second, third, and fourth endoturbinals may be seen.)



F. Muller, del. B. Meisel, photo lith.

1. GEOMYS BURSARIUS 2. ZYGOGEOMYS TRICHOPUS 3. HETEROGEOMYS TORRIDUS
4. CRATOGEOMYS MERRIAMI 5. PLATYGEOMYS GYMNURUS

PLATE 19.

(All natural size.)

1. *Orthogeomys scalops* ♀ ad. Oaxaca, Mexico (skull from above).
2. *Orthogeomys scalops* ♀ ad. Same specimen (base of cranium).

3–7. Median longitudinal section of nasal chamber (vomer and mesethmoid removed) showing turbinated bones.

3. *Geomys bursarius* ♂. Knoxville, Iowa.
4. *Zygogeomys trichopus* ♀. Nahuatzin, Michoacan, Mexico.
5. *Heterogeomys torridus* ♂. Motzorongo, Mexico.
6. *Cratogeomys merriami* ♂. Tlalpam, Valley of Mexico.
7. *Platygeomys gymnurus* ♂. Zapotlan, Jalisco, Mexico.

Key to pl. 19.

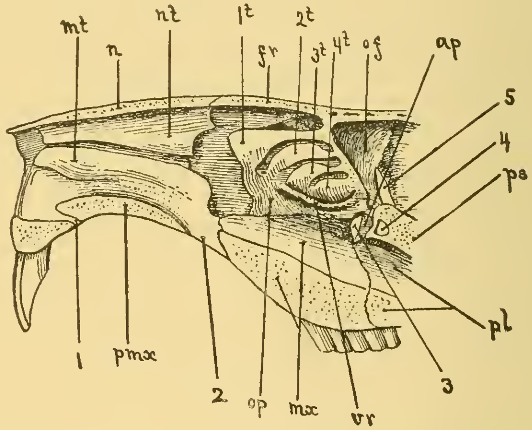
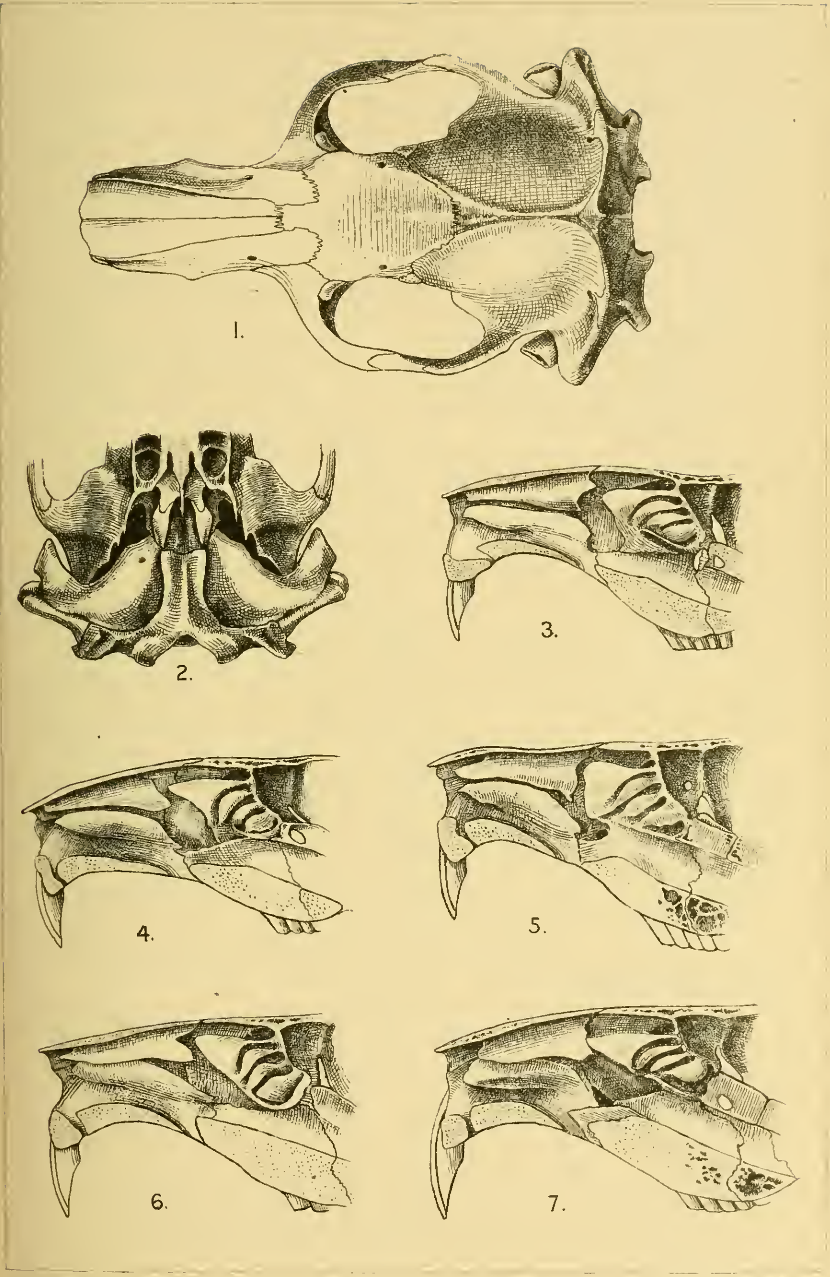


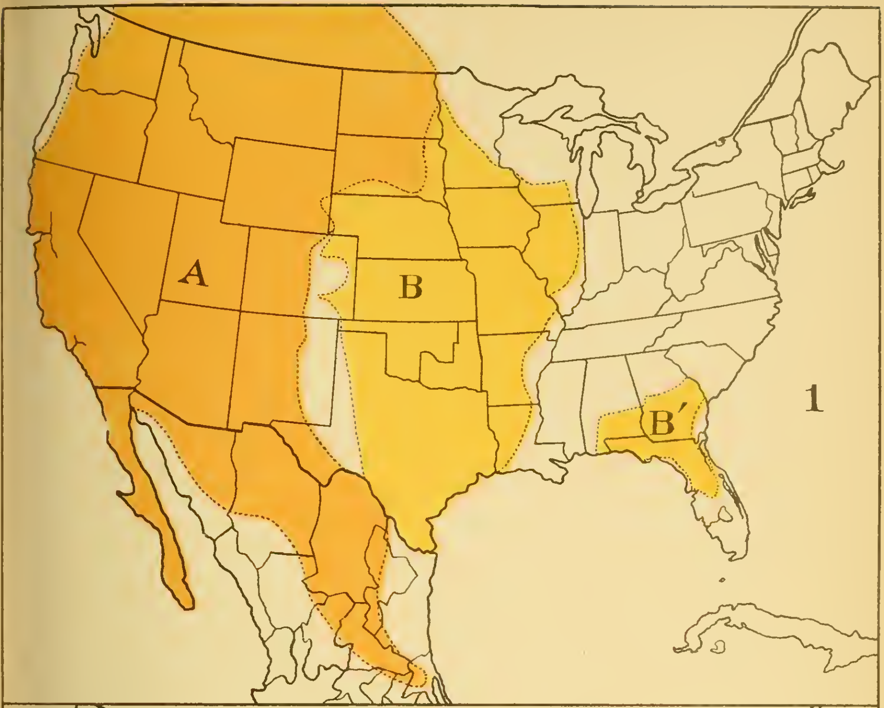
FIG. 10.—Longitudinal vertical median section of front part of skull of *Geomys bursarius*. Mesethmoid and vomer removed to show turbinated bones.

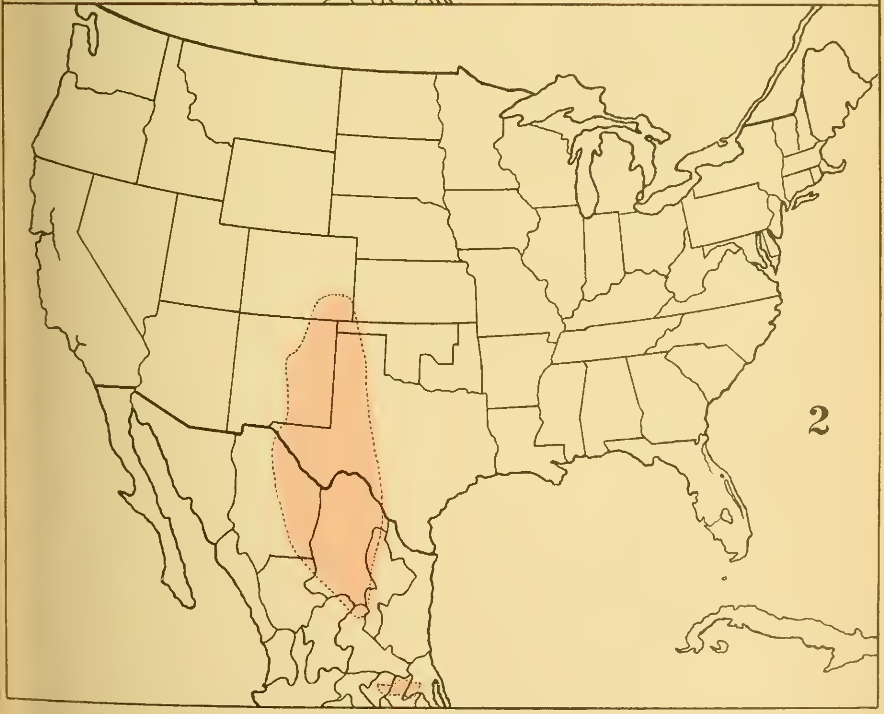
1 Anterior palatine foramen.
2 Incisive foramen.
3 Vacuity in front of presphenoid (present in *Geomys bursarius* and *tuza* only. It is partly overlapped posteriorly by the ascending wing of the vertical plate of the palatine, *ap*.).
4 Presphenoid fenestrum. Present in all species.
5 Upper part of sphenoidal fissure.
1t First or superior endoturbinal.
2t Second endoturbinal.
3t Third endoturbinal.
4t Fourth endoturbinal.
ap Ascending wing of vertical plate of palatine.
fr Frontal.
mt Maxillo-turbinal.
mx Maxilla (the upper pointer rests on the maxillary surface of the narial passage, the lower on the sawed body of the bone).
n Nasal.
nt Naso-turbinal.
op Os planum.
pl Palatine (the upper pointer rests on the palatine face of the narial passage, the lower on the sawed horizontal body of the bone).
pmx Premaxilla.
ps Presphenoid.
vr Vomerine ridge of os planum (unites with the lateral wing of the vomer).



F Muller, del. B Meisel, photo lith.

1. & 2 ORTHOGEOMYS SCALOPS ♀ 3. GEOMYS BURSARIUS 4. ZYGOGEOMYS TRICHOPUS
5. HETEROGEOMYS TORRIDUS 6. CRATOGEOMYS MERRIAMI
7. PLATYGEOMYS GYMNURUS





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MAP 1. —*A* DISTRIBUTION OF GENUS *THOMOMYS.*
B DISTRIBUTION OF GENUS *GEOMYS* (B = *G. bursarius* group; B′ = *G. tuza* group.)

MAP 2.—DISTRIBUTION OF GENUS *CRATOGEOMYS.*

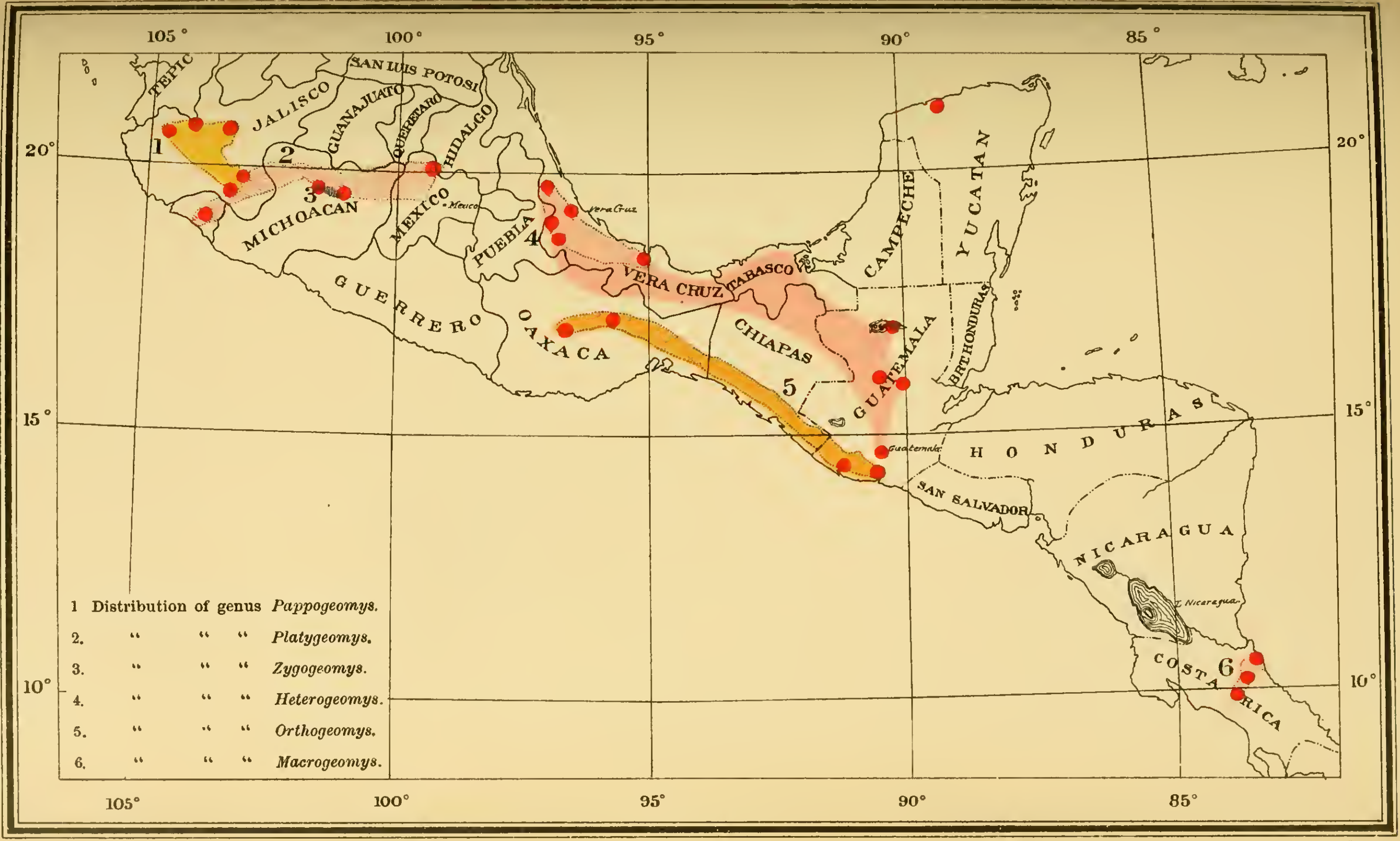

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PLATE XII.

[All double natural size.]

FIGS. 1- 3. *Sorex (Atophyrax) bendirii palmeri.* Oregon City, Oregon. Type. (No. 56898, U. S. Nat. Mus.)

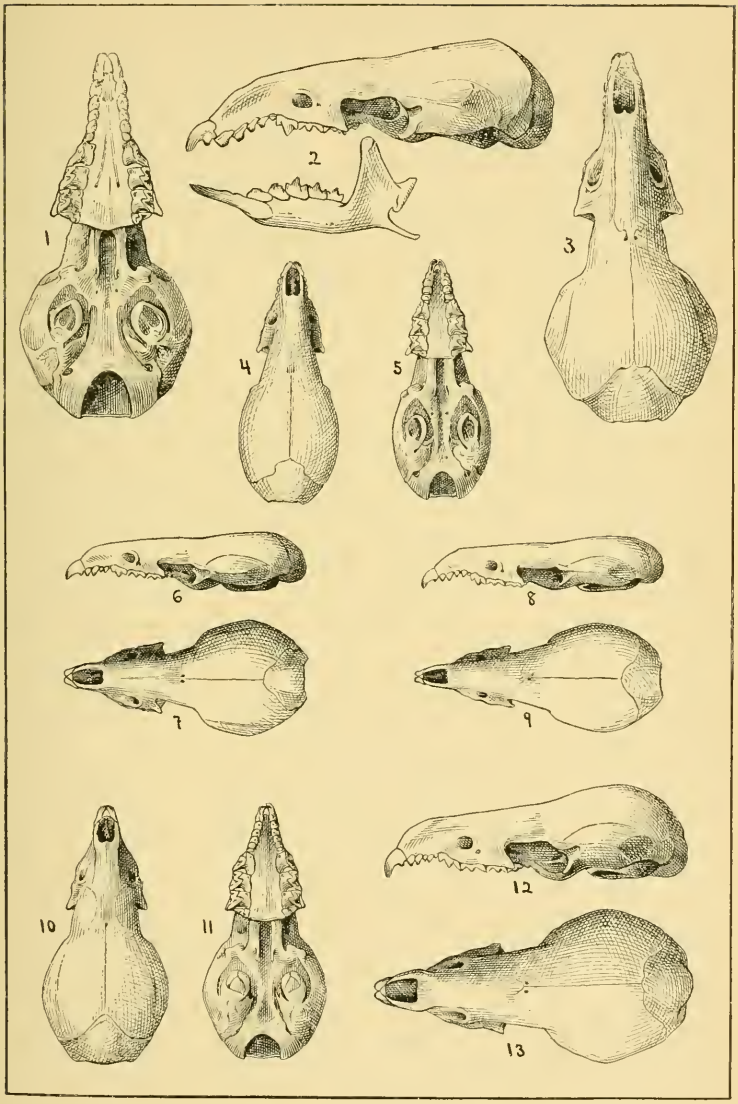
4- 5. *Sorex (Microsorex) hoyi.* Elk River, Minn. (No. 2520, Merriam collection.)

6- 7. *Sorex californicus.* Walnut Creek, Contra Costa County, Calif. (No. 44428, U. S. Nat. Mus.)

8- 9. *Sorex tenellus.* Lone Pine, Owens Valley, California. Type. (No. 32495, U. S. Nat. Mus.)

10–11. *Sorex merriami.* Fort Custer, Mont. Type. (No. 4861, ♀, Merriam collection.)

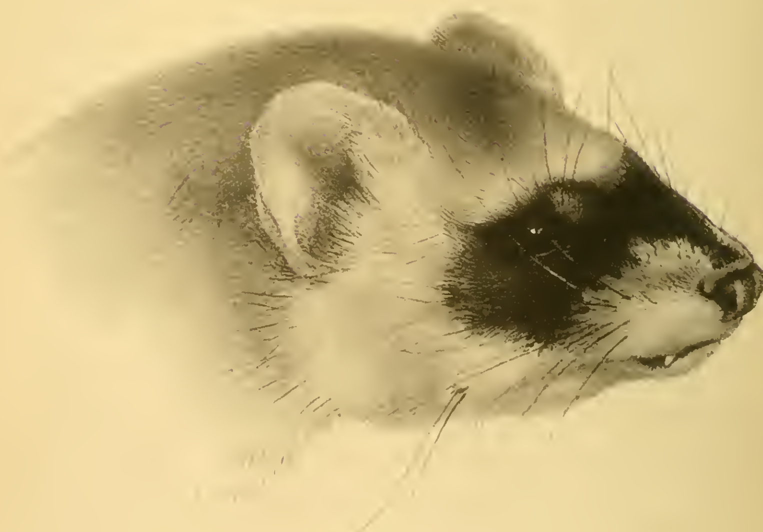
12–13. *Sorex macrodon.* Orizaba, Vera Cruz, Mexico. Type. (No. 58272, ♂, U. S. Nat. Mus.)



1–3. *Sorex bendirii palmeri.*
4, 5. *S. hoyi.*
6, 7. *S. californicus.*
8, 9. *S. tenellus.*
10, 11. *S. merriami.*
12, 13. *S. macrodon.*

Bridled Weasel, Putorius frenatus

Valley of Mexico



Black-footed Ferret, Putorius nigripes

Western Kansas

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF ORNITHOLOGY AND MAMMALOGY

NORTH AMERICAN FAUNA

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SYNOPSIS OF THE WEASELS OF NORTH AMERICA

C. HART MERRIAM

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Washington, D. C., May 9, 1896.

Sir: I have the honor to transmit herewith for publication, as No. 11 of North American Fauna, a Synopsis of the Weasels of North America.

Respectfully,

C. Hart Merriam,
Chief of Division of Ornithology and Mammalogy.

Dr. Chas. W. Dabney, Jr.,
Acting Secretary of Agriculture.

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SYNOPSIS OF THE WEASELS OF NORTH AMERICA.

By C. Hart Merriam.

The present synopsis includes the one ferret and all of the weasels yet discovered in North America north of Panama. Of the true weasels (subgenus *Ictis*) no less than 22 species and subspecies are here recognized, 11 of which are described for the first time.

Until very recently the group has been in a state of chaos, but now, thanks to Outram Bangs's excellent paper entitled 'A review of the weasels of eastern North America,'[1] the obscurity that has so long surrounded our eastern species has been cleared away and the task of revising the whole group is rendered comparatively easy. Additional material is needed from certain parts of the West, particularly from southeastern Alaska and the middle and northern parts of the Great Basin, and much remains to be learned respecting the extent to which intergradation exists between allied forms having contiguous ranges.

Excepting the circumpolar type, represented in America by the weasel of the barren grounds (*Putorius arcticus* nob.), and in Eurasia by the closely related *P. erminea*, the weasels of North America fall naturally into two groups, characterized by important cranial differences, and having complementary geographic ranges. The first is a boreal group comprising five forms: *richardsoni*, *alascensis*, *cicognani*, *streatori*, and *rixosus*, the southernmost of which (*cicognani*) reaches only the northern United States. The other is an austral group comprising the *frenatus* and *longicauda* series and including *P. peninsulæ*, of Florida. Of this series only a single species (*P. arizonensis*) reaches the lowermost of the boreal zones, and this only in the mountains.

Between these two groups are two very interesting species, *noveboracensis* and *tropicalis*—the former inhabiting the eastern United States, the latter the tropical belt of Mexico. Mr. Bangs has already shown that the female of *P. noveboracensis* resembles *P. cicognani*, while the male resembles *P. longicauda*. The case of *P. tropicalis* is exactly parallel, the female resembling *cicognani*, while the male resembles *frenatus*.

[1] Proc. Biol. Soc. Washington, X, pp. 1–24, Feb. 25, 1896.

Among mammals the female is often less specialized than the male and consequently bears more resemblance to the ancestral stock, thus giving a clew to the line of descent when this can not be determined from the male alone. In the present instance the females of *noveboracensis* and *tropicalis* have small, smoothly rounded skulls without sagittal crests and with narrow audital bullæ and inflated squamosals, as in the *cicognani* series, while the males have large angular skulls with well-developed sagittal crests, relatively broad audital bullæ, and flat squamosals, as in the *longicauda-frenatus* series. The inference is that the austral *longicauda-frenatus* series was derived from the boreal *cicognani* stock, and that the differentiation took place in the South. *P. noveboracensis* occupies middle ground geographically, and may have become differentiated from *cicognani* under existing conditions in the area it now inhabits; but *P. tropicalis*, which inhabits tropical Mexico, must either have originated from the *cicognani* stock when the latter was driven southward by the cold of the Glacial epoch, or must have accomplished a very remarkable migration.

Turning now to the weasel of the tundras (*P. arcticus*), the female is also found to resemble the *cicognani* type, indicating—at least so far as the American species go—that the whole group (subgenus *Ictis*) has sprung from an ancestral type related to *P. cicognani*.

Probably *cicognani* itself is a strongly specialized type, although the specialization took place a long time ago and seems to have been in the direction of greater simplicity. The tendency has been toward a narrowing of the skull as a whole and the obliteration of its prominences and angles. The zygomata have been reduced and drawn in close to the sides of the cranium, and the brain case has been narrowed, elongated, and smoothly rounded off, as if to enable the head to pass through small openings. The body as a whole has undergone parallel modification, presenting the extreme degree of slenderness known among the mammalia. This type of weasel seems to have been developed for the express purpose of preying upon field mice or voles, its narrow skull and cylindrical body enabling it to enter and follow their runways and subterranean galleries. The extreme development of the type is presented in *P. rixosus* and *P. streatori*, whose exceedingly small size and almost serpentine form make it possible for them to traverse the burrows of even the smaller mice.

It is an interesting fact that the geographic range of the *cicognani* group is almost coincident with that of the field mice of the subgenus *Microtus*. Farther south, where these mice occur sparingly or not at all, the *cicognani* series of weasels is replaced by the larger and more powerful *longicauda-frenatus* series. Where the ranges of the two overlap, as on the northern plains, the large weasel (*P. longicauda*) preys chiefly on pocket gophers (*Thomomys* and *Geomys*) and ground squirrels (*Spermophilus franklini* and *S. 13-lineatus*), while the smaller species (*cicognani* and *rixosus*) prey chiefly on mice.

Similarly in the far North, where the frozen tundras are inhabited by lemmings as well as voles, two weasels are present: the tiny, narrow-skulled *rixosus*, which feeds mainly on mice, and the large, broad-skulled *arcticus*, which feeds chiefly on lemmings and rabbits.

It seems clear, therefore, that the different types of weasels have been developed by adaptation to particular kinds of food.

It is much to be regretted that specimens of the South American weasels are not available for study in connection with the North American species. The only one I have seen is *P. affinis* Gray, which ranges from Costa Rica to northern South America. While differing specifically from *frenatus* it clearly belongs to the same group.

Except in winter, weasels are usually so difficult to procure in anything like satisfactory series that but few are available from most of the localities represented in collections. As a rule, the number is too small to afford reliable average measurements; hence the averages here given are subject to correction.

The skull drawings in Pl. I and those in the text (except figs. 10, 11, 15, and 16) were made by Benjamin Mortimer. Those in Pls. II to V, inclusive, were drawn by Dr. James C. McConnell under the supervision of the author. About half of the skulls shown in the latter plates were used by Mr. Bangs in his paper already referred to.

Except where the contrary is distinctly stated, all the measurements in this paper were taken in the flesh by the collector. It is hardly necessary to add that all measurements are in millimeters.

Genus PUTORIUS Cuvier, 1817.

Key to subgenera (for American forms only):

Size large, about equaling the mink (*Lutreola*); facial bar black; legs and feet abruptly darker than upper parts .... subgenus *Putorius*.

Size medium or small, never more than half as large as the mink (*Lutreola*); facial bar white or absent; legs and feet concolor with or paler than upper parts .... subgenus *Ictis*.

Subgenus PUTORIUS Cuvier, 1817.

Putorius Cuvier: Règne Animal, I, 147–149, 1817.
Cynomyonax Coues: Fur-Bearing Animals, 99, 147–148, 1877.

PUTORIUS NIGRIPES Aud. & Bach. Black-footed Ferret.

(Pl. I, figs. 1, 1a, 1b.)

1851. *Putorius nigripes* Aud. & Bach.: Quadrupeds N. Am., Vol. II, pp. 297–299, pl. 93, 1851.
1877. Coues: Fur-Bearing Animals, 149–153, 1877.

Type locality.—Plains of the Platte River, in Nebraska.

Geographic range.—Great Plains, from western North Dakota and northern Montana to Texas; not known west of eastern base of Rocky Mountains.

Characters.—Size of the mink; ears rather large; color buffy, with a dark area in middle of back; fore and hind feet, end of tail, and band across face (including eyes) black.

Color.—Ground color pale yellowish or buffy above and below, clouded on top of head (and sometimes on neck also) by dark-tipped hairs; face crossed by a broad band of sooty black, which includes the eyes; feet, lower part of legs, terminal third of tail, and preputial region, sooty black; back, about midway between fore and hind legs, marked by a large patch of dark umber-brown, which fades insensibly into the buffy of surrounding parts; muzzle, lips, chin, a small spot over each eye, a narrow band behind black facial bar, and sides of head to and including ears, soiled white; anterior margin of ear near base clouded with dusky.

Cranial characters.—Skull large and massive, very broad between orbits, and deeply constricted behind postorbital processes,[1] which are strongly developed; zygomata strongly bowed outward; audital bullæ obliquely flattened on outer side; a prominent bead over lachrymal opening.

Compared with our American weasels, the skull of *Putorius nigripes* may be told at a glance by its great size, the basilar length in adult males averaging about 65 mm., and in females about 62 mm. Compared with *P. eversmanni* of southern Siberia, it may be distinguished by the greater postmolar production of the palate, and by other minor cranial characters. From the common polecat of Europe (*Putorius putorius*) it differs in several important characters, as may be seen by reference to Pl. I. In *P. putorius* the postorbital region is very broad, the postmolar part of the palate exceedingly long, and the anterior part of the audital bullæ very different.

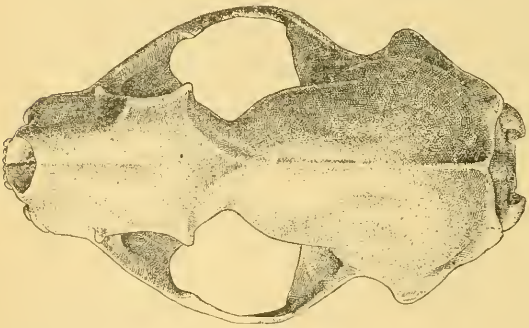

FIG. 1—*Putorius nigripes* ♂ ad. Trego County, Kans.

Remarks.—The black-footed ferret bears no resemblance whatever to any other American mammal, but is very closely related to the Siberian *Putorius eversmanni*. It differs from the latter in having much shorter and coarser fur, larger ears, and longer postmolar extension of the palate.

In some specimens of *Putorius nigripes* the pale buffy of the under parts is clouded across the breast between the fore legs, suggesting the dark breast of *P. eversmanni*. The dark facial mask encircles the eyes

[1] This constriction deepens with age, as in all the weasels. It is very deep in the skull shown in the accompanying text figure (fig. 1), which is that of an old individual; much less deep in the younger specimen shown on Pl. I, fig. 1.

(including the whitish supraorbital spot) and dips slightly forward before passing transversely across the face, so that its posterior border is in front of the plane of the outer angles of the eyes. Its anterior border sometimes extends forward almost to the nasal pad, but this is unusual. The black of the feet reaches up and covers the fore leg to the elbow, except along the outer side, and the hind leg to near the knee, except posteriorly.

Measurements.[1]—Average of 3 males: Total length, 570; tail vertebræ, 133; hind foot, 60. Average of 2 females: Total length, 500; tail vertebræ, 120; hind foot, 55.

Cranial measurements.—Average of 4 skulls of adult males: Basal length, 64; basilar length of Hensel, 62.5; zygomatic breadth, 43; mastoid breadth, 37; breadth across postorbital processes, 22.5; interorbital breadth, 18; breadth of constriction, 12.5; palatal length, 33; postpalatal length, 31.5. Average of 2 skulls of adult females: Basal length, 60.5; basilar length of Hensel, 58.5; zygomatic breadth, 39; mastoid breadth, 34.5; breadth across postorbital processes, 20; interorbital breadth, 16.5; breadth of constriction, 12; palatal length, 31; postpalatal length, 29.

Subgenus ICTIS Kaup, 1829.

Ictis Kaup: Entwickelungs-Geschichte und Naturliches System der Europäischen Thierwelt, pp. 40–41, 1829. (Contains only a single species, *Mustela vulgaris.*) Schulze: Faunæ Saxonicæ, Mammalia, p. 170, 1893.

Arctogale Kaup: Entwickelungs-Geschichte und Naturliches System der Europäischen Thierwelt, p. 30, 1829. (Contains two species, *erminea* and *boccamela.*)

Gale Wagner: Supplement Schreber's Säugthiere, II, p. 234, 1841. (Contains four species, *frenatus, erminea, boccamela,* and *vulgaris.*)

The names *Ictis* and *Arctogale* were proposed simultaneously in the same publication. Each is accompanied by a diagnosis and included species. The two names, therefore, according to Canon 18 of the A. O. U. Code of Nomenclature, are equally pertinent. In sequence of pagination *Arctogale* comes 10 pages ahead of *Ictis*. *Ictis* contains a single species (*vulgaris* = *nivalis* Linn.), while *Arctogale* has two (*erminea* and *boccamela*). The reasons for choosing *Ictis* instead of *Arctogale* are: (1) The type of *Ictis* is fixed beforehand, since it contained only a single species, while in *Arctogale* the type must be established arbitrarily; (2) *Arctogale* is now in current use for another genus of small carnivora;[2] to transfer it to a different group would lead to much confusion, and would be a great and seemingly unnecessary calamity. Hence, since there is no rule to the contrary, the better course seems to be to adopt *Ictis* and allow *Arctogale* to fall into synonymy.

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[1] The number of specimens of which reliable flesh measurements are available is too small to afford satisfactory averages.

[2] *Arctogale* Peters, 1864, a genus of Viverridæ; Gray, Proc. Zool. Soc. London, 1864, pp. 508, 542–543; Blanford, Fauna British India, Mammalia, p. 114, 1888; Flower and Lydekker, Introduction to Study of Mammals, p. 533, 1891; Lydekker, Royal Nat. Hist., I, p. 461, 1893–94.

Furthermore, *Ictis* has been already revived by Schulze (Faunæ Saxonicæ, Mammalia, 170, 1893), though used by him in a much more comprehensive sense than that originally intended.[1]

List of North American Weasels with type localities.

No.	Name.	Type locality.
1	*Putorius cicognani*	Northeastern North America (north of lat. 41°)
2	*cicognani richardsoni*	Fort Franklin, Great Bear Lake.
3	*richardsoni alascensis*	Juneau, Alaska.
4	*streatori*	Skagit Valley, Washington.
5	*rixosus*	Osler, Saskatchewan.
6	*arcticus*	Point Barrow, Alaska.
7	*arcticus kadiacensis*	Kadiak Island, Alaska.
8	*noveboracensis*	State of New York.
9	*washingtoni*	Trout Lake, Mount Adams, Washington.
10	*peninsulæ*	Tarpon Springs, Florida.
11	*longicauda*	Carlton House, Saskatchewan.
12	*longicauda spadix*	Fort Snelling, Minn.
13	*saturatus*	Siskiyou Mountains, Oregon.
14	*arizonensis*	Flagstaff, Arizona.
15	*alleni*	Black Hills, South Dakota.
16	*xanthogenys*	Southern California.
17	*xanthogenys oregonensis*	Rogue River Valley, Oregon.
18	*frenatus*	Valley of Mexico.
19	*frenatus goldmani*	Pinabete, Chiapas, Mexico.
20	*frenatus leucoparia*	Patzcuaro, Michoacan, Mexico.
21	*tropicalis*	Jico, Vera Cruz, Mexico.
22	*affinis*	Colombia, South America.

PUTORIUS CICOGNANI Bonap. Bonaparte's Weasel.

(Pl. II, figs. 3, 3*a*, 4, 4*a*.)

1829. *Mustela (Putorius) vulgaris* Richardson: Fauna Boreali-Americana, Mammalia, pp. 45–46, 1829.

1838. *Mustela cicognanii* Bonaparte: Iconografia Fauna Italica, I, fasc. XXII, p. 4, 1838; Charlesworth's Mag. Nat. Hist., II, p. 37, Jan., 1838.

1839. *Putorius cicognanii* Richardson: Zoology Beechey's Voyage, p. 10*, 1839.

1857. Baird: Mammals North America, pp. 161–163, 1857.

1891. Mearns: Bull. Am. Mus. Nat. Hist., N. Y., III, p. 235, May, 1891.

1896. *Putorius richardsoni cicognani* Bangs: Proc. Biol. Soc. Wash., X, pp. 18–21, Feb. 25, 1896.

1877. *Putorius vulgaris* Coues: Fur-Bearing Animals, pp. 102–109, 1877. Merriam: Mammals Adirondacks, pp. 54–56, 1882 (habits); and most recent authors.

Type locality.—Northeastern North America.

Geographic distribution.—Boreal forest covered parts of North America from New England and Labrador to coast of southeastern Alaska (Juneau, Wrangel, and Loring), and south in the Rocky Mountains to Colorado (Silverton). It occurs in the interior of British Columbia (at Sicamous), but in the Puget Sound region is replaced by a smaller and

[1] Schulze included in *Ictis* the two European weasels, *vulgaris* and *erminea*, and also the mink, *lutreola*, and polecat, *putoria*.

darker form, *P. streatori*. In the United States it is common in New England and New York, and in the forest-covered parts of Minnesota. It probably occurs also in northern Michigan and Wisconsin.

General characters.—Size small; tail slender and rather short; color of under parts covering toes and inner sides of both fore and hind feet; color of upper parts never encroaching on belly, but ending along a straight line.

Color.—Upper parts in *summer pelage:* uniform dark brown, hardly darker on head; end of tail blackish; no dark spot behind corners of mouth; under parts, usually including upper lip, white, more or less tinged with yellow. In *winter pelage:* pure white with a strong yellowish tinge on rump, tail, and under parts; end of tail black.

Cranial characters.—Skull small, light, narrow, and elongated without marked postorbital processes, and only a slight postorbital constriction; zygomata narrow, and not bowed outward; brain case elongate and subcylindric; audital bullæ small, narrow, and subcylindric, almost continuous anteriorly (except in old age) with the greatly inflated squamosals; palate narrow; the tooth rows more nearly parallel than in the other species; skull of female similar to that of male, but smaller. Contrasted with *richardsoni*, the skull of *cicognani* is smaller, the audital bullæ decidedly smaller, and the dentition lighter. In nearly every series of *cicognani* there are one or two old males whose skulls are abnormally large and closely resemble skulls of *richardsoni*, except that the audital bullæ are always smaller.


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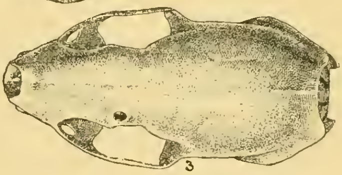
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FIGS. 2 and 3.—*P. cicognani* ♂ ad. Elk River, Minnesota.

Measurements.—Average of 5 males from Ossipee, N. H.: Total length, 278; tail vertebræ, 80; hind foot, 36.5. Average of 3 females: Total length, 230; tail vertebræ, 69; hind foot, 30.5.

PUTORIUS CICOGNANI RICHARDSONI (Bonap.). Richardson's Weasel.

1829. *Mustela (Putorius) erminea* Richardson: Fauna Boreali-Americana, pp. 46–47, 1829. (In part: specimen from Fort Franklin, Great Bear Lake. Not *M. erminea* Linn.)

1838. *Mustela richardsoni* Bonap.: Charlesworth's Mag. Nat. Hist., Vol. XI, p. 38, 1838. (based on Richardson's specimen from Great Bear Lake).

1839. *Putorius richardsoni* Rich.: Zool. Beechey's Voyage of Blossom, Mammalia, 10*, 1839.

1896. Bangs: Proc. Biol. Soc. Washn., X, pp. 1–24, Feb. 25, 1896. (In part.)

Type locality.—Fort Franklin, Great Bear Lake.

Geographic distribution.—Hudsonian timber belt from Hudson Bay to interior of Alaska and British Columbia.

General characters.—Similar to *P. cicognani* but larger; tail of medium length, its terminal third black.

Color.—Upper parts dull chocolate brown, this color reaching down on both fore and hind feet to base of toes; underparts whitish, more or less suffused with yellowish, the pale color extending out in a very narrow and sometimes interrupted strip along inner side of hind feet to toes; tail concolor all around except at tip, which is black for about one-third the total length of tail. In *winter pelage:* white all over except terminal third of tail, which is black; rump and belly more or less tinged with yellowish.

Cranial characters.—Skull long, narrow, and subcylindric like that of *cicognani*, from which it differs chiefly in larger size, larger audital bullæ, and heavier dentition.

Remarks.—*P. richardsoni*, as pointed out by Mr. Bangs, is simply a more northern form of *cicognani*, with which it intergrades completely. It inhabits the Hudsonian timber zone while *cicognani* inhabits the Canadian. On the north, where the timber ends and the tundra begins, the range of *richardsoni* meets that of *arcticus*. The two species differ widely in both cranial and external characters. The light subcylindric skulls of *richardsoni*, with the narrow frontals and appressed zygomata, require no comparison with the broad massive skulls of *arcticus* with their broadly flattened frontals and widely spreading zygomata. The external differences are almost as marked. In *richardsoni* the underparts are nearly white or, at most, only tinged with pale yellowish; the color of the upper parts covers both fore and hind feet, reaching the base of the toes; the tail is relatively long, concolor except at the tip, which is black for about one-third its length. In *arcticus* the under parts are deep yellow; the color of the upper parts stops short of the fore feet and reaches only halfway down the hind feet; the tail is short, yellow below on its basal half, and has a long, black pencil covering at least half its entire length.[1]

Measurements.—(From dry skin of male from Fort Simpson): Total length, 390; tail vertebræ, 95; hind foot, 43 (probably 45).

PUTORIUS RICHARDSONI ALASCENSIS subsp. nov. Juneau Weasel.

(Pl. II, figs. 2, 2*a*.)

Type from Juneau, Alaska. No. 74423, ♂ ad., U. S. National Museum, Dept. Agric. coll. Collected August 22, 1895, by Clark P. Streator. Original number 4806.

General characters.—Similar in size and general appearance to *P. richardsoni*, but white tips of fore and hind feet more extensive and interorbital region very much broader.

Color.—Upper parts dull chocolate brown, this color reaching down on fore legs to wrists and on hind legs to middle of upper side of feet;

[1] It is not strange that Mr. Bangs failed to discriminate between *arcticus* and *richardsoni*. The available material is scanty and mostly of poor quality, and most of the skins had the skulls inside. Through the kindness of Mr. F. W. True, curator of mammals in the United States National Museum, the skulls have been removed and placed at my disposal.

terminal third of tail black; under parts, including upper lip, fore feet, and distal half of hind feet, soiled white, tinged with yellowish. Winter pelage probably white.

Cranial characters.—Skull similar to that of *P. richardsoni*, but very much broader between orbits and across muzzle; postorbital processes more strongly developed; constriction deeper.

Remarks.—Mr. Streator obtained two males of this new weasel at Juneau in the latter part of August. He obtained also, at the same place and time, three females, which in color and markings agree with the males, but are hardly half as large. Their skulls are as small as those of true *cicognani*, which they closely resemble. If they are the females of *alascensis*, as seems probable, then this weasel exhibits as great sexual difference in size as *P. noveboracensis*, in which respect it stands unique as a member of the *cicognani* group. The only alternate possibility is that *cicognani* and *alascensis* occur together at Juneau, and that of the 5 specimens collected there by Streator the 2 males are *alascensis* and the 3 females *cicognani*.

Measurements.—Average of two males from Juneau, Alaska: Total length, 335; tail vertebræ, 95; hind foot, 48. Average of three females from same place: Total length, 270; tail vertebræ, 77; hind foot, 34.

PUTORIUS STREATORI sp. nov. Puget Sound Weasel.

(Pl. II, figs. 5, 5*a*, 6, 6*a*.)

Type from Mount Vernon, Skagit Valley, Washington. No. 76646, ♂ ad., U. S. Nat. Mus., Dept. Agric. coll. Coll. Feb. 29, 1896, by D. R. Luckey. (Original number 3)

Geographic distribution.—Puget Sound and coast region of Washington and Oregon; south at least to Yaquina Bay (Newport), Oregon. Confined to a narrow strip along the coast.

General characters.—Similar to *Putorius cicognani*, but smaller and darker, with color of upper parts encroaching on belly.

Color.—Upper parts, including upper lip and fore and hind feet, uniform dark chocolate brown, darkest on head, and encroaching far on belly and throat (often meeting along middle of belly); terminal third of tail black; under parts narrowly and irregularly white, faintly tinged with yellowish. *In winter pelage* at low altitudes the color of the upper parts is paler (almost drab brown) and the toes may become white; at higher altitudes the whole animal changes to white,[1] except the end of the tail, which always remains black.

Cranial characters.—Skull of male similar to that of male *cicognani*, but smaller, slightly broader interorbitally, and with somewhat more

[1]Mr. R. E. Darrell, of Port Moody, British Columbia, writes me: "I have discovered that, although the weasels do not change color down near salt water, they do change to the white winter coat in the mountains." Specimens in the Department collection from Mount Adams, Washington, killed in February and March, are in the white winter pelage. The type and a female from the same locality (Mount Vernon, Skagit Valley) are in the drab-brown winter pelage.

prominent postorbital processes and smaller audital bullæ. Skull of female very much smaller and more delicate than that of male, resembling female of *cicognani*, but smaller.

Remarks.—*Putorius streatori* is a dark Pacific Coast form of *cicognani*, with which it may be found to intergrade. It differs conspicuously from *cicognani* in the color of the under parts, the dark chocolate brown of the back and sides encroaching far on the throat and usually meeting along the median line of the belly, thus reducing the white to a narrow and irregular strip, which expands on the anterior part of the throat, on the breast behind the fore legs, and immediately in front of the hind legs, and stops abruptly on the under surface of the thighs.

Five winter specimens from Sumas, British Columbia, kindly loaned by Mr. Outram Bangs, point toward intergradation with *cicognani*. In three out of the five, the toes of both fore and hind feet are white, and the color of the upper parts is much paler than in summer pelage. Two of these specimens have the bellies broadly white, as in *cicognani*. They are also much larger than *streatori*. Specimens from Sicamous, in the interior of British Columbia, are fairly typical *cicognani*, having the under parts broadly white; the upper lip, a strip along the inner border of the hind feet, and the toes of both fore and hind feet, white. Specimens from southeastern Alaska (Juneau, Wrangel, and Loring) must also be referred to *cicognani*, and not *streatori*.

Measurements.—Unfortunately, no flesh measurements are available from the type locality. Specimens from Trout Lake, near Mount Adams, Washington, are slightly smaller than the Mount Vernon specimens, and measure as follows: Average of two adult males: Total length, 270; tail vertebræ, 83; hind foot, 33. An adult female: Total length, 210; tail vertebræ, 51; hind foot, 24.

PUTORIUS RIXOSUS Bangs. Bang's Weasel.

(Pl. II, figs. 7, 7a.)

1857. *Putorius pusillus* Baird: Mammals N. Am., pp. 159–161, 1857. (In part: specimen from Pembina.)

1896. *Putorius rixosus* Bangs: Proc. Biol. Soc. Wash., Vol. X, pp. 21–22, Feb., 1896.

Type locality.—Osler, Saskatchewan, Canada.

Geographic distribution.—Boreal America from Hudson Bay to coast of Alaska (St. Michaels); south to northern Minnesota (Pembina) and Montana (Sun River).

General characters.—Smallest weasel known; tail short and without black tip; only American weasel lacking the black tip.

Color.—*Summer pelage:* Upper parts dark reddish brown; tip of tail not darker; under parts white. In *winter pelage:* Pure white all over, including end of tail.

Cranial characters.—Skull (of type specimen, ♀ ad., No. 642 Bangs' Coll.[1]) very much smaller than the smallest female of any other known

[1] I am indebted to Mr. Bangs for the privilege of examining this specimen. Unfortunately, the basioccipital is broken off; hence the basilar length is estimated.

species (total length from occiput to front of premaxillæ, 28.5; basal length, 26.5; zygomatic breadth, 14; length of palate, 11; interorbital breadth, 5.5; breadth across postorbital processes, 7.5; length of audital bullæ, 9.5). The skull is a miniature of *P. cicognani* except that the postorbital processes are more prominent, the brain case more compressed, and there is a distinct sagittal ridge.

Measurements.—Type specimen, female, measured in flesh: Total length, 150; tail vertebræ, 31; hind foot in dry skins, 20–22.

PUTORIUS ARCTICUS sp. nov. Tundra Weasel.

(Pl. II, figs. 1, 1*a*; Pl. V, figs. 6, 6*a*.)

Type from Point Barrow, Alaska. No $\frac{14062}{23010}$ ♂ ad. U. S. Nat. Mus. Collected July 16, 1883, by John Murdoch. Original number, 1672.

Geographic distribution.—Arctic coast and tundras. Specimens examined from Anderson River, Franklin Bay, old Fort Good Hope, lower Mackenzie River, Point Barrow, and St. Michaels.

General characters.—Size large; ears small; tail short but with very long black pencil; underparts yellow (including underside of basal half of tail).

Color—(Type specimen, male adult.) Upper parts, including upper lip, dark yellowish brown; chin white; under parts deep ochraceous yellow, broadly including inner and posterior sides of fore legs, whole of fore feet, distal half and inner side of hind feet, and under side of tail to or nearly to black tip; black tip very long, covering at least half of tail (including long terminal hairs); color of upper parts not encroaching on belly. In *winter pelage*, white all over except long black tip of tail; the white tinged with yellow posteriorly.

Cranial characters.—Skull rather large, broad, and massive; frontal very broad interorbitally; muzzle broad and blunt; postorbital processes moderately developed; postorbital constriction marked; zygomata strongly bowed outward; brain case subtriangular and rather short; audital bullæ subcylindric; postglenoid space smaller than in *richardsoni* and hardly inflated except in female. Contrasted with *P. richardsoni*, the skull of *P. arcticus* is somewhat larger, much broader, and more massive; brain case subtriangular instead of subcylindric; zygomata bowed far outward instead of appressed; postorbital processes more prominent; postorbital constriction much deeper; frontal much broader interorbitally; palate broader posteriorly; dentition heavier. Adult male skulls of *P. arcticus* resemble certain old males of *washingtoni*, but differ in much greater breadth of frontal between orbits, broader muzzle, and blunter postorbital processes. *P. arcticus* resembles true *erminea* of Sweden much more closely than it does any American species.

Remarks.—*Putorius arcticus*, which has been heretofore confounded with *erminea* or *richardsoni*, is one of the most strongly characterized species of the genus. It is a large animal with deep ochraceous yellow under parts and a rather short tail which ends in a remarkably long black pencil. The skull differs from all other American weasels in the great breadth of the frontal region and the breadth and bluntness of the muzzle, in both of which respects it resembles true *erminea*. The only American species whose skull approaches it at all is *P. washingtoni*, as mentioned above. In external characters the differences are too great to require comparison.

It is interesting to find in this country an Arctic circumpolar weasel which, though specifically distinct, is strictly the American representative of the Old World *erminea*. The pattern of coloration, as described above (under *color*), is precisely as in *erminea*, but the tints differ materially. The upper parts in *erminea* lack the golden brown of *arcticus*, and the under parts are very much paler and of a different tint, being pale sulphur yellow instead of ochraceous. Moreover, *arcticus* lacks the whitish border to the ear which is present in *erminea*. In winter pelage the two seem to be indistinguishable except by cranial characters.

A small form of *arcticus* occurs on Kadiak Island, Alaska. It has smaller and narrower audital bullæ, less spreading zygomata, less divergent tooth rows, and decidedly shorter postmolar production of palate. It is probably worthy of recognition as subspecies *kadiacensis*. An adult male (No. 65290) collected April 25, 1894, by B. J. Bretherton, measured in the flesh: Total length, 318; tail vertebræ, 86; hind foot, 44. It is in the white winter pelage, just beginning to change, and the terminal half of the tail is black.

Measurements.—From dry skin of type, male adult, Point Barrow, Alaska: Total length, 380; tail vertebræ, 75; pencil, 55; hind foot, 48 (at least 50 in the flesh).

PUTORIUS NOVEBORACENSIS De Kay. New York Weasel.

(Pl. IV, figs. 1, 1a, 2, 2a; Pl. V, figs. 3, 3a.

1840. *Putorius noveboracensis* De Kay: Catal. Mammalia New York, p. 18, 1840 (*nomen nudum*); Zoology of New York, Mammalia, p. 36, 1842.
1840. Emmons: Rept. Quadrupeds Massachusetts, p. 45, 1840.
1857. Baird: Mammals N. Am., pp. 166–169, 1857.
1896. Bangs: Proc. Biol. Soc. Wash., X, pp. 13–16, Feb. 25, 1896.
1877. *Putorius* (*Gale*) *erminea* Coues: Fur-Bearing Animals, pp. 109–136 (in part), 1877.
Putorius erminea Thompson, Aud. & Bach. (part), Allen, Merriam, and most recent authors.

Type locality.—New York State.

Geographic distribution.—Eastern United States from southern Maine to North Carolina, and west to Illinois.

General characters.—Male large; female small; tail long and bushy, much longer than in *cicognani*, but shorter than in *longicauda;* the black terminal part longer than in any other species except *articus*, covering one-third to one-half the tail and measuring 50 to 75 mm. Animal turns white in winter in northern part of range. Extraordinary sexual difference in size and cranial characters.

Color.—Summer pelage: Upper parts, including fore and hind feet and anal region, and often encroaching irregularly on belly, rich dark chocolate brown, sometimes suggesting seal brown; under parts (usually including upper lip) white, more or less washed with yellowish; no yellow on under side of tail or on hind feet, the color of under parts stopping short of ankle. *Winter pelage:* In southern part of range similar to summer pelage, but upper parts paler, nearly drab brown. Northern specimens white all over except terminal third of tail, which is jet black; throat, belly, posterior half of back and tail always suffused with yellowish.

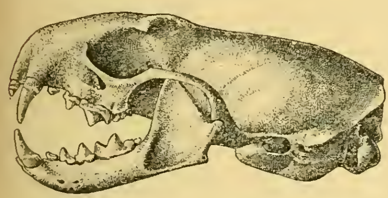
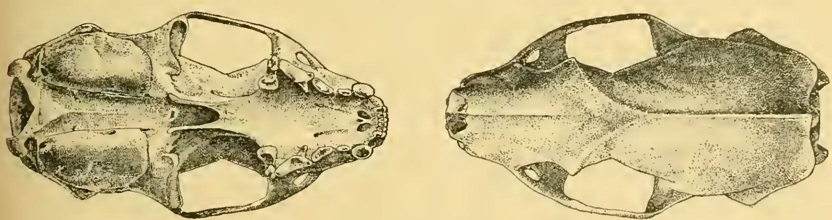


FIG. 4.—*Putorius noveboracensis* ♂ ad. Adirondacks, New York.

Cranial characters.—Skull of male large, heavy, and elongate; sagittal ridge present in adults; postorbital processes and constriction moderately developed; zygomata *not bowed outward:* audital bullæ rather narrowly oval, usually rounded anteriorly as well as posteriorly. Skull of female very small, light, and narrow, with brain case elongate and subcylindric, much as in *cicognani;* audital bullæ small, narrow, and not rising abruptly anteriorly from inflated squamosals, which latter are elongated and strongly inflated as in *cicognani.* Skulls of males may be distinguished from those of male *longicauda* by shorter postorbital processes, less marked postorbital constriction, less triangular brain case, lower sagittal ridge, very much narrower zygomata, which *are not bowed outward*, narrower palate, and narrower audital bullæ, which are more rounded anteriorly. The resemblance to *P. washingtoni* is very much closer, but male skulls of *novebo-*



FIGS. 5 and 6.—*Putorius noveboracensis.* Adirondacks, New York.

racensis may be distinguished by larger size and much larger audital bullæ. The female skull, owing to the inflation of its squamosals inferiorly, needs no comparison with either *washingtoni* or *longicauda*, but is with difficulty separated from *cicognani* in regions where the two species overlap. The postorbital processes are longer and the carnassial and sectorial teeth larger in the females of *noveboracensis* than in *cicognani* from the same localities.

Remarks.—Putorius noveboracensis may usually be distinguished from *P. cicognani* by larger size and also by the longer and more bushy tail, and greater length of the black terminal part. Females of *noveboracensis*, however, sometimes resemble males of *cicognani* rather closely. They may be distinguished not only by the greater length of the tail but also, if in summer pelage, by the absence of yellow from the under side of the tail and inner sides of the hind feet, which parts in *cicognani* usually show more or less yellow.

Measurements.—Average of 10 males: Total length, 407; tail vertebræ, 140; hind foot, 47. Average of 10 females: Total length, 324; tail vertebræ, 108; hind foot, 34.5.

PUTORIUS WASHINGTONI sp. nov. Washington Weasel.

(Pl. IV, figs. 3, 3a, 4, 4a.)

Type from Trout Lake, base of Mount Adams, State of Washington. No. 76522, ♂ ad., U. S. Nat. Mus., Dept. Agriculture collection. Collected December 15, 1895, by D. N. Kaegi.

General characters.—Similar to *P. noveboracensis* in size and general appearance, but with longer tail and shorter black tip. Female very much smaller than male, as in *noveboracensis*.

Color.—Color in summer pelage unknown (probably dark chocolate brown). There are two winter pelages, probably dependent on altitude. In *drab* winter pelage: Upper parts uniform drab brown; end of tail black; under parts white, more or less suffused with pale yellowish. The color of the upper parts encroaches on the sides of the belly as in *noveboracensis*, and a brown spot is present behind the corners of the mouth, which may or may not be confluent with the brown of the cheeks. In the type and two other specimens the hind legs and feet are the same color as the upper parts except that the toes are tipped with whitish and the tips of the fore feet are white. In another specimen, collected January 22, the white is more extensive, covering all of the fore feet and about half of the hind feet. In summer pelage the legs and feet are doubtless the same color as the upper parts, the white of the belly stopping high up on the thighs. In *white* winter pelage: White all over except black tip of tail; tail, rump, and belly strongly suffused with yellow. In one specimen (No. 76604, male, February 7, 1896) the yellow reaches forward over the back nearly to the shoulders; in another (No. 76588, male, February 4, 1896) the whole back is white.

Cranial characters.—The skulls of the two sexes differ greatly: that of the male resembles *noveboracensis* closely in size and general characters, but differs in having the audital bullæ much shorter and the postorbital processes less strongly developed. The postorbital constriction is equally marked. The skull of the female is very much smaller than that of the male, averaging about 38 mm. in length, while the male averages 45 mm. Contrasted with the female of *noveboracensis* the brain case is broader posteriorly and less cylindric. The audital bullæ are more sharply separated from the squamosal inflation and the latter is only slightly marked, not reaching the plane of the bullæ. The resemblance therefore to *P. cicognani* is much less marked in the female *washingtoni* than in the female *noveboracensis*.

Remarks.—This new species is represented in the collection by 14 skulls and 6 skins, of which the greater number are males. The female is darker than the males, and the top of the head is darker anteriorly than the rest of the upper parts, while in the males it is concolor with the back. These differences are probably seasonal, the female not having completed the change from summer to winter pelage, though collected December 11. All are from the Mount Adams region.

Measurements.—The skins, which are well made, afford the following approximate measurements: Male, total length, 240; tail vertebræ, 155; hind foot, 44. Female, total length, 360; tail vertebræ, 120; hind foot, 37.

PUTORIUS PENINSULÆ Rhoads. Florida Weasel.

(Pl . IV, figs. 5, 5a; Pl. V, fig. 5.)

Putorius peninsulæ Rhoads: Proc. Acad. Nat. Sci. Phila., June 1894, 152–155.
Bangs: Proc. Biol. Soc. Wash., X, pp. 10–13, Feb. 25, 1896.

Type locality.—'Hudsons,' 14 miles north of Tarpon Springs, Fla.

Geographic distribution.—Peninsula of Florida; limits of range unknown.

General characters.—Size rather large, about equaling male of *Putorius noveboracensis;* skull similar to that of *longicauda*, but with very large audital bullæ.

Color.—Upper parts dull chocolate brown, darkest on head; upper lip and chin whitish; rest of under parts, including fore feet and toes of hind feet, yellowish; a brown spot behind corners of mouth; a small tuft of white hairs under anterior root of ear. The color of the under parts covers the belly broadly and is not encroached upon by the color of the upper parts. Irregular and inconstant white markings are sometimes present between and behind the eyes.

Cranial characters.—Skull rather massive, resembling that of *longicauda*, but with higher sagittal crest; less spreading zygomata; narrower, higher, and more swollen audital bullæ, and less prominent postorbital processes. Contrasted with *P. noveboracensis* the postorbital constriction is deeper, the brain case higher and more subtriangular, the audital bullæ higher and more swollen, the upper carnassial tooth decidedly larger, and the molar smaller. The upper molar is peculiar: It is short, hardly expanded at either end, and implanted at right angles to the premolar series.

Measurements.—An adult female from Tarpon Springs, Fla.: Total length, 374; tail vertebræ, 127; hind foot, 44.5.

PUTORIUS LONGICAUDA Bonaparte. Long-tailed Weasel.

(Pl. III, figs. 3, 3a, 4, 4a; Pl. V, figs. 1, 1a.)

1829. *Mustela (Putorius) erminea* Richardson: Fauna Boreali-Americana, pp. 46–47, 1829 (in part: Specimen from Carlton House).

1838. *Mustela longicauda* Bonaparte: Charlesworth's Magazine Nat. Hist. N. S., II, p. 37–38, 1838 (based on Richardson's long-tailed variety of *erminea* from Carlton House).

1839. *Putorius longicauda* Rich.: Zool. Beechey's Voyage of Blossom, p. 10, 1839.
1857. Baird: Mammals N. Am., pp. 169–171, 1857.
1877. Coues: Fur-Bearing Animals, pp. 136–142, 1877.
1896. Bangs: Proc. Biol. Soc. Wash., X, pp. 7–8, Feb. 25, 1896.

Type locality.—Carlton House, on North Saskatchewan River, Canada.

Geographic distribution.—Great Plains from Kansas northward.

General characters.—Size large (adult males averaging about 450 mm. in total length); tail very long (vertebræ 155 mm. or more in males), its black tip rather short; under parts always strongly yellowish or ochraceous.

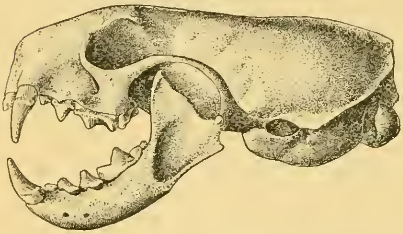
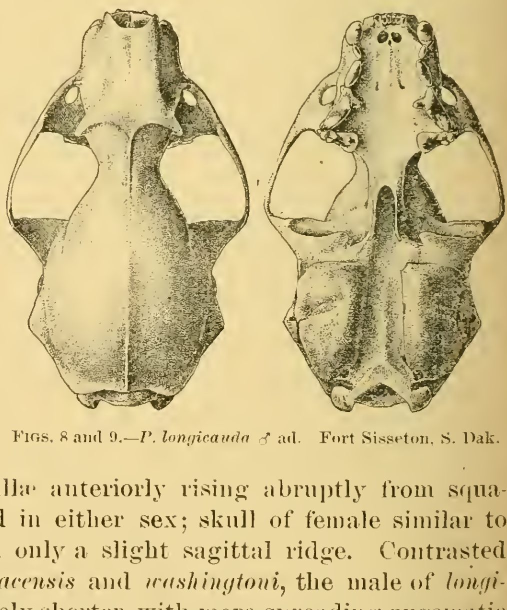


Fig. 7.—*Putorius longicauda.* Fort Sisseton, S. Dak.

Color.—Upper parts pale yellowish brown, or pale raw-umber brown, becoming darker on head; terminal part of tail black; chin and upper lip all the way round white; rest of under parts varying from strong buffy yellow to ochraceous orange, the color extending from throat posteriorly, including upper side of fore feet, inner side of hind feet, and upper side of hind toes; under side of tail more or less suffused with yellowish; soles of hind feet brownish. In worn summer pelage the color of upper parts is decidedly paler, and in some old specimens the upper and lower surfaces are not sharply differentiated. The orange tinge of the under parts is strongest on the throat.



Figs. 8 and 9.—*P. longicauda* ♂ ad. Fort Sisseton, S. Dak.

Cranial characters.—Skull large, broad, and massive, with well-developed postorbital processes, strongly marked postorbital constriction, and a moderate sagittal crest; zygomata bowed strongly outward; brain case subtriangular as seen from above; audital bullæ rather broad and subrectangular; palate broad; dentition heavy; audital bullæ anteriorly rising abruptly from squamosal, which is not inflated in either sex; skull of female similar to male, but smaller, and with only a slight sagittal ridge. Contrasted with male skulls of *noveboracensis* and *washingtoni*, the male of *longicauda* is broader and relatively shorter, with more spreading zygomatic arches, longer postorbital processes, deeper postorbital constriction, and much broader and more rectangular audital bullæ, which as a rule are broadly truncate instead of narrowly rounded anteriorly.

Measurements.—Average of 4 males from plains of Saskatchewan and Alberta: Total length, 450; tail vertebræ, 165; hind foot, 51. Average of 3 females: Total length, 387; tail vertebræ, 144; hind foot, 44.

PUTORIUS LONGICAUDA SPADIX Bangs.

Putorius longicauda spadix Bangs: Proc. Biol. Soc. Wash., X, pp. 8–9, Feb. 25, 1896.

Type locality.—Fort Snelling, near Minneapolis, Minn.

Geographic distribution.—Edge of timber belt in Minnesota, along boundary between Transition and Boreal zones.

General characters.—Similar to *P. longicauda*, but much darker.

Color.—*Summer pelage:* Upper parts chocolate brown, darkest on the head, but paler than in *noveboracensis;* chin and upper lip whitish all round; rest of under parts, including upper surfaces of fore feet and toes of hind feet, buffy yellow; terminal part of tail black. *Winter pelage:* Snow-white everywhere except black tip of tail and a yellowish suffusion on rest of tail, and sometimes also on under side of hind feet.

Cranial characters.—As in *P. longicauda.*

10 11

FIGS. 10 and 11.—*Putorius l. spadix* ♀ ad. Elk River, Minnesota.

Measurements.[1]—Average of 6 males from Fort Snelling, Minn.: Total length, 460; tail vertebræ, 166.5; hind foot, 54.5. Average of 3 females: Total length, 356; tail vertebræ, 132; hind foot, 43.5.

PUTORIUS SATURATUS sp. nov. Cascade Mountain Weasel.

Type from Siskiyou, near southern boundary of Oregon (altitude, about 4,000 feet). No. 65930, ♂ ad., U. S. Nat. Mus., Department of Agriculture collection. Collected June 6, 1894, by Clark P. Streator. Orig. No. 3905.

General characters.—Similar to *P. arizonensis*, but larger and darker, with belly more ochraceous, and with distinct spots behind the corners of the mouth.

Color.—Color of upper parts in summer pelage (June) dark raw umber brown, becoming much darker on the top of the head and nose; terminal part of tail black; a brown spot at corner of mouth which may be confluent with brown of cheeks; color of upper parts extending over outer side of forearm to wrist, and over hind foot to toes; chin

[1]These measurements were taken in the flesh by Dr. E. A. Mearns, to whom I am indebted for them.

white; rest of under parts ochraceous or orange yellow, including the fore feet, and reaching narrowly down the under side of hind leg to ankle, whence it may or may not extend in a narrow line along inner side of foot to toes; under side of tail more or less suffused with golden chestnut; anal region chestnut brown; in worn pelage the colors are everywhere much paler.

Cranial characters.—Skull similar to that of *P. arizonensis* but with postorbital processes broader at base and less peg like.

Remarks.—This handsome weasel replaces *longicauda* on the Cascade and Siskiyou mountains of Oregon and Washington, reaching a short distance into British Columbia. The only specimens examined have come from Siskiyou, Oregon, and Chilliwack, British Columbia (the latter, No. 3553, collection of E. A. and O. Bangs).

Measurements.—Average of 2 males from Siskiyou Mountains, Oregon: Total length, 423; tail vertebræ, 164; hind foot, 48.

PUTORIUS ARIZONENSIS Mearns. Mountain Weasel.

Putorius arizonensis Mearns: Bull. American Museum Nat. Hist., Vol. III, No. 2, pp. 234–235, May, 1891.

Putorius longicauda Merriam: Mammals of Idaho, N. Am. Fauna, No. 5, pp. 83–84, Aug. 1891 (from mountains of Idaho).

Type locality.—San Francisco forest, Arizona (a few miles south of Flagstaff).

Geographic distribution.—Broadly, the Sierra Nevada and Rocky Mountain systems, reaching British Columbia in the Rocky Mountain region, but not known north of the Siskiyou Mountains in the Sierra-Cascade system.

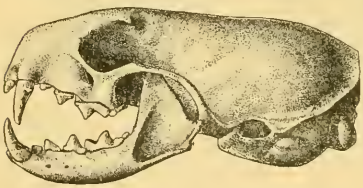


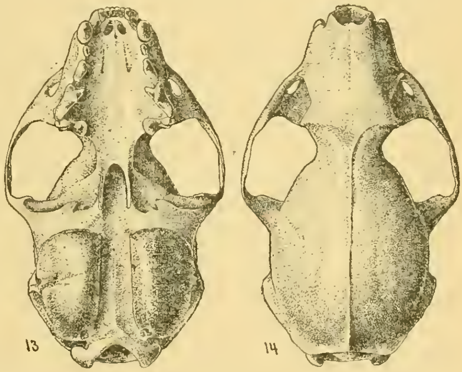
FIG. 12.—*P. arizonensis* ♂ ad. Boulder County, Colo.

General characters.—Similar to *Putorius longicauda* in color and markings, but much smaller in size.

Color.—Upper parts from occiput to black tip of tail, raw umber brown; head decidedly darker; end of tail black; chin and upper lip all round white; rest of under parts including upper surfaces of fore feet and inner half of hind feet and upper surfaces of hind toes ochraceous or ochraceous yellow, varying in tint.

Cranial characters.—Skull similar to that of *longicauda* but decidedly smaller and less triangular; narrower across mastoids and more bulging in parietals.

Remarks.—*Putorius arizonensis* is a mountain form of *longicauda*, which it closely resembles except in size. The type specimen, collected by Dr. Mearns on the pine plateau of Arizona a few miles south of Flagstaff, is an immature female and is of unusually small size. A male obtained by him near the same place is of the normal size, as is another male in the Department collection from Springerville, Ariz., collected by E. W. Nelson. Specimens from the northern Rocky Mountain region (St. Mary Lake, Montana, and Salmon River and Pahsimeroi Mountains, Idaho) differ in color from the typical animal from Arizona and Colorado, and agree with *alleni* from the Black Hills in having the upper parts strongly suffused with golden brown, the yellow of the under parts yellow rather than ochraceous, and the under side of the tail strongly yellow on the basal half or two-thirds. The skulls, however, lack the flattened audital bullæ of *alleni*. Specimens from the Sierra Nevada in California are hardly distinguishable from the Rocky Mountain animal. The only apparent external differences are that the yellow of the under parts reaches up farther under the chin, the white of the upper lip is less extensive, and the under side of the tail is more suffused with yellowish. But none of these characters is constant. In one specimen from Donner, Calif. (No. 2650, female, Merriam Coll.), even the white upper lip is as marked as in Rocky Mountain specimens; it reaches all the way round, fills the space under the nasal pad to the nostrils, and broadens strongly under the eyes. In cranial characters also the differences are slight and inconstant. The postorbital processes are longer and more slender, often becoming peg-like in old males. The audital bullæ average smaller and more convex anteriorly, and in the female are decidedly narrower and more subcylindric. But in an adult female from Fort Klamath, Oreg., the bullæ are nearly as broad as in Rocky Mountain females. The three female skulls I have seen of the Sierra form are decidedly smaller than females from the Rocky Mountains.



FIGS. 13 and 14.—*P. arizonensis* ♂ ad. Boulder County, Colo.

The Sierra specimens show a strong tendency to grade into, or at least toward *xanthogenys*. In nearly half the specimens examined white hairs are present between the eyes, and in several they are sufficiently numerous to form a conspicuous white spot, though the spot is not large and rectangular as in true *xanthogenys*. The white cheek spots I have not seen in Sierra specimens, but the brown spots behind the corners of the mouth are sometimes present (as in No. 30655, male, from Upper Cottonwood Meadows, near Mount Whitney, Calif.).

A specimen from St. George, Utah, an old female, differs in some respects from typical *arizonensis*. The skull is small and relatively short, and the shortening is mainly in the palate and rostral part, which measures 2 mm. less than the average of adult females of *arizonensis* of the same size. Moreover, the postorbital processes are longer and more slender than in any female of *arizonensis* I have examined from either the Rocky Mountain or Sierra systems. Externally the St. George specimen differs from typical *arizonensis* in the following particulars: Yellow of underparts more strongly tinged with ochraceous; white of upper lip narrow and not reaching around anteriorly; brown of upper parts reaching down on outer side of arm to wrist; a small brown spot bearing two bristles just behind each corner of mouth. In this respect, and this only, it resembles *xanthogenys*; there is no trace of white on the cheeks or between the eyes.

Measurements.—Average of 5 males from the Rocky Mountains: Total length, 385; tail vertebræ, 144; hind foot, 44.5. Average of 4 females: Total length, 358; tail vertebræ, 130; hind foot, 40.

PUTORIUS ALLENI sp. nov. Black Hills Weasel.

Type from Custer, Black Hills, South Dakota. No. $\frac{4485}{5120}$, ♂ ad., Merriam collection. Collected July 12, 1888, by Vernon Bailey. Original No. 90.

Geographic distribution.—Black Hills, South Dakota.

Characters.—Similar to *P. arizonensis* in size and general characters, but upper parts more suffused with yellowish and audital bullæ flatter.

Color.—Upper parts from occiput to black tip of tail golden or yellowish-brown, in some lights with an olivaceous tinge; head dark brown, without yellowish tinge; upper lip and chin white; rest of underparts, including inner sides of legs, whole of fore feet, toes of hind feet and under side of basal part of tail, intense buffy yellow.

Cranial characters.—Skull similar to that of *arizonensis*, but audital bullæ much flatter and somewhat smaller; brain case slightly flatter and bulging laterally immediately behind constriction; frontal somewhat broader interorbitally; skull as a whole shorter. The skull of an old female (No. 7441, Am. Mus. Nat. Hist.) is much smaller than the male, and the audital bullæ are narrow and not flattened. In both sexes the postorbital processes are strongly developed.

Remarks.—*Putorius alleni* is an isolated and only slightly differentiated form of *P. arizonensis*, from which it is completely cut off geographically. It is surrounded on all sides by the large weasel of the plains, *P. longicauda*. In worn summer pelage the color differences that distinguish it from *arizonensis* are not apparent.

I take pleasure in naming the species in honor of Dr. J. A. Allen, of the American Museum of Natural History, New York, who has recently published an important paper on the mammals of the Black Hills, and to whom I am indebted for the loan of three additional specimens.

Measurements (of type specimen, male adult).—Total length, 372; tail vertebræ, 137; hind foot, 44.

PUTORIUS XANTHOGENYS (Gray). California Weasel.

1843. *Mustela xanthogenys* Gray: Annals and Magazine Nat. Hist., XI, pp. 118, 1843.
1857. *Putorius xanthogenys* Baird: Mammals N. Am., pp. 176–177, 1857.
1877. *Putorius (Gale) brasiliensis frenatus* Coues: Fur-Bearing Animals, pp. 142–146, 1877 (in part).

Type locality.—Southern California, probably vicinity of San Diego.

Geographic distribution.—Sonoran and Transition faunas of California, on both sides of the Sierra Nevada.

General characters.—Size medium; tail long; face conspicuously marked with whitish, but rest of head not black; under parts ochraceous.

Color.—Upper parts from back of head to terminal part of tail in *summer pelage* raw-umber brown, tinged with golden; in *winter pelage*, drab brown, without yellowish suffusion; head always darker, becoming dusky over nose; a large rectangular spot between eyes, and a broad oblique band between eye and ear, whitish; end of tail black; a brown spot behind corners of mouth; chin white; rest of under parts, including fore feet all round and inner side and toes of hind feet, varying from buffy ochraceous to ochraceous orange. In some specimens the ochraceous covers the greater part of the hind feet as well as the toes.

Cranial characters.—Skull of the *longicauda* type and practically indistinguishable in size and characters from *P. arizonensis*; skull as a whole short and broad; zygomata bowed outward; postorbital processes strongly developed; sagittal ridge distinct; audital bullæ moderate, usually truncate anteriorly; skull of female similar to that of male, but smaller.

Remarks.—*Putorius xanthogenys* inhabits the San Joaquin and Owens valleys and the whole of southern California except the higher mountains. In ascending the mountains it gradually loses the facial markings and seems to grade into *P. arizonensis*, the weasel of the mountain summits.

Measurements.—Average of 7 males from southern California: Total length, 402; tail vertebræ, 156; hind foot, 43.5. Average of 3 females: Total length, 368; tail vertebræ, 135; hind foot, 40.5.

PUTORIUS XANTHOGENYS OREGONENSIS subsp. nov. Oregon Weasel.

Type from Grants Pass, Rogue River Valley, Oregon. No. $\frac{32019}{43828}$, ♀ ad., U. S. Nat. Mus., Dept. Agric. Coll. Collected December 19, 1891, by Clark P. Streator. Original number 1404.

Geographic distribution.—Rogue River Valley, Oregon; limits of range unknown.

General characters.—Similar to *P. xanthogenys* but decidedly larger, darker in color, and with face markings much restricted.

Color.—Upper parts in winter pelage pale chocolate brown, slightly darker on head; a small and ill-defined patch between eyes, and a narrow vertical bar between eye and ear, white; throat white; rest of under parts, including fore feet and inner sides and distal half of hind feet, pale yellowish; terminal one-fifth of tail black; rest of tail above and below concolor with back and without the yellowish tinge which is characteristic of *xanthogenys*.

Cranial characters.—Skull similar to that of *xanthogenys* but larger and decidedly broader. The skull of the type, an adult female, compared with skulls of *xanthogenys* of the same sex and age from southern California, differs in the following particulars: Skull everywhere broader; muzzle, palate, interorbital breadth and constriction very much broader; zygomata more spreading.

Measurements.—Type specimen, female adult: Total length, 412; tail vertebræ, 155; hind foot, 44.

PUTORIUS FRENATUS (Lichtenstein). Bridled Weasel.

(Pl. III, figs. 1, 1a, 1b, 2.)

1813. *Mustela brasiliensis* Sevastianoff: Mem. Acad. Imp. Sci. St. Petersburg, IV, 356–363, Table IV, 1813. (Name on plate only; diagnosis in text.) Preoccupied by *Mustela brasiliensis* [an otter] Gmelin, 1788.
1832. *Mustela frenata* Lichtenstein: Darstellung neuer oder wenig bekannter Saugethiere, Pl. XLII and corresponding text (unpaged), 1832.
1857. *Putorius frenatus* Baird: Mammals N. Am., 173–176, 1857.

Type locality.—Valley of Mexico, near City of Mexico.

General characters.—Size large; tail long; its black tip relatively short; head black, with conspicuous white markings.

Color.—Top of head blackish, interrupted between eye and ear by a broad, whitish band, which is nearly confluent with a patch of same color between the eyes; rest of upper parts brown; a dark spot behind corners of mouth; chin and throat whitish; rest of under parts ochraceous yellow; forefeet to or above wrists whitish or pale buffy yellowish, continuous with and shading into ochraceous of under parts; color of under parts extending down on inner side of hind legs and feet to toes, which are whitish or yellowish white.

Cranial characters.—Skull large and massive, with strongly developed postorbital processes, deep postorbital constriction, marked sagittal crest, and peculiar audital bullæ, which are obliquely truncated anteriorily (the inner side reaching farthest forward) and abruptly highest on inner side, falling away suddenly on outer side so as to form a rounded ridge along the inner side of the longitudinal axis of the bulla. The skull of *frenatus* resembles that of *longicauda*, but is considerably larger, and differs in the form of the audital bullæ just described, and also in the extent of the postglenoid space, which is much larger than in *longicauda*. The dentition is heavy and the upper carnassial tooth relatively shorter than in *longicauda*. The ramus of the under jaw is much more convex inferiorly.

Remarks.—Lichtenstein, in his original description of *Mustela frenata*, states that the tail is about one-third longer than that of the European weasel (*erminea*); that only its extreme tip is black; that the head, ears, and crown are black, this coloring fading into the reddish brown of the upper parts on the back of the head behind the ears; that the facial markings, throat, and breast are white; the remainder of the under parts ocher yellow. The white spot between the eyes is described as heartshaped, and in the colored plate it is shown to be nearly, but not quite, confluent with the white patch between the eye and ear. The colors in the plate are not good, as the whole under parts are white instead of ocher yellow, and the black tip of the tail is not shown. The specimen seems to have been in worn pelage. Lichtenstein had two specimens, both collected by Deppe near the City of Mexico.

Fortunately, the Department collection contains two specimens collected by E. W. Nelson at Tlalpam, in the Valley of Mexico, which may be considered topotypes of *frenatus*, for they not only came from the same locality as Lichtenstein's types, but also agree essentially in every detail with his excellent description. The only points in which the description fails to agree absolutely with the specimens is that in the latter the white of the throat is less pure and the black tip of the tail perhaps a trifle more extensive than one would infer from the description; but the throat is white in contrast with the strongly ochraceous yellow of the rest of the under parts, and a specimen in the United States National Museum from the City of Mexico (No. 1060, ♀ ad., J. Potts) has both throat and breast white, as in the original description.

The statement that only the extreme tip of the tail is black was made in comparison with the European weasel (*erminea*), in which nearly half of the tail is black. Hence the description agrees entirely with the specimens in hand. One point not mentioned in the description is shown in the plate, namely, that the hind feet and toes are in large part whitish or yellowish white. The quantity of white is variable. In a young male from Tlalpam (No. 50827) it is restricted to the inner side of the foot, hardly reaching the toes, while in an adult male from the same locality (No. 50826) it includes the toes. The whitish spot between the eyes is also variable, both in form and extent. Lichtenstein described it as heart-shaped, and his figure shows that it is narrow where it approaches closest to the stripe between the eye and ear, with which it is nearly, but not quite, confluent. This is precisely its condition in the adult male from Tlalpam, which may be considered a duplicate type of the species. In this specimen the median white spot is almost divided by the dark color of the forehead, which pushes down between the eyes, so that the whitish spot might be described as a narrow stripe over each eye, the two becoming confluent below. In the young specimen the white spot is subrectangular and not divided by the black of the forehead.

Note on Putorius brasiliensis.—In 1813 a Russian naturalist, Sevastianoff, gave the name '*Mustela brasiliensis*' to a weasel brought to St. Petersburg by Capt. A. J. Krusenstern on his return from a voyage around the world. The animal was said to have come from Brazil, but no definite locality was given. In the numerous publications that have since appeared relating to the mammals of Brazil and adjacent territory, no weasels are mentioned as inhabiting that country, and the species described from the mountains to the westward differ so widely from Sevastianoff's *brasiliensis* that it is almost certain his animal did not come from Brazil. The original description (including measurements) agrees in every respect with *P. frenatus* of Lichtenstien from the Valley of Mexico, indicating that the two animals are identical. On this assumption the well-known and appropriate name *frenatus* would have to fall before the earlier and inappropriate '*brasiliensis*.' Fortunately, however, Sevastianoff placed his animal in the genus *Mustela*, and the name *Mustela brasiliensis* is preoccupied by Gmelin for a South American otter. (Syst. Nat., ed. 13, p. 93, 1788.) Hence, unless some earlier name is found, *frenatus* will stand for the Mexican bridled weasel.

Measurements.—An adult male from Tlalpam, Valley of Mexico (type locality): Total length, 505; tail vertebræ, 203; hind foot, 53. Average of 6 males from Brownsville, Tex.: Total length, 488; tail vertebræ, 192; hind foot, 51. Average of 3 females from Brownsville: Total length, 438; tail vertebræ, 187; hind foot, 41.5.

PUTORIUS FRENATUS GOLDMANI subsp. nov.

Type from Pinabete, Chiapas, Mexico. No. 77519, ♂ ad., U. S. Nat. Mus., Dept. Agric. coll. Collected Feb. 10, 1896, by E. A. Goldman. Altitude about 8,200 feet (=2,500 meters). Original number 9279.

Geographic distribution.—Mountains of southeastern Chiapas; limits of range unknown.

General characters.—Similar to *P. frenatus* in size and general characters, but tail and hind feet longer; light markings more restricted; black of head reaching much farther back on neck; color of upper parts darker and more extensive, encroaching on sides of belly and covering fore and hind feet; black tip of tail longer.

Color.—Upper parts, including whole of fore and hind feet, dull, dark chestnut brown, washed with black on the neck from shoulders forward, and becoming pure black on the head; face marked by a whitish patch between the eyes, and a narrow, oblique band between eye and ear; a blackish spot behind angle of mouth; color of under parts salmon ochraceous, reaching wrists inferiorly, but not reaching heels; terminal third of tail black.

Cranial characters.—Skull rather large; zygomata moderately spreading; squamosal inflation moderate, but large for a member of the *frenatus* series; audital bullæ small, steep on inner side, and only slightly elevated anteriorly above squamosal inflation. The skull as a whole resembles that of *frenatus*, but differs conspicuously in the greater length and inflation of the postglenoid part of the squamosal, greater breadth of the basioccipital, and in the size and form of the audital bullæ. The latter are very narrow, low anteriorly where they meet the inflated squamosal without an abrupt step, and high along the inner side.

Remarks.—Mr. E. W. Nelson writes me that this fine weasel is found sparingly in the forest about Pinabete, Chiapas, at an altitude of 7,000 to 8,000 feet (2,100 to 2,500 meters). The type specimen was shot in the afternoon while hunting on a heavily wooded hill slope. It was heard making long, slow leaps over the dry, crisp leaves. Coming to a log, it stood up and rested its fore feet on the log, in which position it was shot by Mr. Goldman.

A specimen from Cerro San Felipe, Oaxaca, is intermediate, both in coloration and cranial characters, between typical *frenatus* and *goldmani;* hence there is little room for doubt that complete intergradation exists between the two.

Measurements.—Type specimen, male adult: Total length, 504; tail vertebræ, 201; hind foot, 58.

PUTORIUS FRENATUS LEUCOPARIA subsp. nov.

Type from Patzcuaro, Michoacan, Mexico. No. $\frac{34914}{47179}$, ♂ ad., U. S. Nat. Mus., Dept. Agric. coll. Collected July 27, 1892, by E. W. Nelson. Original number 2960.

General characters.—Similar to *Putorius frenatus*, but slightly larger; black of head extending posteriorly over neck; white face markings much more extensive; the spot between the eyes very much larger and broadly confluent on both sides with whitish area between eye and ear, which area also is much more extensive in all directions than in *frenatus*.

Color.—Upper parts from shoulders to black tip of tail, dark brown; neck, crown of head, nose, ears, and sides of face to a little behind the eye, black; black of head between eyes and ears divided by a broad band of buffy white which is broadly confluent with buffy yellow of throat and chin; a narrow border of whitish on upper lip; rest of under parts ochraceous yellow (including whole of fore feet, inner sides of hind legs and feet, and terminal half or nearly half of upper surfaces of hind feet, where the color becomes paler, being buffy ochraceous, as on the throat).

Cranial characters.—Skull similar to that of *frenatus*, but larger; audital bullæ much narrower; postorbital processes less strongly developed.

Remarks.—This handsome weasel presents the maximum of black and white markings known in the *frenatus* group, the black of the head reaching back over the neck and the white face markings covering a large area. In the type specimen a white stripe 50 mm. in length extends down the middle of the nape from a point between the ears more than halfway to the shoulders. This, however, is probably abnormal, though a trace of it exists in a female from the same locality. This form is the poorest subspecies described in the present paper.

Measurements.—Average of 2 males from Patzcuaro (type locality): Total length, 510; tail vertebræ, 201; hind foot, 53. An adult female from same place: Total length, 400; tail vertebræ, 159; hind foot, 42.

PUTORIUS TROPICALIS sp. nov. Tropical Bridled Weasel.

(Pl. III, figs., 5, 5*a*, 6, 6*a*.)

Type from Jico, Vera Cruz, Mexico No. 51994, ♂ ad., U. S. Nat. Mus., Dept. Agric. coll. Collected July 9, 1893, by E. W. Nelson. Altitude 6,000 feet (=1,800 meters). Original number 5195.

Geographic distribution.—The tropical coast belt of southern Mexico and Guatemala from Vera Cruz southward.

General characters.—Similar to *Putorius frenatus*, but much smaller and darker, with the white face markings less extensive, the belly pale orange instead of ochraceous, and under side of tail very much darker.

Color.—Upper parts deep umber brown with a fulvous tone; head, ears, and neck, black, passing gradually into brown of back just in front of the shoulders; terminal one-fourth (or a little more) of tail, black; face markings as in *frenatus*, but less extensive and whiter; under parts ochraceous buff on throat and fore feet, becoming rich orange buff on belly and inner side of thighs, whence (becoming paler) the color reaches out in a narrow interrupted stripe along the inner side of the hind feet to the toes, which are irregularly buffy.

Cranial characters.—Skull of male similar in general to that of *frenatus*, but smaller, relatively longer, with less spreading zygomata, less strongly developed postorbital processes, and probably broader postorbital constriction (the type skull was infested with parasites); audital bullæ smaller and very much narrower; carnassial teeth and upper molar smaller. The skull of the female is very much smaller than that of the male, and has the smoothly rounded brain case of the *cicognani* group, without trace of a sagittal ridge. The squamosals are strongly inflated, resembling those of *cicognani* and the female of *noveboracensis*. It differs from the female *frenatus* in much smaller size, very much smaller audital bullæ, more inflated squamosals, smoothly rounded brain case without trace of sagittal crest, and broader interorbital constriction, which is immediately behind postorbital processes instead of one-fifth the distance from the processes to the occipital crest (fig. 15).

Remarks.—On first examining the skins of this weasel sent home by Mr. Nelson, I supposed it to be merely a tropical subspecies of *frenatus*; but on comparing the skulls I am forced to accord it full specific rank. The difference is greatest in the females, and is really very remarkable, as may be seen from the accompanying figures (figs. 15 and 16). The female of *frenatus* (fig. 16) resembles the male of the same species (pl. III, fig. 1), while the female of *tropicalis* (fig. 15) resembles the *cicognani* group—representing another section of the genus. The case is parallel to that of *P. noreboracensis* already described. The female of *tropicalis*, like that of *noveboracensis*, shows arrested development or absence of the specialization that characterizes the male, while the females of *washingtoni* and *frenatus* have advanced further and are more like the male. In the case of the female skulls of *frenatus* and *tropicalis* here figured, it is interesting to know that they were taken within a few miles of one another—*frenatus* on Cofre de Perote, at an altitude of about 12,500 feet; *tropicalis* at Jico on the plain below, at an altitude of 5,000 or 6,000 feet.[1]

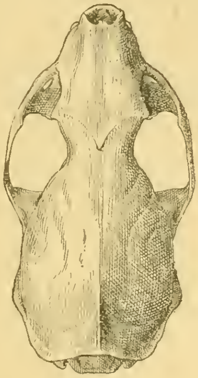


FIG. 15—*P. frenatus* ♀.

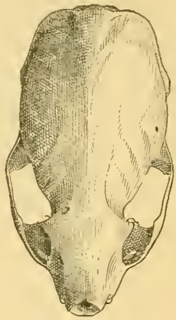


FIG. 16.—*P. tropicalis* ♀.

The Department collection contains four specimens of this weasel, all collected by Mr. Nelson in Vera Cruz. Three of them, two adult males and one old female, are from Jico; the fourth, an immature female, is from Catemaco, and presents the extreme of differentiation in intensity of color. The hind feet are dark throughout and the color of the upper parts is peculiarly dark and rich, as in *P. affinis*.

Measurements.—Average of two adult males from Jico, Vera Cruz (type locality): Total length, 442; tail vertebræ, 175; hind foot, 50. An old female from same place: Total length, 333; tail vertebræ, 121; hind foot, 37.

PUTORIUS AFFINIS (Gray).

Mustela affinis Gray: Annals & Mag. Nat. Hist., 4th ser., XIV, p. 375, Nov., 1874.

Type locality.—"New Granada" [=Colombia].

General characters.—Size large; tail long; color very dark, almost black anteriorly; facial markings obsolete or nearly so.

Color.—Upper parts nearly pure black on head and neck, fading imperceptibly to rich blackish brown on back, rump, and tail; black tip of tail long, but not strongly contrasted with dark color of rest of tail; under parts narrowly ochraceous orange, narrowest behind angle of mouth, where it is encroached on by the blackish of the cheeks. Face usually unmarked, but a whitish streak sometimes present in front of ear.

Cranial characters.—The only skull of this weasel I have seen is from a skin (No. 13770, U. S. Nat. Mus.) collected by Dr. Van Patten, at San Jose, Costa Rica. It is immature, but differs strikingly from *frenatus* in the greater breadth of the frontal region and the flatness of the audital bullæ. The constriction is little marked, which may be due to

[1]The difference in size of the two species is well shown by the flesh measurements of these two specimens. Female *frenatus*, Cofre de Perote: Total length, 418; tail vertebræ, 160; hind foot, 45. Female *tropicalis*, Jico: Total length, 333; tail vertebræ, 121; hind foot, 37.

parasites in the frontal sinuses. The young skull affords the following measurements: Basal length, 50; zygomatic breadth, 29; postpalatal length, 26; palatal length, 24; interorbital breadth, 12; breadth across postorbital processes, 15; breadth of constriction, 14.

General remarks.—There are several specimens from Costa Rica in the National Museum collection which apparently belong to this species. In these specimens the color of the upper parts is exceedingly dark from the color of the tips of the hairs; but the color immediately underlying the black tips is deep fulvous brown, giving a very rich tone to the pelage. The orange of the under parts is narrow and does not reach the feet; on the hind legs it stops on the thighs, and on the forelegs it stops short of the wrists.

Measurements (from dry skins in U. S. Nat. Mus.).—Total length, about 510; tail vertebræ, about 180; hind foot, about 52.

Table of average cranial measurements of North American Weasels.

Name.	Locality.	Sex.	Basal length.	Basilar length of Hensel.	Zygomatic breadth.	Mastoid breadth.	Breadth across postorbital processes.	Interorbital breadth.	Foramen magnum to plane of last molars.	Palatal length.	Postpalatal length.	Number of skulls in average.
P. cicognani	Ossipee, N. H.	♂	38.5	37.5	21	18.5	10.5	8.7	25.5	16.5	22	4
	Elk River, Minn.	♂	40.2	39	22	19.5	11	9	26.5	17	22.5	4
	Do	♀	33.5	32.5	18	16	10	7.8	22	14	19.5	1
	Mount Forest, Ontario.	♀	32.5	31.5	17.5	16	9	7	21.5	14	18	1
P. richardsoni	Great Slave Lake	♂	41.5	40	24	20.5	11.5	9.7	27	18	23	3
P. alascensis	Juneau, Alaska	♂	43	42	24.5	21	14	11	28.5	19	24	1
P. streatori	Skagit Valley, Wash	♂	35	34	20	18	11	8.5	23	15	20	1
	Do	♀	30	29.5	16.5	15	10	7.5	20	12	18	1
	Trout Lake, Wash.	♂	33.5	32.5	18	16.5	9.8	8	22	14.5	19.5	3
	Do	♀	28.5	28	15.5	13.5	8.5	6.5	19	12.5	16.5	1
P. rixosus	Osler, Saskatchewan	♀	[1]26.5	[1]26	14.2	13.5	7.5	5.5	17.5	11	[1]15	1
P. arcticus	Point Barrow, Alaska	♂	44.5	43	29.5	23	14.5	12.5	29	20.5	24	1
	Franklin Bay, Arctic Coast.	♂	43.5	42	27.5	22.5	13	11	28.5	19.5	24	1
	St. Michaels, Alaska	♂	43	42	26.5	22.5	13.5	12	28	19.5	24	1
	Do	♀	38	37	22.5	19	12	10	24.5	16.5	21	1
P. kadiacensis	Kadiak Island, Alaska	♂	[1]42	[1]41	24	20.5	12.5	10.5	[1]27	17.5	[1]24	1
P. noveboracensis	Adirondacks, N. Y.	♂	47	45.5	27	23.5	14.5	11.3	30	21.5	25.5	5
	Do	♀	38.5	37.5	20	18.5	11	8.5	25.5	16	22.5	1
P. washingtoni	Trout Lake, Wash.	♂	44.2	43	26	23	12.5	10.2	27.5	21	23	7
	Do	♀	38.3	37.5	21.5	20	10.5	8.7	24	17.8	20.5	4
P. peninsulæ	Tarpon Springs, Fla.	♀	45.5	44	27	24	14	11	29	21	24.5	1
P. longicauda	Carlton House, Saskatchewan.	♂	48	47	30.5	26	15.5	11.5	30	23	25	1
	Do	♀	43.5	42.5	26	23	12	10.5	26.5	20.5	22.5	1
P. spadix	Elk River, Minn.	♂	48	46.5	29.5	26	14.5	11.5	30	23.5	24	1
	Do	♀	44	43	26	23.5	13	10.5	28	20.5	23.5	1
P. saturatus	Siskiyou Mountains, Oregon.	♂	45	44	29	25	14	11	28.5	21	24	2
P. arizonensis	Springerville, Ariz.	♂	42	41	26	23	12.5	10.5	26.5	20	22	1
	Boulder County, Colo.	♂	44	43	28.5	23	13	10.5	27	20.5	23.5	1
	Sierra Nevada, Cal.	♂	44.5	43.5	28	23	14.5	10.5	28	21	23	4
	Do	♀	39.5	38	22.5	20.5	11.3	9	24	18	21	3
P. alleni	Black Hills, S. Dak.	♂	42	40.8	27	22	13.2	11	26.2	20	22	2
	Do	♀	38.5	37.5	23	.....	12	9	24.5	18	20.5	1
P. xanthogenys	Southern California	♂	44	42.5	27.5	23.5	13.5	9.5	27.5	20.5	23.2	2
	Do	♀	42	41	24	22.5	12	9.5	26	19.5	22	1
P. frenatus	Tlalpam, Mexico	♂	52.5	51	33.5	27.5	15.5	12	33.5	24.5	27.5	1
	Cofre de Perote, Mexico.	♀	45	43.5	25.5	23	13	10	29	19.5	25	1
P. tropicalis	Jico, Vera Cruz, Mexico.	♂	49	47.5	28	24.5	15	10.5	32	22	27	1
	Do	♀	37.5	36.5	22.5	19.5	12	9	24.5	16	21.5	1

[1] Estimated.

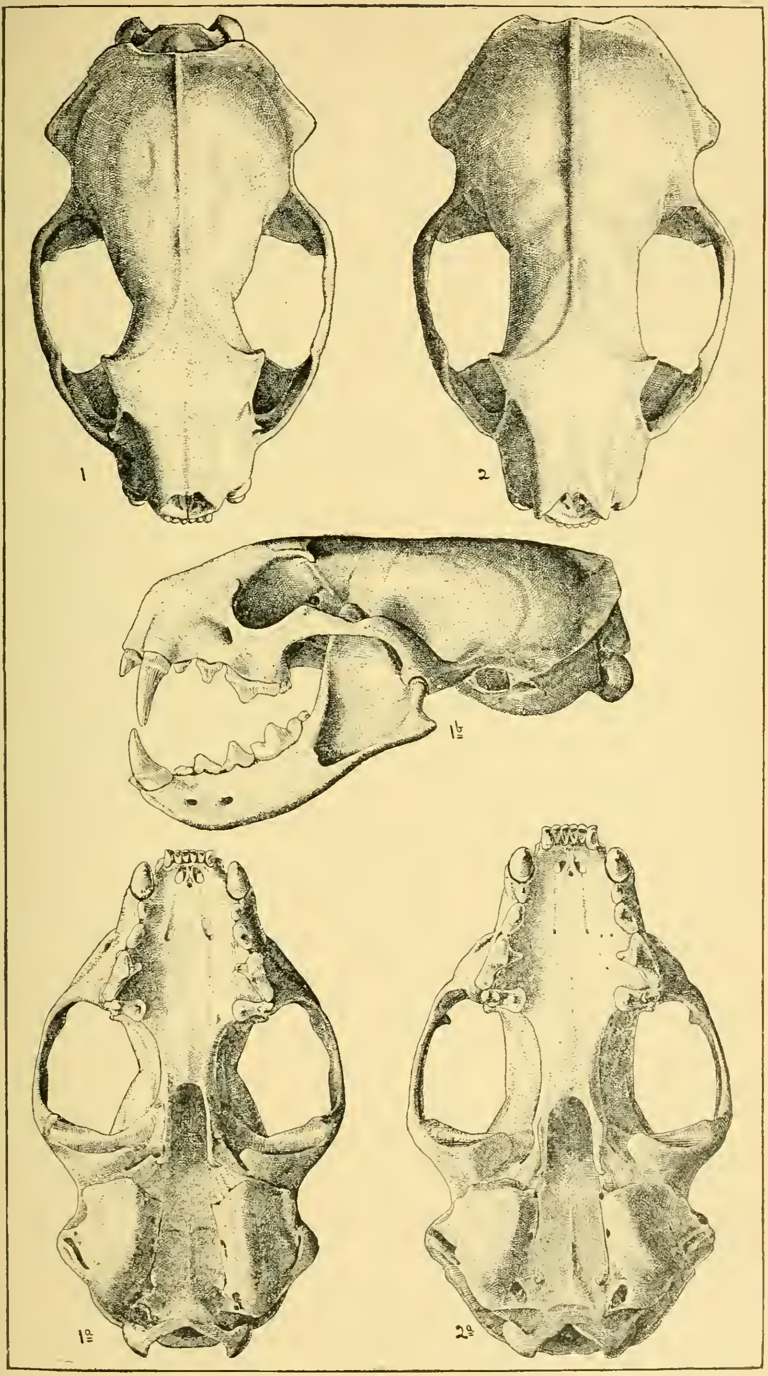
INDEX.

[Synonyms in italics.]

PLATE I.

FIG. 1. *Putorius nigripes*, ♂ ad., Trego County, Kans.
(No. 4143, Merriam coll.)
1. Upper side of skull.
1*a*. Under side of skull.
1*b*. Side view of skull.

2. *Putorius putorius*, ♂ ad., Brunswick, Germany.
(No. 4661, Merriam coll.)
2. Upper side of skull.
2*a*. Under side of skull



1. *Putorius nigripes* ♂ ad. Trego County, Kansas.
2. *Putorius putorius* ♂ ad. Brunswick, Germany.

PLATE II.

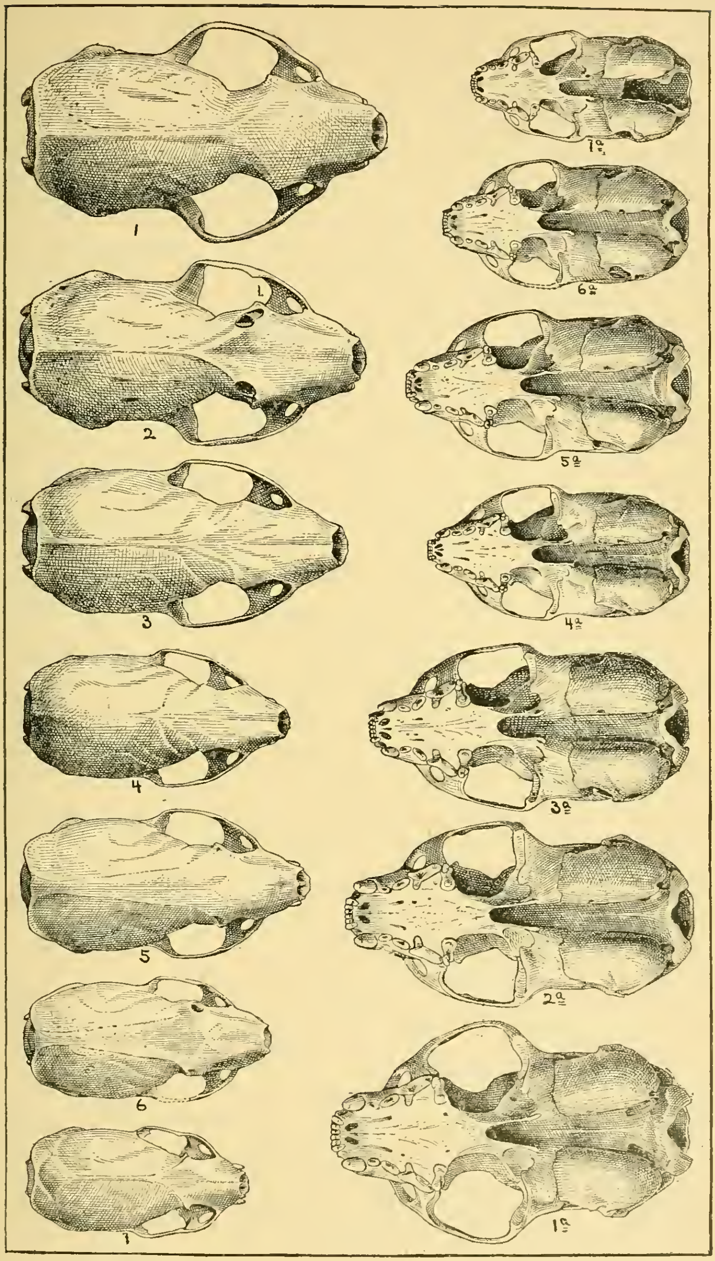
FIG. 1. *Putorius arcticus.* Point Barrow, Alaska (type).
♂ ad., No, 23010, U. S. Nat. Mus.

2. *Putorius alascensis.* Juneau, Alaska (type).
♂ ad., No. 74423, U. S. Nat. Mus., Dept. Agric. coll.

3 and 4. *Putorius cicognani.*
3. ♂ ad., Bucksport, Me., No. 4247, Bangs coll.
4. ♀ ad., Mount Forest, Ontario, No. 789, Bangs coll.

5 and 6. *Putorius streatori.* Mount Vernon, Skagit Valley, Wash.
5. ♂ ad., No. 76646, U. S. Nat. Mus., Dept. Agric. coll. (type).
6. ♀ ad., No. 76623, U. S. Nat. Mus., Dept. Agric. coll.

7. *Putorius rixosus.* Osler, Saskatchewan.
♀ ad., No. 642, Bangs coll. (type).



1. *Putorius arcticus.*
2. *P. alascensis.*
3, 4. *P. cicognani.*
5, 6. *P. streatori.*
7. *P. rixosus.*

PLATE III.

FIGS. 1 and 2. *Putorius frenatus.*

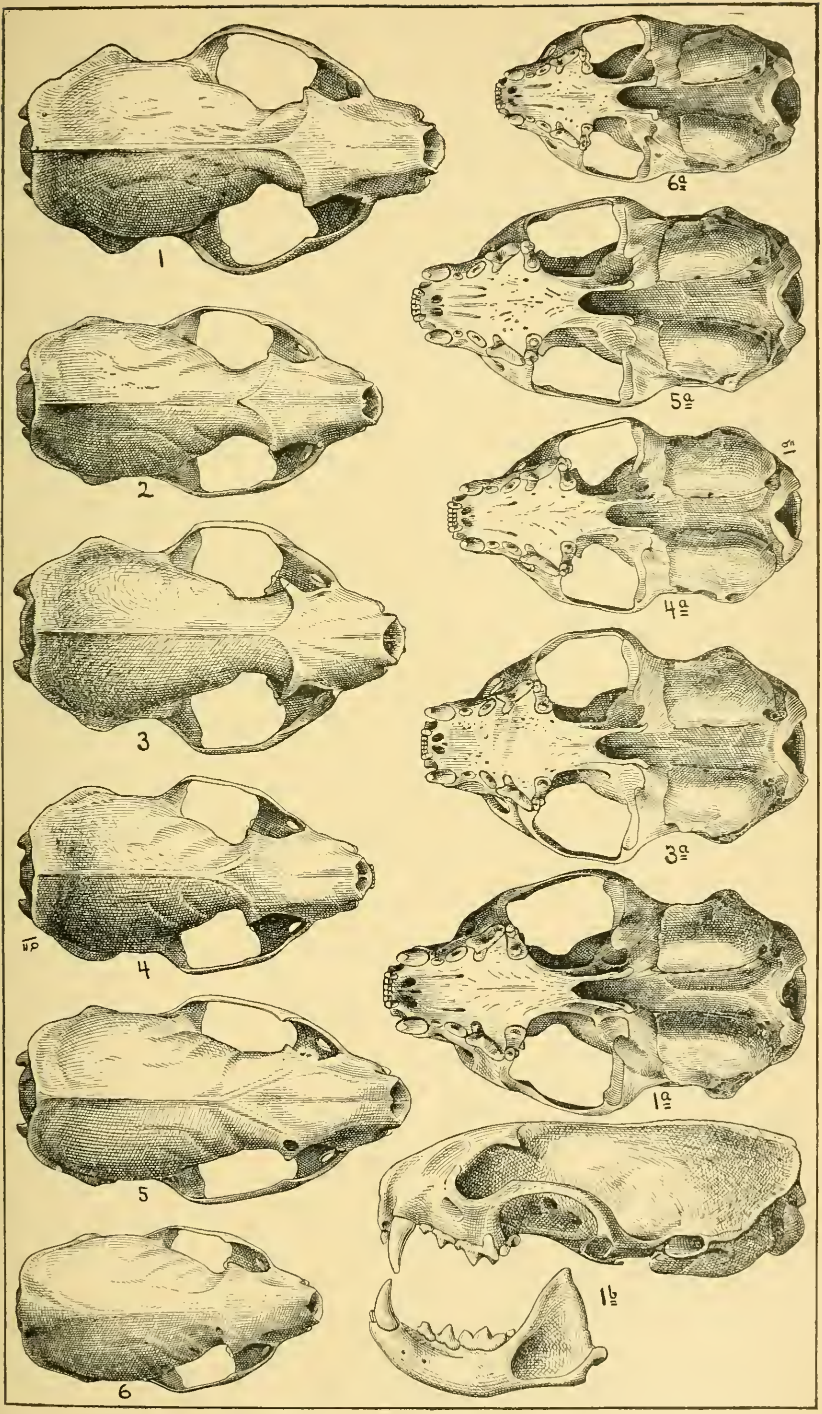
1. ♂ ad., Tlalpam, Mexico, No. 50826, U. S. Nat. Mus., Dept. Agric. coll.
2. ♀ ad., Cofre de Perote, Vera Cruz, Mexico, No. 54278, U. S. Nat. Mus., Dept. Agric. coll.

3 and 4. *Putorius longicauda.* Carlton House, Saskatchewan (type locality).

3. ♂ ad., No. 73183, U. S. Nat. Mus., Dept. Agric. coll.
4. ♀ ad., No. 75483, U. S. Nat. Mus., Dept. Agric. coll.

5 and 6. *Putorius tropicalis.* Jico, Vera Cruz, Mexico.

5. ♂ ad., No. 54994, U. S. Nat. Mus., Dept. Agric. coll. (type).
6. ♀ ad., No. 54993, U. S. Nat. Mus., Dept. Agric. coll.



1, 2. *Putorius frenatus.* 3, 4. *P. longicauda.* 5, 6. *P. tropicalis.*

PLATE IV.

FIGS. 1 and 2. *Putorius noveboracensis.* Adirondacks, New York.

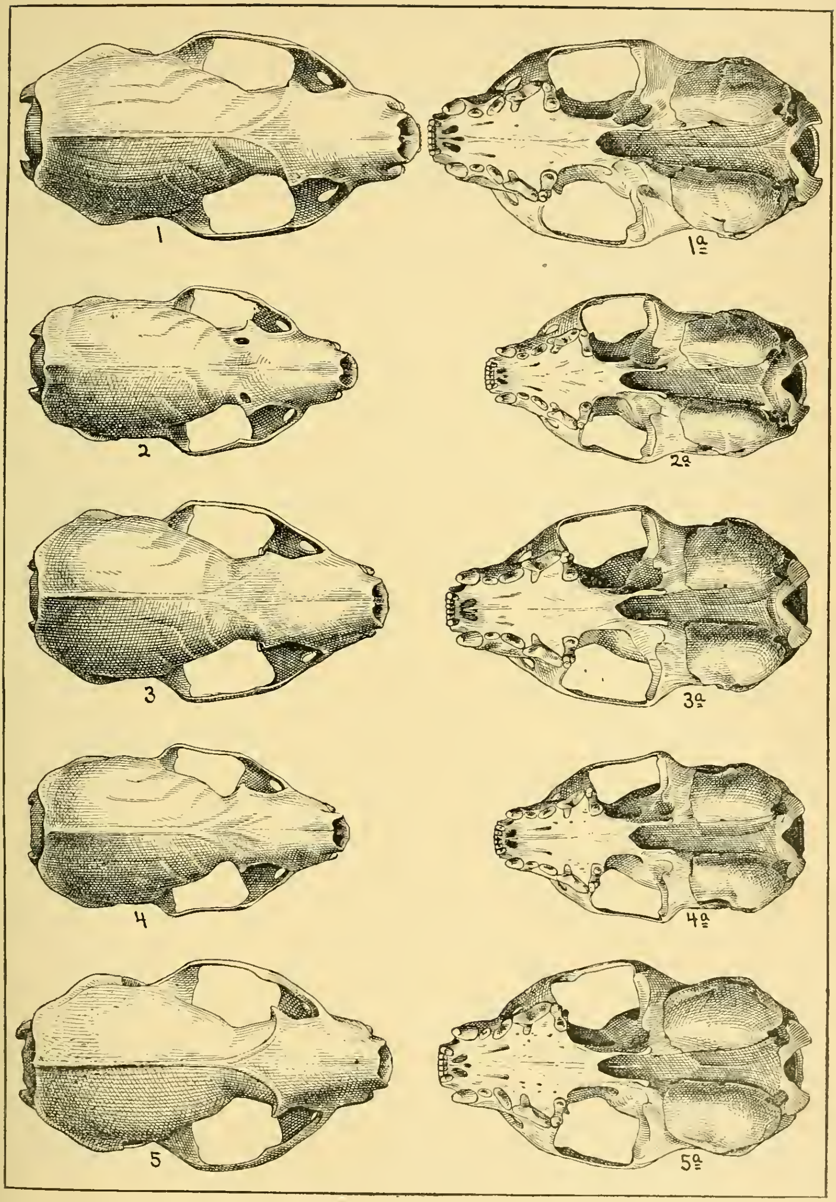
1. ♂ ad., No. 3843, Merriam coll.
2. ♀ ad., No. 5598, Merriam coll.

3 and 4. *Putorius washingtoni.* Trout Lake, Washington.

3. ♂ ad., No. 76322, U. S. Nat. Mus., Dept. Agric. coll. (type).
4. ♀ ad. No. 67321, U. S. Nat. Mus., Dept. Agric. coll.

5. *Putorius peninsulæ.* Tarpon Springs, Fla.

♀ ad., No. 2379., Rhoads coll.



1, 2. *Putorius noveboracensis.* 3, 4. *P. washingtoni.* 5. *P. peninsulæ.*

PLATE V.

FIG. 1. *Putorius longicauda* (Bonap.).

1. ♂ ad., Carlton House, Saskatchewan, No. 73183, U. S. Nat. Mus., Dept. Agric. coll.

1*a*. ♀ ad., Carlton House, Saskatchewan, No. 75483, U. S. Nat. Mus., Dept. Agric. coll.

2. *Putorius cicognani* (Bonap.).

2. ♂, Bucksport, Me. No. 4247, Bangs coll.

2*a*. ♀, Mount Forest, Ontario No. 789, Bangs coll.

3. *Putorius noveboracensis* De Kay.

3. ♂ ad., Adirondacks, New York No. 3843, Merriam coll.

3*a*. ♀ ad., Adirondacks, New York No. 5598, Merriam coll.

4. *Putorius rixosus* nob.

♀ ad. (type), Osler, Saskatchewan. No. 642, Bangs coll.

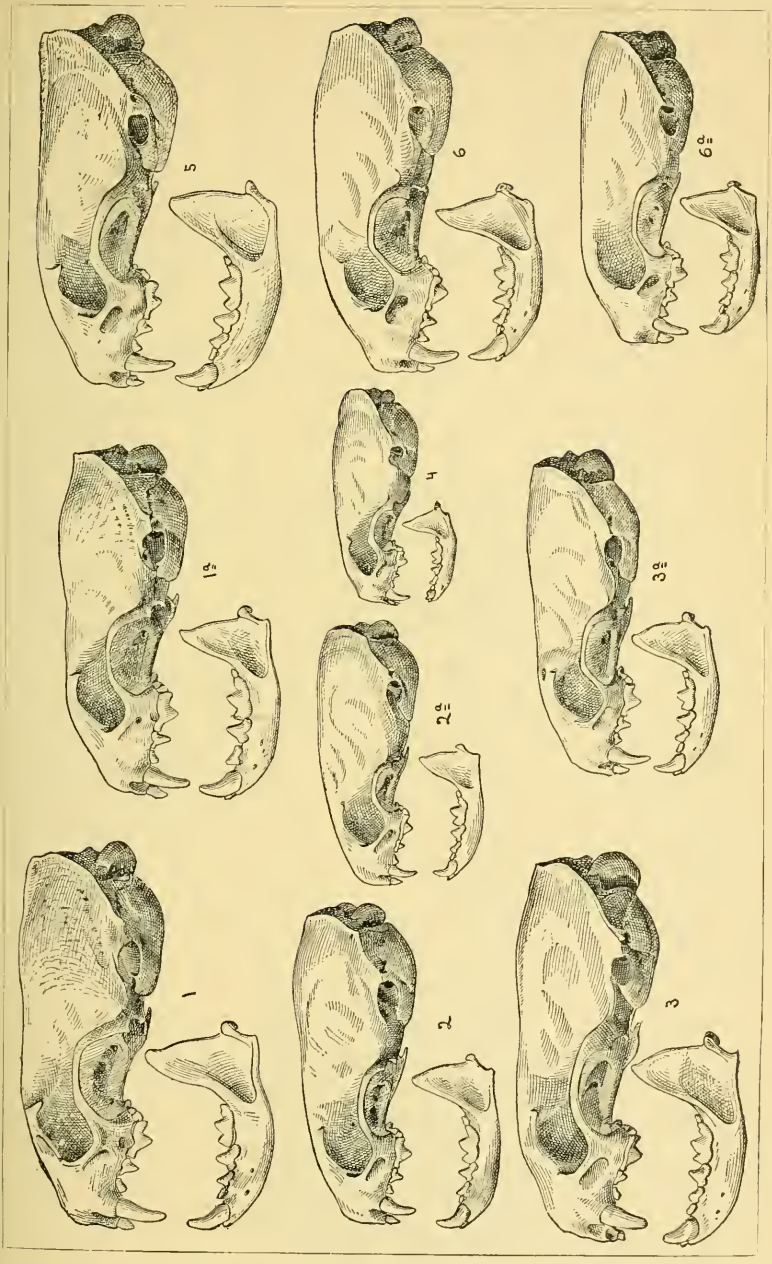
5. *Putorius peninsulæ* Rhoads.

♀ old, Tarpon Springs, Fla. No. 2379, Rhoads coll.

6. *Putorius arcticus* sp. nov.

6. ♂, St. Michaels, Alaska No. 36213, U. S. Nat. Mus.

6*a*. ♀, St. Michaels, Alaska No. 36246, U. S. Nat. Mus.



1. *Putorius longicauda.* 2. *P. cicognani.* 3. *P. noveboracensis.* 4. *P. rixosus.* 5. *P. peninsulæ.* 6. *P. arcticus.*

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GENERA AND SUBGENERA OF VOLES AND LEMMINGS

BY

GERRIT S. MILLER, Jr.

Prepared under the direction of

Dr. C. HART MERRIAM

CHIEF OF DIVISION OF ORNITHOLOGY AND MAMMALOGY

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UNITED STATES DEPARTMENT OF AGRICULTURE,
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Washington, D. C., May 12, 1896.

SIR: I have the honor to transmit herewith, and recommend for publication, the manuscript of No. 12 of North American Fauna, treating of the Genera and Subgenera of Voles and Lemmings, and comprising results of investigations carried on in the Division of Ornithology and Mammalogy by Gerrit S. Miller, jr.

Respectfully,

C. HART MERRIAM,
Chief of Division.

Dr. CHAS. W. DABNEY, Jr.,
Acting Secretary of Agriculture.

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No. 12. NORTH AMERICAN FAUNA. July, 1896.

THE GENERA AND SUBGENERA OF VOLES AND LEMMINGS.

By Gerrit S. Miller, Jr.

The following revision of the genera and subgenera of voles and lemmings is chiefly the result of a study made in the Division of Ornithology and Mammalogy of the collections belonging to the United States Department of Agriculture. This material has been supplemented by specimens from my own private collection and those of Mr. Outram Bangs, Mr. S. N. Rhoads, and Dr. C. Hart Merriam. I have also had access to the voles and lemmings in the American Museum of Natural History, the United States National Museum, and the British Museum. Thanks are due to all who have placed material at my disposal, and especially to Mr. Oldfield Thomas, curator of mammals in the British Museum.

Hitherto no attempt has been made to compare in detail the voles and lemmings of the Old and New Worlds. This is the necessary result of the poor quality and small number of specimens from the opposite side of the Atlantic to be found in museums and private collections in both Europe and America. In consequence of this lack of material, writers who have been thoroughly acquainted with indigenous voles and lemmings have either made no comparison of these with exotic forms, or have reached faulty or at least incomplete conclusions with regard to groups occupying widely separated geographic regions.

For determining the relationships of the different voles and lemmings the collection in the British Museum offers exceptional facilities. It contains representatives of all the recent genera and subgenera found in the Old World, and lacks only one of those peculiar to America. The collection is, moreover, especially rich in specimens identified by the more prominent writers on the subject—a circumstance of the utmost importance.

The drawings for the illustrations in this paper, except fig. 9 and Pls. I and II, were made under my constant supervision by Mr. F. Müller. Pls. I and II were prepared by Dr. James C. McConnell. Figs. 4, 5, 8, and 10 of Pl. II were drawn in ink by Dr. McConnell from pencil drawings made at the British Museum by Mr. Hollick. Fig. 7 of the same plate is by Dr. McConnell from a pencil drawing by Mr. A.

Westergren. The tracings of the enamel pattern of *Microtus luteus* and *M. lagurus* are enlarged from figs. 10, 11, 15, and 16 of Pl. XIII of Büchner's 'Wissenschaftliche Resultate der von N. M. Przewalski nach Central-Asien unternommenen Reisen.' In fig. 22 the enamel patterns of the front lower molar and middle and back upper molars are enlarged from Mr. Hollick's pencil drawing of a specimen from Fokien, China (British Museum Register 92. 10. 12. 52), the other teeth from fig. 1, Pl. XLVI of Milne-Edwards's 'Recherches pour servir à l' Histoire Naturelle des Mammifères.' Fig. 23 is compounded in the same way from Mr. Hollick's drawing and the original figure published by Thomas.

THE SUBFAMILY MICROTINÆ AND ITS MAIN DIVISIONS.

The subfamily *Microtinæ*[1] is a group of murine rodents closely related to the *Neotominæ*, *Cricetinæ*, and *Myotalpinæ*.[2] It is distinguished from the first and second by cranial and dental characters; from the last chiefly by peculiarities in external form.[3] While it is not the purpose of the present paper to discuss the relationships of the *Microtinæ* to any of these, it is important to consider in some detail the larger divisions of the subfamily itself before taking up the genera and subgenera.

The members of the subfamily *Microtinæ* fall naturally into two supergeneric groups, the *Lemmi* and *Microti*, or lemmings and voles. The former includes the genera *Synaptomys*, *Lemmus*, and *Dicrostonyx*, the latter the genera *Phenacomys*, *Evotomys*, *Microtus*, and *Fiber*.

Lemmi.—Skull generally broad and massive; lower incisors short, with roots ending on inner side of molars (Pl. III, fig. 1); crowns of maxillary teeth scarcely, if at all, narrower posteriorly than anteriorly (figs. 10, 11, and 12); tail usually shorter than hind foot (in *Synaptomys* slightly longer); palms and soles usually without distinct tubercles.

Microti.—Skull comparatively slender and lightly built; lower incisors long, with roots ending on outer side of molars (Pl. III, figs. 2 and 3); crowns of maxillary teeth distinctly narrower posteriorly than anteriorly (figs. 17, 19, 21–35); tail usually much longer than hind foot (in the Asiatic species of *Lagurus* distinctly shorter); palms and soles always with distinct tubercles.

In external appearance the lemmings and voles differ considerably. The former are mostly thick-set animals, with powerful fossorial feet, long, dense fur and very short tails, while the latter are more slender, with longer tails and with the fur and feet not so highly modified.

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[1] = *Arvicolinæ* Auct. This name, however, must be abandoned, together with the generic name *Arvicola* (see p. 14).

[2] = *Siphneinæ* Auct. As *Siphneus* (Brants, 1827) must give place to *Myotalpa* (Kerr, 1792) (see Allen, Bull. Am. Mus. Nat. Hist., New York, VII, p. 183, 1895) it is necessary to make a corresponding change in the name of the subfamily.

[3] The characters separating the *Myotalpinæ* from the *Microtinæ* are of much less importance than those separating the latter from any of its other allies. So close, indeed, is the resemblance between the two that it may eventually prove necessary to unite them under one name. Lack of material prevents any final conclusion at present.

Although the voles and lemmings may usually be distinguished at a glance, there are certain genera and subgenera the exact position of which is not at first apparent. Thus the species of *Lagurus*, although voles, so closely resemble lemmings in external appearance that their true relationships have been only very recently detected. On the other hand, *Synaptomys*, a true lemming, has much the superficial appearance of certain forms of *Microtus*.

LIST OF GENERA AND SUBGENERA OF MICROTINÆ.

Genera.	*Subgenera.*	*Types.*
Synaptomys.		Synaptomys cooperi.
	Mictomys.	Synaptomys innuitus.
Lemmus.		Lemmus lemmus.
Dicrostonyx.		Dicrostonyx torquatus.
Phenacomys.		Phenacomys intermedius.
Evotomys.		Evotomys rutilus.
Microtus.		Microtus arvalis.
	Eothenomys.	Microtus melanogaster.
	Anteliomys.	Microtus chinensis.
	Lagurus.	Microtus lagurus.
	Alticola.	Microtus stoliczkanus.
	Hyperacrius.	Microtus fertilis.
	Phaiomys.	Microtus blythii.
	Pedomys.	Microtus austerus.
	Pitymys.	Microtus pinetorum.
	Chilotus.	Microtus oregoni.
	Microtus.	Microtus arvalis.
	Arvicola.	Microtus terrestris.
	Neofiber.	Microtus alleni.
Fiber.		Fiber zibethicus.

The following groups are known to occur in both hemispheres:

Lemmus.
Dicrostonyx.
Phenacomys?
Evotomys.
Microtus (genus and subgenus).
Lagurus.
Pitymys.
Arvicola.

The following groups have been found in the Old World only:

Eothenomys.
Anteliomys.
Phaiomys.
Alticola.
Hyperacrius.

The following groups have been found in America only:

Synaptomys.
Mictomys.
Pedomys.
Chilotus.
Neofiber.
Fiber.

GEOGRAPHIC DISTRIBUTION.

The subfamily *Microtinæ* is distributed throughout the extratropical region of the Northern Hemisphere. In the north some members of the group approach the extreme limit of mammalian life, while in the south a few species enter the northernmost edge of the tropics. The subfamily, which is clearly boreal in origin, reaches its highest development in temperate Europe, Asia, and North America. Although it is probable that no species are common to both continents, five genera and four subgenera of the genus *Microtus* have a circumpolar distribution. On the other hand, no genera are peculiar to the Old World, and only two are confined to America. Asia has five subgenera of *Microtus* not found in America, and America has three not known to occur in the Old World.

HABITS.

The voles and lemmings occur in great abundance throughout the region which they occupy. They live in an endless variety of situations, from sea beaches to marshes and Alpine mountain tops, and from open plains to the densest forests. They are, perhaps, most numerous in well-watered grass lands. In localities where they are abundant most of the species make their presence known by trails or runways traced through the vegetation near their burrows. Occasionally, however, they occupy hollows in decaying logs or among loose rocks, and use natural crevices instead of beaten paths. While the great majority of species spend much of their time on the surface, protected by the overhanging vegetation, a few live almost exclusively underground, and in consequence of this habit have acquired numerous modifications which fit them for the needs of a subterranean life. Others are amphibious and never occur at any great distance from water. At least one member of the subfamily[1] is said to live among the branches of trees. The food is chiefly vegetable, though most species occasionally eat animal food. The vegetable food consists principally of grass stems, though roots, bark, leaves, seeds, and fruit are at times eaten in varying quantities. As voles are readily caught in traps baited with meat, it is probable that flesh forms part of their normal food. Mollusks are eaten freely when they can be obtained.

The voles and lemmings breed very rapidly during the warmer part of the year. The number of young in a litter varies from one or two to ten. Five is, perhaps, the average number in the majority of species, though it is probably less in those in which the females have only four mammæ.

[1] *Phenacomys longicauda* True, from Oregon. In the original description of the species (Proc. U. S. Nat. Mus., XIII, pp. 303–304, Nov. 15, 1890) Mr. True quotes as follows from a letter from Mr. Aurelius Todd, who collected the type specimen: "It lives exclusively, as far as I have been able to ascertain, among the boughs and branches of the Oregon pine trees (*Abies douglasi*), making a nest of a size smaller than a robin's nest. It is usually situated on the upper side of a medium-sized branch, perhaps 6 inches in diameter, and is composed of the leaves of the tree deftly split in two from one end to the other and dried. The nest is neatly and rather ingeniously made, and the sameness of the material is a novelty. * * * The mouse is almost exclusively arboreal in its habits, but I think that I have reason to believe that they sometimes come to the ground for food, as I have seen tracks in the snow around the trees which I think were made by these little animals. They could be tracked up and down the tree, but to no great distance from it, and were most likely in search of food."

The young are born in nests made of soft vegetable fibers. The nests are usually placed in a burrow or beneath shelter of some kind and vary with the size of the animals, but are usually about 200 mm. in diameter. The species of *Fiber* make nests containing several bushels of material. These are conspicuous objects in the marshes where the animals live. Under conditions the nature of which is not understood the rate of increase in certain species is occasionally so enormously accelerated that an area becomes overcrowded and the animals wander into the surrounding country in search of food. So far as known, such 'lemming migrations' and 'vole plagues' are phenomena peculiar to the Old World.[1]

NOMENCLATURE.

Before considering the characters of the genera and subgenera of *Microtinæ* it is necessary to examine a considerable part of the mass of technical literature to which, during the past hundred and forty years, the animals in question have given rise. Since Linnæus published the tenth edition of the Systema Naturæ more than fifty names have been used for the less than two dozen namable superspecific groups recognizable in the subfamily. In considering their claims to recognition the names may be best taken up chronologically.

Mus Linnæus, 1758 (Syst. Nat., Ed. 10, p. 59), contained the following species: *Porcellus*, *leporinus*, *lemmus*, *marmota*, *monax*, *cricetus*, *terrestris*, *amphibius*, *rattus*, *musculus*, *avellanarius*, *sylvaticus*, *striatus*, *longipes*, *jaculus*, *volans*. Since two[2] of these (*lemmus* and *terrestris*) are

[1] An account of the migrations of *Lemmus lemmus* in Norway is given by Prof. R. Collett in Christiania Videnskabs-Selskabs Forhandlinger, 1895, No. 3.

For description of a vole plague in Scotland, see Report of the Departmental Committee appointed by the Board of Agriculture to inquire into a Plague of Field Voles in Scotland. London, 1893.

[2] Apparently three, but *terrestris* and *amphibius* are, as Lataste has already shown, the same animal. The *Mus amphibius* of Linnæus is nothing more than a figment of the imagination based on Ray's misconception that there is a large aquatic vole with webbed feet.

Since the matter is of importance as determining the validity of the current name of one of the most common European mammals, I quote Linnæus's descriptions in full:

"[Mus] terrestris, 7. M. cauda mediocri subpilosa, palmis subtetradactylis, plantis pentadactylis, auriculis vellere brevioribus.

"Mus cauda longissima pilosa, auribus subrotundis vellere brevioribus. Fn. svec. 29. Syst. Nat., 10, n. 5.

"Mus agrestis, capite grandi, brachiuros. Raj. quadr. 218.

"Habitat in Europæ terra et aqua.

"Corpus fuscum subtus pallidum, at non albicans. Caput crassius, ore gibbo. Cauda magis pilosa, quam in Ratto, sed corpore dimido brevior, a pedibus fere longior.

"Hortos Talpæ instar misere effodit palmis licet parvis; natat in fossis et urinatur plantis licet fissis; Radices arborum decorticat, plantarum consumit s. aufert; Pullos anatum in piscinis occidit.

"[Mus] amphibius, 8. M. cauda elongata pilosa, plantis palmatis.

"Mus major aquaticus s. Rattus aquaticus. Raj. quadr. 217.

"Mus aquaticus. Beil. aquat. 35. t. 36.

Microtines, it is necessary to see whether the name can be applied to any genus of the subfamily. Linnæus of course designated no type, but subsequent usage has fixed the name on the congeners of *Mus musculus*. As no sound principle of nomenclature is thus violated, the name *Mus* should be kept in its present signification.

Castor Linnæus, 1758 (Syst. Nat., Ed. 10, p. 58), was originally proposed for the species *fiber* and *moschatus*, but in the twelfth edition of the Systema others were included, among them the muskrat. The name, however, could by no process of subsequent elimination be applied to the latter.

Glis Brisson, 1762 (Regn. Anim., pp. 13, 113), is clearly based on the dormice,[1] although the genus includes 'la Marmotte de Bahama,' 'la Marmotte d'Amerique,' 'la Marmotte de Pologne,' 'la Marmotte des Alpes,' and 'la Marmotte de Strassbourg,' in addition to 'le Loir,' 'le Lerot,' and 'le Croquenoix.' The name must, therefore, take the place of *Myoxus* Schreber, 1781, commonly used for the dormice.[2] As none of the species of Brisson's *Glis* are Microtines, the name would not be mentioned here were it not for its bearing on *Glis* Erxleben, 1777.[3] (See p. 13.)

Cuniculus Brisson, 1762 (Regn. Anim., p. 13), must also be considered, because it invalidates the use of *Cuniculus* Wagler as the generic name of a lemming (see page 16).[4] The genus contained an assemblage of forms which are now put in six genera distributed among five families. Dr. C. Hart Merriam has recently shown (Science, n. s., I, p.

[Continuation of note from page 11.]

"Habitat in Europæ, Africæ fossis, ripis, piscinis, hortis.

"Species mihi non rite cognita.

"Fodit ad fossas et radicis arborum, natat, urinatur, consumit radices, Hortis et satis infestus, capitur Nassis e virgulis confectis sub aqua demersis."

The description of *Mus terrestris* is extended and applies to the water rat in every particular, while the diagnosis of *M. amphibius* is very brief and contains a glaring error in the assertion that the animal has webbed feet. That the common water rat was the animal which Linnæus had in mind when he described *Mus terrestris* is shown by the length and accuracy of the description and by his choice of the specific name (*Mus terrestris* is the Latin equivalent of the Swedish jordråtta). That he never saw '*Mus amphibius*' is clearly indicated by the statement: "Species mihi non rite cognita." It is thus evident that there is no excuse for retaining the specific name *amphibius*, even though the error through which it is now generally used has passed current for nearly a century.

[1] In the Tabula Synoptica Quadrupedum secundum Ordines Sectiones et Genera, on pages 12 and 13, the name is introduced as follows:

Cauda longa, vestita pilis ita dispositis at caudum planum efficiant.......... *Sciurus*

Cauda longa, vestita pilis ita dispositis at caudum rotundam efficiant.......... *Glis*

[2] See Merriam, Science, n. s., I, p. 376, April 5, 1895.

[3] *Glis* Brisson also antedates *Glis* Storr (Prodr. Meth. Mamm. 1780, p. 39), proposed for *Mus tamaricinus*, *M. longipes*, *M. cafer*, *M. sagitta*, *M. jaculus*, *M. nitidula*, *M. avellanarius*, and *M. glis*.

[4] In the synoptic table (pp. 12, 13) the name is introduced as follows:

Cauda brevissima vel nulla:

Auriculis longis .... *Lepus*

Auriculis brevibus vel nullis.. *Cuniculus*

376, 1895) that by elimination *Cuniculus cauda longissima* Brisson (=*Dipus alactaga* Olivier) becomes the type. The name is thus untenable for any of the *Muridæ*, although *Lemmus lemmus* is one of the species included by Brisson in the genus.

Glis Erxleben, 1777 (Syst. Regn. Anim., p. 358), contained *marmota*, *monax*, *canadensis*, *tscherkessicus*, *zemnii*, *lemmus*, *migratorius*, *barabensis*, *arenarius*, *lagurus*, and *œconomicus* [= *Mus songarus* Pall.]. Although this genus contains two lemmings, the name need not be considered, since it is preoccupied by *Glis* Brisson, 1762.

Arctomys[1] Schreber, 1780 (Plates to Schreber's Säugth., CCVII–CCIX, 1780), contained the following species: *marmota*, *monax*, *bobac*, *empetra*, and *citillus*. Of these the first four belong to the genus *Arctomys* as now understood, and the last to *Spermophilus*. The latter genus was defined in 1823 by F. Cuvier (Dents des Mammifères, 1823, 160–162, 255), who restricted the name *Arctomys* to the group to which it is now applied. *Arctomys* Schreber is mentioned here only on account of:

Lagomys Storr, 1780 (Prodromus Methodi Mammalium, p. 39). Although Storr and Schreber bear the same apparent date, it appears safe to take Schreber as the earlier, since Storr alludes to the genus *Arctomys*, and refers directly to the '*Mus glareolus* Schreberi,' a species published at the same time.[2] Storr evidently proposed *Lagomys* merely as a substitute for *Arctomys*, a name which he considered inappropriate, because the animals to which it was applied resemble hares rather than bears.[3] It is thus a synonym of *Arctomys* and requires no further consideration.[4]

Myocastor Kerr, 1792 (Animal Kingdom, I, Mamm., Syst. Cat. Nos. 458–521), included the coypu and muskrat. No type was designated, but subsequent elimination fixed the name on the coypu. (See p. 14.)

Ondatra Link, 1795, (Zool. Beyträge, Vol. I, Pt. II, p. 76), contained the same species as *Myocastor* Kerr, of which the name is thus a synonym.

Lemmus Link, 1795 (Zool. Beyträge, Vol. I, Pt. II, p. 75), has escaped the notice of recent writers. Vague references to it occur in works

[1]This name is apparently antedated by *Marmota* Blumenbach ("Handb. d. Naturgesch., 1779," fide Agassiz). I have been unable to verify the reference, and do not know what species were included by Blumenbach in the genus.

[2]On the dates of the parts of Schreber's Säugthiere, see Sherborn, Proc. Zool. Soc., London, 1891, 587.

[3]"Sequuntur in eundem finem nomina specierum, laudato Pallas pariter ad mures tractarum, quae mihi genus constituerunt, Lagomys, nec Arctomys dictum, nam Lepori aptius quam Urso, comparari posse videantur. Dicendæ species nominibus Ill. Pallas æque adhibitis, hæc sunt; *M. arenarius*, *M. songarus*, *M. furunculus*, *M. cricetus*, *M. accedula*, *M. phæus*, *M. lagurus*, *M. gregalis*, *M. socialis*, *M. œconomus*, *M. rutilus*, *M. glareolus* Schreberi, *M. monax*, *M. marmota*, *M. empetra*, *M. arctomys*, *M. citillus*, *M. lemmus*, *M. torquatus*, *M. hudsonius*, *M. talpinus*, *M. capensis*, *M. aspalax*, *M. typclus*" (sic.).

[4]*Lagomys* Storr of course antedates *Lagomys* Cuvier, 1800, the current name for the pikas.

of the early part of the present century, but of late all traces have disappeared. Lataste (Le Naturaliste, Tome II, p. 473, 1882), after a long and fruitless search, concluded that the name had probably never been published, and that the references of the older authors were merely to Link's manuscript. Mr. Oldfield Thomas has discovered Link's book and finds that the genus *Lemmus* contained the species *socialis*, *lagurus*, *lemmus*, *torquatus*, *glareolus*, and *hudsonius*,[1] representing the modern genera *Lemmus*, *Dicrostonyx*, *Microtus*, and *Evotomys*. As the name *Lemmus* has been restricted by subsequent authors to the species *lemmus* and its near allies, a group to which no other generic name has been specially applied, it must be retained in this sense.[2]

Microtus Schrank, 1798 (Fauna Boica, p. 72), included *M. terrestris*, *M. amphibius* (=*M. terrestris* Linn.), and *M. 'gregarius.'* The *Microtus terrestris* of Schrank is not the *Mus terrestris* of Linnæus, but the common field mouse of Central Europe, *Microtus arvalis* (Pallas). *M. gregarius* Schrank, apparently based on one specimen from Bettbrunn, is probably a young *M. arvalis*. The third species, *M. amphibius*, is the water rat, *Microtus terrestris* (Linnæus). Thus the genus *Microtus* originally contained two species, *arvalis* and *terrestris*. As the latter was made the type of *Arvicola* by Lacépède in 1801, *arvalis* must be taken as the type of *Microtus*.

Fiber Cuvier, described in 1798 but not named until 1800 (Tabl. Élém. de l'Hist. Nat. d. Anim, 141, 1798; Leçons d'Anat. Comp. I, Tabl. I, 1800), is the first and only generic name based exclusively on the muskrat. Cuvier, in establishing this genus, eliminated *Fiber zibethicus* from *Myocastor*, and thus fixed the latter name on *M. coypu*. (See page 13.)

Arvicola Lacépède, 1801 (Mém. de l'Inst., III., Paris, 1801, 489[3]), was based on *Arvicola amphibius* (=*Mus terrestris* Linn.) alone, and not on the European voles in general, as often supposed.[4] Although the name *Arvicola* can not be used in a generic sense, it is available for the subgenus of which *Microtus terrestris* is the type.

Hypudæus Illiger, 1811 (Prodr. Syst. Mamm. et Avium, p. 87), contained the species *lemmus*, *amphibius* (=*terrestris*), and *arvalis*, or the modern genera *Lemmus* and *Microtus*. As no type was designated, and

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[1] Mr. Thomas has kindly sent me a copy of the original diagnosis. It is as follows: "Gen. 8 *Lemmus*, Lemming. Die Thiere dieses Geschlechts kommen mit den vorigen [*Mus*] sehr ueberein, aber die Ohren sind viel kleiner und abgerundet, der Körper gedrungener, die Beine verhältnissmässig kürzer, der Schwanz sehr kurz. Auch weichen sie in der Lebensart von den vorigen ab. Sie nähern sich Arctomys. Hieher gehören: *Mus socialis, lagurus, lemmus, torquatus, glareolus, hudsonius.*"

[2] See note on the names *Brachyurus*, *Myodes*, *Hypudæus*, and *Lemmus*, in Actes de la Société Scientifique du Chili, Tome V, pp. XX, XXI, 1895.

[3] This is sometimes quoted: "Tableau des divisions, etc., de la class des mammifères, 1799." The paper was "lu le 21 prairial an. 7," though not published until 1801.

[4] Lacépède's description is as follows: "44 Campagnol. Deux incisives supérieurs non comprimées; deux incisives inférieurs tranchantes; molaires sillonnées; point d'abajoues; queue velue. Campagnol aquatique—Arvicola amphibius."

as both *Lemmus* and *Microtus* were included in the then undivided genus *Lemmus* Link, the name *Hypudæus* must lapse into synonymy.

Myodes Pallas, 1811 (Zoog. Rosso-As., I. p, 172), embraced ten species, now placed in four genera. The species are: *Lemmus, torquatus, lagurus, œconomus, arvalis, saxatilis, gregalis, socialis, alliarius*, and *rutilus:* the genera: *Lemmus* (*lemmus*), *Dicrostonyx* (*torquatus*), *Microtus* (*œconomus, arvalis, saxatilis, gregalis, socialis, alliarius, lagurus*), and *Evotomys* (*rutilus*). Since *Myodes* contained species of exactly the same modern genera as *Lemmus* Link and no groups not included in the latter, the name is a synonym of *Lemmus*.

Brachyurus Fischer, 1813 (Zoognosia, I, 3d ed , pp. 14, 24; III, 1814, p. 55), contained the species: *arvalis, rutilus, amphibius, lemmus, torquatus, alliarius, blumenbachii, fulvus* Geoffroy, *niloticus* Geoffroy: also the 'species dubiæ': *zemni, gregarius, socialis, lagurus, œconomus*. The name is a pure synonym of *Lemmus* Link, unless it may be applied to some of the exotic or dubious species.[1]

Alriceola Blainville, 1817 (Nouv. Dict. d'Hist. Nat., IX, p. 287), proposed for 'le Genre Campagnol' is probably an erratic misprint for *Arvicola*. No type is mentioned.

Mynomes Rafinesque, 1817 (American Monthly Magazine, II, p. 45), was based on Wilson's figure of the common meadow mouse of the eastern United States. The name is thus a synonym of *Microtus* Schrank, as *Microtus arvalis* and *M. pennsylvanicus* can not be separated subgenerically.

Psammomys LeConte, 1830 (Ann. Lyc. Nat. Hist., N. Y., III, p. 132), is the first name proposed for the subgenus containing *Microtus pinetorum*. It is, however, preoccupied by *Psammomys* Cretzschmar, 1828 (Atlas zu der Reise im Nördl. Afrika. 1ste Abth., Zool. (1826), Heft XI, 1828, p. 56. Type *Psammomys obesus* Cretzschmar) and so can not be used here. The date of *Psammomys* LeConte is usually quoted as 1829, but the paper on this genus, although read on December 21, 1829, was probably not published until after the end of January, 1830, since papers read January 11–25, 1830, are included with it in one signature.

Pitymys McMurtrie and *Ammomys* Bonaparte both appeared in 1831. McMurtrie (American ed. Cuvier's Règne Animal, I, p. 434) pointed out that *Psammomys* LeConte is preoccupied, and for this name substituted *Pitymys*. Bonaparte (Saggio Distrib. Metod. degli Anim. Vert., p. 20, footnote) after showing that LeConte's name *Psammomys* is not tenable, proposed to change it to *Ammomys*, thus preserving the original meaning of the word.[2] It is impossible to tell which name is the earlier,

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[1] This name has been supposed to be preoccupied by *Brachyurus* Spix (Lataste, Ann. Mus. Civ. St. Nat. di Genova, XX, p. 264; Büchner, Wissensch. Result. der von N. M. Przewalski unternomm. Reisen. I, p. 127). Spix's name, however, dates from 1823 and would in no way invalidate *Brachyurus* Fischer, were the latter on other grounds tenable.

[2] "Prendiamo la libertà d' introdurre una piccola mutazione ortografica nel nome dato al nuovo genere dal Sig. LeConte, la quale non ne cambia però il significato."

but in the uncertainty *Pitymys* should be retained as the one adopted by all subsequent writers.

Cuniculus Wagler, 1830 (Nat. Syst. d. Amphibien, p. 31), included three species (*C. lemmus*, *C. torquatus*, and *C. aspalax*) now referred to three genera and two subfamilies. The name has been commonly applied to *torquatus* and its congeners, but its use is invalidated by *Cuniculus* Brisson, published fifty-eight years before.

Hemiotomys DeSélys-Longchamps, 1836 (Essai monograph. sur les Campagnols des environs de Liège, p. 7), was proposed as a section of *Arvicola* (=*Microtus*) to include the species *fulvus* (=*arvalis*) and *amphibius* (=*terrestris*). As each of these had already received a tenable subgeneric name, *Hemiotomys* lapses into synonymy.

Pinemys Lesson, 1836 (Hist. Nat. d. Mamm. et Ois. découv. depuis 1788, Compl. Œuvres de Buffon, V, p. 436), based on *Psammomys pinetorum* LeConte, is a synonym of *Pitymys* McMurtrie.

Lagurus Gloger, 1841 (Gemeinnütz. Hand- u. Hilfsbuch d. Naturgeschichte, I, pp. XXXI, 97), is the earliest available name for the subgenus of which *Mus lagurus* Pallas is the type.[1] (See footnote, p. 49.)

Dicrostonyx Gloger, 1841 (l. c., pp. XXXI, 97), is the tenable name for the genus usually known as *Cuniculus* Wagler.[2] This name has escaped notice until very recently.[3]

Neodon Hodgson, 1849 (Ann. & Mag. Nat. Hist., 2d ser., III, p. 203), is a synonym of *Microtus*, as its type, *N. sikkimensis* Hodgson, can not be separated subgenerically from *Microtus arvalis*.

"*Myolemmus* Pomel, 1854 (Ann. Sci. Soc. Auvergne)," is a synonym of *Dicrostonyx* Gloger. This statement is made on the authority of Trouessart (Cat. Mamm. viv. et foss., Rodentia, Pt. II, p. 156, 1881), as I have had no opportunity to verify the reference.

Misothermus Hensel, 1855 (Zeitschr. der Deutsch. geolog. Gesellsch., VII, p. 492), is stated by the author to be based on *Myodes torquatus* Pall. It is thus antedated by *Myolemmus* Pomel and *Dicrostonyx* Gloger.

Pedomys, *Chilotus*, and *Synaptomys* are three names proposed by Baird in 1857 (Mamm. N. Am., pp. 516, 517, 558). All are tenable for the groups to which they were applied. *Pedomys* and *Chilotus* are subgenera of *Microtus*. Their types are *Microtus austerus* and *M. oregonus*, respectively. *Synaptomys* is a genus, with *S. cooperi* as the type.

[1] Gloger's description is as follows: "Theils auf dem Ural und anderen Gebirgen, theils auch in tieferen Gegenden Sibiriens, giebt es, drei oder vier andere Arten mit kleinen, rundlichen oder spitzigen Daumnägeln und von einfacherer Färbung (*Lagurus*), die zum Theile nicht weniger zum Wandern geneigt scheinen. Z. B. *L. migratorius*."

[2] Gloger says: "Von den nordamerikanischen Lemmingen zeichnen sich manche durch ein Paar höchst sonderbare (gleichsam doppelte) Vorderkrallen aus, die 2 oder gar 3 Spitzen über einander zu haben scheinen, weil sie unter den Nägeln grosse, harte Ballenhervorragungen besitzen. Sie können daher Gabelkraller (Dicrostonyx) heissen."

[3] For a paper on Gloger's generic names for mammals, see Thomas, Ann. & Mag. Nat. Hist., 6th ser., XV, Feb. 1, 1895.

Paludicola Blasius, 1857 (Fauna der Wirbelth. Deutschl., Bd. I, Säugethiere, p. 333), a subgenus of *Arvicola* (=*Microtus*), contained the species: *amphibius* (=*terrestris*), *nivalis*, and *ratticeps*. As the first is a member of the subgenus *Arvicola* and the others each a true *Microtus*, the name can not be used. Moreover, it is preoccupied by *Paludicola* Wagler, 1830 (Nat. Syst. d. Amphibien, p. 206, type *Bufo albifrons* Spix).

Agricola Blasius, 1857 (l. c., p. 334), was proposed as a subgeneric name for *Microtus agrestis*. The differences between this species and the allies of *M. arvalis* are too slight to entitle the groups to rank as distinct subgenera; but assuming that it were desirable to separate them the name *Agricola* would be antedated by *Mynomes* Rafinesque, 1817, based on *Microtus pennsylvanicus*, a form whose superspecific characters are exactly similar to those of *M. agrestis*.

Phaiomys Blyth, 1863 (Journ. Asiat. Soc. Bengal, XXXII, p. 89), is the first and only tenable name proposed for the subgenus having *Microtus blythi* as the type.

Ochetomys Fitzinger, 1867 (Sitzungsb. K. Akad. Wiss. Wien, LVI, June, 1867, p. 47), included the water rats of Europe. It is thus equivalent to *Arvicola* Lacépède.

Praticola Fatio, 1867 (Les Campagnols du Bassin du Léman, p. 36), is a subgenus of *Arvicola* (=*Microtus*) containing: *amphibius* (=*terrestris*), *nivalis*, *arvalis*, *ratticeps*, and *campestris* (=*arvalis?*). As all of these are species either of *Microtus* Schrank, or *Arvicola* Lacépède, the name *Praticola* can not stand. *Praticola* is, moreover, preoccupied in ornithology.

Sylvicola Fatio, 1867 (l. c., p. 63), based on *Microtus agrestis* is exactly equivalent to *Agricola* Blasius, 1857. The name is preoccupied in ornithology, entomology, and conchology.

Terricola Fatio, 1867 (l. c., p. 73), contained *Microtus subterraneus* and *M. savii*. The name is, however, preoccupied in conchology by *Terricola* Fleming, 1828.

Isodelta and *Anaptogonia* Cope, 1873 (Proc. Am. Philos. Soc., XII, p. 87), are the tenable names for two extinct subgenera found in the Post-pliocene cave deposits of Pennsylvania. Their types are *Microtus speothen* and *M. hiatidens*, respectively.

Evotomys Coues, 1874 (Proc. Acad. Nat. Sci. Phila., p. 186), is the tenable name for the genus of which *Mus rutilus* is the type.

Micrurus Forsyth Major, 1876 (Atti della Società Toscana di Sci. Naturali, III, fasc. 1, p. 126), founded on Mina Palumbo's description of *Arvicola nebrodensis* (a *Pitymys*), is preoccupied by *Micrura* Ehrenberg, 1831, a genus of Vermes.

Alticola Blanford, 1881 (Journ. Asiat. Soc. Bengal, L, pt. 2, p. 93), is the only name proposed for the Asiatic subgenus with *Microtus stoliczkanus* as type.

Eremiomys and *Borioikon* Polyakoff, 1881 (Mém. Acad. Imp. Sci. St.

Petersbourg, XXXIX suppl., p. 34), based, respectively, on *Mus lagurus* Pallas and *Mus torquatus* Pallas, are synonyms of *Lagurus* Gloger and *Dicrostonyx* Gloger.

Neofiber True, 1884 (Science, IV, p. 34), was described as a genus with *N. alleni*, the only known species, as type. Recently it has been shown that the characters of the animal are not enough to separate it generically from *Microtus*, of which, however, *Neofiber* forms a well-marked subgenus.[1]

Lasiopodomys Lataste, 1887 (Annali del Mus. Civ. di Storia Naturale di Genova, ser. 2a, Vol. IV, p. 268), is a synonym of *Phaiomys* Blyth, 1863, the species on which the two names were based, *Microtus brandti* Radde and *Microtus blythi* Blanford (=*M. leucurus* Blyth nec *Arvicola leucurus* Gerbe), respectively, being in no way separable subgenerically.[2]

Phenacomys Merriam, 1889 (North Am. Fauna, No. 2, p. 28), is the tenable name for the genus of which *Phenacomys intermedius* is the type.

Campicola Schulze, 1890 (Schriften Naturwiss. Vereins d. Harzes in Wernigerode, V, p. 24), is a subgenus formed for the reception of the species *Microtus arvalis*, *M. subterraneus*, and *M. campestris*. It is thus a compound of two subgenera, *Microtus* (*arvalis* and *campestris*) and *Pitymys* (*subterraneus*), each of which has previously received a tenable name. *Campicola* is, moreover, preoccupied in ornithology (Swainson, 1827).

Bramus Pomel, 1892 (Comptes Rendus, Paris, CXIV, p. 1159), is based on a mandible and the teeth of both jaws of a rodent from the Quaternary phosphorites of Trara de Nédroma near Ain-Mefta, Tunis. Although the author compares this fossil with the bones and teeth of the water rat, he points out such striking differences between the two that it is very doubtful whether *Bramus* can be considered a member of the subfamily *Microtinæ*. (See p. 73.)

Aulacomys Rhoads, 1894 (American Naturalist, XXVIII, p. 182), although based on an abnormal specimen, is the tenable name for a group of American water rats, should the latter be considered subgenerically distinct from *Arvicola*. The peculiarities of the original specimen of *Microtus arvicoloides*, the type of *Aulacomys*, are such that the group was originally given full generic rank.

Mictomys True, 1894 (Proc. U. S. Nat. Museum, XVII, No. 999, p. 242, Advance Sheet, April 26), was proposed as a full genus with *Mictomys innuitus* True for the type and only known species. The name is tenable, but the group is only a subgenus of *Synaptomys*.[3]

Tetramerodon Rhoads, 1894 (Proc. Acad. Nat. Sci. Phila., p. 282), is the most recent synonym of *Microtus*. The author, as Blasius had

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[1] True, Report of the Smithsonian Institution for 1884, Part II, pp. 325–330, Pl. II. Merriam, North American Fauna, No. 5, p. 60, 1890. Chapman, Bull. Am. Mus. Nat. Hist., New York, VI, p. 334, 1894.

[2] See Actes de la Société Scientifique du Chili, IV, p. CLXXXVIII, 1894.

[3] See Merriam, Proc. Biol. Soc. Washington, X, p. 57, 1896.

already done nearly forty years before, divides the subgenus *Arvicola* (= *Microtus*) into two groups, based on the structure of the middle upper molar. To the species with this tooth formed of five prisms he restricts the name *Mynomes*, while to those with the same tooth made up of only four prisms he applies the new name *Tetramerodon*. The character in question is far too trivial to serve alone as the basis for a subgenus. If, however, the advisability of subdividing the genus along such narrow lines be admitted, the name *Tetramerodon* still becomes a synonym of *Microtus*, since *M. arvalis*, the type of the latter, is itself a species with the middle upper molar four parted.

HISTORY OF FORMER CLASSIFICATIONS.

The most important studies of the various groups of *Microtinæ*, but more especially of the subgenera of *Microtus*, are those of De Sélys Longchamps (1836 to 1862), Blasius (1857), Baird (1857), Fatio (1867), Coues (1874), Blanford (1881), and Lataste (1887). The names used by these authors for the subdivisions of *Microtus* adopted in the present classification are shown in the accompanying table:

Table of Names used by Authors for the Subgenera of Microtus.

Names used in the present paper.	De Sélys Longchamps, 1836 to 1862.	Blasius, 1857.	Baird, 1857.	Fatio, 1867.	Coues, 1874.	Blanford, 1881.	Lataste, 1887.
Arvicola	*Hemiotomys*	*Paludicola*	...	*Praticola* (part).	...	...	*Arvicola.*
Microtus	*Arvicola*	*Arvicola* (part).	...	*Praticola* (part).	...	...	
	Mynomes	*Agricola*	*Hemiotomys.*	*Sylvicola*	*Myonomes*	*Neodon*, (part).	*Microtus.*
Pitymys	*Microtus*	*Arvicola* (part).	*Pitymys*	*Terricola*	*Pitymys*	...	*Pitymys.*
Pedomys	...	...	*Pedomys*	...	*Pedomys*	...	
Phaiomys	...	...	...	...	...	*Paludicola*	*Lasiopodomys.*
Chilotus	...	...	*Chilotus*	...	*Chilotus*	...	
Lagurus	...	...	...	...	...	...	
Alticola	...	...	...	...	...	*Alticola*	
Hyperacrius	...	...	...	...	...	*Alticola* part ?.	
Eothenomys	...	...	...	...	...	*Neodon* (part).	
Anteliomys	...	...	...	...	...	...	
Neofiber	...	...	...	...	...	...	

De Sélys Longchamps published two extended papers on the European *Microtinæ*, and later a note supplementary to the first of these. The first paper appeared in 1836 under the title 'Essai Monographique sur les Campagnols des environs de Liège.' In this the author showed that hitherto the voles had been divided into two groups, according to their habits, the aquatic species being separated from those that are strictly terrestial. This proved unsatisfactory because the two were found to intergrade imperceptibly. Hence he proposed to rearrange the species according to the length of the ears. The first division, or that in which the ears are extremely short or apparently absent, he named *Hemiotomys*. This the author subdivided into two sections, neither of which he named. The first contained one species, *Arvicola fulvus* (=*Microtus arvalis*), distinguished by its short tail and by the supposed absence of external ears. The second contained the water rat. To *Arvicola* (=*Microtus*) proper were referred the three species, *arvalis*, *subterraneus*, and *rufescens* (=*Evotomys glareolus*). Six years later, in his Études de Micromammalogie, De Sélys Longchamps followed the same system of classification, but considerably extended it and included species from Asia and North America. This later scheme is as follows:

The genus is first divided into two sections, one of which consists of species with ears shorter than the fur and with very small eyes, the other of species with the ears as long as the fur and with the eyes well developed. The first section contains two groups, (1) *Hemiotomys* with the European water rats and the American *Arvicola riparius* (=*Microtus pennsylvanicus*), and (2) *Microtus* with the species *fulvus*, *savii*, *œconomus*, and certain American forms not mentioned by name. The second section is divided into three groups: (1) *Arvicola* with the species *subterraneus*, *arvalis*, *gregalis*, *alliarius*, *duodecimcostatus*, and *socialis;* (2) *Myodes* with the two species *rubidus* (=*Evotomys glareolus*) and *rutilus* (=*Evotomys rutilus*); (3) *Mynomes* with the species *pratensis* (=*Microtus pennsylvanicus*). These groups and sections the author considers in no way entitled to rank as genera or subgenera. He names them merely for convenience.[1] In a postscript published at the time of distribution of the last copies of the Essai Monographique, twenty-six years after its appearance, the author makes a few corrections in the classification previously adopted. He points out that his *Arvicola fulvus* is merely a young specimen of *A. arvalis* that by accident had lost its external ears, and, furthermore, that the species *subterraneus* should be transferred to the section *Microtus*.

The classification as finally perfected is as follows:

Genus *Arvicola:*
- Group *Hemiotomys* (water rats).
- Group *Microtus* (*subterraneus* and *savii*).
- Group *Arvicola* (typical voles).
- Group *Myodes* (*glareolus*).
- Group *Mynomes* (*pennsylvanicus*).

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[1] Je dois prévenir que je m'opposerais entièrement à l'élévation d'aucune de ces sections au rang de genre ou de sous-genre. Toutes passent de l'une à l'autre par des nuances insensibles dans la longueur de la queue et des oreilles; et, quant au caractère tiré de la racine des dents, il est probable qu'il existe à un degré plus ou moins fort chez d'autres espèces. Si je me suis permis d'imposer à ces groupes des noms latins pris parmi les synonymes du genre, ce n'est nullement pour qu'ils puissent être introduits dans la nomenclature binaire, mais pour donner aux étrangers l'idée des divers noms que j'ai employés en français. (Micromammalogie, p. 87.)

The groups *Hemiotomys*, *Microtus*, and *Arvicola* of De Sélys Longchamps are exactly equivalent respectively to the subgenera *Arvicola*, *Pitymys*, and *Microtus* of the present paper, while *Myodes* is the same as the genus *Evotomys*. The group *Mynomes* based on Rafinesque's description of *Mynomes pratensis* (=*Microtus pennsylvanicus*) should be united with *Arvicola* (*Microtus*, as now understood), a course which the author no doubt would have followed had he been acquainted with the type species.

Blasius published in 1857, in his 'Fauna der Wirbelthiere Deutschlands,' a classification of the voles based primarily on the pattern of enamel folding in the first and second molars of the lower jaw and the second molar of the upper jaw. This system differs in many ways from that of De Sélys Longchamps, and is as follows:

Genus *Arvicola*:
- Subgenus *Hypudæus* (*glareolus*).
- Subgenus *Paludicola* (*amphibius* [=*terrestris*], *nivalis*, *ratticeps*)
- Subgenus *Agricola* (*agrestis*).
- Subgenus *Arvicola*:
  - *A. Arvicola* (*campestris*, *arvalis*).
  - *B. Microtus* De Sélys part (*subterraneus*, *savii*).

The subgenus *Arvicola* Blasius subdivides into two sections, A. *Arvicola* and B. *Microtus* De Sélys (part). The former includes the species *campestris* and *arvalis*, the latter *subterraneus* and *savii*. The subgenus *Hypudæus* and the section *Microtus* are equivalent, respectively, to the genus *Evotomys* and the subgenus *Pitymys* of the present paper. Of the other groups, the restricted *Arvicola* contains the typical species of the subgenus *Microtus*, *Agricola*, a slightly aberrant form of the same, and *Paludicola*, the subgenus *Arvicola* and two aberrant members of the subgenus *Microtus*. Blasius's subgenera *Paludicola* and *Arvicola* are excellent illustrations of the unnatural results of a system of classification based on one set of characters. While there is a general similarity between the enamel pattern of the three species associated in the former, *Microtus terrestris* differs from *M. ratticeps* and *M. nivalis* in the form of the skull, the number of plantar tubercles, the quality of the fur, and in the presence of large musk glands on the sides. In the subgenus *Arvicola* Blasius associates two of the most distinct subgenera of the genus *Microtus* (*Microtus* and *Pitymys*), and treats the differences in the number of mammæ and footpads, form of skull, and size of eyes as matters of trifling importance in comparison with the general similarity of the enamel pattern. On the other hand, the author recognizes *Agricola* as a full subgenus, when the chief character on which the group is based is the presence of a minute supplemental postero-internal prism on the middle upper molar.

The classification adopted by Baird (Mamm. N. Am., 1857) is based on a combination of characters, and is thus much more satisfactory than the artificial arrangement published almost simultaneously by

Blasius. His classification of the subdivisions of *Microtus* is as follows:

Genus *Arvicola*:
  Subgenus *Hypudæus* (*gapperi*).
  Subgenus *Arvicola* (typical voles).
    Section *Hemiotomys* (most of the American species and the European *agrestis*).
    Section *Chilotus* (*oregoni*).
    Section *Pedomys* (*austerus*).
    Section *Pitymys* (*pinetorum*).

Baird's subgenera *Hypudæus* and *Arvicola* are equivalent to the genera *Evotomys* and *Microtus* of the present paper, while his sections *Chilotus*, *Pedomys*, and *Pitymys* are equal to the subgenera of the same names. The section *Hemiotomys* of Baird is the *Arvicola* of De Sélys Longchamps, and the subgenus *Microtus* of the present paper.

In 1867 Fatio published a classification of the European voles in a paper entitled 'Les Campagnols du Bassin du Léman.' This arrangement is essentially the same as that of Blasius. Fatio, however, recognizes *Hypudæus* (=*Evotomys*) as a full genus, and raises the second of Blasius's two sections of the subgenus *Arvicola* to the rank of a subgenus, while the first he unites with *Microtus terrestris*, *M. nivalis*, and *M. ratticeps* to form the subgenus *Praticola*. He also arbitrarily changes the names of certain groups. His classification is as follows:

Genus *Hypudæus* (*glareolus*).
Genus *Arvicola*.
  Subgenus *Praticola* ('*amphibius*,' *nivalis*, *arvalis*, *ratticeps*, *campestris*).
  Subgenus *Sylvicola* (*agrestis*).
  Subgenus *Terricola* (*subterraneus*, *savii*).

The subgenus *Terricola* and the genus *Hypudæus* are equal, respectively, to the subgenus *Pitymys* and the genus *Evotomys* of the present paper. The subgenus *Sylvicola* is equivalent to the subgenus *Agricola* of Blasius, like it containing the pentamerodont species of the subgenus *Microtus*. The subgenus *Praticola* includes the type species of both *Arvicola* and *Microtus*, together with three other tetramerodont species of the latter.

In 1874 Dr. Coues published, in the Proceedings of the Academy of Natural Sciences of Philadelphia, an abstract of his monograph of the North American Muridæ, which appeared in full in Volume XI of the Report of the United States Geological Survey of the Territories (Monographs of North American Rodentia). Here he presented a classification of the American *Microtinæ* based primarily on Baird's review of the group. The differences between the arrangements adopted by Baird and Coues are so slight that a few words only are necessary in regard to the latter. Dr. Coues recognizes the red-backed mice as a distinct genus, which he calls *Evotomys*, after showing that the name *Hypudæus* generally used for the group is untenable. The subgenera of *Microtus* adopted by Dr. Coues are exactly equivalent to Baird's sections of his typical subgenus *Arvicola*. Dr. Coues points out Baird's error in the application of the name *Hemiotomys* De Sélys Longchamps, and substitutes for the latter the equally untenable *Mynomes* Rafinesque.

In 1881 Blanford proposed, in the Journal of the Asiatic Society of Bengal (Vol. L, Pt. II, pp. 88–117), a classification of the voles of the Himalayas, Tibet, and Afghanistan. The species occurring in this region he arranges in three sections, thus:[1]

Genus *Arvicola:*
- Section *Paludicola*, (*blythi, mandrianus*).
- Section *Alticola* (*stoliczkanus, stracheyi, roylei, blanfordi, wynnei*).
- Section *Neodon* (*sikkimensis, melanogaster*).

Blanford's 'sections' *Paludicola* and *Neodon* are excellent instances of unnatural classifications based on single characters. *Microtus blythi* and *M. mandrianus* are species of *Phaiomys*, a subgenus which differs from the water rats or from *Microtus* (*Microtus*) *nivalis* and *M.* (*M.*) *ratticeps* (all of which were included by Blasius in *Paludicola*) in many important characters. Because there is a general likeness in the pattern of enamel folding they are united under one superspecific name. Again, Blanford places in the section *Neodon* the species *Microtus sikkimensis*, which is a slightly abnormal member of the subgenus *Microtus*, and *Microtus melanogaster*, a species with the bony palate formed exactly as in the red-backed mice (*Evotomys*). These members of widely different groups are brought together on account of a very superficial likeness in enamel pattern. Blanford's section *Alticola* is probably equal to the subgenera *Alticola* and *Hyperacrius* of the present paper, though it is still a matter of doubt whether it actually included any members of the latter.

The most recent classification of the subgenera of *Microtus* is that proposed by Lataste. This author has published two important papers on the subject, the first in Le Naturaliste (Tome II, pp. 323, 324, 332–334, 342, 343, 347–349, 1883), and the second in the Annali del Museo Civico di Storia Naturale di Genova (Serie 2*a*, Vol. IV, pp. 259–274, 1887). While recognizing the unsatisfactory nature of the artificial classification adopted by Blasius, Lataste subdivides the voles in accordance with a system fully as arbitrary as that followed by any of his predecessors. According to Lataste the characters derived from the teeth of the voles are of no value except in distinguishing between genera.[2] The subgenera he arranges according to the number of mam-

[1] Blanford adopted Blasius's classification of the voles at large (pp. 91, 92). Except in the case of *Paludicola*, however, he supposed that none of the European sections of the genus *Microtus* are represented in the region with which he deals.

[2] "Chez les Rongeurs du moins, sinon chez tous les Mammifères, les charactères de la denture me semblent d'ordre générique quand ils sont suffisamment nets et tranchés, mais sans aucune importance taxonomique quand ils sont aussi minimes que ceux que l'on invoque d'ordinaire, à la suite de Blasius, chez les Campagnols, et

mæ and plantar tubercles. Although this system leads to a tolerably satisfactory arrangement of the European voles, it can not be applied to the genus at large, since it would unite such distinct groups as *Arvicola* and *Chilotus*, or *Neofiber* and *Pitymys*. Lataste's classification is as follows:

Genus *Microtus*:[1]
  Subgenus *Myodes* (*rutilus, glareolus*).
  Subgenus *Microtus* (*gregalis, arvalis, agrestis, ratticeps, pennsylvanicus, nivalis*).
  Subgenus *Arvicola* (*terrestris, musignani*).
  Subgenus *Pitymys* (*pinetorum subterraneus, socialis, middendorffi*).
  Subgenus *Lasiopodomys* (*brandti*).

The subgenera *Myodes* and *Lasiopodomys* are equal, respectively, to the genus *Evotomys* and the subgenus *Phaiomys* of the present paper. The subgenera *Microtus* and *Arvicola* coincide with groups here recognized under the same names, while the subgenus *Pitymys* is essentially the same as that defined on page 58. Lataste, however, includes in *Pitymys* the species *middendorffii*, which is probably not a member of that group as now understood.

CHARACTERS ON WHICH THE PRESENT CLASSIFICATION OF THE SUBGENERA OF MICROTUS IS BASED.

In the discussion of the systems of classification hitherto adopted, the impracticability of subdividing the genus *Microtus* according to the variations in any one set of characters has been shown. The highly artificial systems of Blasius and Lataste give the best examples of the unnatural results to which any such course must inevitably lead. In the present paper the classification used is based on an assemblage of characters. The more important of these, or the ones least adapted to the special needs of the different animals, and hence least likely to vary, are: Form of skull, structure of bony palate, pattern of enamel folding, number of mammæ, number of plantar tubercles, and presence or absence of musk glands on the sides. Characters of less importance, because more readily modified to fit a species to the special requirements of its environment, and hence more unstable, are: Quality of fur, hairiness of soles, length of tail, form of front feet, size of eyes, and form of external ear. It is only through careful consideration of all these that a satisfactory arrangement of the species can be obtained.

Nearly all of the characters now used have been recognized in classifications already proposed. In every case, however, they have been assigned degrees of importance different from those which they now receive. To take the three most conspicuous examples: De Sélys Longchamps arranged the voles with regard to their external form;

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qui portent sur les extrémités mal définies et éminemment variables, soit postérieur de la dernière molaire supérieure, soit antérieur de la première molaire inférieure." (Ann. del Mus. Civ. di Genova, Ser. 2a, Vol. IV, p. 260 footnote.)

Compare with this the opinion expressed by Büchner. (See footnote, p. 25.)

[1] To Lataste is due the credit of recognizing the true status of the name *Microtus*.

Blasius based his classification on the pattern of enamel folding without regard to external characters, and Lataste subdivided the group according to the numbers of mammæ and plantar tubercles, disregarding everything else. The impossibility of reaching satisfactory results by any of these methods has been pointed out by Büchner, who, however, takes an equally extreme position in his reluctance in any way to subdivide the genus *Microtus*.

Büchner was first to recognize the important fact that the enamel pattern, while variable within certain limits and hence of little value taken by itself, is nevertheless of considerable systematic importance when considered in connection with other characters.[1]

In about 75 per cent of the specimens of a given species the enamel pattern conforms to a type which may be considered normal.[2] Among the abnormal specimens constituting the remainder, the variation, however, is very considerable. In the accompanying illustrations (figs. 1, 2, 3, 4, 5, and 6) are shown some of the conspicuous aberrations in the form of the teeth of *Microtus pennsylvanicus*.[3] In the descriptions which follow the normal enamel pattern is alone considered.

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[1] After mentioning Lataste's view (see footnote, p. 23), Büchner says: "Meiner Ansicht nach liefert im Gegentheil der Bau der Backenzähne, obwohl derselbe zuweilen auch im Bereiche einer Art leicht variirt, ein vorzügliches Merkmal, welches allein genommen für die Charakteristik einer Art nicht genügt, in Verbindung aber mit den übrigen Merkmalen sehr grosse Dienste leistet und von bedeutendem systematischen Werthe ist." (Wissenschaftliche Resultate der von N. M. Przewalski nach Central-Asien unternommenen Reisen. Zool. Theil, Bd. I, Säugethiere, Lief. 3, 1889, p. 97.)

[2] Among 285 specimens of *Microtus pennsylvanicus* 71, or 24.9 per cent have the enamel pattern in some way abnormal. Of these, 26, or 9.1 per cent, have the first outer triangle in m 3 communicating more or less freely with the inner triangle (fig. 3); one has the second outer triangle opening into the posterior loop (fig. 3); two have the posterior loop of very unusual shape (fig. 3); one has a second inner closed triangle in m 3 (fig. 3), and 14, or 4.9 per cent, show a distinct fourth salient angle on the outer side of the same tooth. In the first lower molar 24, or 8.3 per cent. have 6 closed triangles (fig. 4), one has only 3, still another has 7 (fig. 4), while in 5, or 1.7 per cent, there are 4 (fig. 4). Of these 285 specimens m 3 is abnormal in 44 cases, or 15.4 per cent, m 1 in 31 cases, or 10.8 per cent. Grouping the abnormalities according to their frequency, they may be arranged as follows:

m 3 has first outer triangle open in 26 cases, or 9.1 per cent.

m 1 has one additional triangle in 24 cases, or 8.3 per cent.

m 3 has an additional salient angle on the outer side in 14 cases, or 4 per cent.

m 1 has one less triangle than usual in 5 cases, or 1.7 per cent.

m 3 has the posterior loop of very unusual shape in 2 cases, or 0.7 per cent.

m 3 has the second outer triangle abnormal in 1 case, or 0.35 per cent.

m 3 has an additional inner triangle in 1 case, or 0.35 per cent.

m 1 has two additional closed triangles in 1 case, or 0.35 per cent.

m 1 has two less closed triangles than usual in 1 case, or 0.35 per cent.

[3] The drawings here reproduced are all from specimens taken in the eastern and central parts of the United States and adjoining British Provinces. They are selected from the series of about 170 belonging to the United States Department of Agriculture.

The value of the structure of the bony palate as a taxonomic character was first pointed out by Coues,[1] who, however, considered it of rather more importance than it really is. It was at first supposed that the bony palate of all the members of the genus *Microtus* differed in a constant way from those of *Evotomys*. Mr. Oldfield Thomas has, however, recently described a *Microtus* (*M. chinensis*) in which the palate structure of *Evotomys* is almost exactly reproduced; and on further

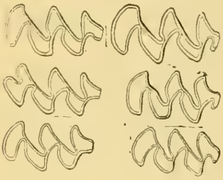

FIG. 1.—First upper molar in six specimens of *Microtus pennsylvanicus*.

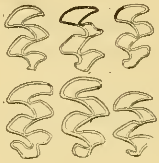

FIG. 2.—Second upper molar in six specimens of *Microtus pennsylvanicus*.

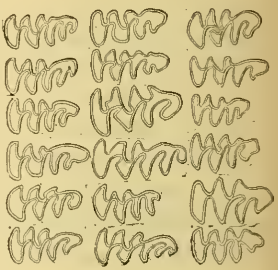

FIG. 3.—Third upper molar in eighteen specimens of *Microtus pennsylvanicus*.

study it appears that several well-marked types may be recognized among the species of the genus. These forms of palate furnish characters of considerable worth in defining many subgenera. In all, several structures remain sufficiently constant to serve as convenient landmarks. The anterior portion of the bony palate, or that formed exclusively by the premaxillaries and maxillaries, has no special interest, as it shows very trifling variations. All the characters of importance are derived from the part lying behind the maxillo-palatine suture. This suture in the typical palate, or that occurring

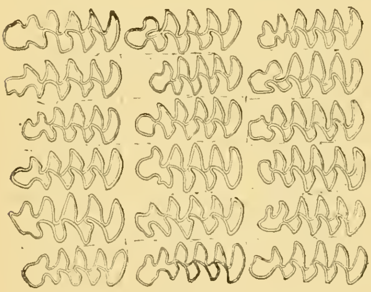

FIG. 4.—First lower molar in eighteen specimens of *Microtus pennsylvanicus*.

FIG. 5.—Second lower molar in four specimens of *Microtus pennsylvanicus*.

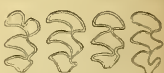

FIG. 6.—Third lower molar in four specimens of *Microtus pennsylvanicus*.

in true *Microtus* and in the great majority of species and subgenera (fig. 7 A) forms a broad, U-shaped loop, the convexity of which is directed forward and whose apex lies about opposite the middle of the second molar. From this point the suture on each side sweeps rapidly backward and outward until, at the level of the anterior edge of the posterior molar, practically the whole width of the palate is occupied by the palatine, and the maxillaries are reduced to a narrow rim around the edges of the alveoli.

[1] Monogr. N. Am. Rodentia, p. 133, 1877.

Until just before acquiring its greatest width, the surface of the palatine is on the same level with the rest of the bony palate, but immediately on reaching this point it changes abruptly at the sides, more gradually in the median line, to the level of the anterior border of the interpterygoid fossa, which lies about 0.5 mm. dorsad of the main part of the bony palate. In the median line the palatine slopes gently dorsocaudad to the edge of the interpterygoid fossa, a distance usually of about 1 mm., but at the sides it breaks away suddenly, and the spaces between the median sloping ridge and maxillaries are occupied by conspicuous pits (fig. 7 A, *l. p*). The floor of each pit is continuous with the backward projection of the palatine, which runs out to join the

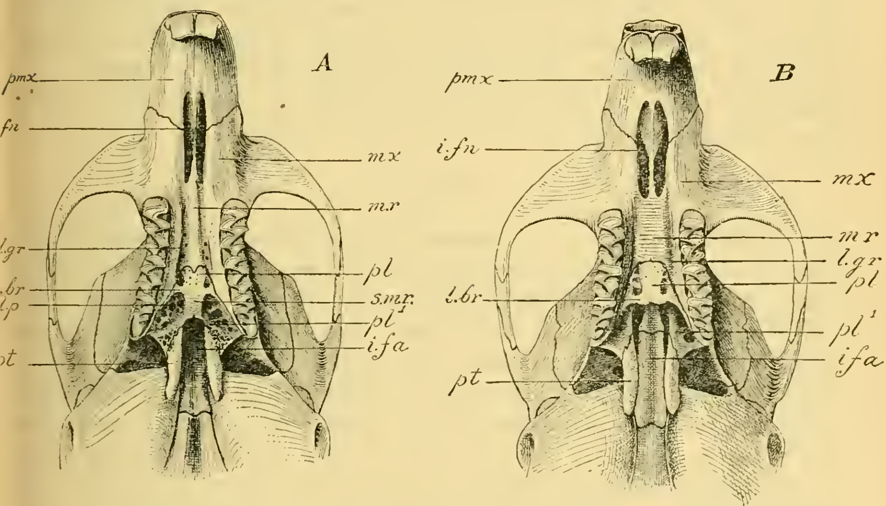

FIG. 7.—Palatal view of skull of *Microtus (Microtus) arvalis* (A) and *Evotomys gapperi* (B). (x 3). *i.fa.*, interpterygoid fossa (reference line crosses pterygoid fossa); *i.fn.*, incisive foramen; *l.br.*, lateral bridge; *l.gr.*, lateral groove; *l.p.*, lateral pit; *m.r.*, median ridge; *mx.*, maxillary; *pl.*, *pl*[1]., palatine; *pmx.*, premaxillary; *pt.*, pterygoid (reference line crosses pterygoid fossa); *s.m.r.*, sloping portion of median ridge.

pterygoid of its side (fig. 7 A, *pt.*). The ventral outline of the interpterygoid fossa (fig. 7 A, *i. fa.*) forms three sides of a figure, which is nearly a parallelogram, open at one end, the longer axis parallel with the main axis of the skull, and the length more than double the width. In front and for a short distance at the sides the fossa is limited by the palatines (fig. 7 A, *pl'.*), but the greater part of its boundary is formed by the pterygoids (fig. 7 A, *pt.*). The open end lies between the hamular processes of the pterygoids. Extending back from the incisive foramina are two distinct lateral grooves (fig. 7 A, *l. gr.*), which traverse the bony palate longitudinally, leaving between them a ridge which posteriorly is continuous with the sloping median ridge already described. In these grooves open numerous foramina, larger and more crowded just in front of the region from which the bony palate slopes away to the level of the pterygoids. The median ridge just here widens abruptly and sends out on each side a short process, which is met by a similar one arising from the palatine on the opposite side of the groove (fig. 7 A, *l. br.*). These processes usually meet and fuse, thus completely obliterating the groove, though they are frequently separated by a narrow space. In *Evotomys* (fig. 7 B) the sloping part of the median ridge has disappeared, together with the lateral pits, but traces of the median ridge (fig. 7 B, *m. r.*), the lateral grooves (fig. 7 B, *l. gr.*), and the bridges (fig. 7 B, *l. br.*) may still be recognized.

At different times subgeneric weight has been given to the form of the external ear, and to the proportional length of the tail to the head and body. Neither one, however, is of any value, except in special, isolated cases. The form of the ear is essentially the same in all the subgenera, though there are slight modifications in length and in the development of the valvular fold by which the meatus is closed.

The relative length of the tail is far too variable to serve as a useful diagnostic character.

KEYS.

The following keys to the genera and subgenera of *Microtinæ* are wholly artificial and do not bring the groups together according to natural affinities. Since analytical keys are of no value except as aids in identifying specimens, it is necessary that they should be based on characters that may be studied without difficulty in ordinary museum material. Such material, however, is usually so imperfect that a single key made with reference to one set of characters (as, for instance, the form of the bony palate or the number of mammæ) might be of little use. Hence several keys are here introduced, each based primarily on a special set of structures. Of the three keys to the genera, No. 1 is made, so far as possible, with reference to the skull alone; No. 2, with reference to the teeth, and No. 3, with reference to external characters. Of the keys to the subgenera of *Microtus*, No. 5 is based primarily on characters derived from the structure of the bony palate, and is thus useless for the identification of specimens the skulls of which are not available for study. Key No. 6 is based on the pattern of enamel folding and may be used with specimens having broken skulls. The lines in italics inserted in parentheses in this key are for the identification of individuals with abnormal enamel patterns. These usually occur in the proportion of about one to four (see p. 25). Hence, one-fourth of any given lot of specimens will agree with the characters given in parentheses; the great majority, however, with those in heavy type. Key No. 7, based primarily on the mammæ and footpads, is made almost exclusively with reference to external characters. It is necessarily incomplete, since the number of mammæ and footpads is in several instances unknown. It is, of course, impossible to use this key except with alcoholic specimens or freshly killed animals. Key No. 8—if it may be called a key—is a rough grouping of the subgenera of *Microtus* according to the essential characters used in the classification here adopted. The keys are in all cases based on the characters of adults only.

1. KEY TO THE GENERA OF MICROTINÆ.

[Based primarily on the skull.]

Skull of adult more than 50 mm. long .... *Fiber*
Skull of adult less than 45 mm. long.
  Molars rooted; skull always less than 30 mm. long.
    Posterior border of palate a thin-edged shelf, continuous between alveoli of posterior molars .... *Evotomys*
    Posterior border of palate not forming a shelf .... *Phenacomys*
  Molars rootless; skull often more than 30 mm. long.
    Middle part of zygoma expanded so as to form an oblique plate about 4 mm. broad .... *Lemmus*
    Middle part of zygoma only slightly expanded.
      Rostrum about $\frac{1}{4}$ total length of skull .... *Synaptomys*
      Rostrum more than $\frac{1}{4}$ total length of skull.
        Postorbital process of squamosal peg-like .... *Dicrostonyx*
        Postorbital process of squamosal shelf-like .... *Microtus*

2. KEY TO THE GENERA OF MICROTINÆ.

[Based primarily on the teeth.]

Length of maxillary tooth row in adult more than 14 mm .... *Fiber*
Length of maxillary tooth row in adult less than 13 mm.
  Roots of lower incisors on inner (lingual) side of molar roots.
    Upper incisors grooved .... *Synaptomys*
    Upper incisors not grooped.
      $\overline{\text{m 1}}$ with 3 closed triangles .... *Lemmus*
      $\overline{\text{m 1}}$ with 7 closed triangles .... *Dicrostonyx*
  Roots of lower incisors on outer side of molar roots.
    Molars rooted.
      Teeth weak; triangles tending to remain open; salient angles rounded .... *Evotomys*
      Teeth strong; triangles closed; salient angles sharp .... *Phenacomys*
    Molars rootless .... *Microtus*

3. KEY TO THE GENERA OF MICROTINÆ.

[Based primarily on external characters.]

Tail flattened laterally .... *Fiber*
Tail terete.
  Tail shorter than hind foot.
    Thumb with strap-shaped nail .... *Lemmus*
    Thumb without strap-shaped nail.
      External ear rudimentary .... *Dicrostonyx*
      External ear well developed .... *Microtus* (Asiatic species of subgenus *Lagurus*)
  Tail longer than hind foot.
    Upper incisors grooved .... *Synaptomys*
    Upper incisors not grooved.
      Color usually reddish; molars weak, with triangles tending to remain open and with salient angles rounded .... *Evotomys*
      Color brownish, grayish, or yellowish; very seldom reddish; molars strong, with closed triangles and sharp salient angles.
        Molars rooted .... *Phenacomys*
        Molars rootless .... *Microtus*

4. KEY TO SUBGENERA OF SYNAPTOMYS.

Mandibular molars with closed triangles on outer side .... *Synaptomys*
Mandibular molars without closed triangles on outer side .... *Mictomys*

5. KEY TO THE SUBGENERA OF MICROTUS.

[Based primarily on the bony palate.]

Palate normal or nearly so (see p. 27).
  Third lower molar with all triangles closed .... *Lagurus*
  Third lower molar normally without closed triangles.
    Claws small, those on front feet always shortest.
      Plantar tubercles 6 .... *Microtus*
      Plantar tubercles 5.
        Tail more than 30 per cent of total length .... *Arvicola*
        Tail less than 30 per cent of total length.
          m 1 with 5 closed triangles .... *Chilotus*
          m 1 with 3 closed triangles .... *Pedomys*
    Claws large, those on front feet usually longest.
      Fur long and soft .... *Phaiomys*
      Fur dense and mole-like .... *Pitymys*
Palate highly abnormal.
  Palate ending in a broad median plate cut off from maxillaries at the sides.
    Third lower molar with all triangles closed .... *Neofiber*
    Third lower molar without closed triangles.
      Skull flat; audital bullæ small .... *Hyperacrius*
      Skull high; audital bullæ large .... *Alticola*
  Posterior border of palate continuous between maxillaries.
    Posterior border of palate straight .... *Eothenomys*
    Posterior border of palate with median projection .... *Anteliomys*

6. KEY TO THE SUBGENERA OF MICROTUS.[1]

[Based primarily on the teeth.]

(m 1 with 6 or 7 closed triangles.)
  (Plantar tubercles 5.)
    (Small; not aquatic; fur short .... Chilotus)
    (Large; aquatic; fur long .... Arvicola)
  (Plantar tubercles 6 .... Microtus)
m 1 with 5 closed triangles.
  m 3 with 3 closed triangles.
    m 3 with triangles always closed .... Neofiber
    m 3 with triangles normally open.
      Plantar tubercles 6.
        Fur not specially modified, claws moderate.
          Posterior loop of m 3 short or strongly curved; palate normal. Microtus
          (Posterior loop of m 3 long and straight; palate abnormal.)
            (Skull broad and flat; plantar tubercles 5 .... Hyperacrius)
            (Skull not broad and flat; plantar tubercles 6 .... Alticola)
        (Fur very long and soft, aspect lemming-like, claws very long. Phaiomys)
      (Plantar tubercles 5.)
        (Small; not aquatic; fur short .... Chilotus)
        (Large; aquatic; fur long .... Arvicola)

[1] Characters in heavy-faced type are those of specimens with normal enamel pattern; characters in italics (inserted in parentheses) are those of specimens with abnormal enamel pattern.

m 3 with 2 closed triangles.
  Triangles in m 3 alternate and closed.
    Aquatic; soles naked; tail long .... Neofiber
    Not aquatic; soles hairy; tail short .... Lagurus
  Triangles in m 3 normally opposite and open.
    Claws small, those on hind feet always longest.
    Mammæ 8; foot pads 5.
      Small; not aquatic; fur short .... Chilotus.
      (*Large; aquatic; fur long* .... *Arvicola*)
    (*Mammæ 4; foot pads 5; skull high* .... *Pedomys*)
  (*Claws large, those on front feet often longest.*)
    (*Fur short and dense* .... *Pitymys*)
    (*Fur long and soft* .... *Phaiomys*)

m 1 with 4 closed triangles.
  m 3 with posterior loop elongated in axis of jaw.
    Skull broad and flat; plantar tubercles 5 .... Hyperacrius
    Skull not broad and flat; plantar tubercles 6 .... Alticola
  (*m 3 with posterior loop rounded or crescentic.*)
    (*m 3 with 3 closed triangles* .... *Microtus*)
    (*m 3 with 2 closed triangles* .... *Arvicola*)

m 1 with 3 closed triangles.
  (*m 3 with 3 closed triangles.*)
    (*Plantar tubercles 6.*)
      (*Posterior loop of m 3 short or strongly curved; palate normal* ... *Microtus*)
      (*Posterior loop of m 3 long and straight; palate abnormal* .... *Alticola*)
    (*Plantar tubercles 5.*)
      (*Mammæ 8; palate normal* .... *Arvicola*)
      (*Mammæ 4; palate abnormal* .... *Hyperacrius*)
  m 3 with 2 closed triangles.
    Sole almost naked .... Arvicola
    Sole hairy.
      (*Palate abnormal* .... *Hyperacrius*)
      Palate normal.
        Claws long, all about equal in length .... Phaiomys
        Claws short, those on front feet shortest .... Pedomys
  (*m 3 with 1 closed triangle* .... *Hyperacrius*)

m 1 with 0 closed triangles.
  m 2 and m 3 of approximately the same form .... Eothenomys
  m 2 and m 3 very different in form .... Anteliomys

7. KEY TO THE SUBGENERA OF MICROTUS.

[Based primarily on mammæ and foot pads.]

Mammæ 10 .... *Phaiomys*
Mammæ 8.
  Plantar tubercles 6.
    Palate normal .... *Microtus*
    Palate abnormal .... *Alticola*
  Plantar tubercles 5.
    Conspicuous musk glands on sides .... *Arvicola*
    No musk glands on sides.
      Color dark brown .... *Chilotus*
      Color light grayish or yellowish .... *Lagurus*

Mammæ 4.
  Size very large .... *Neofiber*
  Size medium or small.
    Plantar tubercles 6 .... *Anteliomys*
    Plantar tubercles 5.
      Skull not flattened .... *Pedomys*
      Skull flattened.
        Palate normal .... *Pitymys*
        Palate abnormal .... *Hyperacrius*

8. SUBGENERA OF MICROTUS GROUPED BY ESSENTIAL CHARACTERS.

Palate normal.—*Microtus, Pedomys, Pitymys, Chilotus, Phaiomys, Arvicola, Lagurus.*

Palate abnormal.—*Neofiber, Alticola, Hyperacrius, Eothenomys, Anteliomys.*

Third lower molar always with closed triangles.—*Neofiber, Lagurus.*

Third lower molar normally without closed triangles.—*Microtus, Pedomys, Pitymys, Chilotus, Phaiomys, Arvicola, Eothenomys, Anteliomys, Alticola, Hyperacrius.*

First lower molar normally with 5 closed triangles and 9 salient angles.—*Microtus, Chilotus, Neofiber, Lagurus.*

First lower molar normally with 3 or 4 closed triangles and 9 salient angles—*Pedomys, Pitymys, Phaiomys, Alticola, Hyperacrius.*

First lower molar normally with 3 closed triangles and 7 salient angles.—*Arvicola.*

First lower molar without closed triangles.—*Anteliomys, Eothenomys.*

Third upper molar normally with 3 closed triangles and 7 to 8 salient angles.—*Microtus.*

Third upper molar normally with 2 closed triangles and 6 salient angles.—*Neofiber, Arvicola, Pitymys, Pedomys, Phaiomys, Chilotus.*

Third upper molar without closed triangles.—*Anteliomys, Eothenomys.*

Mammæ 10.—*Phaiomys.*

Mammæ 8.—*Arvicola, Microtus, Alticola, Chilotus, Lagurus.*

Mammæ 4.—*Neofiber, Pitymys, Pedomys, Anteliomys, Hyperacrius.*

Plantar tubercles 6.—*Microtus, Phaiomys, Anteliomys, Alticola.*

Plantar tubercles 5.—*Neofiber, Arvicola, Pitymys, Pedomys, Chilotus, Lagurus, Hyperacrius.*

DESCRIPTIONS OF LIVING GENERA AND SUBGENERA.

Genus SYNAPTOMYS Baird.

Synaptomys Baird, Mamm. N. Am., p. 558, 1857. Type *Synaptomys cooperi* Baird.

Geographic distribution of type species.—Boreal, Transition, and northern edge of Upper Austral Zone in eastern North America from the Atlantic coast to Minnesota.

Geographic distribution of genus.—North America from northern edge of Lower Austral Zone northward.

Essential characters:

Upper incisors with distinct longitudinal grooves.

Lower incisors with roots on inner (lingual) side of molars.

Molars rootless.

Enamel pattern characterized by great depth of reentrant angles on outer side of maxillary teeth and on inner side of mandibular teeth.

m 1 with three closed triangles and two transverse loops, or with four transverse loops and no closed triangles.

m 3 with four transverse loops and no closed triangles.

Feet not specially modified.

Soles and palms with well-developed tubercles.

Thumb with large flattened ligulate nail.

Tail very slightly longer than hind foot, terete.

External ear well developed.

Skull.—The skull of *Synaptomys* (fig. 9 and Pl. I, figs. 12, 13) is moderately broad, flat, and massive, much less so than in the other *Lemmi*. Rostrum short (nasal bones about one-fourth occipito-nasal length) and strongly deflexed; zygomatic arches not broadly flaring as in *Lemmus* and *Dicrostonyx*,[1] though more so than in the voles; middle portion of zygoma very slightly expanded, the outer surface nearly vertical; brain case not greatly broadened or flattened, and seldom if ever conspicuously ridged or furrowed; interparietal with rounded corners, the antero-posterior diameter more than half the transverse diameter; pterygoids short; interpterygoid fossa about one-sixth basilar length of skull; posterior border of bony palate ending nearly as in typical *Microtus*. (See p. 26, Pl. II, fig. 5, and fig. 7, p. 27.) Front edge of squamosal forming a narrow, shelf-like postorbital process.

Teeth.—Anterior faces of upper incisors with distinct longitudinal grooves. Lower incisor terminating posteriorly a little in front of the hinder edge of the back molar. Throughout its length each mandibular incisor lies wholly on the inner (lingual) side of the molar series. (Pl. III, fig. 1.)

The molars are all rootless. The upper molar series is about one-third the basilar length of skull, the lower series slightly less. The enamel pattern (figs. 8 and 10) is characterized by the great depth of the outer reentrant angles in the maxillary teeth and of the inner reentrant angles in the mandibular teeth. Of the maxillary teeth $\overline{m\ 1}$ and $\overline{m\ 2}$ show no important peculiarities of form except that the outer reentrant angles cut across to the enamel of the extreme inner side, a feature shared by *Lemmus* alone. The posterior upper molar, however, like that of *Lemmus*, differs widely from the corresponding tooth in all other *Microtinæ*. It is formed of four transverse loops. The first and second of these loops are isolated by two deep reentrant angles on the outer side of the tooth, while the third is formed by an equally deep depression on the inner side. The reentrant angles and closed triangles on the inner side of the mandibular molars are greatly developed at the expense of those on the outer side. In the subgenus *Mictomys* the latter wholly disappear except in the last tooth. This has a reentrant angle near the middle, but no closed triangle.

External form.—In general appearance *Synaptomys* resembles the *Microti* much more closely than it does the *Lemmi*, a fact which has given rise to the rather inappropriate names 'lemming-vole' and 'false lemming.' The species of *Synaptomys* are thick-set microtines with large heads, ears that just appear above the moderately long fur, short tails, and small feet. In color they are all dull brownish, darker on the back, paler on the belly. The palms and soles are tuberculate, as in the voles.

General remarks.—*Synaptomys* differs from all the other genera of

[1] The ratio of zygomatic breadth to basilar length is approximately 70 in *Synaptomys*, 75 in *Lemmus* and *Dicrostonyx*, and 65 in *Microtus*.

Microtinæ in its grooved incisors. From the other lemmings it may be known by its unmodified external form, and from the voles by the characters of its molars.

Subgenus SYNAPTOMYS Baird.

Synaptomys Baird, Mamm. N. Am., p. 558, 1857. Type *Synaptomys cooperi* Baird.

Geographic distribution of type species.—Boreal, Transition, and northernmost edge of Austral zone in eastern United States and adjoining British Provinces; west to Minnesota, south to Iowa, Indiana, Ohio, and Maryland.

Geographic distribution of subgenus.—Boreal zone to northern edge of Lower Austral zone in eastern Canada and eastern United States; west to Minnesota, south to Kansas and Virginia.

Essential characters:

Rostrum very heavy.
Palate nearly as in true *Microtus*.
Mandibular molars with closed triangles on outer side
Mammæ 6.

Skull.—The skull of true *Synaptomys* (fig. 9 and Pl. I, fig. 13) differs from that of *Mictomys* in the remarkably heavy rostrum and in certain slight details in the form of the bony palate. The latter is almost exactly as in typical *Microtus*, the slight peculiarities in form being well within the limits of variation in the latter.

Teeth.—The incisors in true *Synaptomys* are, like the rostrum, excessively strongly built. The grooves are usually sharply defined and placed near the outer edges of the teeth.

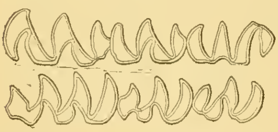

FIG. 8.—Enamel pattern of molar teeth of *Synaptomys cooperi*. (x 5.)

The maxillary teeth differ in no way from those of the species of *Mictomys*. In the molars of the lower jaw, however, the outer edge of each tooth is cut by a deep reentrant angle which isolates a large outer triangle (fig. 8).

Mammæ.—The number of mammæ in *Synaptomys* has been variously recorded as four and six. Dr. Coues, in his monograph of the American *Microtinæ*, states that he finds six, four pectoral and two inguinal, in a female from Brookville, Ind.[1] Quick and Butler,[2] however, noted only four, two pectoral and two inguinal, in specimens from the same locality. Mr. Vernon Bailey records six mammæ in a female collected for the United States Department of Agriculture at Ann Arbor, Mich., and I find the same number in an alcoholic specimen taken at Rogersville, Tenn. It is probable that six is the normal number, and that Quick and Butler overlooked the posterior pair on the breast, as these are smaller than the others, at least in the alcoholic specimen from Tennessee.

[1] Monogr. N. Am. Rodentia, p. 236.
[2] American Naturalist, XIX, p. 114.

General remarks.—The characters distinguishing the subgenera *Synaptomys* and *Mictomys* are discussed under the latter.

Three species of true *Synaptomys* are now known: *S. cooperi* Baird, *S. fatuus* Bangs, and *S. helaletes* Merriam.[1]

Subgenus MICTOMYS True.

1894. *Mictomys* True, Proc. U. S. Nat. Mus., XVII, No. 999, p. 242. Advance sheet, April 26, 1894 (full genus). Type *Mictomys innuitus* True.

1896. *Mictomys* Merriam, Proc. Biol. Soc. Washington, X, p. 57, March 19, 1896 (subgenus).

Geographic distribution of type species.—*Synaptomys innuitus* is known from the type locality only, Fort Chimo, Ungava, Labrador.

Geographic distribution of subgenus.—Hudsonian zone from Labrador to Alaska, south to northern California.

Essential characters:

Rostrum slender.
Palate not as in true *Microtus*.
Mandibular molars without closed triangles on outer side.
Mammæ 8.

Skull.—The skull of *Mictomys* is in general much like that of *Synaptomys* proper, but the whole rostral part (including incisors) is disproportionally slender and weak (fig. 9, and Pl. I, fig. 12). The bony palate is formed on the same plan as that of true *Synaptomys* or of *Microtus* proper, but differs from both of these in the prolongation of the median ridge as a spine projecting into the interpterygoid fossa.

The pterygoids are usually longer and more slender than in *Synaptomys*, and the hamular processes less strongly bent outward.

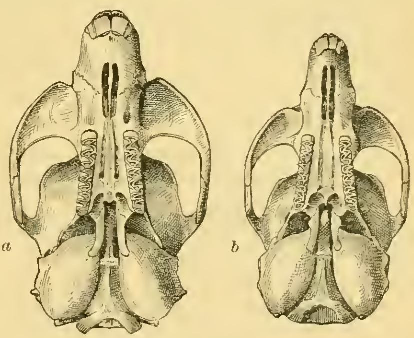

FIG. 9.—*a. Synaptomys helaletes; b. Synaptomys wrangeli.*

Teeth.—The incisors in *Mictomys* are much smaller in proportion to the size of the skull than in the subgenus *Synaptomys*. The grooves in the upper incisors are usually nearer the middle of the tooth, and less well defined than in true *Synaptomys*.

The maxillary teeth (fig. 10) are exactly as in the subgenus *Synaptomys*. The lower molars, however, differ from those of true *Synaptomys* in the absence of reentrant angles on the outer borders of all but the hindermost. Even in this the reentrant angle is never deep enough to isolate an outer triangle.

Mammæ.—In the type of *Synaptomys innuitus* there are eight mammæ, two more than have been recorded in *Synaptomys* proper. Whether

[1] See Merriam, Proc. Biol. Soc. Washington, X, p. 57, 1896.

this difference is constant or otherwise, it is, however, impossible to say.

General remarks.—*Mictomys* was first described as a full genus, but the characters on which it rests are of no more than subgeneric importance. The group is distinguished from true *Synaptomys* by the slender rostrum and incisors, slightly different form of bony palate, crenulate outer border of lower molars, and probably by the number of mammæ also.

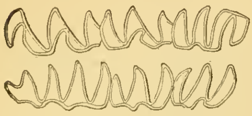

FIG. 10.—Enamel pattern of molar teeth, *Synaptomys innuitus.* (x 5.)

Four species of *Mictomys* have thus far been described, *Synaptomys innuitus* (True), *S. wrangeli* Merriam, *S. dalli* Merriam, and *S. truei* Merriam.[1]

Genus LEMMUS Link.

1795. *Lemmus* Link, Zool. Beyträge, I, Pt. II, p. 75, 1795. Type by elimination *Mus lemmus* Linn.

1811. *Myodes* Pallas, Zoogr. Rosso-Asiat., I, p. 172, 1811 (part).

1877. *Myodes* Coues, Monogr. N. Am. Rodentia, p. 237, 1877, and most subsequent authors.

Geographic distribution of type species.—Arctic region in Asia and eastern Europe.

Geographic distribution of genus.—Arctic region in both hemispheres.

Essential characters:

Upper incisors without grooves.
Lower incisors with roots on inner (lingual) side of molars.
Molars rootless.
Enamel pattern as in *Synaptomys.*
Feet highly modified.
Palms and soles without well-developed tubercles.
Thumb with large flattened 'strap-shaped' nail.
Tail shorter than hind foot, terete.
External ear small but well developed.

Skull.—The skull of *Lemmus* (Pl. I, fig. 6) is perhaps the most highly modified in the family *Microtinæ*. The rostrum, like that of *Synaptomys*, is short in proportion to the length of the skull (nasal bones contained about three and one-half times in occipito-nasal length), the dorsal profile bent abruptly downward. Zygomatic arches very abruptly and broadly flaring, each expanded near the middle into a wide, strongly oblique plate.[2] Brain case broad, flat, and subquadrate in outline, but dwarfed in appearance by contrast with the large zygomata. Pterygoids short (about as in *Synaptomys*). Bony palate terminating essentially as in *Synaptomys*, but lateral pits very deep and anterior

[1] See Merriam, Proc. Biol. Soc. Washington, X, p. 61, 1896.

[2] These plates may be nearly 5 mm. across in the widest part.

edge of interpterygoid fossa carried forward over (dorsad to) overhanging edge of palate (Pl. II, fig. 14). The anterior edge of the squamosal forms a narrow but distinct shelf-like postorbital process, much as in *Synaptomys*, but more strongly developed.

Teeth.—The dentition of *Lemmus* is essentially the same as that of *Synaptomys*. The upper incisors are, however, much more slender in proportion to the size of the skull, and are without the peculiar grooves always present in *Synaptomys*. In the pattern of enamel folding, the only difference between the two genera is that the third transverse loop in the hindermost maxillary tooth is isolated by a single reentrant angle in *Synaptomys*, and by the contact of two reentrant angles in *Lemmus* (fig. 11).

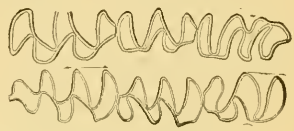

FIG. 11.—Enamel pattern of molar teeth, *Lemmus lemmus*. (x 5.)

External form.—In external form the species of *Lemmus* differ very widely from all other microtines except *Dicrostonyx*. The head is disproportionately large for the short thick body,[1] while the tail is reduced to a mere rudiment only about two-thirds as long as the hind foot. The feet are highly modified to fit the animals to their fossorial habits. While the hind feet are unusually large and strong, the front feet are even more specialized. The thumb is provided with a large ligulate nail and the fingers are armed with long, sharp claws (fig. 12). The claws are, however, simple in form and are not subject to the periodic changes that occur in those of *Dicrostonyx*.

In the alcoholic specimens that I have examined the palms show no trace of tubercles, but the soles bear indications of several very small and exceedingly rudimentary pads close to the base of the toes. The fur is remarkably long and dense, the palms and soles densely furred, and the tail provided with a pencil of stiff bristle-like hairs longer than the tail vertebræ.

FIG. 12.—Left front foot, *Lemmus lemmus* (hair removed).

General remarks.—The species of *Lemmus* are true lemmings with highly modified skull and external form. With these characters they combine the dentition of *Synaptomys* without, however, the peculiar incisors of the latter. *Lemmus* differs from *Synaptomys* in its highly modified skull and external form as well as in the dental character just mentioned. From *Dicrostonyx* it is distinguished by cranial and dental characters and by the well-developed external ears (fig. 15), as well as by the simple claws and large thumb nail.

The species of *Lemmus* at present recognized are *L. lemmus* (Linnæus), *L. obensis* (Brants), *L. schisticolor* (Lilljeborg), and *L. nigripes* (True).

[1] This peculiarity is carried even further in *Lemmus* than in *Synaptomys*.

Genus DICROSTONYX Gloger.

1830. *Cuniculus* Wagler, Nat. Syst. d. Amphibien, p. 31, 1830 (part).
1877. *Cuniculus* Coues, Monogr. N. Am. Rodentia, p. 243, 1877.
1841. *Dicrostonyx* Gloger, Gemeinn. Hand- u. Hilfsbuch d. Naturgesch., pp. XXXI, 97, 1841. Type, an American species, probably *Mus hudsonius* Pall.
1854. "*Myolemmus* Pomel, Ann. Sci. Soc. Auvergne, 1854" (fide Trouessart).
1855. *Misothermus* Hensel, Zeitschr. der Deutsch. geolog. Gesellsch., VII, p. 492, 1855. Type *Myodes torquatus* Pall.
1881. *Borioikon* Polyakoff, Mém. Acad. Imp. Sci. St. Petersbourg, XXXIX, suppl. p. 34, 1881. Type *Myodes torquatus* Pall.

Geographic distribution of type species.—Arctic America.

Geographic distribution of genus.—Arctic region in both hemispheres.

Essential characters:

Upper incisors without grooves.
Lower incisors with roots on inner (lingual) side of molars.
Molars rootless.
Enamel pattern characterized by approximate equality of reentrant angles.
$\overline{\text{m}}$ 1 with 7 closed triangles and 2 transverse loops.
m 3 with 3 or 4 closed triangles and 2 transverse loops.
Feet highly modified.
Palms smooth; soles with rudimentary tubercles.
Thumb with a rudimentary nail.
Tail shorter than hind foot, terete.
External ear rudimentary.

Skull.—The skull of *Dicrostonyx* (Pl. I, fig. 14) in a general way resembles that of *Lemmus*, but is smaller and more lightly built. The zygomata are less broadly flaring and the expansion near the middle is comparatively slight. The outer face of the expanded portion, as in *Lemmus*, is strongly oblique. The rostrum is also lighter and more slender. While the pterygoids are proportionally longer than in *Lemmus*, the posterior edge of the bony palate is formed exactly as in the latter (Pl. II, figs. 12 and 14). The anterior edge of the squamosal gives off a conspicuous peg-shaped postorbital process very different from the postorbital process in *Lemmus* or any of the other *Microtinæ*. These pegs are especially conspicuous when the skull is viewed from the ventral aspect.

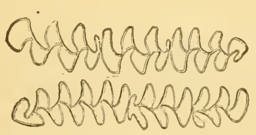

Fig. 13.—Enamel pattern of molar teeth, *Dicrostonyx* from Ungava, Labrador. (x 5.)

Teeth.—Incisors essentially as in *Lemmus*. Molars rootless. Pattern of enamel folding (fig. 13) very different from that of either of the other genera of *Lemmi* and in some respects resembling that of the *Microti*. The reentrant angles on the opposite sides of the teeth are approximately equal in depth, thus producing closed triangles of nearly the same size on the two sides. The first lower molar contains seven closed triangles in addition to a transverse loop at each end. The second lower molar contains a posterior loop followed by four alternating closed triangles and an anterior transverse loop, which is much flattened and so small that the tips of the salient angles do not reach to the level of the tips of the other salient angles of the tooth. Occasionally the anterior outer triangle opens into the transverse loop. The posterior lower molar has a posterior transverse loop followed by three large closed or nearly closed triangles (two on the inner side), and a fourth smaller triangle on the outer side.[1] The maxillary teeth have each a large anterior loop. This is followed in the first by five alternating closed triangles and a small postero-external loop, in the second by four closed triangles and a small postero-external loop, and in the third by four closed triangles and a small rounded terminal loop.

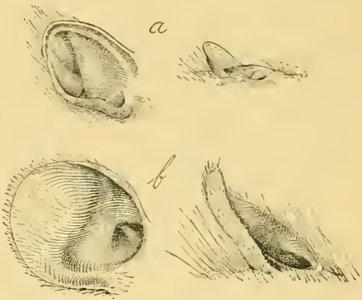

FIG. 14.—Ear, (*a*) *Dicrostonyx*, (*b*) *Lemmus* (double natural size).

External form.—In external form the species of *Dicrostonyx* are even more specialized than the members of the genus *Lemmus*. As in the latter, the head is very large, the tail is reduced to a stub, shorter than the hind foot, and the feet are highly modified for digging. The external ears are, however, mere naked folds of integument lying just behind the meatus (fig. 14 *a*). The fur is long and dense, much as in *Lemmus*. The palms and soles are densely furred, and the tail is provided with a stiff pencil of bristle-like hairs, longer than the tail vertebræ. The hind feet are very broad, the breadth at base of toes being about one-half length of foot.[2] On the hind foot there are several minute, faintly developed tubercles near the base of the toes. The palms are, however, perfectly smooth. The claws on the hind feet are large and well formed, though in no way different from those of *Lemmus*. Those on the front feet are very highly modified, and present seasonal changes in size and form unknown elsewhere among the *Microtinæ*. The thumb (fig. 15) is greatly reduced in size. The thumb nail is so small as readily to escape notice, but the ball of the thumb projects as a distinct tubercle, the surface of which is covered with a thick layer of corneous tissue. The claws on the second and fifth fingers are large, though not peculiar in form. The two middle claws, on the contrary, while in summer not different from those of *Lemmus*, are in winter very greatly enlarged (fig. 15), and

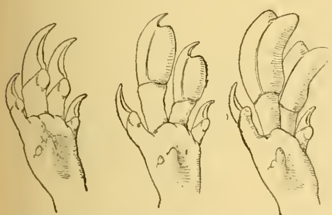

FIG. 15.—Left front foot of three specimens of *Dicrostonyx* from Alaska, showing successive stages in the development of the claws (hair removed).

[1] In *Dicrostonyx torquatus* there is a minute supplemental anterior internal loop which is absent in the species that occurs in Labrador.

[2] In *Lemmus* this breadth is only about one-third length of foot.

wholly unlike those of any other microtine. Dr. Coues's description of the claws of *Dicrostonyx* is so interesting that it may be quoted almost entire. He says (Monogr. N. Am. Rodentia, pp. 248, 249):

> The two middle fore claws attain their maximum of development in winter. In spring and early summer these claws do not appear very different from those of *Myodes* [=*Lemmus*], though averaging larger, more bulbous at base underneath, with the terminal portion slenderer, straighter, and sharper. This bulbous portion underneath grows out simultaneously with increase in length and amount of curvature of the main portion of the claw, until it equals or even exceeds the length of the latter, and is quite as stout, or even stouter, being somewhat broad and pad-like. At this period it runs the whole length of the claw, from which it is separated by a groove along the sides, and by a notch at the end, both of varying depth. The claw then looks nearly like two claws, one underneath the other. The pad would then seem to gradually sever its connection with the main claw by progressive increase in depth of the constriction marked by the lateral groove and terminal notch, as well as by loosening from the base, when it appears like an excrescence; it is finally lost. Thus the process appears to be a periodical one, like the shedding of the horns of ruminants, and not continually progressive with age; and would seem to be connected with the particularly fossorial habits of the quasi-hibernating animal that digs galleries under ground in which to reside during the cold season, as compared with its freer and more active mode of life in summer. At the period of the maximum development of the claws these equal or surpass half an inch in length. * * *

General remarks.—Dicrostonyx is so readily distinguished by its peculiar dentition, highly modified feet, and rudimentary external ears, that it requires no detailed comparison with any other genus.

While *Dicrostonyx torquatus* (Pallas) is the only species now recognized, there are doubtless several others.

Genus PHENACOMYS Merriam.

1889. *Phenacomys* Merriam, North American Fauna No. 2, p. 28, October 30, 1889.

Geographic distribution of type species.—Phenacomys intermedius is known only from the type locality, Kamloops, British Columbia.

Geographic distribution of genus.—Boreal North America; also recorded from the bone breccia of Beremend, southern Hungary, and the Forest Beds of Norfolk and Suffolk, England (Nehring, Naturwissenschaftliche Wochenschrift, Nr. 28, p. 346, July 15, 1894.)[1]

Essential characters:

Upper incisors without grooves.

Lower incisors with roots on outer side of molars.

Molars rooted.

Enamel pattern characterized by approximate equality of reentrant angles in maxillary teeth and great depth of reentrant angles on inner side of mandibular teeth.

$\overline{\text{m}\,1}$ with five closed triangles.

$\underline{\text{m}\,3}$ with two or three closed triangles,

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[1] I have not seen the original description of the remains from Beremend (described by Nehring in Naturwissenschaftliche Wochenschrift, 1883). The teeth from the Forest Beds represent an animal which is certainly not *Phenacomys*. (See note on *Arvicola intermedius* Newton on page 75.)

Bony palate not terminating in a thin-edged shelf continuous between alveoli of posterior incisors.
Feet not specially modified.
Thumb with a small pointed nail.
Tail longer than hind foot, terete.
Fur not specially modified.

Skull.—The skull of *Phenacomys* (Pl. I, fig. 5) differs very slightly in general form from that of typical *Microtus*. The brain case is, however, flatter and more quadrate (but no more so than in the subgenera *Lagurus* and *Pitymys*), and the zygomata bend down somewhat more abruptly in front. The expansion of the zygoma at the region of contact between the malar and the zygomatic process of the maxillary is rather more abrupt than is usual in *Microtus*, but the difference is very trifling. The postorbital processes of the squamosals are slightly more prominent and angular than in *Microtus arvalis* or *M. pennsylvanicus*, but scarcely more developed than in *M. agrestis*, and considerably less so than in *M. alleni*. The audital bullæ are proportionally about the same size as or slightly smaller than in *Microtus arvalis*. They are more globular and less 'subfusiform' than in the typical species of true *Microtus*, but closely resemble those of *M. agrestis*. The palate (Pl. II, fig. 1) is formed essentially as in the members of the subgenus *Lagurus* (Pl. II, figs. 3 and 4).

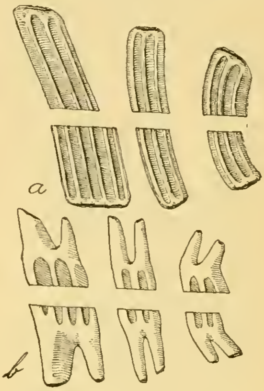

Fig. 16.—Side view of molars, *Phenacomys*. (*a*) young, (*b*) adult. (x 3.)

Teeth.—The teeth of *Phenacomys* differ in many ways from those of the other voles. In young individuals the molars (fig. 16) are rootless, but by the time the animals are full grown each molar has developed two distinct roots, which, however, remain open until an advanced age, though not so long as in the genus *Evotomys*. The pattern of enamel folding (fig. 17) is essentially the same as that of the voles of the subgenera *Pedomys* and *Phaiomys*. (See pp. 56 and 57.) The differences are to be found in the lower molars where the reentrant angles on the inner side are proportionally deeper and those on the outer side proportionally shallower than in *Pedomys*. There is a corresponding difference in the size of the closed triangles on the opposite sides of the teeth. The anterior outer loop in the second lower molar is especially reduced.

Fig. 17.—Enamel pattern of molar teeth, *Phenacomys celatus*. (x 5.)

In *Phenacomys* the root of the lower incisor runs back between the roots of the second and third molars, and terminates on the outer side of the tooth row in the ascending ramus of the jaw, at about the level of the middle of the posterior molar, and distinctly below the dental foramen. (Pl. III, fig. 2.) While exactly this condition is not found elsewhere except in *Evotomys*, it is somewhat closely approached in *Fiber*.

External form.—In external form the species of *Phenacomys* show no peculiarities to distinguish them from the other voles. The body, tail, feet, ears, and eyes are usually proportioned about as in *Microtus arvalis* or *M. austerus*. In *P. longicauda*, however, the tail is proportionally longer than in any of the other known species.

General remarks.—*Phenacomys* is readily distinguished from *Microtus* by the rooted molars. From *Evotomys*, *Phenacomys* is separated by certain characters in the form of the skull, and more especially of the bony palate, as well as by peculiarities in the teeth. The differences between the three genera may be compared in detail as follows:

Microtus.	*Evotomys.*	*Phenacomys.*
Root of lower incisor above dental foramen.	Root of lower incisor below dental foramen.	Root of lower incisor below dental foramen.
Molars rootless throughout life..	Molars rooted in the adult, the roots closed in extreme old age.	Molars rooted in the adult, the roots closed in extreme old age.
Molars large and strong, the salient angles sharp.	Molars small and weak, the salient angle rounded.	Molars large and strong, the salient angles sharp.
Reentrant angles on outer and inner sides of lower molars approximately equal in depth.	Reentrant angles on outer and inner sides of lower molars approximately equal in depth.	Reentrant angles on inner side of lower molars very much deeper than those on outer side.
Skull strong and angular........	Skull weak and rounded........	Skull strong and angular.
Posterior border of bony palate extremely variable.	Posterior border of bony palate a thin-edged shelf continuous between alveoli of posterior molars.	Posterior border of palate never a thin-edged shelf.
Middle portion of zygoma distinctly expanded.	Middle portion of zygoma scarcely expanded.	Middle portion of zygoma distinctly expanded.

Since the discovery of the genus *Phenacomys* the following species have been described: *P. intermedius* Merriam, *P. celatus* Merriam, *P. ungava* Merriam, *P. latimanus* Merriam, *P. orophilus* Merriam, *P. longicauda* True, *P. truei* Allen, and *P. oramontis* Rhoads. The status of these forms is wholly a matter of conjecture.

Genus EVOTOMYS Coues.

1839. *Myodes* DeSélys Longchamps, Études de Micromammalogie, p. 87, 1839 (section).

1883. *Myodes* Lataste, Le Naturaliste, Tome II, p. 349, 1883 (subgenus).

1840. *Hypudæus* Keyserling and Blasius, Die Wirbelthiere. Europas, p. 34, 1840 (subgenus). Type *Mus glareolus* Schreber. (Not *Hypudæus* Illiger, 1811.)

1857. *Hypudæus* Baird, Mamm. N. Am., p. 513, 1857 (subgenus).

1874. *Evotomys* Coues, Proc. Acad. Nat. Sci. Phila., p. 186, 1874 (genus). Type *Mus rutilus* Pall

Geographic distribution of type species.—Arctic region in Europe and Asia, possibly in America also.

Geographic distribution of genus.—Boreal North America, Asia, and Europe.

Essential characters:

Upper incisors without grooves.
Lower incisors with roots on outer side of molars.
Molars rooted.
Enamel pattern characterized by approximate equality of reentrant angles.
m 1 with five closed or nearly closed triangles.
m 3 with three closed triangles.
Feet not specially modified.
Thumb with a small, pointed claw.
Fur not specially modified.
Tail longer than hind foot, terete.

Skull.—The skull of *Evotomys* (Pl. I, fig. 4), as compared with that of the other voles, is characterized by a general weakness and lack of angularity. All the outlines are full and rounded, and the ridges and furrows are slightly developed, even in extreme old age. The interorbital region is broader and the audital bullæ are larger and more inflated than usual in *Microtus* and *Phenacomys*. On the other hand, the zygomata are very slender and scarcely widened in the region of contact between the jugal and the zygomatic process of the maxillary. The mandible also is slender and weak. The bony palate terminates in a thin-edged shelf, continuous between the alveoli of the posterior incisors (fig. 7 and Pl. II, fig. 10). The structure is very different from that found in *Phenacomys* and in typical *Microtus*.[1]

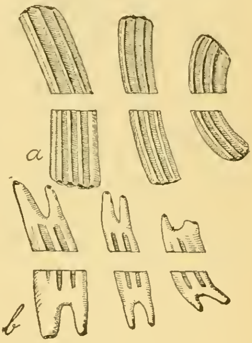

FIG. 18.—Side view of molars, *Evotomys*. (*a*) young, (*b*) adult. (x 3.)

Teeth.—The incisors are exactly as in *Phenacomys*. The lower incisor runs back along the lingual side of the first and second molars, but crosses the line of the molar tooth row between the second and third molars, terminating in the ascending ramus of the mandible at about the level of the middle of the posterior molar and distinctly below the dental foramen. The molars are rootless in the young (fig. 18), but in the adult each is provided with two distinct roots which eventually become fully closed.[2] In one very old individual the crowns of the lower molars are completely worn away, so that each root, with the exception of the anterior root of m 3 (which has been shed) stands alone like a simple, round-topped tooth (Pl. III, fig. 4). The molars are all very narrow and weak, in this character strongly contrasted with the strong, broad teeth of *Microtus* and *Phenacomys*.

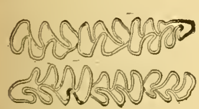

FIG. 19.—Enamel pattern of molar teeth, *Evotomys gapperi*. (x 5.)

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[1] For detailed comparison of the palates of *Evotomys* and *Microtus* see pages 26–28.

[2] In the original description of the genus *Phenacomys* (North Am. Fauna No. 2, p. 30) it is stated that "*Phenacomys* has genuine rooted molars, not half-rooted molars like those of *Evotomys*, which grow from persistent pulps." *Evotomys*, however, has as perfectly rooted molars as *Phenacomys*, though the roots do not close so early in life.

In the number and arrangement of triangles the enamel pattern (fig. 19) is the same as that of the tetramerodont species of *Microtus* (see p. 65). The salient angles are, however, for the most part rounded, and so placed that the triangles are seldom fully closed.

External form.—In external form *Evotomys* does not differ essentially from *Microtus*, although the ears are usually larger. The red or rufous color of most of the species gives them a very different appearance from the other voles.

General remarks.—The characters which separate *Evotomys* from *Microtus* and *Phenacomys* have been presented in such detail under the latter that it is unnecessary to consider them further. The peculiar bony palate of *Evotomys* has been considered one of the best generic characters. Since the discovery that it is perfectly reproduced in two subgenera of *Microtus* (*Anteliomys* and *Eothenomys*) it loses much of its importance.

The genus *Evotomys* is represented in Europe, Asia, and North America by numerous species and subspecies whose interrelationships are at present little understood. Among the American species may be mentioned *E. gapperi* (Vigors), *E. fuscodorsalis* Allen, *E. galei* Merriam, *E. idahoensis* Merriam, *E. californicus* Merriam, and *E. occidentalis* Merriam; among those found in the Old World are *E. rutilus* (Pallas), *E. glareolus* (Schreber), and *E. rufocanus* (Sundevall).

Genus MICROTUS Schrank.

1798. *Microtus* Schrank, Fauna Boica, I, 1ste Abth., p. 72, 1798. Type by elimination *Microtus terrestris* Schrank = *Mus arvalis* Pall.

1883. *Microtus* Lataste, Le Naturaliste, Tome II, p. 348, 1883.

1801. *Arvicola* Lacépède, Mém. de l'Institut, III, p. 489, 1801. Type '*Arvicola amphibius*' = *Mus terrestris* Linn.

Geographic distribution of type species.—Central Europe and parts of Asia.

Geographic distribution of genus.—In both hemispheres the genus *Microtus* ranges from near the northern limit of mammalian life to the edge of the tropics.

Essential characters:

Upper incisors without grooves.
Lower incisors with roots on outer side of molar series.
Molars rootless.
Enamel pattern characterized by approximate equality of reentrant angles.
$\overline{\text{m 1}}$ usually with five closed or nearly closed triangles.
$\underline{\text{m 3}}$ with one, two, or three closed triangles.
Tail nearly always longer than hind foot, terete.
Feet, fur, eyes, and ears very variable.
Thumb never with a well-developed ligulate nail.

Skull.—The skull of *Microtus* varies greatly in shape among the different subgenera. Full descriptions will be given under each of these. Considering the genus at large it is difficult to frame any diagnosis by which the skull may be in every case distinguished from that of the other voles. Most of the characters which at various times have been brought forward for this purpose prove to be either wholly inconstant or constant only when particular subgenera are held in view.

Teeth.—Although the skull of *Microtus* presents no tangible diagnostic characters, the teeth are readily distinguishable from those of all other members of the subfamily. The upper incisors are never grooved except in occasional abnormal specimens. The root of the lower incisor crosses the line of the molar series between the second and third molars, causing a greater displacement of the roots of the latter (Pl. III, fig. 3) than occurs in any other genus. It terminates in the ascending ramus of the mandible at a point slightly above and behind the dental foramen (Pl. III, fig. 3). The molars, even in extreme old age, are never rooted (fig. 20). This character alone distinguishes them from the molars of the other voles. The pattern of enamel folding varies considerably in the different subgenera, and forms one of the numerous characters by which the latter may be separated. Detailed descriptions of the enamel patterns are given in the accounts of the subgenera.

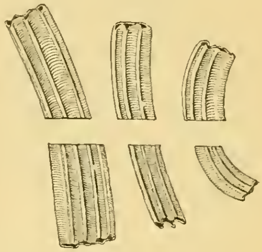

Fig. 20.—Side view of molars of adult *Microtus alleni*. (x 2.)

External form.—In external form the members of the genus *Microtus* vary excessively. Some resemble lemmings so closely that they have been associated with these by certain writers. Others are modified for an aquatic life and in consequence have more the appearance of muskrats (*Fiber*). Still others pass most of their time under ground. In these the ears, eyes, and tail are reduced, the front feet enlarged, and the fur so modified as to suggest that of the moles. The great majority of species, however, show none of these special adaptations, but resemble in a general way the members of the genera *Phenacomys* and *Evotomys*. Whatever may be the modifications in form, the tail is almost invariably longer than the hind foot and the thumb is armed with a small or rudimentary pointed nail (fig. 21).

Fig. 21.—Left front foot, *Microtus terrestris*.

General remarks.—The characters of *Microtus*, as contrasted with *Evotomys* and *Phenacomys*, have already been given (p. 42) and need not be repeated here.

Subgenus EOTHENOMYS[1] Miller.

New subgenus. Type *Arvicola melanogaster* Milne-Edwards.

Geographic distribution of type species.—Moupin, western Sechuen, and western Fokien, China. (Blanford.)

Geographic distribution of subgenus.—*Microtus melanogaster* is the only known species of *Eothenomys*, hence the geographic distribution of the subgenus is the same as that of the type species.

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[1] Ἠώς, the morning (eastern); θεν, from; μῦς, mouse.

Essential characters:

Palate abnormal.
m 3 without closed triangles.
m 1 with triangles frequently open and 8 or 9 salient angles.
m 3 with triangles usually open and 6 salient angles.
Mammæ (number not known).
Plantar tubercles, 5.
Sole hairy.
Claws on hind feet longest.
Fur apparently somewhat modified.

Skull.—In the specimens of *Eothenomys* that I have examined the skull is not in sufficiently good condition to permit of any detailed description. The peculiar structure of the bony palate taken in connection with the teeth is, however, of itself enough to characterize the group.

Bony palate.—Unfortunately in the two specimens of *Microtus melanogaster* that I have seen (82.6.16.11 and 92.10.12.5, British Museum Register) the basal part of the skull is so injured that the form of the interpterygoid fossa can not be determined. The bony palate, however, is sufficiently preserved to show the essential details of its structure (Pl. II, fig. 11). That part of the palate which lies in the level of the roof of the mouth ends abruptly opposite the front end of the back upper molar in a straight-edged shelf which extends without notch or projection from alveolus to alveolus. Although the form is thus strikingly different from that of the typical microtine palate, the vestiges of the structure there present may still be recognized. The lateral grooves and median ridge are present, though slightly developed. The former terminate in two depressions lying just in front of the wide, flat, lateral bridges which completely obliterate the posterior ends of the grooves, and together with the terminal part of the median ridge form the edge of the palatal shelf. The palate in all its essential characters is thus exactly like that of *Evotomys*.

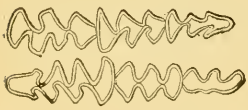

Fig. 22.—Enamel pattern of molar teeth, *Microtus* (*Eothenomys*) *melanogaster*. (x 5.)

Enamel pattern in general.—The enamel pattern in *Eothenomys* (fig. 22) is in many ways remarkable. The triangles in all the teeth tend to remain open, the points of the salient angles are blunt and rounded as in *Evotomys*, the triangles on the outer and inner sides of the teeth are subequal in size, and the maxillary teeth are especially noticeable for their likeness to each other. The figures published by Blanford[1] fail to do justice to the teeth of this species. These are better represented in Milne-Edwards's original plate,[2] in which there is also a hint at the palate structure.

[1] Journ. Asiatic Soc. Bengal, L, pt. II, Pl. II, fig. A.

[2] Recherches p. servir à l'histoire nat. d. Mammifères, Vol. 1, Pl. XLVI, figs. 1c and 1d.

Front lower molar.—The first lower molar has the usual transverse posterior loop and a moderately long rounded anterior loop, with a strong salient angle at each side of the base. It has five lateral triangles, three on the inner side, two on the outer side. These may be perfectly isolated, or more often widely open. Except for the greater tendency to equality in the triangles, the teeth in the lower jaw do not differ very greatly from the mandibular teeth of true *Microtus.*

Back upper molar.—The posterior maxillary tooth most nearly resembles that of *Pedomys.* The anterior loop is followed by two lateral triangles, subequal in size and more or less completely isolated from each other and from the anterior loop. The third lateral triangle is reduced to a strongly developed salient angle on the inner side of the posterior transverse loop. A second salient angle is formed on the outer side of this loop, which thus appears as a crescent joined near the middle of its concavity to the rest of the tooth.

Other teeth.—The middle upper molar has a postero-internal loop nearly as large as the postero-external loop, the two placed opposite each other. The result is a tooth of practically the same shape as the one behind it. The anterior upper molar is likewise provided with a very large postero-internal loop opposite the loop on the outer side, normally terminating the tooth. Thus it very closely resembles the two other maxillary teeth, differing only in its one more closed triangle at the front end.

Mammæ.—The number of mammæ in *Eothenomys* is unknown.

Feet.—The feet are moderately hairy, in this respect not differing from true *Microtus.* Blanford states that there are five well-developed pads on the sole and a rudimentary sixth. The claws are not greatly developed on any of the feet; those on the hind feet are the longest.

Fur.—A skin in the British Museum has the fur of a peculiar, dense, mole-like quality suggestive of *Pitymys.* The specimen appears to be in worn coat, however, and this character may not be normal.

General remarks.—*Eothenomys* is such a well-marked subgenus that it is surprising to find that it has hitherto received no name. In tooth pattern it agrees in a general way with *Microtus sikkimensis,* a circumstance which induced Blanford to place it in the subgenus '*Neodon;*' but the palate structure is widely different from that of the subgenus *Microtus,* to which *M. sikkimensis* really belongs, while the similarity in the enamel pattern of the two species is very superficial.

Subgenus ANTELIOMYS[1] Miller.

New subgenus. Type *Microtus chinensis* Thomas.

Geographic distribution of type species.—*Microtus chinensis* is known from one specimen collected at Kiating-fu, west Sze-chuen, China.

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[1] Ἀντήλιος, eastern; μῦς, mouse.

Geographic distribution of subgenus.—*Microtus chinensis* is the only known species of the subgenus.

Essential characters:

Palate abnormal.
$\overline{\text{m 3}}$ without closed triangles.
$\overline{\text{m 1}}$ with triangles mostly open, and with 9 salient angles.
$\underline{\text{m 3}}$ with triangles mostly open, and with 9 salient angles.
Mammæ, 4.
Plantar tubercles, 6.
Sole moderately hairy.
Claws on hind feet longest.
Fur not specially modified.

Skull.—As remarked by Mr. Thomas in the original description of *Microtus chinensis*, the skull of *Anteliomys* resembles in a general way that of *Evotomys.* Unfortunately, I am unable to add any more definite information concerning its characters.

Bony palate.—The palate of *Anteliomys* (Pl. II, fig. 8) is similar to that of *Eothenomys*, except that the median ridge is produced backward as a distinct spike lying perfectly in the plain of the roof of the mouth. Just in front of the strongly developed lateral bridges, the posterior edges of which form the back rim of the bony palate, lie two pits, in which terminate the lateral grooves. These pits communicate freely over (dorsad to) the lateral bridges with the anterior end of the broad mesopterygoid fossa.

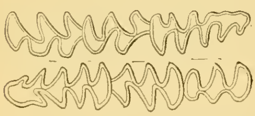

FIG. 23.—Enamel pattern of molar teeth, *Microtus* (*Anteliomys*) *chinensis*. (x 5.)

Enamel pattern in general.—The enamel pattern in *Anteliomys* (fig. 23) is characterized by rounded angles, imperfectly closed triangles, and great complexity in the prisms of the back upper molar.

Front lower molar.—The anterior lower molar is made up of four transverse, perfectly isolated loops. The anterior loop is much the largest and contains three salient angles (two on the inner side). Each of the succeeding loops has two salient angles. The tooth thus contains exactly the same elements as the corresponding one in *Microtus*, the difference in form being due to the fact that in *Anteliomys* the prisms are placed opposite each other instead of alternately. The prisms on the opposite sides of the tooth are nearly equal in size, thus producing the bilaterally symmetrical appearance found to a less degree developed in *Alticola* and *Eothenomys.* The figures in the original description of *Microtus chinensis*[1] give a very poor idea of the teeth.

Back upper molar.—The posterior maxillary tooth is like that of true *Microtus* except that the posterior loop is greatly lengthened and on the lingual side cut by two reentrant angles, of which the anterior is

[1] Ann. & Mag. Nat. Hist., Ser. 6, Vol. VIII, p. 118, August, 1891.

the deeper. There is a salient angle at the outer base of the posterior loop and the outer border is faintly crenulate. A tooth with nine well-developed salient angles is the result.

Other teeth.—The front maxillary teeth are exactly as in tetramerodont *Microtus*. The back molars of the lower jaw are likewise in no way peculiar. They both, however, have the prisms on the two sides opposite, thus lacking all closed triangles.

There is nothing worthy of note in the form of the incisors.

Mammæ.—In the unique type specimen of *Microtus chinensis*, which is a female, there are four teats, all inguinal.

Feet.—The sole is well haired from heel to tubercles. There are six pads on the sole, all well developed.

Fur.—The fur is not specially modified.

General remarks.—In its palate structure *Anteliomys* is related to *Eothenomys*, and more remotely to *Alticola*, together with which it bridges the gap (so far as the palate alone is concerned) between *Microtus* and *Evotomys*. These facts were in part noticed by Mr. Thomas, who says in the original account of *M. chinensis*:

> In some respects it seems to be annectent between *Evotomys* and the rest of the voles, the structure of its palate and some of its dental characters [opposite prisms and rounded angles] showing striking affinities to the former, far as its rootless teeth, fewer mammæ, and different external form separate it from any of the known members of that group.

The enamel pattern is, however, very different from that of *Evotomys*, while the resemblance to that of its nearest relative, *Eothenomys*, is almost equally remote.

Microtus chinensis is the only species of *Anteliomys* thus far known, unless *Microtus middendorffii* (Polyakoff)[1] from Siberia[2] proves to be a member of the same group. The figure of the teeth in the original description of *M. middendorffii* is suggestive of *Microtus chinensis*, though the triangles are very strongly isolated. Neither the palate structure nor the number of mammæ is given by Polyakoff, so it is impossible to come to any conclusion on the subject of the animal's true status.

Subgenus LAGURUS Gloger.

1841. *Lagurus* Gloger, Gemeinn. Hand-u. Hilfsbuch d. Naturgesch., p. 97, 1841 (genus). Type, *Lagurus migratorius* Gloger = *Mus lagurus* Pallas?[3]

1895. *Lagurus* Merriam, Am. Naturalist, XXIX, p. 758, Aug., 1895 (subgenus).

[1] Mém. Acad. Imp. Sci., St. Pétersbourg, XXXIX suppl., p. 70, 1881.

[2] Polyakoff gives the following localities: Taimur, Vilui River, Ayan, and Kara River.

[3] In restoring the generic name *Lagurus* (Ann. & Mag. Nat. Hist., 6th ser., XV, Feb. 1, 1895) Mr. Thomas gives the species *lagurus* as the type. It appears highly probable, however, that Gloger's *Lagurus migratorius* is the *Hypudæus migratorius* of Lichtenstein (Eversmann's Reise nach Buchara, p. 123, 1823) = *Microtus* (*Lagurus*) *luteus* (Eversmann).

1881. *Eremiomys* Polyakoff, Mém. Acad. Imp. Sci., St. Pétersbourg, XXXIX suppl., p. 34, 1881 (genus). Type *Mus lagurus* Pall.

Geographic distribution of type species.—Plateaus of western and central Asia.

Geographic distribution of subgenus.—The range of the subgenus *Lagurus* is very imperfectly known, but probably extends over a large part of the Boreal region in Asia and in western North America.

Essential characters:

Palate slightly abnormal.
m 3 normally with 2 or 3 tightly closed triangles.
m 1 normally with 5 closed triangles and 8 or 9 salient angles.
m 3 normally with 2 or 3 closed triangles and 5 or 6 salient angles.
Mammæ, 8.
Plantar tubercles, 5.
Sole very hairy.
Claws on hind feet longest.
Fur not specially modified.

Skull.—The skull of *Lagurus* (Pl. I, fig. 7[1]) may be at once recognized by the form of the audital bullæ (fig. 24). These are larger than in any other subgenus of *Microtus*, and are especially remarkable on account of the way in which they project backward behind the plane of the occiput. Aside from the audital bullæ, the skull does not differ very noticeably from that of *Pitymys* or *Chilotus*. As compared with that of *Pitymys*, however, the rostrum is considerably more slender. The dorsal outline is flat, as in *Chilotus*.

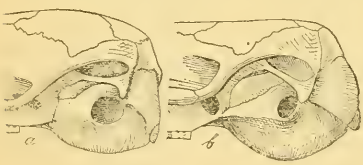

FIG. 24.—Audital bullæ, (*a*) *Microtus* (*Microtus*) *arvalis*; (*b*) *M.* (*Lagurus*) *pallidus*. (x 2.)

Bony palate.—The bony palate (Pl. II, fig. 2) is normal in structure but there is less difference than usual between the levels of the portions lying in front of and behind the lateral bridges. A peculiar flat palate with shallow lateral pits and broad, ill-defined median sloping ridge is the result. This form of palate is much like that of *Phenacomys* (Pl. II, fig. 1).

Enamel pattern in general.—The enamel pattern of *Lagurus* (fig. 25) is characterized by the tight closure of all triangles, notably in the back lower molar, and the great width of the reentrant angles. The latter peculiarity gives the

FIG. 25.—Enamel pattern of molar teeth: (*a*) *Microtus* (*Lagurus*) *pallidus*; (*b*) *M.* (*L.*) *lagurus*; (*c*) *M.* (*L.*) *luteus*. (x 5.)

[1]See also Naturwissenschaftliche Resultate der von N. M. Przewalski unternommenen Reisen, Pl. XIII, figs. 1, 2, 3, 12, 13, and 14.

teeth a drawn-out appearance, which is highly characteristic. Wide reentrant angles occur in the teeth of the young of all Microti; in *Lagurus* this embryonic character is retained by the adults.

Front lower molar.—The number of loops and triangles in the first mandibular tooth is the same as in true *Microtus*. In *Microtus przewalskii* and *Microtus luteus* the anterior loop is simple and much reduced, while in *Microtus lagurus* and *M. pallidus* the loop is exactly as in *Microtus arvalis*.

Back upper molar.—The posterior maxillary tooth differs considerably in form among the various species. In certain American species the loops and angles are arranged exactly as in *M.* (*Arvicola*) *terrestris*, while in *M. przewalskii* and *M. luteus* the tooth, although retaining the same number of elements, is remarkably like that of some of the species of *Alticola*. (See Pl. XIII, Wissensch. Resultate der von N. M. Przewalski nach Cent.-Asien untern. Reisen. Zool. Theil, Bd. I, Lief. 3.) This resemblance to *Alticola* results from the unusual elongation of the posterior loop. In *Microtus lagurus* there are three tightly closed triangles, and the terminal loop has a well developed salient angle on each side at the base.

Other teeth.—In the Old World species (fig. 25) the back lower molar contains four tightly closed triangles. The American species, however (fig. 25), so far as known, have only three closed triangles in this tooth. The other molars are always formed as in tetramerodont *Microtus*. There is nothing peculiar about the incisors.

Mammæ.—In *Microtus pallidus*, or a closely related form, there are eight mammæ, four pectoral and four inguinal. I have been able to find no statement of the number of mammæ in the Asiatic species.

Feet.—Soles densely hairy as in *Phaiomys* and the lemmings; plantar tubercles, five; claws moderately developed, those on hind feet longest.

Fur.—The fur is full and soft, but not highly modified. In color most of the species are dull yellowish or grayish. The marking of *Microtus lagurus* is unique in the genus *Microtus* on account of the strongly developed and sharply defined dark dorsal streak.

General remarks.—The subgenus *Lagurus* is a strongly characterized group, but, as Dr. Merriam has remarked,[1] the species show no peculiarities to separate them generically from *Microtus arvalis*. In *Microtus lagurus*, *M. luteus*, and *M. przewalskii*, the tail is usually shorter than the hind foot, thus adding to the superficial resemblance to the lemmings. No other voles have the tail so short.

The subgenus *Lagurus* is represented in the Old World by *Microtus lagurus* (Pallas), *M. luteus* (Eversmann), and *M. przewalskii* (Büchner). In America there are probably numerous species and subspecies. Among these may be mentioned *Microtus pauperrimus* (Cooper), *M. curtatus* (Cope), and *M. pallidus* (Merriam).

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[1] American Naturalist, XXIX, p. 758, August, 1895.

Subgenus ALTICOLA Blanford.

1884. *Alticola* Blanford, Journ. Asiat. Soc. Bengal, L, Pt. II, p. 89, 1884. Type *Arvicola stoliczkanus* Blanford.

Geographic distribution of type species.—"High plateaus of Northern Ladák (Western Tibet)" (Blanford).

Geographic distribution of subgenus.—Boreal Zone in the Himalayas.

Essential characters:

Palate abnormal.
$\overline{\text{m 3}}$ without closed triangles.
$\underline{\text{m 1}}$ with 4 or 5 closed triangles and 7 salient angles.
$\underline{\text{m 3}}$ normally with 2 closed triangles and 5 or 6 salient angles; posterior loop produced backward in line of jaw.
Mammæ, 8.
Plantar tubercles, 6.
Sole, hairy.
Claws on hind feet longest.
Fur long and soft but not highly modified.

Skull.—The skull in this subgenus (Pl. I, fig. 10) shows no striking peculiarities to distinguish it from that of true *Microtus*. The general shape is usually much as in *Microtus arvalis*, but the zygomatic arches are more flaring and the brain case is somewhat broader and flatter. The rostrum is proportionally longer than in *Microtus* proper, and the audital bullæ (fig. 27) are more inflated and papery.

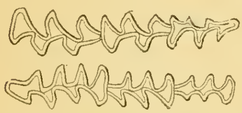

FIG. 26.—Enamel pattern of molar teeth, *Microtus* (*Alticola*) *albicauda* (type). (x 5.)

Bony palate.—The median palatal ridge (Pl. II, fig. 4) widens at a point opposite the space between the second and third molars and is approached, as in the typical microtine palate, by outgrowths from the opposite sides of the lateral grooves. These outgrowths, however, do not meet the median ridge, but leave the lateral grooves open. Just at its widest point the median ridge is squarely truncated. The sloping terminal ridge is entirely lacking and the space that it usually occupies forms the anterior end of the very long rectangular interpterygoid fossa. A structure of much the same appearance could be produced by widening the anterior end of such a hastate interpterygoid fossa as that often present in '*Aulacomys*' (Pl. II, fig. 7) until the whole space acquired an equal breadth. The floors and median walls of the lateral pits would then be so encroached upon as to obliterate the pits, while a few slight further modifications would give a palate indistinguishable from that of *Alticola*. The palate of *Alticola* resembles that of *Neofiber* more closely than it does that of any other subgenera except *Hyperacrius*.

Enamel pattern in general.—The enamel pattern in *Alticola* (fig. 26) differs in many ways from that of any subgenus of *Microtus*. In general it is characterized by (*a*) a tendency to reduction in the number of prisms in the variable teeth; (*b*) by a peculiar irregularity and indefiniteness in outline; (*c*) by a strong tendency toward bilateral symmetry caused by the approximately equal size of the triangles on the opposite sides of the teeth, and (*d*) by the form of the posterior upper molar.

While the figures published by Blanford[1] in his paper on the voles of the Himalayas, Tibet, and Afghanistan are in many ways inaccurate, they give an excellent idea of the general appearance of the teeth in the voles of this group.

Front lower molar.—The first mandibular molar has normally four closed triangles and seven or eight salient angles. Rarely a fifth closed triangle is isolated at the inner basal angle of the anterior loop. The form, relative position, and degree of isolation of the triangles and transverse loops vary greatly with the different species. Any one of the reentrant enamel folds may fail to reach the enamel of the opposite side, and consequently any of the triangles may be open at one or both ends.

Back upper molar.—The posterior maxillary tooth varies in form in the different species. It is, however, always recognizable by the backward prolongation of the posterior loop in the line of the jaw, a character which is found elsewhere in *Hyperacrius*, *Chilotus*, and *Lagurus* only, and in all but the first of these developed to a much less degree. This attenuate posterior loop is followed by three or four more or less incompletely isolated lateral triangles, these by an anterior loop of the usual form. The tooth is most complex in *M. roylei* and *M. blanfordi*, in each of which it has six salient angles and two or three closed triangles.

Other teeth.—Except for the stronger tendency to bilateral symmetry combined with slight irregularity of outline the other molars do not differ from those of ordinary tetramerodont *Microtus*.

Mammæ.—The number of mammæ in the species of *Alticola* has apparently not been recorded. Blanford does not mention it in his descriptions of any of the species, and Mr. G. E. H. Barrett-Hamilton, who has made at my request a special examination of the material in the British Museum, is able to add nothing on the subject. In an adult nursing female of a species of *Alticola* closely allied to *Microtus albicauda* (No. 62162, U. S. Nat. Mus. Ladák side of Kara Korum Pass, Kashmir) there are eight well-developed mammæ. Hence there is little doubt that eight is the normal number in the subgenus.

Feet.—The feet are very hairy, the long hairs on the dorsal surface often nearly concealing the claws. Plantar tubercles six. The claws on all the feet are long and slender, those on the hind feet longer than those in front.

Fur.—As in most high boreal microtines the fur is long and full. Otherwise it is not peculiar.

General remarks.—The subgenus *Alticola* is one of the best characterized groups in the genus *Microtus*. The pattern of enamel folding is unlike that of any of the other subgenera, except *Hyperacrius*, while the palate structure is approached by that of *Hyperacrius* and the

[1] Journ. Asiatic Soc. Bengal, L, Pt. II, Pl. I, figs. B, C, D, and E.

otherwise widely different *Neofiber* only. The tendency to bilateral symmetry in the molars is shared by three other Asiatic subgenera, *Hyperacrius*, *Eothenomys*, and *Anteliomys*.

Alticola, like *Hyperacrius*, is apparently a strictly boreal subgenus. The following species are known: *Microtus stoliczkanus* Blanford, *M. roylii* (Gray), *M. stracheyi* (Thomas), *M. blanfordi* (Scully), and *M. albicauda* (True).

Subgenus HYPERACRIUS[1] Miller.

New subgenus. Type *Arvicola fertilis* True.

Geographic distribution of type species.—"Central Kashmir, the Pir Panjal Range and the Kaj Nag Mountains." (True.)

Geographic distribution of subgenus.—Mountains of central and southwestern Kashmir at elevations ranging mostly from 7,000 to 12,000 feet.

Essential characters:

Palate abnormal.
$\overline{\text{m 3}}$ without closed triangles.
$\overline{\text{m 1}}$ normally with 4 or 5 closed triangles and 7 salient angles.
m 3 normally with 1 or 2 closed triangles and 4 salient angles.
Mammæ 4.
Plantar tubercles 5.
Sole hairy.
Claws on hind feet longest.
Fur short and dense.

Skull.—The skull in the subgenus *Hyperacrius* (Pl. I, fig. 11) differs from that of *Alticola* in its longer rostrum, strongly cuneate nasals, narrower interorbital constriction, more abruptly flaring zygomata, and flatter brain case. The whole dorsal outline of the skull is depressed so that the zygomata are more nearly on the level with the top of the skull than in any other subgenus of *Microtus*. The audital bullæ (fig. 27) are proportionally smaller than in *Alticola*, true *Microtus*, or *Pitymys*. The brain case is much more depressed than in *Microtus* proper (flatter even than in *Pitymys*), and viewed from above it has a peculiar subcircular outline not known elsewhere in the genus. Parietals proportionally smaller than in *Microtus* proper; squamosals and interparietal proportionally larger. The latter in old individuals has much the same shape as in fully adult *Arvicola*, *Neofiber*, and *Fiber*.

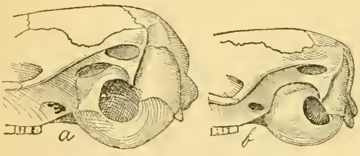

FIG. 27.—Audital bullæ, (*a*) *Microtus* (*Alticola*) *albicauda*; (*b*) *M.* (*Hyperacrius*) *fertilis*. (x 2.)

Bony palate.—The bony palate is exactly as in *Alticola*.

Enamel pattern in general.—The enamel pattern (fig. 28) has the general appearance of that of *Alticola*.

Front lower molar.—The first mandibular tooth is indistinguishable from the corresponding tooth in *Alticola*.

[1] Οἱ ὑπεράκριοι, inhabitants of the heights.

Back upper molar.—The last maxillary tooth has the same general form as that of *Alticola*, but is simpler in structure, thus recalling the corresponding tooth in *Lagurus* (fig. 25). There are usually only two lateral triangles and four salient angles. The posterior loop is lengthened in the axis of the jaw as in *Alticola*.

Mammæ.—There are four mammæ, all inguinal.

Feet.—The feet are well haired, but rather less densely than in *Alticola*. Plantar tubercles five—the faintest possible trace of a sixth sometimes present. Claws on all four feet well developed, those on hind feet longest.

Fur.—The fur is much shorter and more dense than in *Alticola*.

Miscellaneous characters.—The ears, and apparently the eyes, also, are smaller than in *Alticola*. The whiskers are very short, reaching scarcely to the ears, while in *Alticola* they are probably longer than in any other subgenus of *Microtus*.

General remarks.—*Hyperacrius* is most closely related to *Alticola*, from which it differs chiefly in its highly modified skull and reduced number of footpads and mammæ. Minor differences are to be found in the relative size of the ears and in the character of the feet. *Hyperacrius* appears to be modified for a more strictly underground life than *Alticola*. It requires no close comparison with any other subgenus, though it bears a superficial likeness both in external form and in cranial characters to *Pitymys*. The structure of the bony palate and the pattern of enamel folding readily distinguish it from the latter, however.

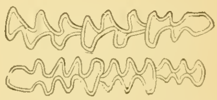

FIG. 28.—Enamel pattern of molar teeth, *Microtus (Hyperacrius) fertilis*. (x 5.)

Whether *Microtus wynnei* may be associated with *Microtus fertilis* in the subgenus *Hyperacrius* is a matter of doubt. At my request Mr. G. E. H. Barrett-Hamilton has examined the specimens of *Alticola* in the British Museum with special reference to the relationships of *M. wynnei*. He finds that this species, as already noticed by Blanford, has only five plantar tubercles, but that in other characters it does not agree with the brief diagnosis of *Hyperacrius* that I sent him. The fur is long, as in the species of *Alticola*, and the skull apparently lacks the peculiar form seen in *Hyperacrius*. The number of mammæ can not be determined in *M. wynnei* nor in any of the species of *Alticola* in the British Museum. For the present it is not safe to attempt to refer *Microtus wynnei* definitely to one subgenus or the other.

Subgenus PEDOMYS Baird.

1857. *Pedomys* Baird, Mamm. N. A., p. 517, 1857. Type *Arvicola austerus* LeConte.

Geographic distribution of type species.—Transition and Upper Austral zones in the central United States and adjoining British Provinces.

Geographic distribution of subgenus.—The range of this subgenus is the same as that of *Microtus austerus*, the only known species.

Essential characters:

Palate normal.

m 3 without closed triangles.

$\overline{m}$ 1 normally with 3 closed triangles and 8 or 9 salient angles.
m 3 normally with 2 closed triangles and 6 salient angles.
Mammæ 4.
Plantar tubercles 5.
Sole thickly haired between heel and tubercles.
Claws moderate in length, those on hind foot longest.
Fur not specially modified.

Skull.—The skull of *Microtus austerus*, the only known species of *Pedomys*, is remarkable for the subcylindric brain case, and great depth of all that part back of the rostrum. While the skull of *Pedomys* is not strikingly different from that of true *Microtus*,[1] it is very unlike the flattened skulls of *Phaiomys*, *Pitymys*, and *Chilotus*, the other groups of small voles resembling *Pedomys* in tooth characters and in number of mammæ and footpads.

Bony palate.—The bony palate is typical, though the interpterygoid fossa is seldom squarely truncate anteriorly.

Enamel pattern in general.—The enamel pattern (fig. 29) is characterized by simplification in the structure of the variable teeth.

Front lower molar.—The first mandibular molar has a posterior transverse loop followed by three closed triangles and an anterior loop. The anterior loop is deeply indented by two reentrant angles, one on each side. These sometimes cut deep enough to isolate a fourth or even a fifth closed triangle, but this rarely takes place. There is often a very faintly developed reentrant angle close to each side of the tip of the anterior loop. In cases where these are strongly marked a front tooth precisely resembling that of *Microtus* is the result.

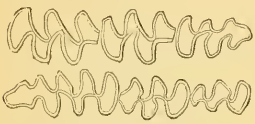

Fig. 29.—Enamel pattern of molar teeth, *Microtus* (*Pedomys*) *austerus*. (x 5.)

Back upper molar.—The posterior maxillary tooth is exactly like that of *Neofiber*, *Pitymys*, *Phaiomys*, *Chilotus*, and typical *Arvicola*, having an anterior transverse loop, two closed triangles and a short posterior loop, from the outer base of which a third closed triangle may sometimes be cut.

Other teeth.—With the exception of the two teeth just described, the dentition of *Pedomys* is like that of the tetramerodont species of the subgenus *Microtus*.

Mammæ.—There are four mammæ, all inguinal.

Feet.—Soles densely hairy between heel and tubercles; pads five, with no indication of a rudimentary sixth.

General remarks.—*Pedomys* agrees in tooth pattern with *Pitymys*, *Chilotus*, and *Phaiomys*, but differs from all three in the shape of the skull, and from the last in the short claws and unmodified fur also.

Subgenus PHAIOMYS Blyth.

1863. *Phaiomys* Blyth, Journ. Asiat. Soc. Bengal, XXXII, p. 89, 1863. Type *Phaiomys leucurus* Blyth=*Microtus blythi* Blandford.

[1] A skull of *Microtus ratticeps* from Norway exactly resembles skulls of *M. austerus* except that the rostrum is more slender.

1887. *Lasiopodomys* Lataste, Annali del Mus. Civ. di Storia Naturale di Genova, ser. 2a, Vol. IV, p. 268, 1887. Type *Arvicola branti* Radde.

Geographic distribution of type species.—"Banks of Tsho Morari and Pankong lakes, Western Tibet, also between Seh and the Pankong Lake at elevations above 13,000 feet." (Blanford.)

Geographic distribution of subgenus.—High plateau region of central and southern Asia. Probably does not occur below the Boreal zone.

Essential characters:

Palate normal.
m 3 without closed triangles.
m 1 normally with 3 to 5 closed triangles and 8 or 9 salient angles.
m 3 normally with 2 to 3 closed triangles and 6 salient angles.
Mammæ probably 10.
Plantar tubercles, 6.
Sole very hairy.
Claws very long and of about equal length on all four feet.
Fur remarkably long and soft.

Skull.—The skull of *Phaiomys* as compared with that of *Pedomys* is readily distinguished by its very different form. The brain case in *Pedomys* is high, long, and almost cylindrical, while that of *Phaiomys* is short, broad, and flat. The zygomatic arches are more broadly flaring in *Phaiomys* than in *Pedomys*, while the upper incisors are usually more prominent. The latter character is, however, inconstant.

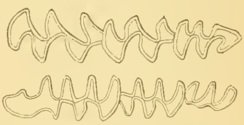

FIG. 30.—Enamel pattern of molar teeth, *Microtus (Phaiomys) strauchi*. (x 5.)

Bony palate.—The bony palate is perfectly normal and requires no detailed description.

Enamel pattern in general.—The enamel pattern (fig. 30) is exactly like that of *Pedomys*, except that the outer reentrant angles in m 3 are somewhat less developed, while the anterior outer reentrant angle in m 2 usually divides the anterior loop into two closed triangles. These differences, however, are trivial and inconstant.

Other teeth.—In some of the members of the subgenus the incisors are directed more forward than usual. The character is, as already stated, wholly inconstant.

Mammæ.—There is still doubt as to the normal number of mammæ in the subgenus *Phaiomys*. Milne-Edwards found only four in a skin of *M. mandrianus;* Büchner found six in a skin of *M. strauchi*, and ten in a skin of *M. fuscus*. I am inclined to think that ten will prove to be the correct number.[1] In the specimen of *M. fuscus* just referred to there were six pectoral mammæ, the rest inguinal.

Feet.—The feet are large and densely haired. The number of tubercles on the sole is still a matter of doubt. Büchner records six in both

[1] That *Phaiomys* probably has a large number of mammæ—at least more than four—was suspected by Lataste, who in 1887 (Annali del Museo Civico di Storia Naturale di Genova, Serie 2*a*, Vol. IV, p. 270) called attention to the fact that Blyth found ten embryos in a female *Microtus blythi*.

M. brandti and *M. strauchi*, but I am able to find only five in a skin of the latter, even after thoroughly relaxing the foot. It is probable that six is the real number, as Büchner's determinations were made from alcoholic specimens. The claws on all four feet are large and about equal in length. That on the thumb is well developed—in this respect perhaps surpassing all other subgenera of *Microtus*.

Fur.—The fur is long and soft, suggesting that of a lemming rather than that of a vole.

General remarks.—In many respects *Phaiomys* resembles *Pedomys* so closely that I should hesitate to separate the two groups were they not already named. There are, however, such differences between them that it is impossible to call them the same, while in all probability more satisfactory material than that now available would show additional characters. In external appearance the two subgenera differ considerably. While *Pedomys* is a typical vole, *Phaiomys* bears a general resemblance to the lemmings. The peculiar aspect of the species of *Phaiomys* is caused by their short tails, large feet, and long, soft fur. The likeness between the species of *Phaiomys* and the yellowish species of the subgenus *Lagurus* is even more striking. From the latter, however, they are readily separable by dental characters.

Microtus blythi (Blanford), *M. mandarinus* (Milne-Edwards), *M. strauchi* Büchner, *M. fuscus* (Büchner), and *M. brandti* (Radde), are perhaps the best-known species of the subgenus *Phaiomys*.

Subgenus PITYMYS McMurtrie.

1830. *Psammomys* LeConte, Ann. Lyc. Nat. Hist., New York, III, p. 132, 1830 (genus). Type *Psammomys pinctorum* Le Conte (not *Psammomys* Cretzschmar 1828).

1831. *Pitymys* McMurtrie, American edition, Cuvier Règne Animal, I, p. 434, 1831 (genus). Type *Psammomys pinctorum* LeConte.

1857. *Pitymys* Baird, Mamm. N. Am., p. 517, 1857 (section).

1887. *Pitymys* Lataste, Annali del Mus. Civ. di Storia Naturale di Genova, serie 2*a*, IV, p. 266, 1887 (subgenus).

1831. *Ammomys* Bonaparte, Saggio Distrib. Metod. degli Anim. Vert., p. 20, footnote, 1831 (genus). Type *Psammomys pinctorum* Le Conte.

1836. *Pinemys* Lesson, Hist. Nat. d. Mamm. et Ois découv. depuis 1788, Compl. Oeuvres de Buffon, V, p. 436, 1836 (genus). Type *Psammomys pinetorum* LeConte.

1867. *Terricola* Fatio, Les Campagnols du Bassin du Léman, p. 36, 1867 (subgenus) (*subterraneus* and *savii*).

1876. *Micrurus* Forsyth Major, Atti della Società Toscana di Sci. Nat., III, fasc. I, p. 126, 1876 (subgenus). Type *Arvicola nebrodensis* Mina Palumbo.

Geographic distribution of type species.—Austral Zone in the eastern United States.

Geographic distribution of subgenus.—Central and southern Europe, eastern United States, parts of Mexico.

Essential characters:

Palate, normal.

m 3 without closed triangles.

m 1 normally with 5 closed triangles and 9 salient angles.

m 3 normally with 2 or 3 closed triangles and 6 salient angles.
Mammæ, 4.
Plantar tubercles, 5.
Sole moderately hairy.
Claws on front feet longest.
Fur short, dense, and mole like.

Skull.—The skulls of the species of *Pitymys* differ considerably among themselves. In *Microtus pinetorum* (Pl. I, fig. 2), the most highly modified, the brain case is very broad and flat and the interorbital region is remarkably wide. The brain case is like that of *Lagurus*, but the broad anterior part of the skull is very different from the latter. The dorsal outline is strongly arched, especially anteriorly from the region between the orbits to the tips of the nasals. The arching is, however, no more strongly marked than in *Microtus arvalis.* In *Microtus subterraneus* the skull is like that of *M. pinetorum*, but the peculiarities are less accentuated. In the Mexican species of *Pitymys* the brain case is narrower and higher than in *M. pinetorum*, and the anterior part of the skull is less heavily built. The zygomatic processes of the maxillæ stand out more nearly at right angles with the side of the skull, thus bringing the broadest part of the zygomatic arch farther forward than in *M. pinetorum.*

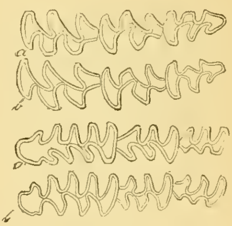

FIG. 31.—Enamel pattern of molar teeth, (*a*) *Microtus* (*Pitymys*) *pinetorum*; (*b*) *M.* (*P.*) *savii.* (x 5.)

Bony palate.—The palate is normal, though the region between the posterior molars is in *M. pinetorum* rather flatter than usual in true *Microtus*, and the anterior outline of the interpterygoid fossa is often somewhat hastate.

Enamel pattern in general.—With the exception of the front lower molar and back upper molar, the enamel pattern (fig. 31) is that of tetramerodont *Microtus.*

Front lower molar.—The anterior mandibular tooth contains the same number of loops and angles as the corresponding tooth in *Microtus arvalis.* As a rule, however, the first and second triangles are not completely isolated from each other or from the anterior loop. The tooth is therefore exactly as in *Pedomys.*

Back upper molar.—The posterior maxillary tooth is simplest in the American species of the subgenus. In these it is like the back upper tooth in *Pedomys* and *Arvicola*, which contain two closed triangles and an anterior and posterior loop. In *M. subterraneus*, however, the tooth is formed exactly as in *M. arvalis*, while in *M. savii* it is somewhat intermediate. In the last-named species the terminal loop is slightly larger than in *M. pinetorum*, and a third closed triangle is usually cut off from the outer base.

Other teeth.—There is nothing peculiar about the incisors or remaining molars.

Mammæ.—In *Pitymys* there are only four mammæ—all inguinal.

Feet.—The soles are moderately hairy. They have five well-developed tubercles, but no trace of a sixth. The claws are well developed on all the feet, those on the front feet either equaling or exceeding those on the hind feet.

In *M. pinetorum* the front feet are much larger and the front legs shorter than in true *Microtus*. These peculiarities are less developed in *M. subterraneus* and *M. savii*. Of the other species I have not seen alcoholic specimens, and so am unable to say which of those mentioned they most closely resemble.

Fur.—The fur in all the known species is remarkably short and dense. This character is most noticeable in *M. pinetorum*, which has an almost mole-like coat.

Miscellaneous characters.—The tail, eyes, and external ears are much reduced in all the species of *Pitymys*. These characters, as well as the peculiarities of the fur and front feet, are distinctly adaptive and fit the animals for their underground life.

General remarks.—While *Pitymys* agrees with *Pedomys* in the number of mammæ and footpads, it is readily distinguished by its highly modified fur, small eyes and ears, and flattened skull. The type and most extremely developed species is further characterized by its greatly shortened front legs.

Pitymys is represented in America by *Microtus pinetorum* (Le Conte) and several forms related to *M. quasiater* (Coues). In Europe a number of species and subspecies occur. Among these the best known are *M. subterraneus* (De Sélys Longchamps) and *M. savii* (De Sélys Longchamps).

Subgenus CHILOTUS Baird.

1857. *Chilotus* Baird, Mamm. N. Am., p. 516, 1857. Type, *Arvicola oregoni* Bachman.

Geographic distribution of type species.—Oregon, Washington, and British Columbia.

Geographic distribution of subgenus.—The range of the subgenus *Chilotus* is coincident with that of the type and only known species.

Essential characters:

Palate normal.
$\overline{\text{m}}$ 3 normally without closed triangles.
$\underline{\text{m}}$ 1 with 5 closed triangles and 9 or 10 salient angles.
m 3 with 2 or 3 closed triangles and 6 salient angles.
Mammæ 8.
Plantar tubercles 5.
Sole moderately hairy.
Claws on hind feet longest.
Fur short and dense.

Skull.—The skull of *Chilotus* (Pl. I, fig. 8) is low and flat, the dorsal outline nearly straight, and the brain case not widened, as in *Pedomys*. As compared with *Pedomys*, the rostrum is remarkably long and slender in proportion to the rest of the skull.

Bony palate.—The palate is normal and calls for no further remark.

Enamel pattern in general.—The enamel folding (fig. 32) is like that of the tetramerodont species of *Microtus*, except that the back upper tooth is a little simplified.

Front lower molar.—The first mandibular molar is exactly like that of typical *Microtus*.

Back upper molar.—The back maxillary tooth contains a transverse anterior loop, two lateral closed triangles, and a somewhat lengthened terminal loop. The latter has at each side of its base a conspicuous angle, the outer one of which is often isolated as a third closed triangle. The tooth has six salient angles, two to each of the transverse loops and one to each of the closed triangles.

Other teeth.—As already stated, the remaining teeth are formed exactly as in tetramerodont *Microtus*. One specimen from British Columbia has the lateral triangles closed in the back lower molar.

Mammæ.—There are eight mammæ, four pectoral and four inguinal.

Feet.—Soles moderately hairy from heel to tubercles; plantar tubercles five, all well developed; claws on hind feet longest; front feet not modified like those of typical *Pitymys*.

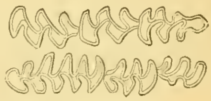

FIG. 32.—Enamel pattern of molar teeth, *Microtus (Chilotus) oregoni*. (x 5.)

Fur.—The fur is shorter and more dense than in true *Microtus*, but the modification is not carried so far as in *Microtus (Pitymys) pinetorum*.

General remarks.—*Chilotus* combines the mammæ and foot pads of *Arvicola* with the nearly typical enamel pattern of *Microtus* and has a form of skull peculiarly its own. In general it is modified in the same direction as *Pitymys*, but to a much less degree.

Great stress has been laid on the form of the ear as a character of this subgenus. In the original description[1] Baird says:

A specimen in alcohol, from Steilacoom, received since the preceding description was prepared, is, in size, much as described. The ears are low, orbicular, the membrane thickened, the margins or conchal portion much inflected or incurved, like a half-open apple blossom, the concha being inflected all round. The antitragus is well developed, but rather low. The surfaces of the ear appear perfectly naked, with, however, a ciliation of long hairs toward the roots of the concha, on the dorsal surface. A close examination of the auricle in the dried specimen shows a few scattered, very short, white hairs.

The structure of the ear, though in many respects similar to that of *A. pinetorum*, is yet essentially different. Thus the upper and lower roots of the margin of the ear meet anteriorly so as to form even a low rim to the meatus anteriorly, completely inclosing the aperture; the edge of the concha is inflected; the region inside the auricle, around the meatus, naked, and the antitragus so much developed as to be capable of completely closing the meatus. In *A. pinetorum* the roots of the upper and lower margins of the ear are widely separated, by a space of a quarter of an inch, the space between these roots and anterior to the meatus perfectly plane; the edges of the concha, or of the auricle, not inflected at all; the inner space around the meatus partly hairy; the antitragus very slightly developed, not valvular, nor capable of closing the meatus at all.

[1] Mamm. N. Am., p. 538, 1857.

Through Mr. True's kindness I have been able to examine one of the alcoholic specimens on which Baird based this description. This specimen (No. 2533, from Tomales Bay, Cal.[1]) is in good condition and shows most of the peculiarities to which attention was called. The thickening of the edge of the auricle is, however, due to disease or to the action of the parasites which often attack the rims of the ears in the voles and other small rodents. The anterior base of the ear is not essentially different from the same region in *Pitymys*, though the valvular fold is slightly more developed. It is probable that by means of this fold the meatus in *Pitymys*, as well as in most if not all of the voles, can be tightly closed.

Subgenus MICROTUS Schrank.

1798. *Microtus* Schrank, Fauna Boica, I, 1ste Abth., p. 72, 1798. Type by elimination *Microtus terrestris* Schrank = *Mus arvalis* Pall.
1817. *Mynomes* Rafinesque, Am. Monthly Magazine, II, p. 45, 1817. Type *Mynomes pratensis* Raf. = *Arvicola pennsylvanicus* Ord.
1836. *Hemiotomys* DeSélys Longchamps, Essai Monographique sur les Campagnols des environs de Liège, p. 7, 1836, part (included *arvalis* and *terrestris*).
1857. *Hemiotomys* Baird, Mamm. N. Am., p. 515, 1857.
1849. *Neodon* Hodgson, Ann. and Mag. Nat. Hist., 2d ser., III, p. 203, 1849. Type *Neodon sikkimensis* Hodgson.
1857. *Paludicola* Blasius, Fauna der Wirbelthiere Deutschlands, I, p. 333, 1857, part (included *terrestris, nivalis,* and *ratticeps*).
1857. *Agricola* Blasius, Fauna der Wirbelthiere Deutschlands, I, p. 334, 1857. Type *Arvicola agrestis*.
1867. *Praticola* Fatio, Les Campagnols du Bassin du Léman, p. 36, 1867, part (included *terrestris, nivalis, arvalis, ratticeps,* and *campestris*).
1867. *Sylvicola* Fatio, Les Campagnols du Bassin du Léman, p. 63, 1867. Type *Arvicola agrestis*.
1890. *Campicola* Schulze, Schriften Naturwiss. Vereins d. Harzes in Wernigerode, V, p. 24, 1890, part (included *arvalis, subterraneus,* and *campestris*).
1894. *Tetramerodon* Rhoads, Proc. Acad. Nat. Sci. Phila., p. 282, 1894. Type *Arvicola tetramerus* Rhoads.

Geographic distribution of type species.—Central Europe.

Geographic distribution of subgenus.—Boreal region of both hemispheres, south to Mexico, northern India, and southern Europe.

Essential characters:

Palate normal.
m 3 without closed triangles.
m 1 normally with 5 closed triangles and 9 salient angles.
m 3 normally with 3 closed triangles and 7 or 8 salient angles.
Mammæ, 8.
Plantar tubercles, 6.
Sole moderately hairy.
Claws of hind feet longest.
Fur not specially modified.

Skull.—In true *Microtus* (Pl. I, fig. 3) the skull lacks the peculiar modifications found in such subgenera as *Lagurus*, *Pitymys*, *Chilotus*,

[1] No. 2529 from Steilacoom, Wash., also mentioned by Baird, is lost.

and others. Within certain limits, however, the skull varies considerably in size and form, so that it is difficult to frame any accurate diagnosis. The skull of *Microtus arvalis* figured on Plate I represents the form characteristic of the great majority of species. One of the most notable departures from this type is seen in the skull of *Microtus nivalis*, which has an unusually low, broad brain case, and flat dorsal outline.

Bony palate.—The bony palate in the subgenus *Microtus* (fig. 7 A, and Pl. II, fig. 5) shows in its most perfect development the form which may be considered the normal one in the genus, since it is characteristic of most of the subgenera and of the vast majority of species. As this palate has already been described (pp. 26–27) it is necessary here to notice a few departures from the type form only. In young individuals the sloping ridge is broader than in the adults, while in very old individuals it often becomes very abrupt and at the same time greatly narrowed. These two extremes, which are usually characteristic of immaturity and old age, occur as the normal condition in the adults of certain species. In *Microtus nivalis* the ridge is broad and flat, while in *M. agrestis*, *M. ratticeps*, and most of the American species it is narrow and abrupt. Occasionally (especially in *M. agrestis* and *M. ratticeps*) the anterior edge of the interpterygoid fossa is encroached upon by the projecting median ridge. The latter, on the other hand, may be slightly cleft in the median line, thus foreshadowing the first step in the series of changes which lead to the very different palate of *Evotomys*.

FIG. 33.—Enamel pattern of molar teeth, (*a*) *Microtus* (*Microtus*) *arvalis*; (*b*) *M.* (*M.*) *nivalis*; (*c*) *M.* (*M.*) *pennsylvanicus*; (*d*) *M.* (*M.*) *ratticeps*. (x 5.)

Enamel pattern in general.—The enamel pattern in the subgenus *Microtus* (fig. 33) is characterized by the large number of loops and angles in the first lower molar and last upper molar.

Front lower molar.—The first lower molar normally contains a posterior transverse loop, five closed triangles, two of which are on the outer side and three on the inner side, and finally an anterior loop which is usually more or less deeply cut by two reentrant angles, one on each side of the loop, the outer of which is always the more posterior of the two. With these loops and triangles are usually associated nine well-developed salient angles, two formed by the posterior transverse loop, one by each of the five closed triangles, and one by each side of the base of the anterior loop. That part of the anterior loop which lies in front of the reentrant angles may develop a salient angle on its inner side, less frequently one on the outer side. Very rarely the loop may be cut by a third reentrant angle. This condition occurs in adult specimens of *Microtus agrestis*, *M. pennsylvanicus*, also in the type of *M.* (*Arvicola*) *arvicoloides* (fig. 35), and probably in any other species with the tooth formed after the pattern of *Microtus arvalis*. The other variations in the form of the front lower molar are the result of the greater or less development of the reentrant angles normally present at the anterior end. Sometimes the fourth reentrant angle (counting from behind) on the lingual side of the tooth fails to meet the third on the opposite side. Very rarely the anterior outer triangle opens in a like manner into the anterior inner triangle, and the latter at the same time communicates with the anterior loop, thus producing a tooth like that normally present in *Pedomys* and *Pitymys*. Rather frequently a sixth closed triangle is cut off from the outer basal corner of the anterior loop, and occasionally a seventh triangle is isolated at the inner side of the greatly reduced loop.

The variations just described are purely individual and occur in the species having the tooth of the typical form. Two notable variations from this form are normally found in *Microtus ratticeps* and *M. nivalis*. In the former (fig. 33*d*) the fifth triangle opens into the short, unindented anterior loop. There is here an actual reduction in the elements of the ooth, which has only eight salient angles, thus resembling the corresponding tooth in *Pedomys*. In *M. nivalis* (fig. 33*b*), while there are five closed triangles and nine salient angles, the anterior loop is small and crescentic, much resembling the posterior loop in the maxillary teeth of *Eothenomys*.

Back upper molar.—The last upper molar is normally made up as follows: An anterior transverse loop, succeeded by three closed triangles, two smaller ones on the outer side and a larger one on the inner side, these in turn by a posterior loop of variable shape. The tooth usually contains seven salient angles, two to each of the transverse loops and one to each of the three closed triangles.

Variations in the form of this tooth are numerous. Beginning at the anterior end where the structure is most definite, it is found that the first outer triangle very frequently opens into the large inner triangle, less often into the anterior loop. The second outer triangle very rarely opens into the inner triangle, but is rather frequently in communication with the posterior loop. The posterior loop varies in form and size, the variations being partly individual and partly characteristic of species. For the present it is unnecessary to discriminate in all cases between the two categories. The most usual form and that found in the type species, *Microtus arvalis* (fig. 33*a*) is an irregular crescent with the concavity directed inward and backward and the posterior tip thickened, the whole joined to the rest of the tooth at a point on the convexity midway between the middle and the anterior extremity. This nearly crescentic form is usually distorted by the elongation and straightening of the anterior limb, so that the resulting shape is more like that of the letter J. The thickened posterior extremity of the loop is often extended and cut by a reentrant angle on the lingual side, so that the crescent is modified into the form of a rude E. Occasionally the anterior extremity of the crescent is isolated as a second inner triangle. The convex side of the crescent may develop a more or less prominent salient angle. This condition is normal in *Microtus ratticeps* and *Microtus chrotorrhinus*, but occurs also in other species. In the aberrant *Microtus nivalis* the structure of this tooth is simplified so that it is essentially as in *Arvicola*, *Pedomys*, and *Pitymys*.

Other teeth.—The first and second upper molars contain each an anterior transverse loop and, respectively, three and two closed triangles. In *Microtus agrestis*, *M. sikkimensis*, *M. pennsylvanicus*, *M. terrænovæ*, and *M. aztecus* the inner edge of m 2 is produced into a conspicuous loop, which frequently becomes isolated, so as to form a closed triangle about half the size of the others. The European species with m 2 formed in this way have been placed in a subgenus called *Agricola* or *Sylvicola*, while the American species have been referred to *Mynomes* in a restricted sense. The American species with m 2 exactly as in *Microtus arvalis* have received the name *Tetramcrodon*. While the name *Tetramerodon* can not be used in a subgeneric sense, it is frequently convenient to speak of the voles with the enamel pattern of *M. arvalis* as the tetramerodont species to distinguish them from their pentamerodont allies. In *Microtus sikkimensis* a supplemental triangle is developed in m 1 as well as in m 2. On account of this peculiarity the animal has been made the type of the genus or subgenus '*Neodon*.' Neither *Neodon* nor *Agricola* are worthy of recognition as subgenera distinct from *Microtus*. Their characters are of trifling importance, while in other species of *Microtus* (as, for instance, *M. nivalis*, *M. guentheri*, and occasionally *M. pennsylvanicus*) intermediate conditions can be found.

Mammæ.—In the subgenus *Microtus* the mammæ are always eight, four pectoral and four inguinal. No exceptions to this number are known.

Feet.—There are six turbercles on the sole. Five of these are always well developed, but the sixth is variable in size, being especially large in *M. ratticeps*. The sole is always moderately hairy from heel to tubercles. It is never densely furred as in *Phaiomys* or naked as in *Neofiber*. The claws on all four feet are moderately developed, those on the hind feet always slightly larger than those on the front feet, the latter never specially developed for digging (cf. *Pitymys*).

Fur.—The fur is moderately full and soft, neither long and silky as in *Phaiomys* nor dense and mole-like as in *Pitymys*.

General remarks.—The subgenus *Microtus* needs comparison with the groups having normal or very slightly abnormal palates: *Arvicola*, *Pedomys*, *Pitymys*, *Chilotus*, *Phaiomys*, and *Lagurus*. From all the others it differs too widely to give rise to confusion. *Lagurus* is distinguished from *Microtus* by the tightly closed triangles in the posterior mandibular tooth, *Arvicola* by the presence of large musk glands on the sides, *Pedomys* and *Pitymys* by reduction in the numbers of both mammæ and plantar tubercles, *Chilotus* by reduction in the latter only, and *Phaiomys* by an increase in the number of mammæ and by the very large claws. More extended comparisons will be found under each of these subgenera.

This subgenus is the most widely and generally distributed, as well as the one containing the largest number of species. Although the species of *Microtinæ* are still very imperfectly known, there is little doubt that the members of the subgenus *Microtus* greatly outnumber the species of all the other genera and subgenera together. Conspicuous representatives of the subgenus *Microtus* are (in the Old World): *Microtus arvalis* (Pall.), *M. agrestis* (Pall.), *M. ratticeps* (Keys. & Blas.), *M. nivalis* (Martins), *M. guentheri* (Dansford & Alston), *M. sikkimensis* (Hodgson); (in America): *Microtus pennsylvanicus* (Ord), *M. terrænovæ* (Bangs), *M. xanthognathus* (Leach), *M. chrotorrhinus* (Miller), *M. longicauda* (Merriam), *M. mogollonensis* (Mearns), *M. townsendi* (Bachman).

Subgenus ARVICOLA Lacépède.

1801. *Arvicola* Lacépède, Mém. de l'Institut, Paris, III, p. 489, 1801 (genus). Type, '*Arvicola amphibius*' = *Mus terrestris* Linn.

1883. *Arvicola* Lataste, Le Naturaliste, Tome, II, p. 349, 1883 (subgenus).

1836. *Hemiotomys* De Sélys Longchamps, Essai Monographique sur les Campagnols des environs de Liège, p. 7, 1836, part (included *arvalis* and *terrestris*).

1857. *Paludicola* Blasius, Fauna der Wirbelthiere Deutschlands, I, p. 333, 1857, part (included *terrestris*, *nivalis*, and *ratticeps*).

1867. *Ochetomys* Fitzinger, Sitzungsber. K. Akad. Wiss. Wien, LVI, p. 47, 1867. (No type mentioned, but genus intended to include all the water rats of Europe.)

1867. *Praticola* Fatio, Les Campagnols du Bassin du Léman, p. 36, 1867, part (included *terrestris*, *nivalis*, *arvalis*, *ratticeps*, and *campestris*).

1894. *Aulacomys* Rhoads, American Naturalist, XXVIII, p. 182, 1894. Type, *Aulacomys arvicoloides* Rhoads.

Geographic distribution of type species.—Northern Europe.

Geographic distribution of subgenus.—Northern part of Northern Hemisphere, exclusive of America east of the Rocky Mountains.

Essential characters:

Palate slightly abnormal.
$\overline{\text{m 3}}$ occasionally with closed triangles.
$\overline{\text{m 1}}$ normally with 3 to 5 closed triangles and 7 to 9 salient angles.
$\underline{\text{m 3}}$ normally with 2 or 3 closed triangles and 6 to 8 salient angles.
Mammæ 8.
Plantar tubercles 5.
Sole almost naked.
Claws on hind feet longest.
Fur slightly modified.
Musk glands present on sides of body.

Skull.—The skull of the larger Old World species of *Arvicola* (Pl. I, fig. 9) is nearly as large as that of *Neofiber*. In the American species

(Pl. I, fig. 1) it is smaller, though considerably larger than in most species of *Microtus* proper. Aside from its large size and prominent ridges, the skull of *Arvicola* differs from that of *Microtus* in its broader, shorter brain case, more widely flaring zygomatic arches, and proportionally slender rostrum. The peculiar appearance of the rostrum is heightened by the fact that the incisors project more than usual. Some of these characters are more noticeable in the American species, though the latter show no cranial peculiarities of sufficient importance to separate them subgenerically from those of the Old World. In the American species the skull is usually more lightly built and less strongly angular than in the typical members of the genus (compare figs. 1 and 9 of Pl. I).

Bony palate.—The bony palate is usually normal, but occasionally the median sloping ridge is divided in the median line, so that the interpterygoid fossa is hastate anteriorly (Pl. III, fig. 7). This condition occurs most frequently in the American species, but even among these it is inconstant.

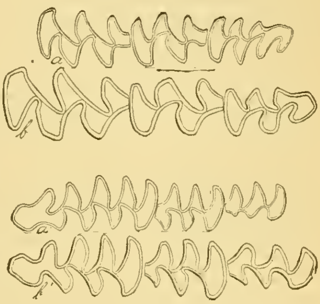

Fig. 34.—Enamel pattern of molar teeth, (*a*) *Microtus* (*Arvicola*) *macropus*; (*b*) *M.* (*A.*) *terrestris*. (x 5.)

Enamel pattern in general.—The enamel pattern in typical *Arvicola* (fig. 34*b*) is characterized by the great reduction in the number of closed triangles and salient angles in the front lower molar and back upper molar. In these peculiarities, though closely approached by *Pitymys*, *Pedomys*, and *Phaiomys*, it presents the extreme conditions found in the genus. The third lower molar shows the tendency to closure of the lateral triangles characteristic of all the larger members of the genus. The pattern of enamel folding in the molar teeth of the American species of *Arvicola* (fig. 34*a*) is, on the other hand, exactly like that of the tetramerodont species of the subgenus *Microtus* (e. g., *Microtus arvalis* and most of the western American species).

Front lower molar.—In the typical species the simplification in the structure of the teeth is carried furthest in the first lower molar. This tooth normally contains a posterior transverse loop followed by three closed triangles (one on the outer side, two on the inner side) and a terminal transverse loop which is deeply constricted in the middle. Each transverse loop forms two salient angles and each lateral triangle one, making seven in all. Deviations from this form are very rare. In one or two specimens I have seen a fourth triangle isolated on the outer side, thus producing a tooth much like the corresponding one in *Microtus* (*Microtus*) *ratticeps*, a species which has the last upper molar very complicated in structure. The front lower molar in typical *Arvicola* differs from that of the other groups in which it has only three closed triangles in the reduced number of salient angles—seven instead of nine. Since this tooth in the American species has the same structure as in *Microtus arvalis*, no special description is necessary.

Back upper molar.—In the typical species the last upper molar has an anterior transverse loop, a closed triangle on each side, and a very short, simple terminal loop. With these loops are associated six salient angles, two on each of the terminal loops and one on each closed triangle. Rarely the posterior terminal loop is reduced by the isolation of the outer basal angle as a third closed triangle, but this seldom happens, while the resulting form of tooth is quite different from that found in any member of the subgenus *Microtus* except the aberrant *M. nivalis*. In the American species this tooth is formed exactly as in *Microtus arvalis*.

Mammæ.—There are eight mammæ in *Arvicola*, as in *Microtus*.

Feet.—In *Arvicola* the soles are very sparsely haired or almost naked between the tubercles and the heel.

The tubercles are only five in number, as the small one which in *Microtus* lies midway between the large proximal tubercle and the base of the fifth toe is absent. Claws moderately developed, those on hind feet slightly the larger.

Fur.—The fur is close, dense, and long, the under fur especially thick and woolly. It thus resembles the fur of *Neofiber*, though the modification is not carried so far as in the latter.

Miscellaneous characters.—The species of *Arvicola* are provided with a large musk gland on each side of the abdomen. These glands lie immediately in front of the hind legs and are very conspicuous in alcoholic specimens. In a half-grown male *Microtus terrestris* from St. Petersburg, Russia, each gland is 13 mm. long by 6 mm. wide. They are regularly oval in outline, the long axis parallel with the long axis of the body. The surface, which is slightly raised above that of the surrounding skin, is closely and irregularly wrinkled, and has much the appearance of very finely honeycombed tripe. Each gland bears a sprinkling of fine hairs much shorter than the fur, but at first sight appears to be naked. In dried skins the positions of the glands are indicated by tufts of grease-soaked fur.

General remarks.—The subgenus *Arvicola* is distinguished from all other groups with similar enamel pattern or with like numbers of mammæ and foot pads by the presence of the large glandular masses on the sides of the body. The species are all water rats, and, with the exception of *Microtus* (*Neofiber*) *alleni*, they considerably exceed the other members of the genus in size.

Although this subgenus is now for the first time recorded from America, at least three species of *Arvicola* inhabiting the western United States have been described within the past five years. These are *Microtus macropus* (Merriam), *M. arvicoloides* (Rhoads), and *M. principalis* Rhoads. *Microtus macropus* was supposed to be "one of the western members of the subgenus or section *Mynomes*," that is, a tetramerodont *Microtus*.[1] *Microtus arvicoloides* was made by its descri-

[1] North American Fauna No. 5, p. 60, July, 1891.

ber the type of a new genus, *Aulacomys*,[1] while *M. principalis*, closely allied to both *M. macropus* and *M. arvicoloides*, was referred by the same author to true *Microtus*.[2] This confusion arose from the fact that the subgeneric and generic determinations were based chiefly on dental characters. Hence *Microtus macropus* and *M. principalis* were naturally considered members of the subgenus *Microtus*, since both have the enamel pattern characteristic of the tetramerodont species of that group.

The teeth of the type and only known specimen of *Microtus arvicoloides*, on the other hand, show certain characters which, although clearly abnormal, led to an entire misunderstanding of the animal's true relationships. The first of these abnormal characters, and the one which suggested the name *Aulacomys*, is seen in the upper incisors. Each of these has a narrow longitudinal median groove. They can not, however, be considered as entitling the species to generic rank, since similar though fainter grooves are occasionally found in almost any species of *Microtus*, while they are absent in the vast majority of specimens of '*Aulacomys*.' The second abnormality in the type of *Microtus arvicoloides* is in the form of the front lower molar. This tooth (fig. 35) has two reentrant angles on the outer side of the anterior loop instead of one as usual in *Microtus*. The supplemental reentrant angle, like the grooves in the incisors, is purely an individual character, which may crop out in any species of *Microtus*, with the front lower molar formed as in *M. arvalis*, and which is absent in all the other thirty or more specimens of '*Aulacomys*' that I have seen. The subgenus *Aulacomys* if retained as distinct from *Arvicola* must rest on characters of enamel pattern alone, since in all other peculiarities it agrees perfectly with the latter. The differences in enamel folds are rather considerable, since '*Aulacomys*' has the highly complicated pattern of true *Microtus*, while the species of typical *Arvicola* have the simplest pattern of any known. While it seems highly inadvisable to base subgeneric divisions on such characters, the decision rests on purely individual judgment.

FIG. 35.—Abnormal front lower molar of type specimen of '*Aulacomys*' *arvicoloides*. (x4.)

In the Old World numerous species and subspecies are probably confused under the name '*Arvicola amphibius*.' *Microtus musignani* (De Sélys Longchamps) and *M. monticola* (De Sélys Longchamps) appear to be especially distinct from *M. terrestris* (Linn.).

Subgenus NEOFIBER True.

1884. *Neofiber* True, Science, IV, p. 34, July 11, 1884 (full genus). Type *Neofiber alleni* True.

1891. *Neofiber* Merriam, North American Fauna, No. 5, p. 59, July, 1891 (subgenus).

Geographical distribution of type species.—Florida. "Doubtless a common animal in favorable localities throughout the State." (Chapman.)

[1] American Naturalist, XXVIII, p. 182, February, 1894.

[2] American Naturalist, XXIX, p. 940, October, 1895.

Geographical distribution of subgenus.—The range of the subgenus *Neofiber* is the same as that of the type and only known species.

Essential characters:

Palate abnormal.
m 3 with all triangles closed.
m 1 with 5 closed triangles and 9 salient angles.
m 3 with 2 closed triangles and 6 salient angles.
Mammæ 4.
Plantar tubercles 5.
Sole naked.
Claws on hind feet longest.
Fur highly modified.

Skull.—The skull of *Neofiber* is characterized by its large size, great depth through the frontal region, and conspicuous development of postorbital processes. The ratio of fronto-palatal depth to basilar length is about 41 in *Neofiber*, while in true *Microtus* it is only about 35. As the occiput in *Neofiber* is not correspondingly high the dorsal outline of the skull curves gently and regularly from front to back, with the highest point just behind the orbits. When viewed from above the skull of *Neofiber* differs from that of *Microtus* chiefly in the larger squamosals, smaller parietals and interparietal, and in the sharp-pointed postorbital processes. The latter project over the orbital cavity as square-cornered shelves, which are especially noticeable when viewed from below.

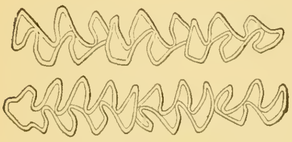

FIG. 36.—Enamel pattern of molar teeth, *Microtus* (*Neofiber*) *alleni*. (x 4.)

Palate.—The bony palate in *Neofiber* (Pl. II, fig. 9) differs widely from that of *Microtus*, and exactly resembles that of *Fiber* (p. 72).

Enamel pattern in general.—In general the enamel pattern of *Neofiber* (fig. 36) is characterized by a tendency to reduction in the number of angles in the variable teeth and to the tight closure of all triangles. The latter peculiarity gives the teeth the greatest possible strength.

Front lower molar.—The first molar in the lower jaw exactly resembles the corresponding tooth in *Microtus* except that the anterior loop is rather shorter than in the typical members of that subgenus. In one specimen (No. 23453, U. S. Nat. Mus.) the anterior loop has two indentations on the outer side, thus suggesting *Anaptogonia*.

Back upper molar.—The third maxillary tooth is like that in the subgenera *Pitymys*, *Pedomys*, *Phaiomys*, *Chilotus*, and typical *Arvicola*, as it has only two closed triangles and six salient angles.

Other teeth.—The back lower molar has all the triangles tightly closed, in this respect differing from all other subgenera except *Lagurus*. Closed triangles are sometimes formed in the third lower molar of almost any of the larger voles, but *Neofiber* and *Lagurus* are the only groups in which they are always present. Outside the subgenus *Lagurus*, most of the known species of which are small, the tendency to closure of the triangles in this tooth increases with the size of the animals until in such large species as *Microtus alleni* and the members of the genus *Fiber* they are always tightly closed. *Microtus terrestris*, the only species approaching *M. alleni* in size, has closed triangles in m 3 very often, while in one specimen the tooth is formed exactly as in *Neofiber*. *M. principalis* Rhoads, another large species, also rather frequently shows closed triangles in this tooth. The incisors, like those of *Fiber*, are short, broad, and very strong, in this respect reaching the opposite extreme from that attained by '*Aulacomys*.'

Mammæ.—Apparently the number of mammæ in *Neofiber* has never been stated in print. Mr. Outram Bangs writes me, however, that he found four inguinal teats in an adult female *Microtus alleni* which he took in Brevard County, Fla., during February, 1895.

Feet.—Soles wholly naked, foot pads five, as in *Arvicola;* claws on hind feet longest.

Fur.—The fur is modified to meet the requirements of an aquatic life in the same way and to almost the same extent as in the genus *Fiber*. The under fur is exceedingly thick, woolly, and dense, while the longer hairs are very glossy and lustrous. This condition is suggested in *Arvicola*, where, however, the modification is not carried so far.

Miscellaneous characters.—Whether *Neofiber* is provided with musk glands like those of the other water rats is at present uncertain. Collectors have failed to notice them, but they might easily escape detection in the thick fur unless specially searched for. The only alcoholic specimen that I have examined is not full grown. This shows no trace of the glands even when the skin of the sides is raised and examined from beneath.

General remarks.—In *Neofiber* are combined the mandibular enamel pattern of *Lagurus* with the maxillary enamel pattern and external characters of typical *Arvicola*, complicated by a reduction in the number of mammæ as in *Pedomys* and *Pitymys*.

Genus FIBER Cuvier.

Fiber Cuvier [Tabl. Élém. de l'Hist. Nat. des Anim., p. 141, 1798], Leçons d'Anat. Comp., I, tabl. I, 1800. Type *Castor zibethicus* Linn.

Geographic distribution of type species.—North America north of the southern border of the United States.

Geographic distribution of genus.—The range of the genus *Fiber* is essentially the same as that given for the type species.

Essential characters:

Upper incisors with anterior faces smooth.
Lower incisors with roots on outer side of molars.
Molars rooted.
Enamel pattern characterized by approximate equality of reentrant angles on outer and inner sides of molars.
Feet modified for swimming.
Tail flattened laterally.

Skull.—The skull (fig. 37) differs very slightly from that of *Microtus* except that it is considerably larger than in any known species of the latter, and has a proportionally longer rostrum. The bony palate (Pl. II, fig. 12) resembles that of the species of *Alticola* and *Neofiber* in the extension forward of the interpterygoid fossa and suppression of the sloping part of the median ridge. The posterior border is thus squarely cut off immediately behind the lateral bridges. A vestige of the sloping ridge usually persists in the form of a median spine projecting into the interpterygoid space. The skull of *Fiber* is peculiar in the expansion of the squamosals on the dorsal surface of the skull at the expense of the parietals. The postorbital processes of the squamosals form prominent triangular projections closely resembling those of *Neofiber*. The interparietal is squarish in outline and usually somewhat longer transversely than antero-posteriorly.

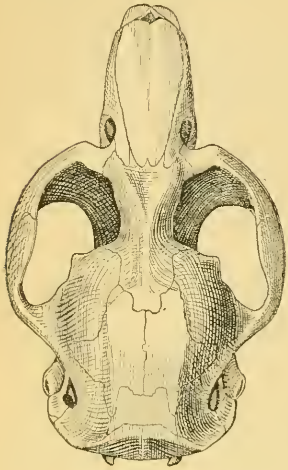

Fig. 37.—Skull of *Fiber zibethicus* (natural size).

Teeth.—The molars are all rooted in the adults (fig. 38), though the roots on the back lower tooth are usually less well developed than those on the others. Otherwise the teeth are exactly as in *Microtus*. The enamel pattern (fig. 39), most closely resembles that of *Microtus* (*Neofiber*) *alleni*, but differs in the larger anterior loop of the first lower molar. This loop is cut by two deep reentrant angles, which often isolate two additional closed triangles, making seven in all.

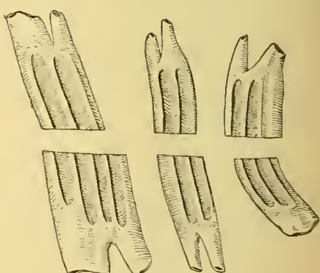

Fig. 38.—Side view of molars, *Fiber zibethicus*. (x 1½.)

Feet.—The feet are large and so formed that they can be turned edgewise when carried forward, thus producing the least possible resistance to the water while the animal is swimming. This character is, however, to a certain extent, reproduced in the more aquatic species of *Microtus* and can not be considered diagnostic of *Fiber*.

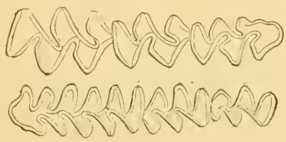

Fig. 39.—Enamel pattern of molar teeth, *Fiber zibethicus*. (x 2½.)

Miscellaneous characters.—The tail is strongly compressed laterally, making an effective rudder. The peculiar form of the tail is scarcely noticeable in the young even when large enough to leave the nest, but develops rapidly as the animals increase in size.

The fur of the species of *Fiber* is highly modified to produce a thoroughly waterproof covering. The long hairs are remarkably close and glossy, while the under fur is very dense. In the character of the fur *Fiber* is approached by some of the aquatic species of *Microtus*, especially *M.* (*Arvicola*) *terrestris* and *M.* (*Neofiber*) *alleni*.

General remarks.—Fiber is very closely related to *Microtus*, from which it is distinguished by its flattened, rudder-like tail, and rooted molars.

In addition to the well-known musk rat, *Fiber zibethicus*, three forms, whose interrelationships are not yet understood, are now recognized. These are: *Fiber zibethicus pallidus* Mearns, *F. obscurus* Bangs, and *F. rivalicius* Bangs.

DESCRIPTIONS OF EXTINCT GENERA AND SUBGENERA.

Three extinct rodents referred by authors to the family *Microtinæ* have been made the types of superspecific groups. Two of these, from the Postpliocene of Pennsylvania, are subgenera of *Microtus*; the third, from the Quaternary phosphorites of Trara de Nédroma, near Ain-Mefta, Tunis, is a genus of doubtful affinities. As these groups are necessarily based almost wholly on dental characters, it is impossible to describe them in the same manner as the living genera and subgenera. It is furthermore impossible to form a clear judgment of the validity of the groups in question without examination of the actual specimens. Such examination I have not been able to make. Hence the few conclusions here reached are necessarily incomplete and unsatisfactory.

The genus *Bramus* Pomel (Comptes Rendus, Paris, CXIV, p. 1159, 1892), from the Quaternary Phosphorites of Tunis is represented by one species, *Bramus barbarus* Pomel. Of this animal the mandible and the teeth of both jaws are known.[1] These show characters which suggest the *Castoridæ*.

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[1] Les molaires montrent sur leur couronne la structure de celles du rat d'eau, dont elles ont à peu près les dimensions. On y voit une double série d'encoches et d'angles alternatifs qui correspondent latéralement à des arêtes saillantes, 5 en dedans et 4 en dehors à la première dent inférieure, 3 de chaque côté aux deux suivantes inférieures et aux deux premières supérieures et 2 seulement avec arête postérieure à la troisième d'en-haut. Chez *Arvicola* cette dernière est beaucoup plus compliquée, ayant trois paires d'arêtes et un fort contrefort postérieur. Dans la fossile les sillons sont moins profonds, à angles moins vifs, ainsi que les arêtes, et les lignes d'émail ne se soudent pas d'un côté à l'autre de la couronne, ainsi qu'elles le font chez *Arvicola*; il en résulte une lign. médiane continue de dentine sur la couronne, au lieu d'une série alternative de petits triangles bordés d'émail; de sorte que la dent d'*Arvicola* est, en réalité, formée de deux rangées de prismes distincts, tandis que celle du fossile est un prisme unique fortement sillonné sur les côtés. Il y a plus de ressemblance avec certains Gerbilles, qui ont cependant les molaires bien moins prismatiques et autrement constituées.

Les molaires des *Arvicola* ne sont jamais radiculées sauf peut-être chez les très vieux sujets. Dans notre fossile, je les ai trouvées toujours radiculées dès qu'elles percent l'alvéole dentaire; leur fût, quoique franchement prismatique, est bien moins allongé. Ses deux racines, à la vérité, sont très longtemps ouvertes à leur extrémité, The molars, which are rooted, do not differ essentially in enamel pattern from those of living species of *Microtus*, except that the back upper tooth is remarkably simple in structure, and the reentrant angles in all the teeth are so shallow that the triangles are open. While the front lower molar has nine salient angles, as in typical *Microtus*, the posterior maxillary tooth has only four and a very small terminal loop. The author remarks that the open triangles give the teeth of *Bramus* a resemblance to those of some of the *Gerbillidæ*, but this likeness must be very superficial. The most remarkable character of *Bramus* is the form of the mandible, which is like that of *Castor* and very unlike that of any of the *Muridæ*. It is probable that *Bramus* is the type of a group differing too widely from any of the recent *Microtinæ* to be united with them in one subfamily.

The subgenera *Isodelta* and *Anaptogonia* were described by Prof. E. D. Cope in 1873 (Proc. Amer. Philos. Soc., XII, p. 87). Both are based on teeth from the Postpliocene deposit in Port Kennedy Cave, Pennsylvania. *Anaptogonia* is very different from any of the living subgenera of *Microtus*—so different that, as Professor Cope suggests, it may be eventually recognized as a distinct genus. *Isodelta*, on the other hand, is hardly separable from *Pitymys*, since the characters pointed out as diagnostic of the two groups are not beyond the range of variation among the species of one subgenus.

The original description of *Microtus hiatidens*, the type of the subgenus *Anaptogonia*, is as follows:

> Represented by several molar teeth. These are several times as large as the teeth occupying the same position in any of the species already mentioned in this essay, and suggest the genus *Fiber*. The distinctive features of the latter are the compressed, oar-like tail, with rooted molars, and it is evident that the relationship of this species is not to it. Perhaps it is neither an *Avicola* (sic.) [=*Microtus*] nor a *Fiber*, since it differs in the structure of the teeth from the known species of both. None of the triangles are isolated, but are connected by a narrow strip of dentine, which is narrow posteriorly, but widens anteriorly until it opens out into the terminal loop. Thus the sectional name *Anaptogonia* may be found ultimately applicable to a separate genus. The separation of the enamel folds merely carries to the highest degree that which is seen in the anterior part of the tooth of *A. sigmodus*.
>
> In the inferior m 1 the triangles, which do not open on one side to the anterior loop, are $1\frac{4}{3}$, then one on each side, and the short, wide, terminal loop, which is bilobed or emarginate in the middle of the end. The ridges, which are very prominent and acute, are, therefore, $\frac{6}{5}$; at the extremity there are two short ones, between

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mais elles sont de bonne heure parfaitement distinctes l'une de l'autre. La troisième molaire inférieure, un peu plus arquée que dans *Arvicola*, ne descend pas à la face interne de l'incisive, mais reste tout à fait au-dessus, et ses racines seules s'insinuent un peu latéralement sur cette face.

L'os mandibulaire présente des différences beaucoup plus importantes. Son apophyse angulaire, restant presque dans le plan général de l'os, ne fait en arrière qu'une légère saillie bordant la branche montante, qu'elle suit très haut sous le condyle pour se terminer en simple petit cran. Il y a une grande analogie de forme avec ce que l'on voit chez les Castors. Dans *Arvicola*, au contraire, l'apophyse angulaire est basse et se rejette obliquement en arrière en forme de cuilleron fortement crochu et tordu, rappelant du reste, sauf cette torsion la disposition de cette partie chez les autres Muridés.

which a third and more prominent one rises a little below the grinding surface. A little more attrition would give the distal loop a trilobate outline, and a little more, an acuminate one, from the loss of the lateral angles: finally the median ridge disappears also.

The subgenus *Isodelta* is considered by Professor Cope to show an exaggeration of the characters of *Pitymys.* The type and only known species, *Microtus speothen*, is described as follows:

This species is represented by the entire dentition of the left ramus mandibuli, with a few fragments of the adjacent bone. As already pointed out, its characters entitle it to rank as a distinct section of the genus. Thus, the triangles of the inner side of the anterior inferior molar are one less than in any species of the section *Arvicola* [=*Microtus*]. The anterior loop presents two well-marked angular basal areas, while its terminal portion is regularly rounded. * * * That this is not one of the species of *Pitymys*, in which the basal lobe of the anterior trefoil has been cut off by unusual inflexion of the enamel angle, is demonstrated by the structure of the second molar, which is precisely that of typical *Arvicola* [=*Microtus*], all the triangles from the posterior being isolated and alternating, producing the formula $1\frac{2}{2}0$. The third molar has the usual formula, 1–1–1, the posterior two lobes being crescentic, the anterior trapezoid.

NOTE ON ARVICOLA INTERMEDIUS NEWTON.

In a paper entitled 'The Vertebrata of the Forest Bed Series of Norfolk and Suffolk'[1] Mr. E. T. Newton describes numerous remains of a microtine rodent with well-developed fangs on the molar teeth and intermediate in size between *Arvicola amphibius* [=*Microtus terrestris*] and the smaller voles. This animal, which Mr. Newton named *Arvicola intermedius*, has been recently referred to the genus *Phenacomys*.[2] While the species is certainly not an *Arvicola* [=*Microtus*], it appears to be equally far removed from *Phenacomys* and probably from *Evotomys* and *Fiber* also. The teeth are described as follows:

I have now before me about 40 vole jaws from the "Forest Bed" which, although differing somewhat in size, agree precisely in the patterns of their teeth. Only 14 of these allow the bases of their teeth to be seen, but nine of these have more or less distinct fangs; the other five have no fangs, but are most probably immature, as in other particulars they agree precisely. I have likewise some hundreds of isolated molar teeth, and a very large proportion of these are fanged. * * * The great variation in the size of these fanged teeth would lead one to suspect that they represent more than one species, but there are no sufficient grounds for their separation. * * * The patterns of the grinding teeth are so nearly like those of *A. amphibius* as scarcely to need description, and it is on the presence of fangs in the adult that the chief distinction between the two species rests; nevertheless, there are a few points deserving of notice. In one of the largest and most perfect mandibular rami (figs. 3, 3*a*) the entire molar series, measured along the alveolar margin, is 0.33 inch (8.5 mm.). Mr. Reeves's specimen, from the Bramerton Crag (fig. 12), is a little larger. The first molar has the five inner and four outer angles alternating, but the anterior two are not so prominent as is usually the case in *A. amphibius*, and the front of the tooth is somewhat more rounded (fig. 3*b*). In the Bramerton jaw this is especially the case (fig. 12*a*). All the anterior lower teeth from the "Forest Bed" series which I have seen have the infoldings of the enamel behind the anterior prism less deep than in those examples of *A. amphibius* which I have been able

[1] Memoirs of the Geological Survey, England and Wales. London, 1882.
[2] Nehring, Naturwissenschaftliche Wochenschrift, Nr. 28, July 15, 1894.

to examine; and hence the dentinal portion of the anterior prism is more widely confluent with the second inner and outer prisms; it is, in fact, an exaggeration of the form indicated by Blasius, fig. 186 (Säugethiere Deutschlands, p. 345). The second molar has three inner and three outer angles alternating. The third molar has likewise three inner and three outer angles, but the alternation of the prisms is so slight that the opposing inner and outer prisms are confluent. * * * I am not acquainted with any specimen which shows the three upper molars in place, but Mr. Savin has two specimens which retain the first and second upper grinders (fig. 1), and Mr. Reid has obtained several isolated specimens of last upper molars. The anterior upper molar (fig. 1*a*) has three inner and three outer angles alternating; the second tooth has three outer and two inner angles alternating. The third upper molars vary somewhat; in some only three inner and three outer angles can be counted (fig. 2*a*), while others have three inner and four outer angles. The widely confluent character of the front prisms of the lower anterior molar is repeated in these hinder upper ones. It will be noticed that in all Blasius's figures of the last upper teeth (l. c., p. 345) the anterior inner fold (cement space) and the two anterior outer folds extend across the teeth and meet the enamel of the opposite side, while in one case (fig. 190) the two inner folds pass across. Now, in most of the teeth under consideration it is only the one anterior inner and one anterior outer fold which pass across; in some instances the second outer fold passes farther inward, but I do not think that in any instance it touches the opposite side.

The teeth of '*Arvicola*' *intermedius* differ in numerous characters from those of *Fiber*, *Evotomys*, and *Phenacomys*, the only known living microtines with rooted molars. The small size of the remains and the simple structure of the first lower molar are sufficient to indicate that the animal is not closely related to *Fiber*, although the character of the roots of the molars, as shown in figs. 5, 6, and 7 of Pl. XIII, is strongly suggestive of this genus. The figure of the inner side of the lower jaw (Pl. XIII, fig. 3*a*) suggests that the posterior molar is strongly displaced by the shaft of the incisor, as in *Microtus*. This character alone would show that the species is neither an *Evotomys* nor a *Phenacomys;* but the peculiarities of the enamel pattern furnish additional reasons for its exclusion from these genera. The enamel pattern (fig. 40) is, as Mr. Newton remarks, almost exactly like that of *Microtus terrestris* (see fig. 34). It thus lacks the deep reentrant angles on the inner side of the lower molars characteristic of *Phenacomys*, and the rounded salient angles and opposite triangles characteristic of *Evotomys*. The last lower molar in particular is noticeably different from that of either *Evotomys* or *Phenacomys*. '*Arvicola*' *intermedius* is apparently still further removed from *Evotomys* by the large size of the teeth as compared with the jaw. There can be little doubt that the animal represents a genus distinct from any now living.[1] In the absence of specimens, however, nothing would be gained by an attempt to name and define the group.

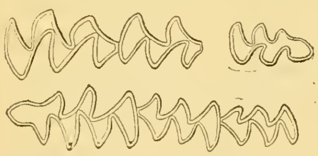


FIG. 40.—Enamel pattern of molar teeth, *Arvicola intermedius*. From Newton.

[1] Whether the rooted microtine teeth mentioned by Nehring (Naturwissenschaftliche Wochenschrift, Nr. 28, July 1894) and by Forsyth Major (Atti Soc. Ital. Sci. Nat., XV, p. 389) belong to animals congeneric with *Arvicola intermedius* is purely a matter of conjecture.

INDEX.

[Synonyms in italics.]

PLATE I.

[Enlarged one and one-half times.]

FIG. 1. *Microtus (Arvicola) macropus.* Wood River, Idaho.
(No. 31630, U. S. Nat. Mus.)

2. *Microtus (Pitymys) pinetorum.* Washington, D. C.
(No. 30332, U. S. Nat. Mus.)

3. *Microtus (Microtus) arvalis.* Cepin, near Esszek, Slavonia.
(No. 3035, collection of Gerrit S. Miller, jr.)

4. *Evotomys.* Portland, N. Dak.
(No. 35835, U. S. Nat. Mus.)

5. *Phenacomys oramontis* Rhoads. Mount Baker Range, British Columbia.
(No. 3562, collection of Gerrit S. Miller, jr.)

6. *Lemmus nigripes.* St. George Island, Alaska.
(No. 42680, U. S. Nat. Mus.)

7. *Microtus (Lagurus) curtatus.* Reese River, Nevada.
(No. 32498, U. S. Nat. Mus.)

8. *Microtus (Chilotus) oregoni.* Sumas, British Columbia.
(No. 4160, collection of Gerrit S. Miller, jr.)

9. *Microtus (Arvicola) terrestris.* Braunschweig, Germany.
(No. 1934, collection of C. Hart Merriam.)

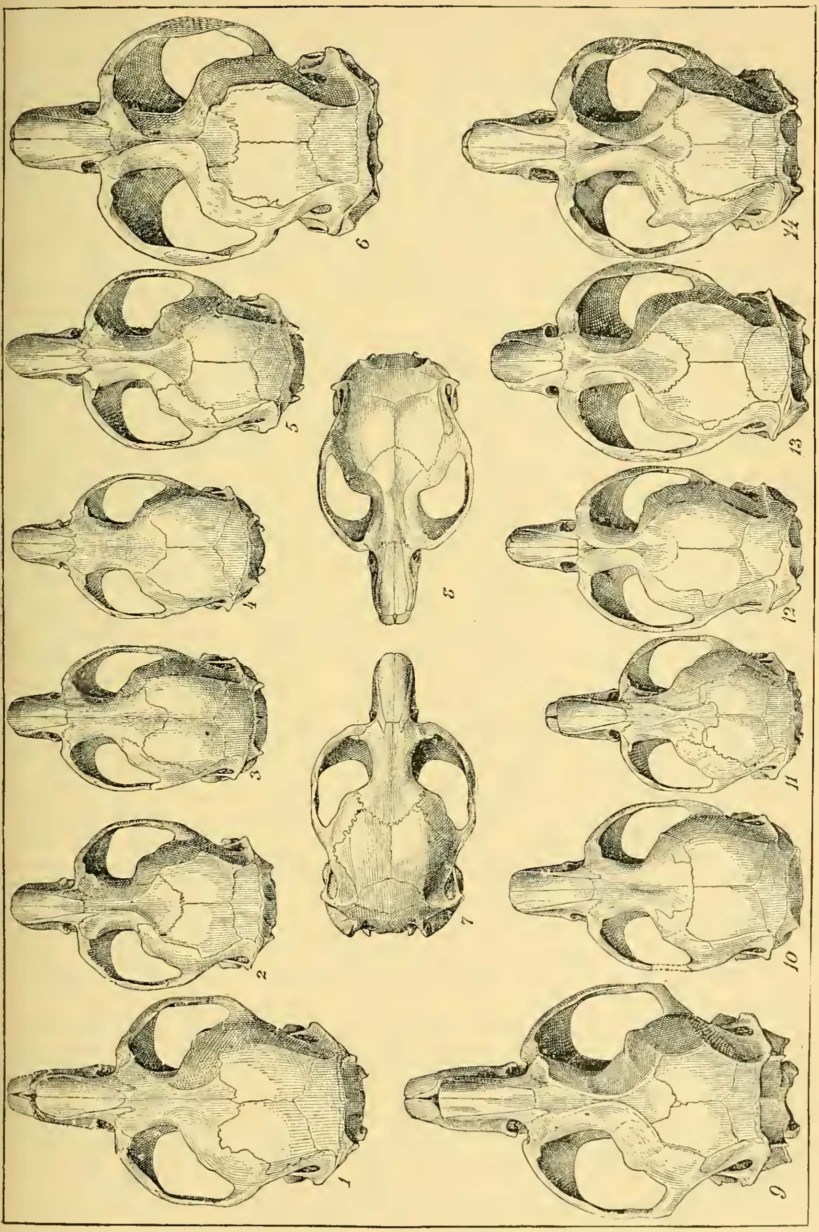
10. *Microtus (Alticola) albicauda.* Type. Braldu Valley, Ballistan.
(No. 36916, U. S. Nat. Mus.)

11. *Microtus (Hyperacrius) fertilis.* Pir Panjal Range, Kashmir.
(No. 35511, U. S. Nat. Mus.)

12. *Synaptomys (Mictomys) wrangeli.* Wrangel, Alaska.
(No. 74720, U. S. Nat. Mus.)

13. *Synaptomys (Synaptomys) helaletes.* Dismal Swamp, Virginia.
(No. 75172, U. S. Nat. Mus.)

14. *Dicrostonyx torquatus.* Petschora, Russia.
(No. 3621, collection of Gerrit S. Miller, jr.)



1. *Microtus macropus.*
2. *Microtus pinetorum.*
3. *Microtus arvalis.*
4. *Evotomys gapperi.*
5. *Phenacomys oramontis.*
6. *Lemmus nigripes.*
7. *Microtus curtatus.*
8. *Microtus oregoni.*
9. *Microtus terrestris.*
10. *Microtus albicauda.*
11. *Microtus fertilis.*
12. *Synaptomys wrangeli.*
13. *Synaptomys helaletes.*
14. *Dicrostonyx torquatus.*

PLATE II.

[Enlarged two and one-half times.]

FIG. 1. Bony palate of *Phenacomys*. Salmon River Mountains, Idaho.
(No. 31249, U. S. Nat. Mus.)

2. Bony palate of *Microtus* (*Lagurus*) *pallidus*. Reese River, Nevada.
(No. 32498, U. S. Nat. Mus.)

3. Bony palate of *Microtus* (*Pitymys*) *pinetorum*. Washington, D. C.
(No. 30332, U. S. Nat. Mus.)

4. Bony palate of *Microtus* (*Alticola*) *blanfordi*. Nultar Valley, Kashmir.
(British Museum Register, 81. 3. 1. 23.)

5. Bony palate of *Microtus* (*Microtus*) *arvalis*. Geneva, Switzerland.
(British Museum Register, 79. 9. 25. 52.)

6. Bony palate of *Microtus* (*Lagurus*) *lagurus*. Gurjeff, Russia.
(No. 3619, collection of Gerrit S. Miller, jr.)

7. Bony palate of *Microtus* (*Arvicola*) *arvicoloides*. Type. Lake Kichelos, Washington.
(No. 1358, collection of S. N. Rhoads.)

8. Bony palate of *Microtus* (*Anteliomys*) *chinensis*. Type. Western Sze-chuen, China.
(British Museum Register.)

9. Bony palate of *Microtus* (*Neofiber*) *alleni*. Florida.
(No. 23452, U. S. Nat. Mus.)

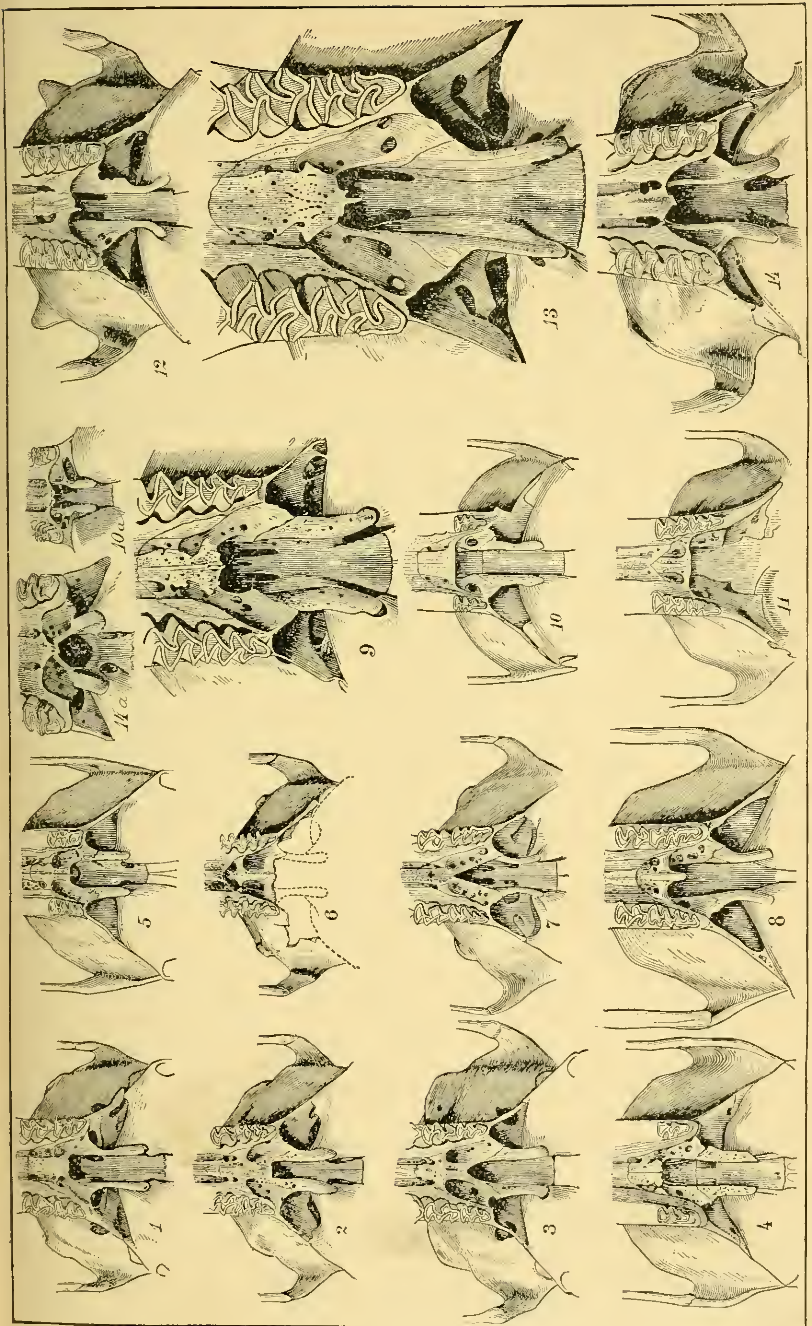
10. Bony palate of *Evotomys glareolus*. Christiania, Norway.
(British Museum Register, 84. 10. 31. 11.)
10. View perpendicular to plain of palate.
10*a*. View from below and behind at strong angle with plain of palate.

11. Bony palate of *Microtus* (*Eothenomys*) *melanogaster*. Western Fokien, China.
(British Museum Register, 92. 10. 12. 52.)

12. Bony palate of *Dicrostonyx torquatus*. Petschora, Russia.
(No. 3621, collection of Gerrit S. Miller, jr.)

13. Bony palate of *Fiber*. Lake George, New York.
(No. 67689, U. S. Nat. Mus.)

14. Bony palate of *Lemmus lemmus*. Vola. (From St. Petersburg Museum.)
(No. 3620, collection of Gerrit S. Miller, jr.)
14. View perpendicular to plain of palate.
14*a*. View from below and behind at strong angle with plain of palate.



1. *Phenacomys.*
2. *Lagurus.*
3. *Pitymys.*
4. *Alticola.*
5. *Microtus.*
6. *Lagurus.*
7. *Arvicola.*
8. *Anteliomys.*
9. *Neofiber.*
10. *Evotomys.*
11. *Eothenomys.*
12. *Dicrostonyx.*
13. *Fiber.*
14. *Lemmus.*

PLATE III.

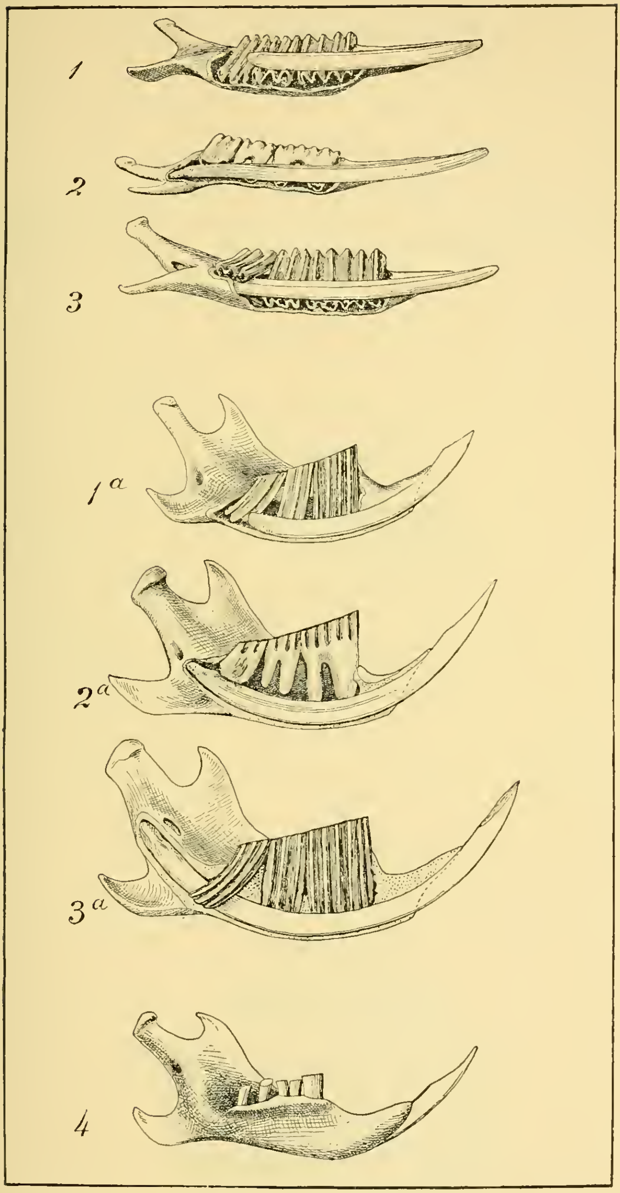
[Enlarged two and two-thirds times.]

FIG. 1. *Synaptomys cooperi.* Roan Mountain, North Carolina.
(No. 50865, U. S. Nat. Mus.)
1. Left mandible from beneath; bone cut away to expose roots of teeth.
1*a*. Left mandible from inner side; bone cut away to expose roots of teeth.

2. *Phenacomys oramontis* Rhoads. Mount Baker, British Columbia.
(No. 3562, collection of Gerrit S. Miller, jr.)
2. Left mandible from beneath; bone cut away to expose roots of teeth.
2*a*. Left mandible from inner side; bone cut away to expose roots of teeth.

3. *Microtus pennsylvanicus.* West Tisbury, Mass.
(No. 1885, collection of Gerrit S. Miller, jr.)
3. Left mandible from beneath; bone cut away to expose roots of teeth.
3*a*. Left mandible from inner side; bone cut away to expose roots of teeth.

4. *Evotomys gapperi.* Seekonk, Mass.
(No. 193, collection of Gerrit S. Miller, jr.)
Left mandible showing effect of excessive wear on teeth.



1. *Synaptomys.*
2. *Phenacomys.*
3. *Microtus.*
4. *Evotomys.*

U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF BIOLOGICAL SURVEY

NORTH AMERICAN FAUNA

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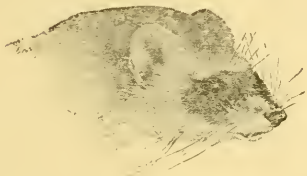

REVISION OF THE NORTH AMERICAN BATS OF THE FAMILY VESPERTILIONIDÆ

BY

GERRIT S. MILLER, Jr.

Prepared under the direction of

Dr. C. HART MERRIAM

CHIEF OF DIVISION OF BIOLOGICAL SURVEY

WASHINGTON

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF BIOLOGICAL SURVEY,
Washington, D. C., July 1, 1897.

SIR: I have the honor to transmit herewith, and recommend for publication, the manuscript of No. 13 of North American Fauna, comprising a monographic revision of the bats of the family *Vespertilionidæ* inhabiting North America north of Panama, by Gerrit S. Miller, jr. It is based mainly on material belonging to the Biological Survey, where the work has been done.

The Department is constantly in receipt of bats sent for identificaion and of letters of inquiry concerning these animals; but heretofore, owing to the chaotic state of the literature relating to this group and the uncertainty respecting the status of the various species, it has been impossible to answer such inquiries with any degree of certainty. The present paper is intended to remove these difficulties.

Respectfully,

C. HART MERRIAM,
Chief, Biological Survey.

Hon. JAMES WILSON,
Secretary of Agriculture.

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No. 13. NORTH AMERICAN FAUNA. October, 1897.

REVISION OF THE NORTH AMERICAN BATS OF THE FAMILY VESPERTILIONIDÆ.

By Gerrit S. Miller, Jr.

Writers on American bats have published a large mass of facts concerning the distribution and comparative anatomy of members of the family *Vespertilionidæ*. Unfortunately, however, no work has yet appeared in which the numerous species by which this group is now known to be represented in North America[1] are treated from the standpoint of the systematic zoologist. In other words it has hitherto been impossible for anyone not thoroughly acquainted with the extensive and scattered literature of North American bats to identify specimens correctly. The present paper has been prepared with special reference to the long-felt want of a ready means to accomplish this object.

MATERIAL.

The greater part of the material on which this revision is based is contained in the collection of the Biological Survey of the U. S. Department of Agriculture. This collection of bats, which consists of more than 3,000 specimens, chiefly in alcohol, has been brought together during the past few years by the field naturalists of the Survey. In addition, the writer has examined the bats in the United States National Museum, the American Museum of Natural History, and several private collections, making a total of about 2,700 specimens of North American *Vespertilionidæ*. It is to be regretted that so few South American bats are contained in the museums of the United States that no definite conclusions can be reached concerning the relationships of several Mexican species to the forms occurring farther south. For this reason certain questions of nomenclature must for the present remain in a condition of uncertainty. It is also to be regretted that comparatively few well-prepared skins are available for comparison. Without good series of dry specimens it is impossible to determine the limits of individual variation in color, as conclusions of the most general kind only can be based on specimens that have been subjected to the action of alcohol. Series of bat skins as extensive as those by which most groups of small North American mammals are now represented will doubtless prove

[1] In the present paper the term North America is used to indicate the whole of the North American continent and the West Indies.

the existence of several well-marked geographic races in addition to those now recognizable.

In the lists of specimens examined it has not been thought necessary to distinguish between those contained in the National Museum proper and those in the collection of the Biological Survey. Specimens from other collections, however, are always specially designated.

CHANGES IN COLOR OF SPECIMENS PRESERVED IN ALCOHOL.

Bats which have been kept in alcohol for a period of more than a few months become so altered in color that they furnish reliable characters of size and form only. The rate and amount of change appear to vary with different species as well as with the strength of the preservative fluid and the amount of exposure to light. I have seen two lots of specimens of one species collected at the same place and on practically the same date and supposedly treated in the same way, yet after six years' immersion in alcohol those in one bottle still retained essentially their normal color, as proved by comparison with skins collected at the same time, while those in another bottle were so bleached as to show scarcely a semblance of their original appearance.

While the details of the changes produced by alcohol are not known, it may be said that a gradual bleaching and ultimate entire loss of color is the general rule, though as a preliminary step browns are often very noticeably reddened. The subject is one that merits experimental study.

SEXUAL VARIATION.

The range of sexual variation in North American *Vespertilionidæ* is always slight and in many cases scarcely appreciable. For the most part it consists in the slightly greater average size of the females. Even this is often trifling or absent, as in the case of *Myotis lucifugus longicrus* from Nicasio, Cal., six males of which average: Total length, 95.1; tail vertebræ, 45.8; forearm, 37.8; ear, 11.8; tragus, 7.3; while six females from the same locality average: Total length, 96.3; tail vertebræ, 44.1; forearm, 37.3; ear, 12.1; tragus, 7.2. In general, however, it is necessary to take this factor into consideration when comparing specimens from widely separated localities. I know of no instances of constant sexual differences in color among North American *Vespertilionidæ*, and only one of differences in cutaneous structures, that of *Rhogeëssa gracilis*, in which the only known male has in each ear a distinct glandular swelling, absent in the two females that I have examined (see Pl. I, fig. 7).

AGE VARIATION.

Young bats when nearly full grown often present characters different enough from those of the adults to cause confusion in identification. The fur of such immature specimens is usually shorter and more woolly than that of the adults and the color darker and duller. The immature skull differs in size and form from that of the adult, but as the sutures disappear at an early age, it is often somewhat difficult to recognize.

I have found that the best guide to the age of those bats that I have studied is the condition of the finger joints. In specimens young enough to furnish unreliable characters these are always large and loosely formed, with epiphyses separate from the ends of the phalanges and metacarpals, both of which are distinctly enlarged for some distance from the joint (fig. 1 *a*). In adults the finger joints are small and compact, the epiphyses no longer visible, and the phalanges of essentially the same diameter throughout (fig. 1 *b*). These differences are equally apparent in alcoholic specimens and in dried skins.

FIG. 1.—Wings of *Vespertilio serotinus*: *a*, adult; *b*, immature (natural size).

GEOGRAPHIC VARIATION.

As compared with other small mammals, bats show remarkably little geographic variation in size, proportions, or color. Thus breeding individuals of *Nycticeius humeralis* from Carlisle, Pa., Dismal Swamp, Virginia, and the extreme southern point of Texas are alike in color,[1] while in size they agree almost as closely as any three lots of specimens from one locality.[2] The only difference that can be found is a slight northward increase in size of the ears. Specimens of *Myotis lucifugus* from Washington, D. C., are not distinguishable from a series taken on Kadiak Island, Alaska, and skins of *Lasiurus cinereus* from Minnesota are exactly like others from southern California. While such constancy of characters in wide ranging species is unparalleled among American mammals, the only ones of which it is yet possible to

[1] So far as can be ascertained from comparison of specimens in alcohol.

[2] See table of measurements on page 120.

speak with certainty, the explanation of the fact is probably very simple. Living throughout the warmer part of the day in cool, dark, and for the most part damp situations, bats, even in widely separated localities, are exposed to comparatively little variation in temperature. Feeding at a distance above the surface of the ground and during the hours between sunset and sunrise, when colors are scarcely distinguishable, they are practically freed from that necessity for protective coloration which binds the color of most mammals so closely to that of their surroundings. From this reduction in the force of two of the most powerful factors in the production of geographic variation—differences in temperature and need for protective coloration—the comparative constancy in the characters of bats naturally results.

GEOGRAPHIC DISTRIBUTION.

From the peculiar habits of bats it results that the ranges of these animals are less closely limited by life areas than in the case of most mammals. To be more accurate, the frequent dampness and usual low, even temperature of the retreats occupied by bats during the hot part of the day expose the animals to essentially similar conditions wherever they may be, so that a given region of like environment is much more extended geographically for a bat than for most other mammals.[1]

Therefore, although many species seemingly disregard the laws of geographic distribution, their independence is more apparent than real.

MIGRATION.

A factor which introduces much uncertainty into the study of the distribution of bats is the little understood migrations which some species are known to make. That many bats migrate is a well-established fact, but the extent to which migration affects the apparent distribution of species is not known.

Although there are probably earlier references to the subject, the first mention of bat migration that I have seen is by Dobson, in his Catalogue of the Chiroptera in the British Museum, published in 1878. In his remarks on the geographic distribution of *Pipistrellus abramus*, Dobson says: "Found during the summer months in the Palæarctic region throughout middle Europe; * * * evidently migrates northward, * * * as it has never been taken in Europe in winter" (p. 227). In 1888 Dr. C. Hart Merriam published evidence in the Transactions of the Royal Society of Canada (V, Section V, p. 85), which showed conclusively that two American bats, *Lasionycteris noctivagans* and *Lasiurus cinereus*, perform regular periodical migrations. No details of the

[1]Analogous conditions are found in sphagnum bogs and heavy, damp woodlands, in which animals of northern affinities, such as shrews, lemmings, and red-backed mice, extend far south of the normal limit of their kind.

extent or exact dates of the northward and southward movements could then be given further than that the known southern records of the hoary bat (South Carolina, Georgia, Bermuda Islands) were all during autumn and winter, and that the silver-haired bat occurred in spring and fall about the light-house on Mount Desert Rock, 30 miles off the coast of Maine, a treeless islet where bats were at other times unknown. In August and September, 1890 and 1891, I had an opportunity to watch the appearance and disappearance of three species of bats, *Lasionycteris noctivagans*, *Lasiurus borealis*, *and Lasiurus cinereus*, at Highland Light, Cape Cod, Massachusetts. The animals, which were not to be found during the early summer, suddenly became numerous shortly after the middle of August and remained abundant for about a month, when they as suddenly disappeared. The regularity with which this phenomenon occurred on the two successive years over which my observations extended shows that the migration of bats is probably as definite as to dates and paths as that of birds.[1]

MEASUREMENTS.

For general purposes of identification, ten measurements are useful. These are: Total length, tail vertebræ, tibia, foot, forearm, thumb, longest finger, height of ear from meatus, width of ear, and height of tragus. The lengths of the separate phalanges of the fingers are important in special cases only.

The tables which accompany the descriptions of the different forms contain average measurements of specimens selected from as wide a range of localities as possible. Whenever the full complement of measurements is given, it is to be understood that all have been taken from alcoholic specimens by the writer. When the total length, length of tail, and the three measurements of the ear are omitted, the measurements have been taken from the dried skin. In a few cases the skin measurements are supplemented by the collector's measurement of total length and tail vertebræ. The use of specimens preserved in alcohol introduces a source of error in two measurements—total length and length of tail. According to the strength of the preservative fluid, both body and tail are to a varying degree shrunk or relaxed, so that considerable discrepancies in the averages of specimens taken at different localities by different collectors may result. In general, it is probable that these two measurements as given in the tables are a trifle shorter than they would have been if taken from fresh material.

It is unfortunate that detailed measurements of individuals can not be published, since averages are of use for comparison with averages only, and it often happens that a single specimen must be identified. Averages, moreover, give no indication of the normal range of individual variation at a particular locality.

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[1] A detailed account of the migration of bats on Cape Cod was published in Science, N. S., V, No. 118, pp. 541-543, April 2, 1897.

ILLUSTRATIONS.

The illustrations in this paper are reproductions of pen-and-ink drawings made under my constant supervision by Mr. Frank Müller. Special difficulty has been encountered in obtaining satisfactory representations of the external ear and of the crowns of the teeth.

The ears of alcoholic specimens are generally sufficiently altered in form, by pressure and by the action of the preservative fluid, to retain only approximately the appearance which they had in the living animal. This is especially the case with such large-eared species as *Antrozous pallidus*, *Corynorhinus macrotis*, *Myotis evotis*, and others. In the impossibility of reproducing their original appearance, it has been thought best to represent the ears in a uniform but somewhat unnatural position, with the conch flattened and the external basal lobe turned outward. This will account for the apparently undue width of certain drawings.

The crown views of the teeth were first sketched with the aid of a camera lucida and afterwards corrected and finished by the use of hand lenses. The great difficulty in obtaining accurate and uniform results arose from the impossibility of keeping specimens in exactly comparable positions and from the considerable changes in outline resulting from every slight variation in the angle of vision. Therefore the drawings are not wholly satisfactory. They are published, however, in the belief that, such as they are, they may help to an understanding of the characters of the species.

NOMENCLATURE OF NORTH AMERICAN VESPERTILIONIDÆ.

To arrive at final conclusions in regard to the nomenclature of the *Vespertilionidæ* of North America, it will be necessary to consider in detail all names that have been based on those members of the group that inhabit the region in question, and also a few based on allied Old World species. The names may best be taken up alphabetically.

1. Generic and Subgeneric Names.

Adelonycteris H. Allen, **1892** (Proc. Acad. Nat. Sci., Phila., 1891, p. 466, Jan. 19, 1892), was proposed as a substitute for *Vesperus* Keys. & Blas., preoccupied in Entomology by *Vesperus* Latreille, 1829. The name is, however, a synonym of *Vespertilio* Linnæus, 1758, *Eptesicus* Rafinesque, 1820, and also of *Cnephæus* Kaup, 1829.

Aeorestes Fitzinger, **1870** (Sitzungsber. Math.-Nat. Cl. K. Akad. Wiss., Wien, LXII, Abth., I, pp. 427–436), is a synonym of *Myotis* Kaup, 1829. The group included three South American species, *Myotis villosissimus*, *M. nigricans*, and *M. albescens*.

Antrozous H. Allen, **1862** (Proc. Acad. Nat. Sci. Phila., p. 248), is the only generic name based on *Vespertilio pallidus* Le Conte.

Atalapha Rafinesque, **1814** (Précis des Découv. et Travaux Somiologiques, p. 12), is clearly based on a Sicilian bat.[1] The use of the name for a genus confined to America is therefore impossible.

Brachyotus Kolenati, **1856** (Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 174–177), is a subgeneric name based on three European species of '*Vespertilio*' (*mystacinus*, *daubentonii*, and *dasycneme*) with ears shorter than head.

Cateorus Kolenati, **1856** (Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 162–163), a subgeneric name based on '*Vesperus*' *serotinus*, is a synonym of *Vespertilio* Linnæus.

Cnephæus Kaup, **1829** (Skizzirte Entw.-Gesch. u. Natürl. Syst. d. Europ. Thierw., 1ster Theil, p. 103), is a generic name based on *Vespertilio serotinus* Schreber, a species congeneric with *Vespertilio fuscus* of America. The name is a synonym of *Vespertilio*.

Cnephaiophilus Fitzinger, **1870** (Sitzungsber. K. Akad. Wiss., Wien, LXII, Abth. I, p. 81), is a genus composed of very heterogeneous elements among which no type is mentioned. The species referred to it are *macellus* ('Borneo'), *pellucidus* ('S. E. Asia, Philippines'), *ferrugineus* ('Mittel-Amerika, Surinam'), and the North American *noctivagans*. Whether or not the name may be available for some of the other species, it certainly is not for the one which comes within the limits of the present paper, since this was already provided with the generic name *Lasionycteris*.

Comastes Fitzinger, **1870** (Sitzungsber. Math.-Nat. Cl. K. Akad. Wiss., Wien, LXII, Abth. I, p. 565), is a synonym of *Myotis* Kaup, unless it may eventually be shown that the species on which it was based, *capaccinii*, *megapodius*, *dasycneme* and *limnophilus*, are subgenerically distinct from *Myotis myotis*.

Corynorhinus H. Allen, **1865** (Proc. Acad. Nat. Sci. Phila., p. 173), proposed as a generic name for *Plecotus macrotis* Le Conte and *P. townsendi* Cooper, is the only available name for the group of which *Corynorhinus macrotis* is the only known species.

Dasypterus Peters, **1871** (Monatsber. K. Akad. Wiss., Berlin, 1870, p. 912, published 1871), was established as a subgenus of *Atalapha* (=*Lasiurus*) to contain the species *intermedia*, *egregia*, *ega*, and *caudata*. It has recently been raised to full generic rank by Dr. Harrison Allen.

Eptesicus Rafinesque, **1820** (Annals of Nature, p. 2), originally con-

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[1] II. G. ATALAPHA (Chauve-souris). Incisives nulles aux deux mâchoires, canines et machelières aigues: aucune crête sur le nez, queue presqu'entièrement unie aux membranes.

2. *Atalapha sicula.*—Oreilles de la longueur de la tête, et auriculées, une verrue sous la lèvre inférieure; corps roux brunâtre en dessus, roux cendré en dessous, ailes et museau noiratre, queue saillante par une pointe obtuse.—Obs. J'ai observé cette espèce en Sicile, elle diffère de l'*Atalapha americana* (*Vespertilio noreboracensis* Lin.), autre espèce du même genre, par ses deux premiers et son dernier caractère.

tained two species, *E. melanops* and *E. mydas*.[1] *Eptesicus melanops* is without doubt the *Vespertilio fuscus* of Beauvois. *E. mydas*, however, can not be identified (see p. 32). The first species must therefore be taken as the type. Since this species is congeneric with *Vespertilio murinus* Linnæus (= *Vesperugo discolor* Natterer), the type of the genus *Vespertilio*, the name *Eptesicus* is a synonym of *Vespertilio*.

Euderma H. Allen, **1892** (Proc. Acad. Nat. Sci. Phila., 1891, p. 467, published Jan. 19, 1892), is the tenable name for the genus of which *Histiotus maculatus* J. A. Allen is the type and only known species.

Histiotus Gervais, **1855** (Exped. Comte de Castelnau Am. du Sud, Zool., Mammif., p. 77, Pl. XII), was based on the South American *Plecotus velatus* of Geoffroy. *Euderma maculatum* was originally described as a member of this genus, the name of which has not otherwise appeared in the literature of North American *Vespertilionidæ*.

Hypexodon Rafinesque, **1819** (Journal de Physique, de Chimie, d'Histoire naturelle et des Arts, LXXXVIII, p. 417), can not be identified with any known group of bats. The characters which Rafinesque assigns to the type species[2] may be those of a mutilated and distorted specimen of some of the small species of *Nycticeius*, *Pipistrellus*, or *Myotis*.

Hypsugo Kolenati, **1856** (Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 167–169), is a synonym of *Pipistrellus* Kaup. It was based on '*Vesperugo*' *maurus* Blasius and '*V.*' *kraschenikowii* Eversmann.

Isotus Kolenati, **1856** (Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 177–179), is a subgeneric name based on two European species of '*Vespertilio*' (*nattereri* and *ciliatus*) which have the ear about equal in length to the head. It is of course a synonym of *Myotis* Kaup, 1829, and of *Selysius* Bonaparte, 1841.

Lasionycteris Peters, **1865** (Monatsber. K. Preuss. Akad. Wiss., Berlin, 1865, p. 648), is the first name proposed for the genus of which *Vespertilio noctivagans* Le Conte is the only known species.

Lasiurus Gray, **1831** (Zoological Miscellany, No. 1, p. 38), is the first

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[1] The original diagnosis of the genus *Eptesicus* is as follows:

"1. N. G. EPTESICUS. Four acute fore-teeth to the upper jaw, in two equal pairs, separated by a great interval and a large flat wart, each pair has two unequal teeth, the outside tooth is much larger and unequally bifid, the outside one much larger, inside tooth small and entire. Six fore-teeth to the lower jaw, equal very small, close and truncate. Canine teeth very sharp, curved and long. Grinders unequally trifid. Snout plain, nose without appendages. Ears separated, auriculated. Tail mucronate.—This genus appears to differ from all those of Geoffroy and Cuvier, among the extensive tribe of Bats. The name means house-flyer."

[2] 1. Nouveau genre. HYPEXODON. (Chauve-souris.) Museau nu; narines rondes, saillantes; incisives supérieures nulles, 6 inférieures émarginées, une verrue à la base extérieure des canines inférieures. Queue engagée dans la membrane. Le reste comme le genre *Vespertilio*.—I espèce *H. mystax*. entièrement fauve, dessus de la tête brun, ailes et membranes noires, queue mucronée, des moustaches, oreilles brunes auriculées, nervures intérieures et transversales; longueur totale, 3 pouces, dont la queue 2 pouces. En Kentucky.

name based on the bats of the American genus commonly but wrongly called *Atalapha*. It was introduced as follows: "The bats, the *Vespertiliones* of Geoffroy, might for convenience be divided into three genera, the true bats, *Vespertilio* * * *, the *Pachyotus* * * *, and the hairy tailed species of America (*Lasiurus*)." As the only hairy-tailed American bats known in 1838 were members of the modern genus *Lasiurus*, this brief statement may be taken as a definite indication of the author's meaning. In 1838 Gray referred the species *pruinosus* (=*cinereus*), *lasiurus* (=*borealis*), and *blossevillei* (=*borealis*, *fide* Dobson) to the group, which he then regarded as a subgenus or section of *Scotophilus* (Mag. Zool. & Bot., II, p. 498, Edinburgh, 1838).

Marsipolæmus Peters, **1872** (Monatsber. k. Preuss. Akad. Wiss., Berlin, p. 260), was proposed in a subgeneric sense for a Mexican bat, *Vesperus albigularis* Peters, about the size of *Vespertilio fuscus*, with the dentition of that species, but with the outer border of the ear continuous with a fold of skin which extends back from the corner of the mouth, under and behind which a distinct pocket is formed. I have never seen this bat, and am unable to say what value is to be placed on the characters described. (See p. 104.)

Meteorus Kolenati, **1856** (Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 167–169), is a synonym of *Vespertilio* Linnæus. It was proposed as a subgenus of '*Vesperus*' to include the species *nilssoni*, *discolor*, *savii*, *leucippe*, and *aristippe*.

Myotis Kaup, **1829** (Skizzirte Entw. Gesch. u. Natürl. Syst. der Europ. Thierw., 1ster Theil, p. 106), is the first name based on the large, long-eared, thirty-eight-toothed bat wrongly called *Vespertilio murinus* by Schreber.[1] It is therefore the tenable name for the genus of which this animal is the type. As the *Vespertilio murinus* of Schreber is not the *Vespertilio murinus* of Linnæus, another specific name must be applied to the former. The name *myotis* Bechstein[2] is available for this purpose. Hence the *Vespertilio murinus* of Schreber and of European writers in general must stand as *Myotis myotis* (Bechstein).

Nannugo Kolenati, **1856** (Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 169–172), is a synonym of *Pipistrellus* Kaup, 1829. It was proposed as a subgenus of '*Vesperugo*' to include the European species *pipistrellus*, *kuhlii*, and *nattereri*.

Noctula Bonaparte, **1837** (Iconografia Fauna Italica, I, fasc. XXI, under *Vespertilio alcythoe*), based on *Vespertilio serotinus* Schreber is a synonym of *Vespertilio* Linnæus.

Nycticeius Rafinesque, **1819** (Journal de Physique, de Chimie, d'Histoire Naturelle et des Arts, LXXXVIII, p. 417), contained two species,

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[1] Kaup says: "Fledermäuse von riesenmässiger Grösse, mit nacktem Gesicht, getrennten, kopfslangen Ohren, langen lanzettförmigen Ohrendeckeln, und 38 Zähnen."

[2] *Vespertilio myotis* Bechstein, Gemeinnütz. Naturgesch. Deutschlands, Bd. I, p. 1145, 1791 (*fide* Blasius).

N. humeralis Raf. and *N. tesselatus* Raf. Nothing in the description[1] indicates which of these the author considered as the type. *Nycticeius tesselatus* Raf. is *Lasiurus borealis* (Müller), and *N. humeralis* may with some degree of probability be identified with the small brown bat more generally known as *Nycticejus crepuscularis* Le Conte.[2] There is certainly nothing in the diagnosis of the genus or in the description of *Vespertilio humeralis* previously published in the American Monthly Magazine that precludes this possibility, while the size, the number of incisors, and the naked uropatagium point directly toward it. As *borealis* was removed to the genus *Lasiurus* by Gray in 1838, *humeralis* becomes the type of *Nycticeius*. The orthography of this name has had several emendations, as *Nycticeus*, *Nycticejus*, *Nycticea*, and *Nycticeyx*.

Nyctilestes Marsh, **1872** (Amer. Journ. Sci. & Arts, 3d ser., IV, p. 215), is a fossil genus based on part of a lower jaw and molars from Eocene or Lower Miocene strata near Henrys Fork, Wyoming. The remains present no characters to distinguish them generically from *Vespertilio*. Only one species, *Nyctilestes serotinus*, has been described.

Nyctitherium Marsh, **1872** (Amer. Journ. Sci. & Arts, 3d ser., IV. p. 127), is a genus based on the fragments of two lower jaws found with teeth in place, from Tertiary strata at Grizzly Buttes, Wyoming. The original description indicates no characters by which these teeth may be distinguished from those of small species of *Pipistrellus* or *Vespertilio*.

Nystactes Kaup, **1829** (Skizzirte Entw.-Gesch. u. Natürl. Syst. der Europ. Thierw., 1ster Theil, p. 108), based on *Vespertilio bechsteinii* Leisler is strictly synonymous with the same author's *Myotis*.[3]

Pachyotus Gray, **1831** (Zool. Misc., No. 1, p. 38), was first used as the name for a genus made by the combination of *Nycticeius* and *Scotophilus*. Later (Mag. Zool. & Bot., II, p. 498, 1838) Gray transferred it to *Vespertilio villosissimus* Geoffroy in a subgeneric sense. The name is of course untenable.[4]

Pipistrellus Kaup, **1829** (Skizzirte Entw.-Gesch. u. Natürl. Syst. der Europ. Thierw., 1ster Theil, p. 98). This name was based on *Vespertilio pipistrellus* Schreber, a species strictly congeneric with the '*Vesperugo*

[1]2. NYCTICEIUS. (Chauve-souris.) Diffère du genre précédent [*Hypexodon*] par 2 incisives supérieures séparées par un grand intervalle, accolées aux canines et à crénelures aiguës, 6 incisives inférieures tronquées, point de verrues aux canines.—Ce genre contient au moins 2 espèces, *N. humeralis* et *N. tesselatus*, que j'ai déjà décrits dans l'*American Monthly Magazine*, sous la dénomination générique *Vespertilio*, avec plusieurs autres nouvelles espèces de ces contrées.

[2]See Thomas, Ann. & Mag. Nat. Hist., 1891, 528.

[3]Kaup says: "Fledermäuse mit sehr langen getrennten Ohren, langem zugespitzem Ohrendeckel, 38 Zähnen und spitzmausähnlichem Rüssel."

[4]The original reference is as follows: "The bats, the *Vespertiliones* of Geoffroy, might for convenience be divided into three genera, the true bats, *Vespertilio*, with thin ears and membranes and a hairy face, the *Pachyotus*, with thick ears and membranes and bald swollen cheeks, including the genera *Nycticejus* and *Scotophilus*, and the hairy-tailed species of America (*Lasiurus*)."

georgianus' of the United States. It antedates the name *Vesperugo* by exactly ten years.

Plecotus Geoffroy, **1818**[1] (Description de l'Égypte, Mammifères, p. 112), included three species, 'l'Oreillard de Daubenton,' 'la barbastelle,' and a new species from Timor.[2]

As no American bats are congeneric with the species originally included in this genus, the name can not be used for any of the genera now under consideration. It has been applied to the species of *Corynorhinus*.

Rhogeëssa H. Allen, **1866** (Proc. Acad. Nat. Sci. Phila., p. 285), was proposed as a genus to contain the species *R. parvula* H. Allen and *R. tumida* H. Allen. The group, whose validity has not been questioned, has received varying treatment at the hands of different writers. Dobson placed it as a subgenus under '*Vesperugo*,' but Thomas has recently pointed out its close relationship to *Nycticeius*. The latter disposition appears to be the more natural.

The name has been amended to *Rhogöessa* by Marschall (Nomenclator Zoologicus, Mamm., p. 11, 1873).

Scotophilus Leach, **1821** (Trans. Linn. Soc. London, XIII, pt. 1, p. 69), type *S. kuhlii* Leach, is a genus peculiar to the Old World, where it apparently replaces the *Lasiurus* of America. It is mentioned here merely because the name has been used for the North American species of *Lasiurus*, *Vespertilio*, *Lasionycteris*, and *Pipistrellus* at times when these bats were supposed to be congeneric with Old World species.

Selysius Bonaparte, **1841** (Iconografia Fauna Italica, I, Introduzione [p. 3]), is a synonym of *Myotis* Kaup, 1829. It was based on the common European *Vespertilio mystacinus* of Leisler.

Synotus Keyserling and Blasius, **1839** (Wiegmann's Archiv f. Natur. geschichte, 5ter Jahrgang, Bd. I, pp. 305, 306), was based on the barbastelle, a European bat representing a genus not known to occur in America. The name, however, has been applied to the American genus afterwards called *Corynorhinus*. It is antedated by *Barbastella* Gray, 1821 (London Medical Repository, XV, p. 309. Type *Vespertilio barbastellus* Schreber).

Taphozous Geoffroy, **1818**[1] (Description de l'Égypte, Mammifères, p. 113), based on 'Le lerot-volant' and 'le *V. lepturus*,' which are without representatives in America. The red bat (*Lasiurus borealis*) was, however, included in this genus by Godman under the name *Taphozous rufus*.[3]

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[1] See Sherborn, Proc. Zool. Soc. London, 1897, p. 288.

[2] Dents incisives $\frac{4}{6}$; canines $\frac{2}{2}$; molaires $\frac{5\text{–}5}{6\text{–}6}$. Nez *simple et saillant;* chanfrein *large et méplat.* Oreilles *plus grandes* que la tête, et réunies; oreillon intérieur. Membrane interfémorale étendue et à angle saillant. Queue longue et toute entière enveloppée.

Obs. Les trois espèces de ce genre sont, l'oreillard de Daubenton, la barbastelle et une nouvelle espèce de Timor.

[3] Fauna Americana, p. 23, 1825.

Fitzinger[1] refers to a '*Taphozous brachmanus* Godman' among the synonyms of *Lasiurus* '*rufus*' (= *borealis*). This name, however, I have been unable to find in any of Godman's writings.

Vesperides Coues, **1875** (in Coues and Yarrow, Zool. of Wheeler's Exped., p. 83), was proposed as a subgenus of *Vespertilio* based on *Vespertilio noctivagans* Le Conte. The name is antedated by *Lasionycteris* Peters, 1865.

Vespertilio Linnæus, **1758** (Syst. Nat., 10th ed., I, p. 31), contained seven species: *vampyrus*, *spectrum*, *perspicillatus*, *spasma*, *leporinus*, *auritus*, and *murinus*. These have all been removed to other genera, as follows: *vampyrus* to *Pteropus* in 1762 (Brisson, Regn. Anim., ed. II, pp. 13, 153), *leporinus* to *Noctilio* in 1766 (Linnæus, Syst. Nat., 12th ed., p. 88), *spasma* to *Megaderma* in 1810 (Geoffroy, Ann. Mus. d'Hist. Nat., XV, p. 197), *auritus* to *Plecotus* in 1818 (Geoffroy, Descript. de l'Égypte, Mammifères, p. 112), *murinus*[2] to *Eptesicus* in 1820 (Rafinesque, Annals of Nature, 1820, p. 2), *perspicillatus* to *Artibeus* in 1821 (Leach, Trans. Linn. Soc. London, XIII, p. 75), and *spectrum* to *Vampyrus* in 1821 (Leach, Trans. Linn. Soc. London, XIII, p. 79).

The only European species are *auritus* and *murinus*, one of which must therefore become the type of the genus. The species *auritus* was removed to the genus *Plecotus* by Geoffroy in 1818, leaving *murinus* as type of the genus *Vespertilio*. The *Vespertilio murinus* of Linnæus is, however, a totally different animal from the bat afterwards described under the same name by Schreber. To understand the case fully it is necessary to go back to the first and second editions of Linnæus's Fauna Suecica. In the first he records only one bat, the 'Läderlapp,' 'Flädermus' or 'Nattblacka,' *Vespertilio caudatus, naso oreque simplici* (No. 18, p. 7, 1746). In the second edition he mentions two, *V. caudatus, naso oreque simplici, auriculis duplicatis, capite majoribus*, and *V. caudatus, naso oreque simplici, auriculis capite minoribus* (No. 2, pp. 1, 2, 1761). In the tenth edition of the Systema Naturæ these had been given binomial names, *Vespertilio auritus* and *V. murinus*, respectively. The account of the teeth of the latter in the second edition of Fauna Suecica is as follows:[3]

Dentes primores superiores 6, acuti distantes.
inferiores 4, acuti contigui.
Laniarii superiores 2, anteriore majore.
inferiores 3, antico maximo.
Molares utrinque 3, tricuspidati.

[1] Sitzungsber. K. Akad. Wiss. Wien, LXII, 1ste Abth., p. 402, 1870.

[2] Although Rafinesque did not actually place the species *murinus* in the genus *Eptesicus* he based the latter on a strictly congeneric form.

[3] In the first edition the dental formula is the same, except that the lower incisors are said to be five in number, an error corrected in the second edition.

It therefore appears that the *Vespertilio murinus* of Linnæus is a bat with ears shorter than the head, and with the dental formula:

$$i, \frac{2-2}{3-3}{}^{1}; \; c, \frac{1-1}{1-1}; \; pm, \frac{1-1}{2-2}; \; m, \frac{3-3}{3-3} = 32.$$

The only common Scandinavian bats which combine these characters are the two usually known as *Vesperugo nilssoni* and *Vesperugo discolor*. To these strictly congeneric European species and their exotic representatives the generic name *Vespertilio* must be applied, regardless of its long misuse for a different genus.

The current misidentification of Linnæus's *Vespertilio murinus* has been recognized by at least three writers on European bats, Nilsson, Blasius, and Lilljeborg. Nilsson[2] discusses the matter at considerable length and arrives at the conclusion that the name *murinus* must be substituted for *discolor*, while the bat commonly known as *murinus* must take the specific name *myotis* Bechstein. As this author unites the genera '*Vesperugo*' and '*Vespertilio*,' he has nothing to say in regard to the validity of the generic names used by Keyserling and Blasius.

Blasius[3] regarded Nilsson's identification of *Vespertilio murinus* as doubtful, though he admitted that the animal described by Linnæus under that name could not have been the one generally called *Vespertilio murinus* by European authors at large. He therefore reasoned that Linnæus's name might be disregarded as undeterminable and in no way invalidating Schreber's later application.

Lilljeborg alone questioned the tenability of the generic name *Vespertilio* for the thirty-eight-toothed bats of Europe.[4] He says:

> * * * As regards modifying the Linnæan generic name *Vespertilio*, it may be urged that Linnæus did not include in it any of the species referred to it by Keyserling and Blasius. Further, it would have been more correct to apply the name *Vespertilio* to the preceding genus ['*Vesperugo*'], since one of the species included in the genus by Linnæus (*Vespertilio murinus*) agrees, in all important characters at least, with the genus mentioned, as shown above. As, however, the modification of the name introduced by Keyserling and Blasius has become time-sanctioned, it will be retained, although we consider the objections against it reasonable.[5]

Vesperugo Keyserling and Blasius, **1839** (Wiegmann's Archiv f. Naturgesch., 5ter Jahrgang, Bd. I, p. 312), was proposed as a genus to contain the following species up to that time commonly associated with *Vesper-*

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[1] In Linnæus's statement the figures 4 and 6 are evidently transposed.

[2] Skandinavisk Fauna, I, Däggdjuren, 2d ed., 1847, pp. 17–20.

[3] Naturgesch. d. Säugethiere Deutschlands, pp. 74, 84, 1857.

[4] Sveriges och Norges Ryggradsdjur, I, Däggdjuren, p. 144, footnote, 1874.

[5] * * * I afseende på tillämpningen här af det Linneanska genus-namnet *Vespertilio*, kan deremot invändas, att Linné icke uti detta genus upptagit en enda af de arter, som Keyserling & Blasius derunder beskrifvit, och att det hade varit rättare, att använda detta namn för föregående slägte ['*Vesperugo*'], emedan en af de af Linné uti sl. *Vespertilio* upptagna arterna—*Vespertilio murinus* Lin.—åtminstone till hufvudsaklig del, enligt hvad ofvan blifvit anfördt tillhör nämde slägte. Då emellertid den af Keyserling & Blasius införda tillämpningen af namnet vunnit häfd, vilja vi bibehålla den, ehuru vi anse invändningen vara befogad.

tilio: *serotinus*, *discolor*, *nilssoni*, *savii*, *leucippe*, *aristippe*, *noctula*, *leisleri*, *kuhlii*, *albolimbatus*, *nathusii*, and *pipistrellus*. The first six were placed in the new subgenus *Vesperus*, the others in the subgenus *Vesperugo*. Hence the type must be a member of the second group. This group, however, contains two modern genera, the first represented by the species *noctula* and *leisleri*, the second by *kuhlii*, '*albolimbatus*' (=*kuhlii*, *fide* Dobson), '*nathusii*' (=*abramus*, *fide* Dobson), and *pipistrellus*. These had already been named *Pterygistes* and *Pipistrellus*, respectively, by Kaup in 1829. Hence *Vesperugo* is untenable in any connection.

Vesperus Keyserling and Blasius, **1839** (Wiegmann's Archiv f. Naturgesch., 5ter Jahrgang, Bd. I, p. 313), proposed as a subgenus of '*Vesperugo*' to include the species *serotinus*, *discolor*, *nilssoni*, *savii*, *leucippe*, and *aristippe*, is antedated by *Cnephaeus* Kaup, 1829, *Eptesicus* Rafinesque, 1820, and *Vespertilio* Linnaeus, 1758. It is moreover preoccupied in Entomology by *Vesperus* Latreille, 1829.

2. Specific and Subspecific Names.

Affinis (Vespertilio). H. Allen, Monogr. Bats N. Am., p. 53, **1864**. The type of Dr. Harrison Allen's *Vespertilio affinis*, now in the United States National Museum, proves to be a typical example of *Myotis lucifugus*. It is therefore in no way related to the *Vespertilio nitidus* or *V. albescens* of Dr. Allen's second monograph.

Albescens (Vespertilio). E. Geoffroy, Ann. Mus. d'Hist. Nat., Paris, VIII, p. 204, **1806**. This is a South American species of *Myotis*, probably closely related to *M. velifer* (J. A. Allen). The measurements given by Azara and quoted in the original description are: Total length, 80 mm.; tail, 33; extent of wings, 235; ear, 14. The name *albescens* has been used by Dr. Harrison Allen for *Myotis yumanensis*, *M. evotis*, *M. californicus* ('*Vespertilio albescens melanorhinus*'), *M. velifer*, *M. thysanodes* (under *M. velifer*), and *M. lucifugus* ('*Vespertilio albescens affinis*'), which he unites as subspecies.

Albigularis (Vesperus). Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin, p. 260, **1872**. *Vespertilio albigularis* (Peters) is the type of the subgenus *Marsipolaemus*. The characters given in the original description indicate a well marked species, with which, however, I am wholly unacquainted. The type was collected in Mexico.

Alleni (Rhogeëssa). Thomas, Ann. & Mag. Nat. Hist., 6th ser., X, p. 477, **1892**. This is the only name for this species.

Americana (Atalapha). Rafinesque, Précis des Decouv. Somiologiques, p. 12, **1814**. This is a synonym of *Lasiurus borealis* (Müller), though properly speaking the name is a nomen nudum (see p. 106).

Arquatus (Vespertilio). Say, Long's Expedition to the Rocky Mountains, I, p. 167, footnote, **1823**. The description clearly indicates *Vespertilio fuscus* Beauvois.

Auduboni (Vespertilio). Harlan, Featherstonehaugh's Monthly American Journal of Geology and Natural History, I, p. 220, Pl. II, November, **1831**. Both description and plate indicate the silver-haired bat.

Austroriparius (Vespertilio lucifugus). Rhoads, Proc. Acad. Nat. Sci. Phila., p. 227, May, **1897.** *Vespertilio lucifugus austroriparius* Rhoads is a synonym of *Myotis lucifugus* (Le Conte). The type, a two-thirds grown young from Tarpon Springs, Florida, shows numerous characters by which it may be distinguished from northern adults, but the full grown topotypes are, as originally determined by Dr. Harrison Allen (see Rhoads, l. c.), indistinguishable from northern specimens of *lucifugus* that have been immersed in alcohol for a similar period. Even if it were assumed that the Tarpon Springs bat differed in some way not now discoverable from the '*lucifugus* of North Carolina and northward,' there could be little doubt that the southern form was the one originally described by Le Conte. (See page 63).

Bellii (Scotophilus). Gray, List Spec. Mamm. Brit. Mus., p. 30, **1843.** *Scotophilus bellii* Gray is a nomen nudum probably based on one of the West Indian forms of *Vespertilio fuscus.* Gray's account is as follows: "BELL'S BAT. SCOTOPHILUS Bellii. *a* In spirits. West Indies.—Presented by Thomas Bell, Esq., F. R. S."

Borealis (Vespertilio). Müller, Natursyst. Suppl., p. 21, **1776.** Müller's *Vespertilio borealis* is the first name based on the red bat, *Lasiurus borealis.*

Brevirostris (Vespertilio). Maximilian, Wiegmann's Archiv. f. Naturgeschichte, 1861, Bd. I, p. 195. *Vespertilio brevirostris* of Maximilian is probably *Myotis lucifugus* (Le Conte). The original measurements are: Total length, 3″; extent, 9″ 4‴; ear from crown, 5½‴; tragus, 1⅛‴.

Calcaratus (Vespertilio). Rafinesque, American Monthly Magazine, III, p. 445, **1818.** No known bat agrees with the description of Rafinesque's *Vespertilio calcaratus*, which is as follows: "Tail one-third, body dark brown above, dark fallow beneath, wings black, shafts rose-coloured, a spur at the inner side of the elbow, hind feet black. Length 4 inches, breadth 12."

Californicus (Vespertilio). Aud. & Bachm., Journ. Acad. Nat. Sci. Phila., VIII, Pt. II, p. 285, **1842.** This is the earliest name based on the small western bat commonly known as *Vespertilio nitidus* H. Allen. The original description is as follows: [1]

V. californicus (Californian bat).—V. fusco lutescens, vellere longo et molli; trago longitudino dimidium auris excedente.

Californian bat.—With long silky hairs; tragus more than half the length of the ear; color light yellowish brown.

Description.—Anterior upper fore teeth bilobate. Head small; nose sharp; *ears of moderate size,* erect, rather narrow, and pointed. *Tragus linear, attenuated.* Wings of moderate length, which together with the ears are naked. *Interfemoral membrane with a few scattered hairs; feet small;* nails slightly hooked. Tail projecting a little beyond the interfemoral membrane.

Color.—The pelage, *which is unusually long for the size of the body,* and very soft and glossy, is, on the upper surface, *dark plumbeous from the base, and broadly tipt with*

[1] I have italicized statements specially applicable to '*V. nitidus.*'

light yellowish brown; on the under surface the color is a little darker, owing to the outer extremities of the hairs being more narrowly edged with the prevailing color on the back, exhibiting the darker shades beneath. The ears and tragus are blackish—the nose, chin, wings, and interfemoral membrane dark brown.

Hab.—We have obtained but a single specimen, which was captured at California.

Dentition.—Incisors $\frac{2\text{-}2}{6}$. Canines $\frac{1\text{-}1}{1\text{-}1}$.

Dimensions.—Length of head and body, 1 inch 7 lines [40 mm.]; length of tail, 1 inch 5 lines [35.8]; length of spread, 7 inches 6 lines [190]; height of ear posteriorly, 3 lines [6.35]; height of tragus, 2 lines [3.8].

The only other small bats known to occur in California are *Pipistrelius hesperus*, *Myotis thysanodes*, *M. yumanensis*, *M. evotis*, and *M. lucifugus longicrus*. That *Vespertilio californicus* can not be *Pipistrellus hesperus* is shown by the description of the tragus. From *Myotis thysanodes* it is separated by its small size and unfringed interfemoral membrane; from *M. yumanensis* by its small feet; from *M. evotis* by its short ears, and from *M. lucifugus longicrus* by its light color and small size. *Myotis thysanodes* and *M. lucifugus longicrus* are moreover comparatively rare bats in California, while '*Vespertilio nitidus*' is one of the most common and universally distributed species.

Carolii (Vespertilio). Temminck, Monographies de Mammal., II, p. 237 (13me Monogr.), **1835-41.** The *Vespertilio carolii* of Temminck is without doubt *Myotis lucifugus* (Le Conte). That it is a *Myotis* is shown by the number of teeth, six molars in each jaw, while that it is not *M. subulatus*, the only other species known to occur in the vicinity of Philadelphia or New York, is shown by the short ear, 11.5 mm. in length.[1]

Carolinensis (Vespertilio). Geoffroy, Ann. du Mus. d'Hist. Nat., Paris, VIII, p. 193, **1806.**[2]

This species is *Vespertilio fuscus* Beauvois. Dr. Harrison Allen in

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[1] The essential part of the original description is as follows:

"Taille et formes de notre pipistrelle, mais les oreilles plus longues. * * * oreilles médiocres, ovoïdes, un peu découpées à leur bord extérieur, sans lobe ou prolongement en avant; tragus en feuille de saule * * *. Dents incisives 4 par paire en haut et 6 en bas; molaires 6 partout; les deux premières fausses molaires de la mâchoire supérieure très petites, courtes et pointues.

"Pelage bicolore partout. Joues, côtes du cou et toutes les parties supérieures d'un brun-roussâtre à base des poils noirs; en dessous d'un blanc jaunâtre à la pointe et brun-foncé à la base * * *.

"Longueur totale 3 pouces 5 lignes, dont la queue prend 1 pouce 4 lignes; envergure 8 pouces 6 lignes; antibrachium 1 pouce 4 lignes; hauteur de l'oreille depuis le crâne jusqu'au bout 5 lignes; * * *.

"*Patrie.* L'Amérique septentrionale, dans les environs de Philadelphie et de New-York."

[2] The original description is as follows:

"2. *Vesp*[*ertilio*] *carolinensis.* Le vespertilion de la Caroline est moins grand que le précédent ['*V. murinus*'], mais d'ailleurs il lui ressemble beaucoup. Il a ses oreilles et oreillons de même forme et de même dimension relative; son poil est aussi de deux couleurs, cendré-noirâtre d'abord et brun-marron à la pointe. L'extrémité des poils est en dessous d'un jaune tirant sur le ventre; enfin les oreilles sont garnies de poils dans presque la moitié de leur longueur, et la queue a une petite portion qui n'est pas enveloppée par la membrane interfémorale. Ces considérations réunies à celles his recent monograph has applied the name *carolinensis* to the Georgian bat (*Pipistrellus subflavus*), but there is no reason to doubt that Geoffroy's animal was the large brown bat. The head and skull are both figured, the former on Pl. I, the latter on Pl. II. These are only a trifle smaller than the head and skull of *Vespertilio serotinus* figured on the same plates, and very much larger than the figures of the head and skull of *Pipistrellus pipistrellus*, a species of about the same size as *P. subflavus*. The teeth are very indistinctly shown in the figure, but in the two copies which I have examined[1] I can find no indication of the second upper premolar of *Pipistrellus*.

Chrysonotus (Vespertilio). J. A. Allen, Bull. Am. Mus. Nat. Hist., N. Y., VIII, p. 240, November 21, **1896**. *Vespertilio chrysonotus* J. A. Allen, from Kinney Ranch, Wyoming, is a pale example of *Myotis evotis* (H. Allen), with mutilated tail. (See p. 80.)

Ciliolabrum (Vespertilio). Merriam, Proc. Biol. Soc. Washington, IV, p. 1, **1886**. *Vespertilio ciliolabrum*, Merriam, is the only name based on the pallid race of *Myotis californicus* inhabiting the plains of South Dakota, Kansas, and Texas. The type was taken at Banner, Kansas.

Cinereus (Vespertilio). Beauvois, Catalogue Raisonné du Museum de Mr. C. W. Peale. Philadelphie, p. 18, **1796**. *Vespertilio cinereus* Beauvois (originally misspelled *linereus*) is the first name based on the hoary bat, *Lasiurus cinereus*. The description is so detailed and accurate as to leave no doubt as to the animal that Beauvois had in mind.[2] The type came from Pennsylvania, somewhere near Philadelphia, where the species undoubtedly occurs during migrations.

Crassus (Vespertilio). F. Cuvier, Nouv. Ann. Mus. d' Hist. Nat., Paris, I, p. 18, **1832**. I can not identify F. Cuvier's *Vespertilio crassus*. The

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tirées de la teinte différente du pelage, m'ont paru établir avec assez de certitude la non-identité d'espèce de ce vespertilion avec le *murinus;* c'est ce qu'indiquent en outre les proportions du crâne. Le chanfrein est plus court et plus large dans le vespertilion de la Caroline. En voici les dimensions: longueur du corps, 61 millimètres; de la queue, 28; de l'envergure, 259.

"Cette espèce n'a point encore été décrite: elle m'a été remise par M. Bosc, qui se l'est procurée lors de son séjour à la Caroline. Ce savant naturaliste a bien voulu m'informer qu'elle y est excessivement commune. On la reconnoîtra aux caractères suivans: *Oreilles oblongues, de la longueur de la tête, relues en partie; oreillon en demi cœur. Pelage d'un brun marron en dessus, jaunâtre en dessous.*"

[1] In the Harvard College library, Cambridge, Mass., and in the Smithsonian library, Washington, D. C.

[2] 17. Chauve-souris grise. Deux premières dents supérieures fort petites & peu apparentes. Tête blanchâtre; oreilles roudes, plates, blanches, le pourtour noir, une appendice à la base. Poils du corps gris, vers la base; noirs vers la pointe & blancs à l'extrémité; de sorte que l'animal à l'air d'être moucheté de blanc. Ces poils s'étendent jusque sur la membrâne qui enveloppe la queue. La membrâne ailiforme est également velue en dessons à la partie antérieure, ainsi qu'au dessus à la base de l'ongle saillant. Cette membrâne est environ une fois plus grande que dans l'espèce précédente [*Vespertilio fuscus*]. Elle a de douze à quatorze pouces d'envergeure. Les narines sont émarginées.

Grey Bat. *Vespertilio linereus* [sic].

Elle ne se trouve point décrite dans les auteurs. Cette chauve-Souris se trouve dans la Pensilvanie.

animal may be *Nycticeius humeralis*, but there is nothing in the original description[1] to indicate this with certainty. Fortunately the name is not needed as all the species now known to inhabit the eastern United States were already named at the time when it was published.

Creeks (**Vespertilio**). F. Cuvier, Nouv. Ann. Mus. d'Hist. Nat., Paris, I, p. 18, **1832**. *Vespertilio creeks* F. Cuvier is another unidentifiable species. Le Conte, however, who sent the type specimen to Cuvier, states that the animal is the same as *Nycticea crepuscularis* Le Conte (=*N. humeralis* Rafinesque). Nothing in the original description[2] contradicts this assertion.

Crepuscularis (**Nycticea**). Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, p. 431, **1831**. This bat is the *Nycticeius humeralis* of Rafinesque.

Cubanus (**Vesperus**). Gundlach, Monatsber. K. Preuss. Akad. Wiss., Berlin, p. 150, **1861**. The description of this species indicates a *Nycticeius* closely related to *N. humeralis*. As I have seen no Cuban specimens, I am unable to say whether the animal is specifically distinct from the mainland form (see p. 121).

Cubensis (**Scotophilus**). Gray, Ann. Nat. Hist., IV, p. 7, **1839**. *Scotophilus cubensis* Gray is evidently the Cuban *Vespertilio*. The original description is as follows:

> Fur blackish brown (in spirits); wings dark, blackish; underside of the interfemoral membrane whitish, with scattered hairs; feet large; heel bone short, tapering; ears moderate, entire; tragus ovate-lanceolate. Body and head 2¾; tail 1⅝; fore arm 1¾. Hab. Cuba.

This is the first name based on the animal to which it refers.

Cyanopterus (**Vespertilio**). Rafinesque, American Monthly Mag., III, p. 445, **1818**. Rafinesque's *Vespertilio cyanopterus* can not be identified with any known bat. The original description is as follows:

> Tail one-third, 2 incisores above, 6 beneath, body dark gray above, bluish gray beneath, wings of a dark bluish gray, shafts black, ears auriculated, longer than the head. Length 3 inches, breadth 10.

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[1] A la tête des Murinoïdes, deux fausses molaires anomales de chaque côté des deux mâchoires; l'oreille obtuse el l'oreillon en couteau.

Toutes les parties supérieures du corps sont d'un brun-marron grisâtre, et les parties inférieures blondes; les poils, à leur origine, sont plus foncés qu'à leur extrémité.

Des moustaches garnissent les côtés de la lèvre supérieure et l'extrémité de la mâchoire inférieure.

Longueur du corps, du bout du museau à l'origine de la queue, 2 pouces; de la queue, 1 pouce 8 lignes; envergure, 8 pouces 8 lignes.

Cette espece est due à M. Lesueur, qui l'a envoyée de New-York, sous le nom que je lui ai conservé.

[2] 5° Le V. Creeks, *V. Creeks*.

A la tête du Sérotinoïdes, point de fausses molaires anomales à la mâchoire supérieure, et une seule à l'inférieure; l'orielle est échancrée, et l'oreillon en couteau; les parties supérieures sont d'un brun jaunâtre, les parties inférieures d'un gris sale, les poils de toutes ces parties sont noirs à leur base. Des moustaches garnissent les côtés du museau et le dessous de l'extrémité de la mâchorie inférieure.

Longuer du corps, du bout du museau à l'origine de la queue, 2 pouces; de la queue, 1 pouce 6 lignes; envergure, 9 pouces.

De Géorgie. Dû aux recherches de M. le major Leconte.

Cynocephalus (Nycticea). Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, p. 432, **1831.** This is a free-tailed bat, the common *Nyctinomus* of the southeastern United States.

Domesticus (Vespertilio). Green, Doughty's Cabinet of Natural History, II, p. 290, **1832.** The description refers without much doubt to *Myotis lucifugus* Le Conte, named only one year previously. Type locality a village in western Pennsylvania near a stream which enters the Ohio a few miles from Pittsburg.

Dutertreus (Vespertilio). Gervais, in Ramon de la Sagra's Hist. de l'Ile de Cuba, Mamm., p. 6; Atlas, Tome II, **1840.** This is *Vespertilio fuscus cubensis* (Gray), as shown by the number of teeth, 32, and by the size, forearm 47 mm.

Erythrodactylus (Vespertilio). Temminck, Monographies de Mamm., II, p. 238 (13me Monogr.), **1835–41.** Temminck describes his *Vespertilio erythrodactylus* as a bat with short, roundish ears, long tail, interfemoral membrane hairy on basal half above, four upper incisors, and general reddish-brown color.[1]

This is a combination of characters normally possessed by no known North American bat. The type is said to have come from the neighborhood of Philadelphia. It is probably *Pipistrellus subflavus* reddened by alcohol (see p. 8).

Evotis (Vespertilio). H. Allen, Monogr. North Am. Bats, p. 48, **1864.** This is the first name for the large-eared *Myotis* of the western United States.

Exilis (Vespertilio). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 283, **1866.** *Vespertilio exilis* is a synonym of *Myotis californicus.* The type came from Cape St. Lucas.

Frantzii (Atalapha). Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin (1870), p. 908, **1871.** Peters's *Atalapha frantzii* from Costa Rica is the small, scantily furred southern race of *Lasiurus borealis.* It had previously been described as *Atalapha mexicana* by Saussure.

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[1]Taille moindre que la *pipistrelle.* Tout l'antibrachium, la base des doigts et la membrane interdigitale du premier doigt rougeâtre; les autres membranes noires. Oreilles poilues depuis la base jusqu'à plus de moitié de la longueur, petites ovoïdes; tragus en feuille de saule; queue très longue à grand bout libre; membrane interfémorale en dessus moitié poilue; par dessous, rayée de veines en losange, d'où naissent des soies très courtes disposées à claire-voie. Dents incisives 4 par paire en haut et 6 en bas; molaires 5 partout, seulement une fausse molaire à la mâchoire supérieure.

Pelage long, fin et soyeux; en dessus tricolore, au dessous bicolore. Toutes les parties supérieures d'une teinte brune-rougeâtre; mais un peu jaunâtre à la tête et au cou; les poils étant noirs à la base, puis jaunâtre et le bout brun-rougeâtre; moitié de l'interfémorale très poilue; en dessous brun foncé à la base et brun-roussâtre au bout; membranes des flancs et interfémorale couvertes de poils rares.

Longueur totale 2 pouces 10 lignes ou 3 pouces pour maximum, dont la queque prend 1 pouce 4 lignes; antibrachium 1 pouce 2 lignes; envergure 7 pouces 6 lignes ou 8 pouces au maximum. * * *

Patrie. L'Amérique septentrionale dans les environs de Philadelphie.

Funebris (Lasiurus). Fitzinger, Sitzungsber. K. Akad. Wiss., Wien, 1ste Abth., LXII, p. 46, 1870. *Lasiurus funebris* Fitzinger, based on the *Nycticejus noveboracensis* of Temminck,[1] from Tennessee and Missouri, is a synonym of *Lasiurus borealis* (Müller), as shown by the reference to the reddish-brown color and white shoulder spot.

Fuscata (Atalapha). Rafinesque, Annals of Nature, p. 2, 1820. Rafinesque's *Atalapha fuscata* can not be identified. The original description is as follows:

> Ears longers than the head, auriculated and blackish; tail three-sevenths of total length, jutting only by an obtuse point; body brownish above, grayish beneath shoulders and cheeks dark brown; hind feet blackish, hairy above; wings blackish brown.—Found in the northern parts of the state of New York and in Vermont. Total length three and an half inches. My genus *Atalapha* (Prec. dec.) contain all the Bats without fore teeth; there are 3 or 4 species of them in the United States all blended under the name of *Vespertilio* (or *Noctilio*) *noveboracensis* by the writers.

Fuscus (Vespertilio). Beauvois, Catalogue Raisonné du Museum de Mr. C. W. Peale. Philadelphie, p. 18, 1796. *Vespertilio fuscus* Beauvois is the first name based on the common brown bat of the eastern United States.[2] The original description is faulty, as it contains a glaring error with respect to the number of upper incisors, which are said to be only two. Nevertheless there can be no doubt as to the animal that Beauvois intended to describe, since only one brown bat of the size of *Myotis myotis* ('la chauve-souris ordinaire de France') inhabits the region about Philadelphia.

Georgianus (Vespertilio). F. Cuvier, Nouv. Ann. Mus. d'Hist. Nat., Paris, I, p. 16, 1832. The specific name *georgianus* long passed current for the small *Pipistrellus* inhabiting the eastern United States. In 1893 H. Allen substituted for it the older name *carolinensis* Geoffroy. As already shown, however, there can be no doubt that Geoffroy's animal was *Vespertilio fuscus*. It is equally certain that Cuvier's name can not be applied to the Georgian bat, since his description probably refers to a *Myotis*, while in the same paper Cuvier accurately describes the Georgian bat as *Vespertilio subflavus*. Le Conte, who collected the specimens on which several of Cuvier's species were based, describes the Georgian bat under the name *georgianus*,[3] and expressly states that

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[1] Monographies de Mammalogie, II (13me Monogr.), p. 158.

[2] 16. Chauve-souris brune. Deux premières dents supérieures, distantes l'une de l'autre, & voisines des canines, une fois plus courtes que ces dernières: oreilles nues, noirâtres, ovales, avec un appendice à leur base; queue presqu'aussi longue que le corps (la tête excepté) membrâne ailiforme noirâtre: poils du corps bruns en dessus, grisâtres en dessous.

Brown bat. *Vespertilio fuscus.*

Cette Chauve-souris est la plus commune que l'on trouve dans les environs de Philadelphie. Elle ressemble beaucoup à la chauve-souris ordinaire de France, mais en diffère essentiellement par le nombre des dents de la machoire supérieure.

[3] Proc. Acad. Nat. Sci. Phila., VII (1854–55), p. 434, 1856.

this was the animal that the French author had in hand. The evidence is so strongly against this view that Le Conte's statement may be safely disregarded.[1]

Greenii (Scotophilus). Gray, List Spec. Mamm. Brit. Mus., p. 30, **1843.** Gray's *Scotophilus greenii* is a *nomen nudum* which refers without much doubt, however, to *Vespertilio fuscus.* The name is introduced as follows: "GREEN'S BAT. SCOTOPHILUS Greenii. *a* In spirits.—North America. Presented by Jacob Green, M.D."

Gryphus (Vespertilio). F. Cuvier, Nouv. Ann. Mus. d'Hist. Nat., I, p. 15, **1832.** Dr. Harrison Allen has recently used the name '*Vespertilio*' *gryphus* for the '*V.*' *lucifugus* and '*V.*' *subulatus* of his first monograph which he unites as subspecies.[2] The combination of characters; two premolars in each jaw, light yellow color, and hairy lips,[3] is not known in any bat inhabiting the eastern United States. Hence the description is wholly undeterminable. Le Conte refers the name to *Vespertilio fuscus*,[4] but this determination is very doubtful.

Henshawii (Vespertilio nitidus). H. Allen, Monogr. Bats N. Am., p. 103, **1893.** *Vespertilio nitidus henshawii* H. Allen is a synonym of *Myotis californicus*, based on pale examples of the latter from near Wingate, N. Mex.

Hesperus (Scotophilus). H. Allen, Monogr. N. Am. Bats, p. 43, **1864.** This is the first name based on the common *Pipistrellus* of the southwestern United States.

Humeralis (Vespertilio). Rafinesque, American Monthly Mag., III, p 445, **1818.** While there is nothing absolutely diagnostic in the original

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[1] The original description of *Vespertilio georgianus* is as follows:

"A la tête des Murinoïdes; l'oreille est échancrée et l'oreillon en alêne. Toutes les parties supérieures du corps sont colorées par un mélange de noir et de blond jaunâtre. Le noir paroît, parceque la pointe des poils qui est blonde ne recouvre pas, à cause de sa brévité, le reste de la longueur de ces poils qui est noir. Les parties inférieures sont grises, mais mélangées de noir, par la même cause qui fait paroître cette couleur aux parties supérieures. Des moustaches garnissent les côtés des lèvres supérieures, et le dessous de l'extrémité de la mâchoire inférieure.

"Longueur du corps, du bout du museau à l'origine de la queue, 1 pouce 6 lignes; de la queue, 1 pouce 2 lignes; envergure, 7 pouces.

"De Géorgie. Dû aux recherches de M. le major Leconte."

[2] Monogr. Bats N. Am., p. 75, 1893.

[3] The description is as follows:

"A la tête des Murinoïdes et deux fausses molaires anomales fort petites de chaque côté des deux mâchoires; l'oreille est échancrée et l'oreillon en couteau. Toutes les parties supérieures du corps sont d'un blond jaunâtre, les parties inférieures sont grises, mais les poils des uns et des autres sont noirs à leur extrémité inférieure. Les parties nues sont violâtres. Des moustaches garnissent les côtés de la lèvre supérieure et le dessous de l'extrémité de la mâchoire inférieure. Longueur du corps, de l'extrémité du museau à l'origine de la queue, 1 pouce 9 lignes; de la queue, 1 pouce 2 lignes; envergure, 7 pouces 10 lignes.

"Des environs de New York. Dû aux recherches de M. Milbert."

[4] Proc. Acad. Nat. Sci. Phila. VII (1854–55), p. 434, 1856.

description[1] of this species, its subsequent treatment is such as to leave no reasonable doubt that Rafinesque had in mind the bat afterward named *Nycticea crepuscularis* by Le Conte. In 1819 Rafinesque based the genus *Nycticeius* on two of his species of *Vespertilio* which differed from all others known to him in the possession of only two incisors in the upper jaw. One of these, *V. tesselatus*, was the red bat, *Lasiurus borealis*. The other, *V. humeralis*, must have been the twilight bat, as there is nothing in the description that precludes it, and no other small species with two upper incisors is known in the eastern United States.

Incautus (Vespertilio). J. A. Allen, Bull. Am. Mus. Nat. Hist., VIII, p. 239, November 21, **1896**. *Vespertilio incautus* J. A. Allen, is a synonym of *Myotis velifer* (J. A. Allen), based on specimens of the latter from San Antonio, Tex. (See p. 59.)

Intermedius (Lasiurus). H. Allen, Proc. Acad. Nat. Sci. Phila. (1862), p. 146, **1863**. This is the only specific name based on the bat now known as *Dasypterus intermedius*.

Keenii (Vespertilio subulatus). Merriam, American Naturalist, XXIX, p. 860, September 1, **1894**. *Vespertilio subulatus keenii* is the only name based on the dark form of *Myotis subulatus* occurring on the Queen Charlotte Islands, British Columbia.

Lanceolatus (Vespertilio). Maximilian, Reise in das Innere Nord-America, I, p. 364, footnote, **1839**. The specific name *lanceolatus* was proposed by Maximilian as a substitute for *subulatus*, should the animal which he designated by the latter name prove to be different from Say's.[2] Maximilian's *subulatus* is described at considerable length and is probably the *Vespertilio lucifugus* of Le Conte. The following measurements are given: Total length, 3″ 1‴; extent, 8″ 9‴; tail, 1″ 3‴; ear, 6‴; tragus, 2½‴.

Lasiurus (Vespertilio). Schreber, Säugthiere, Abth. I, Pl. LXII B, published with Abth. IV, Heft 34, **1781**.[3] The figure of *Vespertilio lasiurus* is a good representation of the red bat (*Lasiurus borealis* Müller, 1776). Dobson[4] cites this name as dating from 1775, in which case it would be the earliest for the species. This is, however, a mistake. Pl. LXII appeared with Abth. I in 1774, but Pl. LXII B, was not published until 1781 with Abth. IV, Heft 34. The species is mentioned in Abth. I (p. 176) as 'Die nordamerikanische Fledermaus.'

Lasurus (Vespertilio). Boddaert, Elenchus Animalium 1, p. 71, **1785**.

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[1] Tail three-sevenths, upper incisores 2, remote, lower 6, body dark brown above, shoulders black, gray beneath, wings, tail, ears, and snout blackish, eyes under the hair, ears longer than the head, elliptical, auriculated. Length 3 1–2 inches, breadth 11.

[2] Diese Fledermaus beschrieb ich in meinem Tagebuche unter der Benennung *Vesp. lanceolatus*, sie hat aber viel Aehnlichkeit mit Say's *V. subulatus*. Zu Bethlehem in Pennsylvanien erhielt ich zwei Exemplare * * * .

[3] For date of publication see Sherborn, Proc. Zool. Soc. London, 1891, p. 589.

[4] Catal. Chiroptera Brit. Mus., p. 269, 1878.

Vespertilio lasurus Boddaert is probably a misprint for *V. lasiurus*, since reference is made to Schreber's plate.[1]

Lecontii (Plecotus). Cooper, Ann. Lyceum Nat. Hist. New York, IV, p. 72, **1848.** Concerning *Plecotus lecontii*, Cooper says:

The name *macrotis* I have ventured to supersede, as being in nowise distinctive of the species, but in reality derived from a generic character, which in some species is more developed than in the present. The ears being therefore rather *small* for the genus, this name becomes contradictory; and no American naturalist will regret the opportunity thus afforded of paying a well merited tribute to the discoverer of so many rare and remarkable animals of this country.

The name is of course a synonym of *macrotis* Le Conte.

Leibii (Vespertilio). Aud. & Bach., Journ. Acad. Nat. Sci. Phila., VIII, Pt. II, p. 284, **1842.** *Vespertilio leibii* Aud. & Bach., from Erie County, Mich. [now Ohio] is probably *Myotis lucifugus* Le Conte. The measurements are as follows: "Length of head and body 1 inch 7 lines; tail 1 inch 4 lines; spread 7 inches; height of ear posteriorly 2½ lines; tragus 1 line."

Longicrus (Vespertilio). True, Science, VIII, No. 203, p. 588, Dec. 24, **1886.** *Vespertilio longicrus* True, is the only name based on the common western subspecies of *Myotis subulatus.*

Lucifugus (Vespertilio). Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, p. 431, **1831.** The original description of *Vespertilio lucifugus* Le Conte is as follows:

Anterior upper fore-teeth bilobate; body above dark brown, beneath cinereous; nose sub-bilobate; face with a nakedish prominence on each side; ears oblong, naked, tragus sub-linear, half as long as the ears; tail projecting a little beyond the membrane; length to the insertion of the tail two inches and a quarter; tail one inch and a quarter.

From this alone it would be impossible to identify the animal that the writer had in mind. Fortunately, Le Conte treated the species in more detail in a paper published in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1855 (pp. 431–438). Here he recognizes three species of '*Vespertilio*' with thirty-eight teeth as occurirng in the eastern United States. These are *V. subulatus*, *V. lucifugus*, and *V. georgianus*. *V. georgianus* is clearly *Pipistrellus subflavus*, which Le Conte placed with the thirty-eight-toothed species through an error in counting the teeth. *V. lucifugus* and *V. subulatus* of Le Conte are evidently based on individual variations in the shorter-eared of the two eastern species of *Myotis*. The only differences in Le Conte's descriptions of the two forms are the following: *V. subulatus:* Ear slightly emarginate; length 2.9; tail 1.1; extent 9.4; head .9; ears .4; orillon .3. *V. lucifugus:* Ears so much emarginated as to appear hooked; length 3.8; tail 1.6; extent 11.7; head .75; ears .45; orillon .2.

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[1] Boddaert's account is as follows:

"Lasurus. 16. V. cauda longissima, rostro obliquo truncato, *la longue Queue.* Schreb., tab. 52. B *longtailed Bat.*"

Habitat: "Quare Doct. Erxleben, Zimmermann, Pennant hunc notabilem vespertilionem omiserunt, mihi latet."

Macleayii (Scotophilus). Gray, List Spec. Mamm. Brit. Mus., p. 30, 1843. *Scotophilus macleayii* Gray is a nomen nudum, probably based on *Vespertilio fuscus cubensis.* Gray says merely: "MACLEAY'S BAT. SCOTOPHILUS MacLeayii *a* In spirits. Male. Cuba.—Presented by W. S. MacLeay, Esq."

Macropus (Vespertilio). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 288. 1866. *Vespertilio macropus* H. Allen is a synonym of *Myotis yumanensis* (H. Allen). The name is, moreover, preoccupied by *Vespertilio macropus* Gould, 1854.[1]

Macrotis (Plecotus). Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, p. 431, 1831. *Plecotus macrotis* Le Conte is the first name certainly applied to the bat now known as *Corynorhinus macrotis.* Rafinesque's *Vespertilio megalotis* may have been the same animal, but his description is so poor that it is impossible to determine what he refers to.

Maculatus (Histiotus). J. A. Allen, Bull. Am. Mus. Nat. Hist., New York, III, p. 195, 1891. *Histiotus maculatus* is the name under which the bat now known as *Euderma maculatum* was first described.

Megalotis (Vespertilio). Rafinesque, American Monthly Mag., III, p. 446, 1818. There is nothing in the original description[2] of Rafinesque's *Vespertilio megalotis* by which the species can be identified. It is possibly the animal afterwards named *Plecotus macrotis* by Le Conte.

Melanops (Eptesicus). Rafinesque, Annals of Nature, p. 3, 1820. When Rafinesque transferred his *Vespertilio phaiops* to the genus *Eptesicus*, he changed the specific name to *melanops*, thus adding another to the synonyms of *Vespertilio fuscus.*

Melanorhinus (Vespertilio). Merriam, North American Fauna, No. 3, p. 46, September 11, 1890. *Vespertilio melanorhinus* Merriam is a synonym of *Myotis californicus*, based on a specimen of the latter from San Francisco Mountain, Arizona.

Melanotus (Vespertilio). Rafinesque, American Monthly Mag., III, p. 445, 1818. Rafinesque's *Vespertilio melanotus* is hopelessly indeterminable. The original description is:

> Tail one-third, brown above, gray beneath, body blackish above, whitish beneath, wings dark gray, shafts black, ears auriculated, rounded. Length 4 1-2 inches, breadth 12 1-2.

Melas (Eptesicus). Le Conte, Proc. Acad. Nat. Sci. Phila., VII (1854–55), p. 438, 1856. In a paper on the bats of the United States published in 1856, Le Conte refers to *Eptesicus melas* Rafinesque as an unidentified species. I have been able to find no such name in any of Rafinesque's writings and therefore suppose that *Eptesicus melas* is a misprint for *E. mydas*, especially as the latter is not mentioned by Le Conte.

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[1] Mammals of Australia, III (*fide* Dobson).

[2] Tail three-eighths of total length, body dark gray above, pale gray beneath, ears very large, duplicated, auricules nearly as long. Length 4 inches, breadth 12 inches.

Merriami (Vesperugo). Dobson, Ann. & Mag. Nat. Hist., XVIII, p. 124, **1886.** *Vesperugo merriami* Dobson, was based on a specimen of *Pipistrellus hesperus* from Red Bluff, Tehama County, Cal., wrongly supposed to have been taken at Locust Grove, N. Y.

Mexicana (Atalapha). Saussure, Revue et Mag. de Zool., 2e sér., XIII, p. 97, **1861.** *Atalapha mexicana* Saussure is the first name based on the southern race of *Lasiurus borealis*, afterwards described by Peters as *Atalapha frantzii.*

Mexicanus (Vespertilio). Saussure, Revue et Mag. de Zool., 2e sér., XII. p. 282, July, **1860.** Under the name *Vespertilio mexicanus* Saussure described the large, dark Mexican form of *Myotis californicus*, which had hitherto received no name.

Miradorensis (Scotophilus). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 287, **1866.** *Scotophilus miradorensis* H. Allen is the only name based on the large southern form of *Vespertilio fuscus.*

Monachus (Vespertilio). Rafinesque, American Monthly Mag., III, p. 445, **1818.** The original description of Rafinesque's *Vespertilio monachus* leaves no doubt that it refers to *Lasiurus borealis* (Müller). It is as follows:

Tail one-fourth, hairy above, fringed laterally, body pale, fallow above and below, head and neck covered with a longer fur of a dark red fallow, wings dark gray, shafts red, hind feet black, nose red, ears concealed in the fur. Length 4 inches, breadth 12.

Monticola (Vespertilio). Aud. & Bach., Journ. Acad. Nat. Sci. Phila., I, No. 7, p. 92, October, **1841.** *Vespertilio monticola* is probably *Pipistrellus subflavus* (F. Cuvier), though the description is not wholly pertinent to this species. The original account is as follows:

Vespertilio monticola (Mountain bat).—V. vespertilione subulata brevior; auriculus brevioribus; tragus nonexcedentibus, dimidiam longitudinem auriculæ; colore fulvo.

Mountain Bat.—Smaller than Say's bat (*V. subulatus*); ears shorter; tragus, less than half the length of the ear; color, yellowish brown. Upper fore teeth bilobate, ears moderate, naked, erect, rather broad at base; tragus linear, subulate, body small; wings long; tail projecting a line beyond the interfemoral membrane, which is slightly sprinkled with hair above and beneath.

Color.—The nose and chin are black; ears light brown; wing membranes dark brown. The whole of the fur of the body, above and beneath, is from the roots, of a uniform yellowish-brown color.

The species differs from Say's bat not only in color, but in the much shorter ears and tragus. The size and shape of the tragus we have found an invaluable guide in our American bats; the ears of the present species, when alive, are always erect; while those of Say's Bat are folded backward like those of the long-eared Bats—*Plecotus.* * * *

Dimensions.—Length of head and body, 1 inch 8 lines; length of tail, 1 inch 6 lines; length of spread, 8 inches; height of ear posteriorly, 3 lines; height of tragus, 1¼ lines.

N. B.—The tragus in Say's Bat is four-and-a-half lines in height. Several specimens of this Bat were obtained during the summer, on the mountains of Virginia, at the Grey Sulphur Springs. They were uniform in size and color.

Mydas (Eptesicus). Rafinesque, Annals of Nature, p. 3, **1820.** The description of *Eptesicus mydas* leaves the species hopelessly indeterminable. It is as follows:

Fulvous above, grey beneath; wings, ears and tail, pale brown, shafts whitish; ears double the length of the head; tail naked, slightly mucronate, nearly as long as the body.—I have observed it in the barrens of Kentucky flying in the houses. Total length three inches, of which the tail includes five-twelfths. Ears three-quarters of an inch long. I mentioned it under the name of *Vesp. mydas* in my account of the Bats of the western states, (Am. Mag. v. 3). I have since instituted two other genera with them, *Hypexodon* and *Nycticeius* (Prodr. 70 N. G. An); the others are probably Atalaphes. I know already fifteen species of Bats in the United States, almost all new ones.

No bat is known to occur in Kentucky that combines the characters attributed to this animal.

Mystax (Vespertilio). Rafinesque, American Monthly Mag., III, p. 445, **1818.** This species which Rafinesque had already referred to as *Noctilio mystax*,[1] is described as follows:

Tail two-fifths of total length, upper incisores none, lower 6, 2 warts at the lower jaw, body entirely fallow, top of the head brownish, ears brown, auriculated, longer than the head. Length 5 inches, breadth 14.

In the diagnosis of the genus *Hypexodon*, based on this species, some further characters—such as 'nostrils round, projecting,' and 'lips whiskered'—are added, which only serve to increase the impossibility of identifying the animal.

Nigricans (Vespertilio). Maximilian, Beiträge Naturgesch. Brasil., II, p. 266, **1826.** *Myotis nigricans* (Maximilian) is a species closely related to *M. californicus*, which it replaces in the tropical fauna from southern Mexico southward. The name was applied to *M. californicus* by Dr. Harrison Allen in his recent monograph (1893). In the original description Maximilian cites Schinz ('Thierreich u. s. w. B. I. p. 179') as authority for the name. As I have been unable to verify this reference I do not know whether the name was actually published before 1826.

Nitidus (Vespertilio). H. Allen, Proc. Acad. Nat. Sci. Phila. (1862), p. 247, **1863.** *Vespertilio nitidus* H. Allen, is the common small brown bat of the western United States and therefore the name is a synonym of *V. californicus* Aud. & Bach., 1842.

Noctivagans (Vespertilio.) Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, p. 431, **1831.** This is the first name based on the silver-haired bat, *Lasionycteris noctivagans*.

Noveboracensis (Vespertilio). Erxleben, Syst. Regni Anim., I, p. 155, **1777.** Erxleben's *Vespertilio noveboracensis* was based on the New York bat of Pennant (Synop. Quadr., p. 367), 'Die nordamerikanische Fledermaus' of Schreber (Säugthiere, I, p. 176), and 'Der Neujorker' of Müller (Natursyst. Suppl., p. 20). It is therefore the red bat, *Lasiurus borealis*.

Noveboracus (Vespertilio). Boddaert, Elenchus Animalium, I, p. 71, **1785.** This is the red bat, *Lasiurus borealis* Müller. Boddaert men-

[1] American Monthly Mag., III, p. 354.

tions the white shoulder marks characteristic of the species and refers to Schreber and Pennant.

Obscurus (Vespertilio). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 281, **1866.** *Vespertilio obscurus* H. Allen, is one of the numerous synonyms of *Myotis californicus.* The type specimens came from Lower California.

Oregonensis (Vespertilio). H. Allen, Mongr. Bats N. Am., p. 61, **1864.** The wording of Dr. Allen's account of *Vespertilio oregonensis* is so ambiguous as to leave some doubt as to whether he intended to apply the name to specimens from Fort Yuma and Cape St. Lucas (Nos. 5405, 5537, and 5402) or to a skin labeled *oregonensis* by Le Conte. In either case the name is a synonym of *V. californicus* Aud. & Bach. Under *V. nitidus* he says:

> Nos. 5405, 5537, and 5402, four specimens in all, present the following peculiarities: The fur is longer than in others of the collection. On the back the base of the hair is blackish; upper third pale yellow, turning to a delicate light-yellowish russet brown; on the belly the hair is dark brown at the base, with light tips; the hairs on the interfemoral membrane are also of a light color. In other respects the characters are the same as the other specimens. The dried specimen, No. 5512, labeled by Dr. Le Conte *V. oregonensis,* though never described by him, probably belongs to this variety. If the individuals having the above coloration should be found to constitute a new species, this name will be reserved for it.

Pallidus (Vespertilio). Le Conte, Proc. Acad. Nat. Sci. Phila., VII, (1854–55) p. 437, **1856.** *Vespertilio pallidus* Le Conte is the only name based on the Eastern form of *Antrozous*, the type of the genus. Le Conte stated that his species came from California, but this is evidently an error, as pointed out by Baird and Harrison Allen. The type, now in the United States National Museum, is labeled 'Fort Clark, Texas.' It agrees in all respects with skins taken in the same region by Dr. E. A. Mearns.

Parvula (Rhogeëssa). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 285, **1866.** *Rhogeëssa parvula* H. Allen, from the Tres Marias Islands, Mexico, is probably distinct from any of the members of the genus that occur on the mainland. The type is now mislaid or lost.

Pfeifferi (Atalapha). Gundlach, Monatsber. K. Preuss. Akad. Wiss., Berlin, p. 152, **1861.** Gundlach's *Atalapha pfeifferi* is the only name based on the Cuban form of *Lasiurus borealis.*

Phaiops (Vespertilio). Rafinesque, American Monthly Mag., III, p. 445, **1818.** Under the name *Vespertilio phaiops*, Rafinesque gave an accurate description of *Vespertilio fuscus* Beauvois. He says:

> Tail one-third of total length, naked, mucronate, body dusky bay above, pale beneath, face, ears and wings blackish, 4 incisores in the upper jaw, 2 on each side, divided by a large flat wart, unequal, the outside ones larger and bilobed, 6 small incisores at the lower jaw. Length 4 1-2 inches, breadth 13.

Priscus (Nyctitherium). Marsh, American Journ. Sci. & Arts, 3d ser., IV, p. 128, **1872.** *Nyctitherium priscus* Marsh is a name based on a fragment of a fossil lower jaw from the Eocene or lower Miocene near Henrys Fork, Wyoming.

Propinquus (Vesperus). Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin, p. 262, 1872. *Vesperus propinquus* Peters from Santa Ysabel, Guatemala, is the small southern form of *Vespertilio fuscus.* I can find no other name based on this animal.

Pruinosus (Vespertilio). Say, Long's Expedition to the Rocky Mountains, I., p. 167, footnote, 1823. *Vespertilio pruinosus* Say, is the hoary bat, *Lasiurus cinereus* (Beauv.). It was described from a specimen taken at Engineer Cantonment, Washington County, Nebraska, 3 miles above the mouth of the Boyer River and not far from Council Bluffs, Iowa.

Pulverulentus (Vespertilio). Temminck, Monogr. de Mamm., II, p. 235, (13e Monogr.), 1835–1841. Under the name *Vespertilio pulverulentus* Temminck gives an accurate description of a specimen of *Lasionycteris noctivagans* taken on the Missouri River.

Rafinesquii (Plecotus). Lesson, Manuel de Mammalogie, p. 96, 1827. *Plecotus rafinesquii* Lesson is a name based on Rafinesque's indeterminable *Vespertilio megalotis.*[1]

Rubellus (Vespertilio). Beauvois, Catalogue Raisonné du Museum de Mr. C. W. Peale. Philadelphie, p. 18, 1796. *Vespertilio rubellus* Beauvois is the red bat, *Lasiurus borealis* (Müller).[2]

Rubra (Vespertilio). Ord, in Guthrie's Geography, 2d American ed., II, p. 291, 1815 (Rhoads' Reprint, 1894). This is another synonym of *Lasiurus borealis* (Müller). The name appears in a nominal list of North American bats. In a footnote, however, Ord says: "Described by Mr. Wilson. See American Ornithology, Vol. VI, p. 60." Wilson's description, as well as his figure on plate 50 (fig. 4) of the 1812 edition, refers unquestionably to the red bat.

Rufus (Vespertilio). Warden, Description des Etats-Unis de l'Amérique Septentrionale, V, p. 606, 1820. Warden's *Vespertilio rufus* is another synonym of *Lasiurus borealis* based on Wilson's description and figure.

Salarii (Vespertilio). F. Cuvier, Nouv. Ann. Mus. d'Hist. Nat., Paris, 1, p. 15, 1832. Like most of the species described in the same paper,

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[1] The original description is as follows:

"Pelage d'un gris foncé en dessus, et d'un gris pâle en dessous; oreilles très grandes et doubles, pourvues d'oreillons aussi longs qu'elles; n'est peut-être qu'une variété de notre oreillard. Habite les Etats-Unis."

[2] 18. Chauve-Souris rougeatre. Deux premières dents plus petites que les canines, mais apparentes, tête ainsi que le corps d'une couleur rougeâtre mêlée de quelques poils blanchâtres. Oreilles couleur de chair, nues, repliées et appendiculiées à leur base. Narines émarginées et distantes l'une de l'autre. Vespertilio rubellus. Redish bat.

Les poils du corps forment quelques fois des zones rougeatres et blanches. La membrâne ailiforme est velue en dessus à la partie antérieure, et couverte de poils roux dessus et autour de la queue. L'individu que nous décrivons est d'autant plus curieux qu'il a été pris avec trois petits qu'il porte sur son ventre. Ce qu'il y a de plus particulier, c'est que d'eux d'entr'eux ressemblent parfaitement à la mère pour la couleur et l'autre est tout à fait roux. La membrane ailiforme est convertes de raie un peu transparentes qui vues au jour, représentent des quarrés en forme de Lozange. La couleur noire de cette membrane contraste avec les couleurs du corps et celle des divisions des pattes de devant, qui sont de couleur de chair, lorsque l'animal est en vie.

Vespertilio salarii is indeterminable. No known North American bat combines hairy lips, reddish brown color, and two premolars in each jaw.[1]

Seminola (Atalapha borealis). Rhoads, Proc. Acad. Nat. Sci. Phila., p. 32, **1895.** This is the dull mahogany-brown race of *Lasiurus borealis* peculiar to the Austroriparian fauna. No other name has been based on this animal.

Septentrionalis (Vespertilio gryphus). Trouessart, Catalogus Mammalium tam Viventium quam Fossilium, p. 131, **1897.** Trouessart's *Vespertilio gryphus* var. *septentrionalis* is the only name unquestionably based on the *Myotis* commonly known as *Vespertilio subulatus* Say. It is merely a latinization of 'northern form of *Vespertilio gryphus*,' the designation applied by Dr. Harrison Allen in his Monograph of 1893 to the *V. subulatus* of his first monograph.

Serotinus (Nyctilestes). Marsh, Am. Journ. Sci. & Arts, 3d ser., IV, p. 215, **1872.**. The name *Nyctilestes serotinus* was applied by Marsh to the fossil jaw of a bat found by him at Grizzly Buttes, Wyoming.

Subflavus (Vespertilio). Cuvier, Nouv. Ann. Mus. d'Hist. Nat., Paris, I, p. 17, **1832.** *Vespertilio subflavus* is one of the few North American bats named by F. Cuvier that can be identified. It is without doubt the Georgia bat (*Pipistrellus subflavus*), commonly known as '*Vesperugo georgianus*.' The peculiar coloring of this species, unique among the bats of the eastern United States, is very accurately described.[2] This is the first account of an American bat in which this color pattern is referred to. The mixture of dark and light hues in Cuvier's *V. georgianus* is due to the shortness of the fur in his specimen, which allows the dark bases of the hairs to appear irregularly on the surface. This is not at all the case with the small *Pipistrellus* of the eastern United States. In this bat the hairs are tricolored, dark at the bases, yellowish

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[1]The original description is as follows:

"A la tête des Murinoïdes et deux fausses molaires de chaque côté des deux mâchoires; l'oreille est échancrée et l'oreillon en couteau. Toutes les parties supérieures du corps sont d'un brun-marron grisâtre, et les parties inférieures gris-blanchâtres. Aux parties brunes les poils sont plus foncés à leur moitié inférieure qu'à leur supérieure; ils sont noirs dans cette inférieure aux parties gris. Les parties nues sont brunes, des moustaches garnissent les côtés de la lèvre supérieure et le dessous de l'extrémité de la mâchoire inférieure.

"Longueur du corps, du bout du museau à l'origine de la queue, 1 pouce 6 lignes; de la queue, 1 pouce 7 lignes; envergure, 7 pouces 7 lignes.

"Des environs de New York. Dû aux recherches de M. Milbert."

[2]The original description is as follows:

"A la tête des Murinoïdes; l'oreille est échancrée, et l'oreillon en demi-cœur. Les parties supérieures du corps sont d'un blond gris clair, légèrement ondulées de brunâtre; les parties inférieures d'un blanc jaunâtre; les poils des parties supérieures sont noirs à leur base, blanchâtres dans la plus grande partie de leur longueur, et brunâtres à leur pointe; ceux des parties inférieures sont noirs à leur moitié inférieure, et d'un blanc jaunâtre à leur autre moitié. Des moustaches garnissent les côtés de la lèvre supérieure, et le dessous de l'extrémité de la mâchoire inférieure.

"Longueur du corps, du bout du museau à l'origine de la queue, 1 pouce 6 lignes; de la queue, 1 pouce 3 lignes; envergure, 7 pouces.

"De Géorgie. Dû aux recherches de M. le major Leconte."

in the middle, and dark at the extreme tips. This is exactly what Cuvier describes as the character of the fur of his 'Blondin' (*P. subflavus*).

Subulatus (Vespertilio). Say, in Long's Exped. to Rocky Mts., II, p. 65 footnote, **1823.** The original description of *Vespertilio subulatus* leaves the species undeterminable. It is as follows:

Ears longer than broad, nearly as long as the head, hairy on the basal half, a little ventricose on the anterior edge, and extending near to the eye; tragus elongated, subulate; the hair above blackish at base, tip dull cinereous; the interfermoral membrane hairy at base, the hairs unicoloured, and a few also scattered over its surface, and along its edge, as well as that of the brachial membrane; hair beneath black, the tip yellowish-white; hind feet rather long, a few setæ extending over the nails; only a minute portion of the tail protrudes beyond the membrane. Total length, $2\frac{8}{10}$ inches. Tail, $1\frac{1}{5}$ inches.

While there is nothing in this account that refers unquestionably to the longer eared of the two species of *Myotis* inhabiting the eastern United States, the name has passed current for this animal so long that, after careful consideration of all the evidence, I am unwilling to substitute for it Trouessart's name *septentrionalis*, the only one unequivocally based on the species. Say's *Vespertilio subulatus* came from the Arkansas River, near the present town of La Junta, Colorado. The bats of this region are not well known, but at present *Myotis evotis*, *M. californicus ciliolabrum*, and *M. lucifugus longicrus* are the only members of the genus *Myotis* which may confidently be expected to occur there. From the known range of *Myotis subulatus* to the north and west, however, its regular occurrence in Colorado is by no means impossible. Apparently Le Conte was the first subsequent writer to define the name *subulatus*, and, as has already been shown, his animal was an individual variation of the shorter eared of the two eastern species. If this determination be taken as final, there can be no question as to the necessity of adopting the name *septentrionalis* for the longer eared animal, but at present the power of the 'first reviser' is so much in question that too much should not be staked on it. Harrison Allen, in 1864, applied the name *subulatus* to the longer eared of the two forms, and in this sense it passed unchallenged until 1893, when the same author united the *lucifugus* and *subulatus* of his earlier monograph under the specific name *gryphus*. This change has not been generally adopted, so that in retaining the specific name *subulatus* I am merely continuing the usage of the past thirty-four years, not, however, without grave misgivings that the reasons for so doing are in reality unsound.

Teliotis (Atalapha). H. Allen, Proc. Amer. Philos. Soc., XXIX, p. 1, **February 11, 1891.** *Atalapha teliotis* H. Allen is the only name based on the Californian form of *Lasiurus borealis*.

Tenuidorsalis (Vespertilio). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 283, **1866.** This is a synonym of *Myotis californicus* based on a specimen (No. 5533, U. S. Nat. Mus.) from Cape St. Lucas, Lower California.

Tesselatus (Vespertilio). Rafinesque, American Monthly Mag., III, p. 445, **1818.** Rafinesque's *Vespertilio tesselatus* is *Lasiurus borealis* (Müller). The original description is as follows:

Tail half of total length, hairy above, upper incisores 2, remote, lower 6, body fallow above, head pale, dirty fulvous beneath, with a faint fallow collar, with 2 hairy white spots above near the thumb, membrane blackish, netted of fulvous internally and clotted of same externally, shafts fulvous, nose bilobate, ears nearly concealed by the hair. Length 4 inches, breadth 12.

Townsendi (Plecotus). Cooper, Ann. Lyceum Nat. Hist. New York, IV, p. 73, **1837.** *Plecotus townsendi* Cooper is the only name based on the form of *Corynorhinus* inhabiting the northwestern United States.

Tumida (Rhogeëssa). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 286, **1866.** *Rhogeëssa tumida* H. Allen is the only name based on the small Mexican bat to which it is now applied.

Ursinus (Vespertilio). Temminck, Monographies de Mammalogie, II (13ᵉ Monogr.), p. 235, **1835-41.** The description of Temminck's *Vespertilio ursinus* refers without much question to *Vespertilio fuscus* Beauv., though the statement is made that there is no false molar in the upper jaw. Color, size, and external characters, however, agree with *V. fuscus.*

Velifer (Vespertilio). J. A. Allen, Bull. Am. Mus. Nat. Hist., New York, III, p. 177, **1890.** The name *Vespertilio velifer* has been applied by Dr. J. A. Allen to a large species of *Myotis* occurring in Mexico and the southwestern United States. The animal is closely related to the *Vespertilio albescens* of Dobson and may eventually prove to be the same as *V. albescens* Geoffroy.

Velox (Nyctitherium). Marsh, Am. Journ. Sci. & Arts, 3d ser., IV, p. 127, **1872.** *Nyctitherium velox* is a fossil bat from the Eocene or lower Miocene near Henry Fork, Wyoming.

Veræcrucis (Vesperugo). Ward, American Naturalist, XXV, p. 745, August, **1891.** *Vesperugo veræcrucis* Ward is the only name based on a form of *Ptpistrellus* occurring in southern Mexico.

Virginianus (Vespertilio). Aud. & Bach., Journ. Acad. Nat. Sci. Phila., I, No. 7, p. 93, October, **1841.** *Vespertilio virginianus* can not be identified with any degree of certainty, though it is without much doubt one of the small species of *Myotis.* The original description is as follows:

Vespertilio virginianus (Virginian bat).—V. vespertilione monticolâ paululum longior, auriculus paululum longioribus magisque acutis; dentibus primoribus maxillæ superioris simplicibus; interfemorali membranâ nudâ; corpore supra fuligineo-fusco; subtus cinereo-fuscato.

Virginian bat.—A little larger than the Mountain Bat; ears a little longer and more pointed; upper fore teeth simple; interfemoral membrane naked; sooty brown above, ash brown beneath.

Dentition.—Incisors $\frac{2-2}{6}$. Canines $\frac{1-1}{1-1}$.

In size this species is intermediate between *V. carolinensis* and *V. subulatus.* The ear is naked, less rounded, and more pointed than either of the other closely allied species. The tragus is very narrow, linear, and less than half the length of the ear. The tail is inclosed in the interfemoral membrane, except the penultimate joint, which is free. The anterior upper fore teeth, instead of being sub simple, as in the *V. carolinensis,* or bilobate, as in *V. subulatus* and *V. montanus,* are simple.

Color.—The nose, upper lip and upper jaw are black; wings dark brown. The back is sooty brown; on each shoulder, at the insertion of the wing, there is a circular black spot about 1 lines in diameter; on the under surface cinerious brown.

Dimensions.—Length of head and body, 2 inches 5 lines; length of tail, 1 inch; length of spread, 8 inches 8 lines; height of ear posteriorly, 4 lines; height of tragus, 1¾ lines.

Hab.—Mountains of Virginia.

Volans (Vespertilio). H. Allen, Proc. Acad. Nat. Sci. Phila., p. 232, **1866.** *Vespertilio volans* H. Allen is another of the numerous synonyms of *Myotis californicus.* The name was based on a specimen from Cape St. Lucas, Lower California.

Yumanensis (Vespertilio). H. Allen, Monogr. N. Am. Bats, p. 58, **1864.** *Myotis yumanensis* of H. Allen is the small, large-footed bat, to which the same author a few years later applied the name *macropus*, and finally in his second Monograph regarded as identical with *Myotis albescens* (Geoffroy).

In a paper published in the Proceedings of the Philadelphia Academy of Natural Sciences for 1866, Dr. Allen gives a revised description of *M. yumanensis*, based on a Fort Yuma specimen not mentioned in the original account of the species. This specimen was *M. californicus*, as shown by the very small hind foot which measured only two lines, or 4.2 mm., about half as much as the foot of *M. yumanensis.*

LISTS OF NORTH AMERICAN VESPERTILIONIDÆ.

Forty-six species and subspecies of *Vespertilionidæ* are here recognized as occurring in America north of Panama and in the West Indies. This number will probably be materially increased when the West Indian and Central American species are better known, and when adequate series of skins from the mainland permit the definition of certain geographic races which doubtless exist but whose characters can not be determined from the material now in collections. The North American forms now known, with the names used for them by Harrison Allen in 1864, Dobson in 1878 and Harrison Allen in 1893, are as follows:

Comparative table of names used for North American Vespertilionidæ.

Names used in the present paper.	H. Allen, 1864.	Dobson, 1878.	H. Allen, 1893.
Antrozous pallidus (Le Conte)	Antrozous pallidus (part).	....	Antrozous pallidus (part).
Antrozous pallidus pacificus Merriam.	Antrozous pallidus (part).	Antrozous pallidus ...	Antrozous pallidus (part).
Euderma maculatum (J. A. Allen).	....	....	Euderma maculata.
Corynorhinus macrotis (Le Conte).	Synotus macrotis.....	....	Corynorhinus macrotis.
Corynorhinus macrotis pallescens subsp. nov.	Synotus townsendi...	....	Corynorhinus townsendi.
Corynorhinus macrotis townsendi (Cooper).	....	Plecotus macrotis.....	
Myotis velifer (J. A. Allen)..	....	....	Vespertilio albescens velifer (part).
Myotis lucifugus (Le Conte).	Vespertilio lucifugus.	Vespertilio carolii	Vespertilio gryphus lucifugus. Vespertilio albescens affinis.

Comparative table of names used for North American Vespertilionidæ—Continued.

Names used in the present paper.	H. Allen, 1864.	Dobson, 1878.	H. Allen, 1893.
Myotis lucifugus longicrus (True).			Vespertilio nitidus longicrus.
Myotis lucifugus alascensis subsp. nov.			
Myotis yumanensis (H. Allen)	Vespertilio yumanensis.		Vespertilio albescens. Vespertilio nitidus macropus. Vespertilio nitidus (pedomorphic variety).
Myotis yumanensis saturatus. subsp. nov.			
Myotis californicus (Aud. & Bach.).	Vespertilio nitidus	Vespertilio nitidus	Vespertilio nitidus. Vespertilio nitidus henshawi. Vespertilio albescens melanorhinus. Vespertilio nigricans (part).
Myotis californicus ciliolabrum (Merriam).			Vespertilio nitidus ciliolabrum.
Myotis californicus caurinus subsp. nov.			
yotis californicus mexicanus (Saussure).			
Myotis nigricans (Maximilian).		Vespertilio nigricans	Vespertilio nigricans (part).
Myotis subulatus (Say)	Vespertilio subulatus	Vespertilio subulatus	Vespertilio gryphus (northern form).
Myotis subulatus keenii (Merriam).			
Myotis evotis (H. Allen)	Vespertilio evotis	Vespertilio evotis	Vespertilio albescens evotis.
Myotis thysanodes sp. nov			Vespertilio albescens velifer (part).
Lasionycteris noctivagans (Le Conte).	Scotophilus noctivagans.	Vesperugo noctivagans.	Lasionycteris noctivagans.
Pipistrellus hesperus (H. Allen).	Scotophilus hesperus.		Vesperugo hesperus.
Pipistrellus hesperus australis subsp. nov.			
Pipistrellus subflavus (F. Cuvier).	Scotophilus georgianus.	Vesperugo georgianus	Vesperugo carolinensis.
Pipistrellus subflavus obscurus subsp. nov.			
Pipistrellus veræcrucis (Ward).			
Vespertilio fuscus Beauvois.	Scotophilus fuscus	Vesperugo serotinus var. Vesperus fuscus.	Adelonycteris fuscus.
Vespertilio fuscus miradorensis (H. Allen).			
Vespertilio fuscus propinquus (Peters).		Vesperugo propinquus	
Vespertilio fuscus bahamensis subsp. nov.			
Vespertilio fuscus cubensis (Gray).			
Vespertilio albigularis (Peters).		Vesperugo albigularis	
Lasiurus borealis (Müller)	Lasiurus noveboracensis.	Atalapha noveboracensis.	Atalapha noveboracensis.
Lasiurus borealis seminolus (Rhoads).			
Lasiurus borealis pfeifferi (Gundlach).		Atalapha noveboracensis var. pfeifferi.	
Lasiurus borealis teliotis (H. Allen).			Atalapha teliotis.

Comparative table of names used for North American Vespertilionidæ—Continued.

Names used in the present paper.	H. Allen, 1864.	Dobson, 1878.	H. Allen, 1893.
Lasiurus borealis mexicanus (Saussure).	....	Atalapha noveboracensis var. frantzii.	
Lasiurus cinereus (Beauvois)	Lasiurus cinereus	Atalapha cinerea	Atalapha cinerea.
Dasypterus intermedius H. Allen.	Lasiurus intermedius.	Atalapha intermedia..	Dasypterus intermedius.
Nycticeius humeralis Rafinesque.	Nycticejus crepuscularis.	Nycticejus crepuscularis.	Nycticejus humeralis.
Nycticeius humeralis cubanus (Gundlach).	....	....	
Rhogeëssa tumida H. Allen..	....	Vesperugo parvulus..	
Rhogeëssa parvula H. Allen.	....	....	
Rhogeëssa gracilis sp. nov...	....	....	
Rhogeëssa alleni Thomas....	....	....	

List of North American Vespertilionidæ, with type localities.

Name of species	Type locality.
Antrozous pallidus (Le Conte)	El Paso, Texas.
Antrozous pallidus pacificus Merriam	Old Fort Tejon, Cañada de las Uvas, California.
Euderma maculatum (J. A. Allen)............	Near Piru, Ventura County, California.
Corynorhinus macrotis (Le Conte)..........	Georgia (probably near Riceboro).
Corynorhinus macrotis pallescens subsp. nov.	Keam Cañon, Navajo County, Arizona.
Corynorhinus macrotis townsendi (Cooper)..	Columbia River, Oregon.
Myotis velifer (J. A. Allen)................	Santa Cruz del Valle, near Guadalajara, Jalisco, Mexico.
Myotis lucifugus (Le Conte)................	Georgia (probably near Riceboro).
Myotis lucifugus alascensis subsp. nov.....	Sitka, Alaska.
Myotis lucifugus longicrus (True)...........	Puget Sound.
Myotis yumanensis (H. Allen)	Old Fort Yuma, California.
Myotis yumanensis saturatus subsp. nov....	Hamilton, Washington.
Myotis californicus (Aud. & Bach.).........	California.
Myotis californicus caurinus subsp. nov....	Massett, Queen Charlotte Islands, British Columbia.
Myotis californicus ciliolabrum (Merriam)..	Trego County, Kansas.
Myotis californicus mexicanus (Saussure)...	Mexico (probably Vera Cruz, Puebla, or Oaxaca).
Myotis nigricans (Maximilian)............	Fazenda de Aga, near Iritiba River, Brazil.
Myotis subulatus (Say)...................	Arkansas River, near La Junta, Colorado.
Myotis subulatus keenii (Merriam)..........	Massett, Queen Charlotte Islands, British Columbia.
Myotis evotis (H. Allen)..................	Monterey, California.
Myotis thysanodes sp. nov.................	Old Fort Tejon, California.
Lasionycteris noctivagans (Le Conte).......	Eastern United States (exact locality unknown).
Pipistrellus hesperus (H. Allen)............	Old Fort Yuma, California.
Pipistrellus hesperus australis subsp. nov...	Barranca Ibarra, Jalisco, Mexico.
Pipistrellus subflavus (F. Cuvier)..........	Georgia (probably near Riceboro).
Pipistrellus subflavus obscurus subsp. nov ..	Lake George, New York.
Pipistrellus veracrucis (Ward)	Las Vegas, Jalapa, Vera Cruz, Mexico.
Vespertilio fuscus Beauvois................	Philadelphia, Pennsylvania.
Vespertilio fuscus miradorensis (H. Allen)..	Mirador, Vera Cruz, Mexico.
Vespertilio fuscus propinquus (Peters)......	Santa Ysabel, Guatemala.

List of North American Vespertilionidæ, with type localities—Continued.

Name of species.	Type locality.
Vespertilio fuscus bahamensis subsp. nov	Nassau, New Providence, Bahamas.
Vespertilio fuscus cubensis (Gray)	Cuba.
Vespertilio albigularis (Peters)	Mexico.
Lasiurus borealis (Müller)	New York.
Lasiurus borealis seminolus (Rhoads)	Tarpon Springs, Florida.
Lasiurus borealis pfeifferi (Gundlach)	Cuba.
Lasiurus borealis teliotis (H. Allen)	California.
Lasiurus borealis mexicanus (Saussure)	Mexico (probably Vera Cruz, Puebla, or Oaxaca).
Lasiurus cinereus (Beauvois)	Philadelphia, Pennsylvania.
Dasypterus intermedius H Allen	Matamoras, Tamaulipas, Mexico.
Nycticeius humeralis Rafinesque	Kentucky.
Nycticeius humeralis cubanus (Gundlach)	Cuba.
Rhogeëssa tumida H. Allen	Mirador, Vera Cruz, Mexico.
Rhogeëssa parvula H. Allen	Tres Marias Islands, Mexico.
Rhogeëssa gracilis sp. nov	Piaxtla, Puebla, Mexico.
Rhogeëssa alleni Thomas	Santa Rosalia, near Autlan, Jalisco, Mexico.

DESCRIPTIONS.

FAMILY VESPERTILIONIDÆ.

Characters.—Bats with turbinal bones folded, bony palate defective anteriorly owing to the absence of palatal processes to the premaxillæ (fig. 2*b*); molars with conspicuous W-shaped cusps; tail included nearly to tip in large interfemoral membrane; muzzle and nostrils variable, but former never provided with distinct noseleaf.

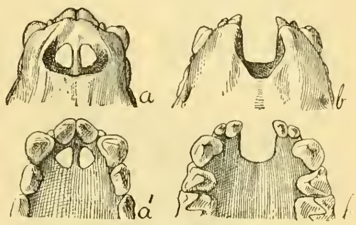

FIG. 2.—Anterior part of rostrum of species of (*a*) *Phyllostomatidæ* and (*b*) *Vespertilionidæ* (× 3).

Remarks.—The family as thus defined is represented in North America by three well-marked subordinate groups, each of which may be ranked as a subfamily. Specimens from the region in question may be referred to their proper groups by the following wholly artificial key.

KEY TO THE SUBFAMILIES OF NORTH AMERICAN VESPERTILIONIDÆ.

Lower incisors 4 .... *Antrozoinæ* (p. 41)

Lower incisors 6.

  Ears joined at anterior base .... *Plecotinæ* (p. 46)

  Ears separate .... *Vespertilioninæ* (p. 54)

Subfamily ANTROZOINÆ.

This subfamily is represented by the genus *Antrozous* peculiar to southwestern North America. Its members may therefore be recognized by their generic characters.

Genus ANTROZOUS H. Allen.

1862. *Antrozous* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 247.
1864. *Antrozous* H. Allen, Monogr. N. Am. Bats, p. 67.
1878. *Antrozous* Dobson, Catal. Chiroptera Brit. Mus., p. 170.
1893. *Antrozous* H. Allen, Monogr. Bats N. Am., p. 64.

Type species.—*Antrozous pallidus* (Le Conte).

Geographic distribution.—Austral zones from Texas to the Pacific, and from the Columbia River to Queretaro on the tableland of Mexico.

Generic characters.—Dental formula: $i, \frac{1\text{-}1}{2\text{-}2}$; $c, \frac{1\text{-}1}{1\text{-}1}$; $pm, \frac{1\text{-}1}{2\text{-}2}$; $m, \frac{3\text{-}3}{3\text{-}3} = 28$; mammæ 2; muzzle truncate; nostrils surrounded by a horseshoe-shaped ridge (fig. 3); lower lip free in front.

FIG. 3.—Muzzle of *Antrozous pallidus* (× 2).

Remarks.—The genus *Antrozous* differs so widely from all others occurring in America that it needs no comparison with any of these. In many ways, however, it resembles *Nyctophilus* of the Old World.[1] While adult *Antrozous* invariably has only two lower incisors in each mandible, an immature individual from Silver City, N. Mex., has a third on the right side (fig. 4). The outer lower incisor is probably normally present in the young, though very early crowded out by the growth of the others.

One species and one subspecies are known, both of which occur in the United States.

KEY TO THE SUBSPECIES OF ANTROZOUS.

Forearm 48 mm. to 53 mm.; color, whitish drab gray .... *pallidus* (p. 43)
Forearm 56 mm. to 60 mm.; color, pale yellowish, drab-brown .... *pacificus* (p. 45)

[1] See H. Allen, Monogr. Bats N. Am. (1893), p. 65.

ANTROZOUS PALLIDUS (Le Conte). Pale Bat.

1856. *Vespertilio pallidus* Le Conte, Proc. Acad. Nat. Sci. Phila., VII (1854–1855) p. 437.
1862. *Antrozous pallidus* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 247.
1864. *Antrozous pallidus* H. Allen, Monogr. N. Am. Bats, p. 68 (part).
1878. *Antrozous pallidus* Dobson, Catal. Chiroptera Brit. Mus., p. 171 (part).
1893. *Antrozous pallidus* H. Allen, Monogr. Bats N. Am., p. 66 (part).

Type locality.—El Paso, Texas. (Type No. 5467, U. S. National Museum.)

Geographic distribution.—Lower Austral zone throughout the desert region of eastern California, Nevada, Arizona, New Mexico, and western Texas.

General characters.—Size large (average length of forearm about 50 mm.); ears large, reaching 20 mm. beyond tip of nose when laid forward; color very pale drab-gray.

Ears.—The ears (Pl. I, fig. 10) are larger than in any other North American *Vespertilionidæ* except the species of *Plecotinæ*. Laid forward they extend about 20 mm. beyond the tip of the nose. The anterior bases are rather close together, but separate. In form the ear is so simple as to call for no very detailed description. Anterior border strongly convex immediately above well-marked anterior lobe, then almost straight to narrowly rounded-off tip. Posterior border slightly concave immediately below tip, then gently convex to base. Posterior basal lobe very slightly developed. A transverse ridge 4 mm. in length extends obliquely upward and forward from near posterior base of tragus.

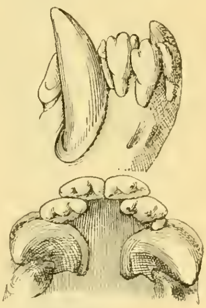

FIG. 4.—Abnormal front teeth of *Antrozous pallidus*, showing three incisors on right side. No. 60119 from Silver City, N. Mex. (10).

Tragus long, straight, and slender. Anterior border nearly straight to narrow tip. Posterior border at first almost parallel with anterior border, then slightly convex to notch above well-developed basal lobe. Whole posterior margin of tragus faintly crenulate.

Membranes.—The membranes are thick and leathery, much more so than in any of the North American *Vespertilioninæ* which approach this species in size. Wing membranes attached at base of toes; interfemoral membrane at base of terminal caudal vertebra. Free border of interfemoral membrane considerably longer than calcar.

Feet.—The feet are broad and strong, about half as long as tibia. Toes armed with large claws and sprinkled with a few short hairs on dorsum of phalanges.

Fur and color.—The fur is sparse and short, that on middle of back only about 8 mm. in length. It is closely confined to the body, and extends on ears and membranes in a narrow border along extreme base only.

On the back the fur is pale drab gray, most of the hairs with faintly dusky tips. Belly grayish white, tinged with drab on sides.

Skull.—The skull of typical *Antrozous pallidus* (fig. 5) varies in greatest length from 18 mm. to 20 mm., and in zygomatic breadth from 11 mm. to 12.5 mm. Brain case, rostrum, and palate broad. Length of bony palate behind molars (exclusive of median spine) usually less than width at base of median spine.

Teeth.—The teeth (fig. 6 *a*) are large and strong. Upper premolar transversely long and narrow. First lower premolar small and closely wedged between canine and second premolar.

Measurements.—See table, page 46.

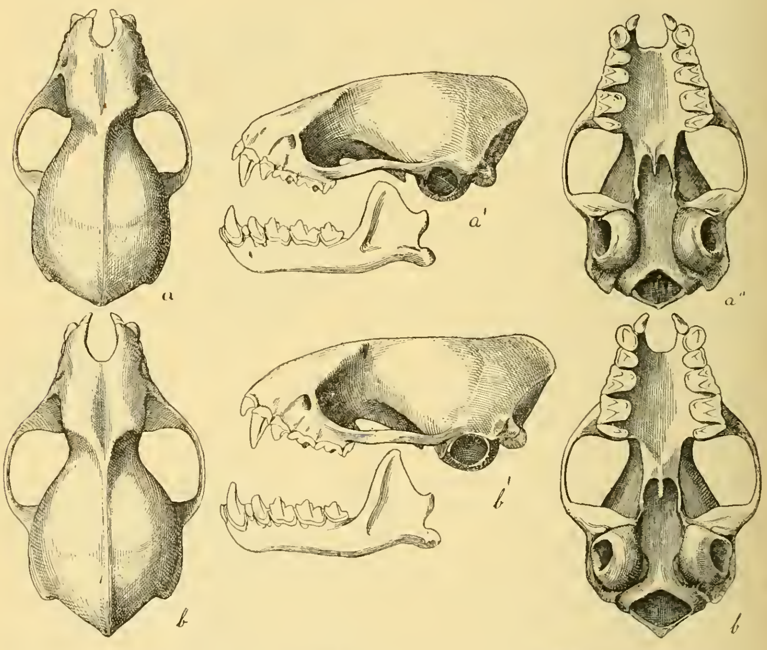

FIG. 5.—Skulls of (*a*) *Antrozous pallidus* and (*b*) *Antrozous pallidus pacificus* (× 2).

Specimens examined.—Total number, 64, from the following localities:

Arizona: Mouth of Colorado River, 1; Yuma, 5.

California: Old Fort Yuma, 1; Owens Valley, 2; Panamint Valley, 1; Walker Basin, 2.

Nevada: Amargosa Desert, 1; Timpahute Mountains, 2.

New Mexico: Silver City, 4 (skins).

Texas: Comstock, 6; Devils River, 8; El Paso, 1 (skin, type); Fort Hancock, 20 (3 skins); Painted Cave, 3; Paisano, 1; Sycamore Creek, 6.

General remarks.—In the original description of *Antrozous pallidus* the animal is said to be a native of California, but both Baird[1] and Harrison Allen[2] have shown that the type specimen came from El Paso,

[1] Rept. Mex. Bound. Surv., II, p. 5, 1859.

[2] Monogr. N. Am. Bats, p. 69, 1864.

Texas. The type, now in the United States National Museum, is in good preservation and clearly referable to the Eastern form.

Typical *Antrozous pallidus* is readily distinguishable from *A. p. pacificus* by its smaller size, paler color, shorter, broader skull, and narrower upper premolar.

ANTROZOUS PALLIDUS PACIFICUS Merriam.

1864. *Antrozous pallidus* H. Allen, Monogr. N. Am. Bats, p. 68 (part).
1878. *Antrozous pallidus* Dobson, Catal. Chiroptera Brit. Mus., p. 171 (part).
1893. *Antrozous pallidus* H. Allen, Monogr. Bats. N. Am., p. 66 (part).
1897. *Antrozous pallidus pacificus* Merriam, Proc. Biol. Soc. Washington, XI, p. 180, July 1, 1897.

Type locality.—Old Fort Tejon, Cañada de las Uvas, California.

Geographic distribution.—Austral zones in the United States west of the Rocky Mountains, south to Lower California and Queretaro.

General characters.—Slightly larger than typical *Antrozous pallidus* (total length about 120 mm., average length of forearm about 54 mm.); color, yellowish drab-brown.

Ears, membranes, and distribution of fur.—Essentially as in typical *pallidus*.

Color.—Color uniform yellowish drab throughout to base of hairs; under parts clear and unmixed with darker; back strongly but irregularly shaded by the dusky tips of the hairs.

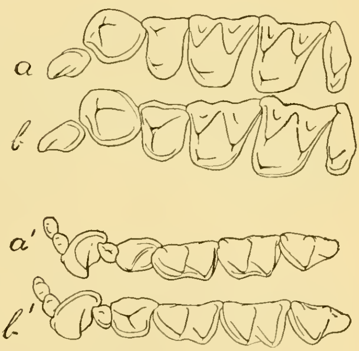

FIG. 6.—Teeth of (*a*) *Antrozous pallidus* and (*b*) *Antrozous pallidus pacificus* (× 5).

Skull.—The skull of *Antrozous pallidus pacificus* (fig. 5 *b*) varies in greatest length from 20 mm. to 22 mm., and in zygomatic breadth from 13 mm. to 14 mm. Brain case, rostrum, and bony palate considerably narrower than in typical *pallidus*. Supraoccipital region more pointed and overhanging than in typical *pallidus*. Length of bony palate behind molars (exclusive of median spine) usually equal to or greater than width at base of median spine.

Teeth.—Teeth (fig. 6 *b*) essentially as in true *pallidus* except that all are larger and the upper premolar is conspicuously broader and shorter.

Measurements.—See table, page 46.

Specimens examined.—Total number, 59, from the following localities:

California: Alhambra, 1; Bear Valley, 8; Berkeley, 1; Dulzura, 6; Fort Crook, 1; Fresno, 3; Old Fort Tejon, 6; Poso Creek, 1 (skin); Santa Barbara, 3; Santa Ysabel, 4 (3 skins); Witch Creek, 2.

Lower California: Cape St. Lucas, 3; Comondu, 5 (skins); San Fernando, 5 (Miller coll.).

Oregon: Fort Dalles, 1 (skin); Twelve Mile Creek, 1.

Queretaro: Jalpan, 7.

Utah: St. Thomas, 1.

General remarks.—Antrozous pallidus pacificus needs no comparison with typical *pallidus* further than that already given under the latter.

Average measurements of subspecies of Antrozous pallidus.

Subspecies.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
pallidus	Texas: El Paso..................	1[1]	....	....	20.5	10	49	9	92	....	....	....
	Comstock..................	4 ♀♀	105	44.2	21	10	51	8.5	85	28	18.4	11.6
	Fort Hancock..............	4 ♀♀	115	46	20	10	49	8.3	86	30	20	14
	Sycamore Creek	6 ♀♀	109	44.6	20.6	10	51	8.9	88	28.5	18.6	13
pacificus	Queretaro: Jalpan...............	6 ♀♀	114	47.8	22.6	10.8	54.5	9.4	93	30	19	14
	California: Santa Ysabel.........	4 ♂♂	....	....	22	11	54.5	9.5	94	....	....	....
	Dulzura...............	4 ♀♀	118	46.7	22.2	11	53.5	9.5	91	30	19	13
	Oregon: Fort Dalles..............	1 ?	....	....	21	11	55	9	96	....	....	....
	Twelve Mile Creek	1 ?	....	....	20	12	56	10	93	....	....	....

[1] Type.

Subfamily PLECOTINÆ.

This subfamily is represented in North America by two genera, *Corynorhinus* and *Euderma* which may be recognized among the other *Vespertilionidæ* of the region by their huge ears, joined together across the forehead. None of the North American *Vespertilioninæ* show this peculiarity.

Genus EUDERMA H. Allen.

1891. *Histiotus* J. A. Allen, Bull. Am. Mus. Nat. Hist., N. Y., III, p. 195 (not Gervais 1855).

1892. *Euderma* H. Allen, Proc. Acad. Nat. Sci. Phila., 1891, p. 467, Jan. 12, 1892.

1893. *Euderma* H. Allen, Monogr. Bats N. Am., p. 60.

Type species.—Euderma maculatum (J. A. Allen).

Geographic distribution.—The genus *Euderma* is at present known from one specimen taken in Ventura County, California.

Generic characters.—Dental formula: $i, \frac{2\text{-}2}{3\text{-}3}$; $c, \frac{1\text{-}1}{1\text{-}1}$; $pm, \frac{2\text{-}2}{2\text{-}2}$; $m, \frac{3\text{-}3}{3\text{-}3} = 34.$ Ears (Pl. I, fig. 11) even larger than in *Corynorhinus*, joined together across forehead and with posterior base of tragus united with external basal lobe. Face without evident glandular swellings.

Remarks.—The genus *Euderma* resembles *Corynorhinus* more closely than any other American bat, but differs in the presence of two less premolars, in the simple nostrils, and in the more complicated structure of the ear. Only one species is known.

EUDERMA MACULATUM (J. A. Allen).

1891. *Histiotus maculatus* J. A. Allen, Bull. Am. Mus. Nat. Hist., III, p. 195, February 20, 1891.

1893. *Euderma maculata* H. Allen, Monogr. Bats N. Am., p. 61.

Type locality.—Near Piru, Ventura County, California (probably at mouth of Castac Creek[1]). Type in American Museum of Natural History (No. $\frac{3920}{2991}$.) Skull now lost.

Geographic distribution.—*Euderma maculatum* is known from the type locality only.

General characters.—Size large; ears about three-fourths as long as forearm; color blackish blotched with white.

Ears.—Ears very large (Pl. I, fig. 11), fully three-fourths as long as forearm, joined together across forehead by a low band of membrane; anterior basal lobe continuous with keel which extends upward from anterior base of tragus and fades into substance of ear at about terminal part of lower fourth, beyond which it continues to tip as a well-defined line; anterior border of ear nearly straight through lower half, then gently convex to broadly rounded off tip; posterior border slightly concave immediately below tip, then convex to base; posterior basal lobe joined to base of tragus by a low band, below which a distinct pocket is formed; back of this band a conspicuous ridge extending inward toward meatus; ear membrane marked by about fifteen transverse ridges; anterior margin of ear sprinkled with whitish hairs.

Tragus nearly straight on anterior border, convex on posterior border except at posterior base, where it is straight for a distance of 2 mm. (the resulting form strongly suggests a table knife with short blade).

Membranes.—The membranes are broad and ample, the wing membrane (Pl. III, fig. 3) attached at base of toes, the interfemoral membrane at base of terminal caudal vertebra. Free border of interfemoral membrane apparently longer than calcar.

Feet.—The feet are moderately large, a little less than half as long as tibia. Toes sparsely sprinkled with short bristly hairs on dorsal surface and armed with strong claws. Calcar indistinct in the dried skin, but apparently short and without keel or terminal lobule.

Fur and color.—The fur is full and soft, about 12 mm. in length on middle of back. It extends on extreme base of ear, and on membranes forms a very narrow border close to body.

Back very dark sepia, almost black; occiput and fore part of neck distinctly less dark; hairs on sides and on middle of back faintly annulated with gray near tips; patch at base of tail and on each shoulder pure white; whole ventral surface of body white, the blackish bases of the hairs showing through irregularly; fur everywhere blackish at base; ears and membranes light brown.

Skull and teeth.—As the skull of *Euderma maculatum* is lost, I quote the descriptions published by Dr. J. A. Allen and Dr. Harrison Allen. The former writes:

Skull and dentition.—Basilar length, 16.5 mm. (0.65 in.); total length, 19 mm. (0.75 in.); zygomatic width, 10.9 mm. (0.43 in.); height, 7.6 mm. (0.30 in.); length of

[1] This information was given to members of a Biological Survey party by the collector of the type specimen.

lower jaw, 12.7 mm. (0.50 in.); height at condyle, 3.3 mm. (0.13 in.); height at coronoid process, 3.8 mm. (0.15 in.); length of upper tooth row, 6.86 mm. (0.27 in.); length of lower tooth row, 7.6 mm. (0.30 in.).

Dental formula: incisors, $\frac{2-2}{6}$; canines, $\frac{1-1}{1-1}$; premolars, $\frac{1-1}{2-2}$; molars, $\frac{3-3}{3-3} = \frac{11}{18} = 32$.

The skull is thin and papery, being evidently that of a young animal. The facial portion is narrow and pointed; the brain case is quadrate, flattened above, but rises abruptly at the frontal border, the forehead being suddenly depressed.

The lower border of the zygomatic arch is curved upward; the upper border is greatly expanded vertically, the upper border of the malar forming a high angular process at the middle of arch; the zygomatic process of the squamosal is short, and, with the malar, passes forward in a line nearly parallel with the axis of the skull, with only a very slight outward curvature. The tympanic bullæ are enormously expanded, having an antero-posterior length of 5.84 mm. (0.23 in.), and a transverse breadth of 3.3 mm. (0.13 in.), their length fully equaling one-third of the length of the skull. In other respects the ventral aspect of the skull presents nothing peculiar. The lower jaw is narrow, the coronoid process small, rising but little above the condyle; the angle is well developed.

The dentition is weak, the incisors and canines being very small, relatively to the molar series. The outer upper incisor is about one-half the size of the inner; both have a small outer cusp at the base. The upper canine is about equal in size to the anterior half of the upper premolar. The molars present nothing distinctive. The lower incisors are slightly double-notched (trifid); the lower canines are very small; the first premolar is about half the size of the second.

In his original account of the genus *Euderma*, Dr. Harrison Allen describes the skull and teeth as follows:

Skull.—Brain-case low, quadrate, the height one-half the bimastoid diameter. The metencephalon as long as mesencephalon and pro-encephalon. Sagittal crest rudimentary, does not extend beyond a line answering to the middle of the zygoma—the remaining portions of the posterior temporal crest widely separated—the anterior not defined. Dorsum of face-vertex with a shallow concavity which is not sharply defined; orbit with inflated inner wall and rugose elevated upper border; lachrymal tubercle marked. Infra-orbital canal short; the foramen on line with interval between second premolar and first molar. Line of the upper margin of the anterior nasal aperture if produced would intersect the second premolar; tympanic bone apparently incomplete above.

The paroccipital process bold, trenchant; sterno-mastoid impression deeply concave; mastoid composed entirely of the squamosal element. Zygoma quite as in *Corynorhinus*—the squamosal part twice as wide as maxillary; spheno-palatine foramen present, of large size. Occipital crest trenchant. Tympanic bone greatly inflated, equals one-third the length of the skull, not touching basi-occipital, or basi-sphenoid; excavate anteriorly. It extends to a line which answers to the middle of the glenoid cavity. The mesopterygoid fossa as long as one-third the distance from the posterior palatal border to the incisors. The sphenoidal foramen is at the bottom of a deep recess. The coronoid process is round, small, raised scarcely one-third the height of the ascending ramus; lower border of the horizontal ramus near the angle slightly concave. The angle is raised from the plane on which the mandible rests * * *

Upper teeth.—Incisors contiguous, slightly inclined toward the median line, but the lateral tooth separated from the canine by a moderate interval. Central incisor cuspidate, with a small cuspule projected midway on the posterior surface; a distinct cuspule also arises from the cingulum posteriorly. Lateral incisor one-half the size of the central, and cuspidate, with a small cuspule arising from the cingulum on the anterior and a second on the posterior portion. Canine not larger than the second premolar, the buccal surface is abruptly convex. The first premolar is small, not wedged in, with complete cingulum. The space between it and canine narrower than that between it and second premolar. The second premolar as long as the canine and slightly fluted. Molars as in *Corynorhinus*.

Lower teeth.—Incisors crowded, trifid, i. e., the main cusp possesses a well-developed cuspule on each side of the base, the cingulum on the posterior side being large. The first and second teeth overlap for a distance equaling one-half of their diameters. The third incisor retains a posterior cuspule which is larger than the anterior and separated from the main cusp by a wide interval. The canine is small and projects but a slight degree above the incisors. It exhibits a marked cuspule on the cingulum anteriorly.

Measurements (from skin).—Total length, 110; tail vertebræ, 50; tibia, 21; foot, 9; forearm, 50; thumb, 6.8; longest finger, 91; ear from meatus, 34; width of ear, 22; tragus, 13; greatest width of tragus, 5.

Specimens examined.—One, the type (Am. Mus. Nat. Hist., New York).

General remarks.—*Euderma maculatum* differs so widely from all other known bats that no comparison with any is necessary. Its peculiar color at first suggests albinism, but since the fur is everywhere dark at base, even in the white areas, the pattern is probably normal. It is useless to hazard any conjecture as to its probable geographic range or exact faunal position.

The following note on this bat is kindly furnished by Dr. C. Hart Merriam:

The type of this remarkable genus and species, recently described by Dr. J. A. Allen, is believed to have been obtained at the mouth of Castac Creek in the Santa Clara Valley, near San Fernando, Cal. The type specimen remains the only one thus far collected, but the species probably ranges over much of the Lower Sonoran Desert region in summer. While in Vegas Valley, Nev., I was told by the Stuarts, the owners of Vegas Ranch, that a very large bat "with ears like a jackass and a white stripe on each shoulder" is abundant at that place in the summer, but does not occur in spring or fall. They stated that it had not yet arrived at the date of our visit, May 1, 1891.

Genus CORYNORHINUS H. Allen.

1831. *Plecotus* Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, Appendix, p. 431 (not *Plecotus* Geoffroy 1818).

1864. *Synotus* H. Allen, Monogr. N. Am. Bats, p. 62 (not *Synotus* Keyserling & Blasius 1839).

1865. *Corynorhinus* H. Allen, Proc. Acad. Nat. Sci., Phila., p. 173.

1878. *Plecotus* Dobson, Catal. Chiroptera Brit. Mus., p. 177 (part).

1893. *Corynorhinus* H. Allen, Monogr. Bats N. Am., p. 53.

Type species.—*Corynorhinus macrotis* (Le Conte).

Geographic distribution.—Austral zones throughout the United States, and in Mexico south at least to Vera Cruz. Limits of range imperfectly known.

Generic characters.—Dental formula:

$$i, \frac{2-2}{3-3}; \quad c, \frac{1-1}{1-1}; \quad pm, \frac{2-2}{3-3}; \quad m, \frac{3-3}{3-3} = 36.$$

Skull (fig. 8, p. 52) slender and highly arched, the rostral portion relatively smaller and weaker than in any other North American genus of the family (with the possible exception of *Euderma*, the only known skull of which is now lost). Ears very long, (Pl. I, fig. 9), joined together across forehead, and with tragus free from external basal lobe. Region between eye and nostril occupied by a prominent thickened ridge which terminates in a conspicuous club-shaped enlargement (fig. 7). First phalanx of third finger shorter than second (Pl. III, fig. 2).

General remarks.—Corynorhinus differs widely from the other known American genera of *Vespertilionidæ*, but somewhat closely resembles the Old World *Plecotus*. From the latter it is separated by its differ-

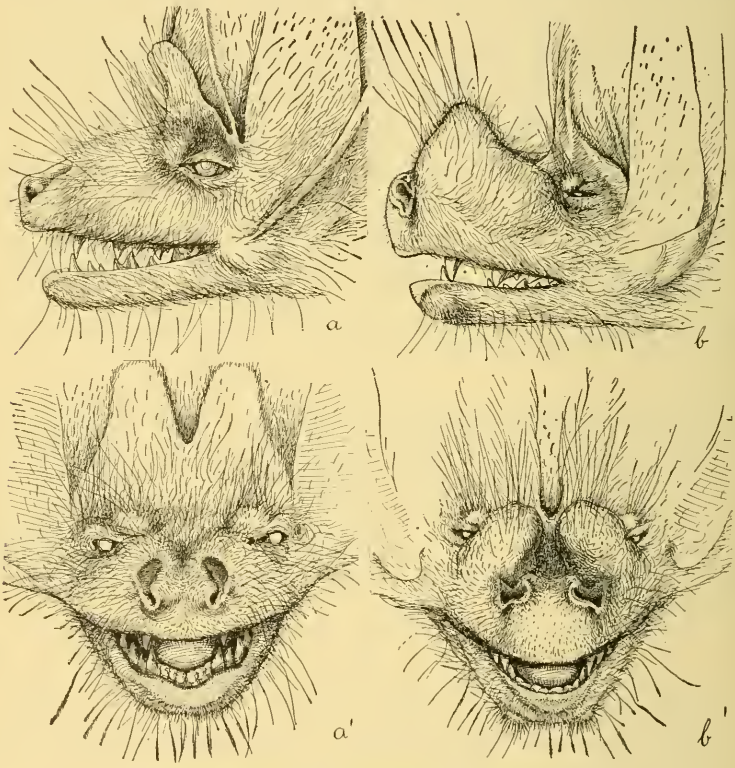

FIG. 7.—Muzzles of (*a*) *Plecotus* and (*b*) *Corynorhinus* (×2).

ently formed nostrils, conspicuously glandular muzzle, and differently proportioned fingers (fig. 7, and Pl. III, figs. 1 and 2). The genus is represented by one species which may be divided into three subspecies, differing from each other chiefly in color. All of these occur in the United States. The material by which this genus is now represented in collections is very unsatisfactory.

KEY TO THE SUBSPECIES OF CORYNORHINUS.

Fur everywhere distinctly bicolor .... *macrotis* (p. 51)
Fur not distinctly bicolor.
  Color yellowish gray .... *pallescens* (p. 52)
  Color blackish brown .... *townsendii* (p. 53)

CORYNORHINUS MACROTIS (Le Conte). Big-eared Bat.

1831. *Plecotus macrotis* Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, Appendix, p. 431 (Georgia).

1837. *Plecotus lecontii* Cooper, Ann. Lyc. Nat. Hist. N. Y., IV, p. 72. (Name proposed as substitute for *macrotis*.)

1864. *Synotus macrotis* H. Allen, Monogr. N. Am. Bats, p. 63.

1865. *Corynorhinus macrotis* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 173.

1893. *Corynorhinus macrotis* H. Allen, Monogr. Bats N. Am., p. 55.

Type locality.—Georgia (see Proc. Acad. Nat. Sci. Phila., 1855, p. 434), probably near the Le Conte Plantation, 5 miles south of Riceboro.

Geographic distribution.—Lower Austral zone in the eastern United States.

General characters.—Size large (forearm 41 mm. to 42 mm., ear about 32); fur everywhere distinctly bicolor; general color yellowish brown.

Ears.—The ears of typical *Corynorhinus macrotis* do not appreciably differ from those of the other subspecies. They are so different from those of all other North American bats as scarcely to require detailed description. They may be instantly recognized by their length, much more than half that of forearm, and by the form of the tragus. This is simple, with a large basal lobe, and wholly free from the auricle. In *Euderma maculatum*, the only other North American bat with ears approaching those of *Corynorhinus* in size, the tragus is joined to the external basal lobe.

Membranes.—The membranes are broad and ample. In texture they are remarkably thin and delicate for so large a bat. Wings (Pl. III, fig. 2) attached at side of metatarsus just below base of toes. Uropatagium extending to extreme tip of tail.

Feet.—The feet are slender, less than half as long as tibiæ, and armed with strong claws. Calcar a little shorter than tibia, and about equal to free border of interfemoral membrane. It is without vestige of keel on posterior border. The termination is obscure and without lobule. Back of toes sprinkled with long bristly hairs.

Fur and color.—The fur is soft and silky, that on middle of back averaging about 12 mm. in length. In distribution it shows no striking peculiarities. It extends a short distance on the dorsal base of the ear, but scarcely reaches the wings or interfemoral membrane.

Back uniform yellowish brown, much as in *Myotis lucifugus;* the hairs everywhere sepia through a little more than the basal half and with very indistinctly pale tips. Belly grayish white; throat and chest darker and more tinged with yellowish. Throughout the ventral surface the fur is very sharply bicolor, the dark bases of the hairs considerably darker than on the back. The light tips are too short wholly to conceal the dark under fur. Ears and membranes light brown.

Skull and teeth.—The skull (fig. 8) and teeth (fig. 9) have been sufficiently described under generic characters. An adult skull from Houma, La. (♀ No. 45894, United States National Museum, Biological Survey collection), measures: Greatest length, 16; zygomatic breadth, 9; breadth of rostrum at posterior border of large premolar, 5; mandible, 10.6; upper tooth row (exclusive of incisors), 5.2; lower tooth row, 6.8.

Measurements.—See table, page 54.

Specimens examined.—Total number, 9, from the following localities:

Alabama: Greensboro, 1 (skin, Merriam coll.).
Kentucky: Bowling Green, 1.
Louisiana: Houma, 4 (skins).
Mississippi: Bay St. Louis, 1.
South Carolina: Hardeeville, 1 (skin, Miller coll.).
Virginia: Dismal Swamp, 1 (skin).

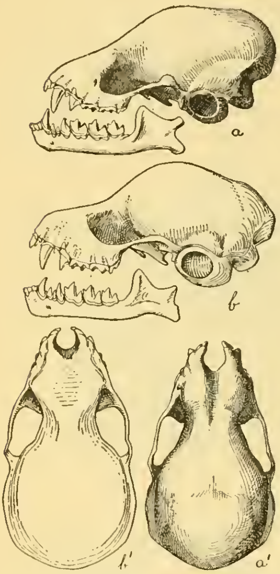

FIG. 8.—Skulls of (*a*) *Corynorhinus townsendii* and (*b*) *C. macrotis* (× 2).

General remarks.—Typical *Corynorhinus macrotis*, like the western subspecies, is distinguishable at a glance from all other North American bats by its generic characters. Among the forms of *Corynorhinus* it may be distinguished by its conspicuously bicolored fur. The limits of this animal's range are not well understood, but it is probably a characteristic species of the Austroriparian fauna.

CORYNORHINUS MACROTIS PALLESCENS subsp. nov.

1864. *Synotus townsendi* H. Allen, Monogr. N. Am. Bats, p. 65 (not *Plecotus townsendi* Cooper, 1837),
1893. *Corynorhinus townsendi* H. Allen, Monogr. Bats N. Am., p. 58.

Type from Keam Cañon, Navajo County, Arizona. Adult ♀ (skin), No. 65534, U. S. National Museum (Biological Survey collection). Collected August 3, 1894. by Dr. A. K. Fisher. Collector's No., 1715.

Geographic distribution.—Probably throughout the Austral zones from California, Colorado, and western Texas to southern Mexico.

General characters.—Similar to typical *macrotis*, but much paler in color; fur nowhere distinctly bicolor.

Color.—Back yellowish drab gray, becoming paler about head, the hairs with faintly defined light plumbeous bases and faintly darker tips. Belly slightly paler than back, but hairs without distinctly lighter tips and with darker basal area so ill defined as to be scarcely visible. Ears and membranes light brown.

FIG. 9.—Teeth of (*a*) *Corynorhinus townsendii* and (*b*) *C. macrotis* (× 5).

Measurements.—See table, page 54.

Specimens examined.—Total number, 30, from the following localities:

Arizona: Fort Huachuca, 2; Keam Canyon, 1 (skin).
California: Dulzura, 1; Owens Lake, 1; Owens Valley, 1.

Colorado: Larimer County, 1 (skin, Miller coll.).
Guanajuato: Santa Rosa, 17.
Michoacan: Patzcuaro, 1.
Oaxaca: Oaxaca, 1.
San Luis Potosi: Hacienda La Parada, 1.
Texas: East Painted Cave, 1.
Utah: 1.
Vera Cruz: Jico, 1.

General remarks.—Corynorhinus macrotis pallescens differs from true *macrotis* in its much paler, more uniform coloration. While this form is represented in the National Museum by numerous specimens in alcohol, the series of skins is very incomplete. Until this series can be greatly increased the limits of distribution of the subspecies must remain purely a matter of conjecture.

The differences in form of the inner upper incisor which have been supposed to distinguish this race from true *macrotis*[1] appear to be inconstant. While the few specimens of typical *macrotis* that I have seen have this tooth without exception bicuspidate, western specimens vary greatly. In a series from Santa Rosa, Guanajuato, both extremes are represented, while several specimens are with difficulty referred to one or the other (fig. 10).

FIG. 10.—Left upper incisors of *Corynorhinus macrotis pallescens* from Santa Rosa, Guanajuato, Mexico.

This is the bat to which Dr. Harrison Allen has applied the name *townsendi*. True *townsendi*, however, the type of which came from the Columbia River, is the dark northwest coast form.

CORYNORHINUS MACROTIS TOWNSENDII (Cooper).

1837. *Plecotus townsendii* Cooper, Ann. Lyc. Nat. Hist., N. Y., IV, p. 73. (Columbia River.)

1878. *Plecotus macrotis* Dobson, Catal. Chiroptera Brit. Mus., p. 180 (not *Plecotus macrotis* Le Conte, 1831).

Type locality.—Columbia River, Oregon.

Geographic distribution.—Humid coast district of Oregon, Washington, and southern British Columbia.

General characters.—Similar to typical *macrotis*, but much darker; fur nowhere distinctly bicolor.

Color.—Back uniform dark brown, the hairs indistinctly light plumbeous at base, and very faintly tipped with yellowish. Belly dark brown, the hairs light plumbeous at base. Ears and membranes blackish.

Measurements.—See table, page 54.

Specimens examined.—Total number, 3, from the following localities:

British Columbia: Comox, 1 (skin).
Oregon: Creswell, 1; Gold Beach, 1.

[1] H. Allen, Monogr. Bats N. Am., p. 58, 1893.

General remarks.—Corynorhinus macrotis townsendii is the dark northwest coast representative of the species. In coloration it bears a close resemblance to the other bats peculiar to the same region. It is so different in general appearance from *macrotis* and *pallescens* that it needs no special comparison with them. More material is necessary before the exact relationship of this form to the others can be determined.

While this is the true *townsendii* of Cooper, it is not the bat to which Harrison Allen has applied the name. The latter is *C. macrotis pallescens.* It was on a specimen of this form from Vancouver Island that Dobson based his description of '*Plecotus*' *macrotis* in the Catalogue of Chiroptera in the British Museum.

Average measurements of subspecies of Corynorhinus.

Subspecies.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
macrotis	South Carolina: Hardeeville	1 ♀	.....	...	21	10	41	7.4	73	....	....	....
	Kentucky: Bowling Green	1 ♂	105	52	22	10	43.4	7	77	32	23	14
	Louisiana: Houma	4 ♀ ♀	106	48.5	21.5	9.4	41.5	7.5	73	32	....	....
pallescens	Arizona: Keam Canyon	1 ♀[1]	105	49	20.6	9.6	42.6	6	76	....	....	....
	Fort Huachuca	1 ♂	95	45	19	9	....	6	71	33.4	21.4	14.6
	Colorado: Larimer County	1 ♀	.....	....	21.6	9.6	44	7	77	....	....	....
	Texas: East Painted Cave	1 ♀	90	45	21	9.6	41	5	73	33	20	14.6
	Guanajuato: Santa Rosa	10	99.3	48.1	20	9	41.9	6.6	77	33.9	23.7	12.7
townsendii	British Columbia: Comox	1 ♀	.....	....	21.4	10	42	6.6	76	....	....	....
	Oregon: Gold Beach	1 ♀	105	51	22	9.4	44	7	80	33	24	15
	Creswell	1 ♀	100	48	22	9.8	43	7	77	34	21	14

[1] Type.

Subfamily VESPERTILIONINÆ.

This subfamily contains the great majority of North American *Vespertilionidæ.* Those of its members that occur in the region in question may be known by their simple muzzles and nostrils, separate ears, ample interfemoral membranes, and six incisors in the lower jaw.

KEY TO GENERA OF VESPERTILIONINÆ OCCURRING IN AMERICA NORTH OF PANAMA.

[Based on dental characters only.]

Upper incisors 2.
- Upper premolars 2.
  - Mandibular tooth-row more than 8 mm .... *Dasypterus* (p. 115)
  - Mandibular tooth-row less than 7 mm.
    - Third lower incisor much smaller than second or first.. *Rhogeëssa* (p. 122)
    - Third lower incisor about equal to second or first .... *Nycticeius* (p. 118)
- Upper premolars 4 .... *Lasiurus* (p. 105)

Upper incisors 4.
- Upper premolars 2 .... *Vespertilio* (p. 95)
- Upper premolars more than 2.
  - Upper premolars 4.
    - Lower premolars 4 .... *Pipistrellus* (p. 87)
    - Lower premolars 6 .... *Lasionycteris* (p. 85)
  - Upper premolars 6 .... *Myotis* (p. 55)

Genus MYOTIS Kaup.

1829. *Myotis* Kaup, Skizzirte Entw.-Gesch. u. Natürl. Syst. d. Europ. Thierw., I, p. 106. Type *Vespertilio murinus* Schreber (not *V. murinus* Linn.).

1829. *Nystactes* Kaup, Skizzirte Entw.-Gesch. u. Natürl. Syst. d. Europ. Thierw., I, p. 108. Type *Vespertilio bechsteinii* Leisler.

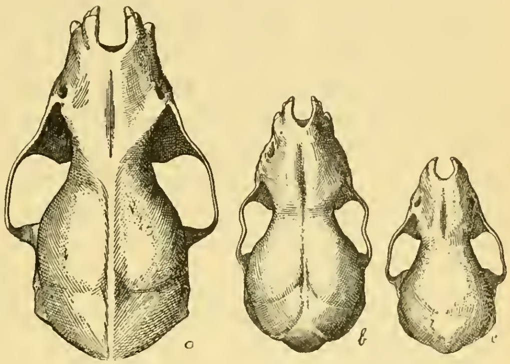

FIG. 11.—Skulls of (*a*) *Myotis myotis*, (*b*) *M. thysanodes*, and (*c*) *M. nigricans* (×2).

1839. *Vespertilio* Keyserling & Blasius, Wiegmann's Archiv f. Naturgesch., 5ter Jahrg., Bd. 1, p. 306 (not *Vespertilio* Linnæus, 1758).

1841. *Selysius* Bonaparte, Iconografia Fauna Italica, I, Introduzione [p. 3]. Type *Vespertilio mystacinus* Leisler.

1856. *Brachyotus* Kolenati, Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 174–177. Based on the species *mystacinus, daubentonii*, and *dasycneme*.

1856. *Isotus* Kolenati, Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 177–179. Included the species *nattereri* and *emarginatus*.

1864. *Vespertilio* H. Allen, Monogr. N. Am. Bats, p. 46. (Not *Vespertilio* Linn., 1758.)

1870. *Aeorestes* Fitzinger, Sitzungsber. Math.-Nat. Cl. K. Akad. Wiss., Wien, LXII, Abth. I, pp. 427–436. Included the species *villosissimus, albescens*, and *nigricans*.

1870. *Comastes* Fitzinger, Sitzungsber. Math.-Nat. Cl. K. Akad. Wiss., Wien, LXII, Abth. I, pp. 565–579. (Included *capaccinii, megapodius, dasycneme* and *limnophilus*.)

1878. *Vespertilio* Dobson, Catal. Chiroptera Brit. Mus., p. 281 (not *Vespertilio* Linnæus 1758).

1893. *Vespertilio* H. Allen, Monogr. Bats N. Am., p. 70. (Not *Vespertilio* Linn., 1858).

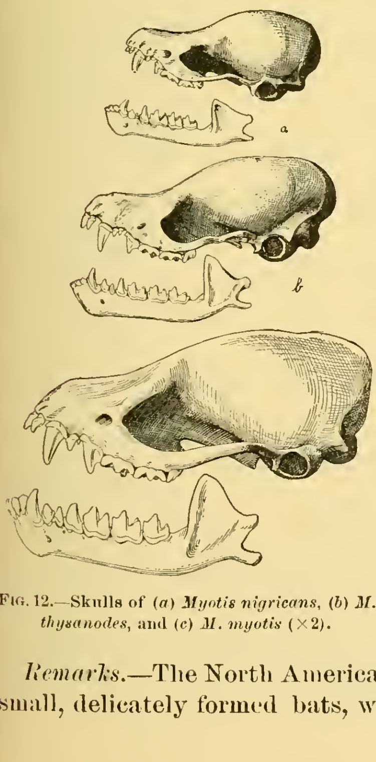

FIG. 12.—Skulls of (*a*) *Myotis nigricans*, (*b*) *M. thysanodes*, and (*c*) *M. myotis* (×2).

Type species.—*Myotis myotis* (Bechstein) = *Vespertilio murinus* Schreber et Auct., nec Linn.

Geographic distribution.—Temperate and tropical parts of both hemispheres.

Generic characters.—Dental formula:

$$i,\ \frac{2-2}{3-3};\ c,\ \frac{1-1}{1-1};\ pm,\ \frac{3-3}{3-3};\ m,\ \frac{3-3}{3-3}=38.$$

Remarks.—The North American members of the genus *Myotis* are all small, delicately formed bats, which, aside from their dental formula, shared by no other American genus of *Vespertilionidæ*, are usually recognizable by their slender forms, long tails, hairy faces, narrow ears, and tapering, straight, or recurved tragi. As I have had no opportunity to study any of the Old World species except *M. myotis*, I can make no attempt to define the genus in detail, but the dental formula, coupled with the characters of the family, is sufficient to distinguish the genus among American bats. The species of *Myotis* differ greatly among themselves, especially in size (see figs. 11 and 12). It may eventually prove necessary to divide the genus into two or more subgenera.

KEY TO NORTH AMERICAN FORMS OF MYOTIS.

Free border of uropatagium conspicuously fringed .... *thysanodes* (p. 80)
Free border of uropatagium not conspicuously fringed.
  Forearm more than 40 mm.
    Ear when laid forward extending barely beyond nostril .... *velifer* (p. 56)
    Ear when laid forward extending 7 to 10 mm. beyond nostril .... *evotis* (p. 77)
  Forearm less than 40 mm.
    Ear when laid forward extending 7 to 10 mm. beyond nostril .... *evotis* (p. 77)
    Ear when laid forward extending less than 6 mm. beyond nostril.
      Fur on back not distinctly bicolor .... *nigricans* (p. 74)
      Fur on back distinctly bicolor.
        General color whitish gray.
          Foot 8 to 10 mm .... *yumanensis* (p. 66)
          Foot 5 to 7 mm .... *ciliolabrum* (p. 72)
        General color never whitish gray.
          Forearm 30 to 35 mm.
            Color light yellowish gray .... *californicus* (p. 69)
            Color yellowish brown.
              Forearm 31 to 33 mm .... *caurinus* (p. 72)
              Forearm 32 to 36 mm .... *mexicanus* (p. 73)
          Forearm 34 to 40 mm.
            Tibia less than 15 mm .... *saturatus* (p. 68)
            Tibia 15 to 19 mm.
              Ear and tragus slender, the latter 9 mm. or more in length.
                Color light brown .... *subulatus* (p. 75)
                Color blackish .... *keenii* (p. 77)
              Ear and tragus short and broad, the latter 8 mm. or less in length.
                Tibia 17.5 to 20 mm .... *longicrus* (p. 64)
                Tibia 15 to 17 mm.
                  Ear 12 to 14 mm .... *lucifugus* (p. 59)
                  Ear 14 to 16 mm .... *alascensis* (p. 63)

MYOTIS VELIFER (J. A. Allen).

1890. *Vespertilio velifer* J. A. Allen, Bull. Am. Mus. Nat. Hist., N. Y., III, p. 177, Dec. 10, 1890.

1896. *Vespertilio incautus* J. A. Allen, Bull. Am. Mus. Nat. Hist., N. Y., VIII, p. 239, Nov. 21, 1896. (Texas.)

Type locality.—Santa Cruz del Valle, near Guadalajara, Jalisco, Mexico.

Geographic distribution.—Near border line between upper and lower Sonoran zones from Missouri and Indian Territory south to Hidalgo, northern Michoacan, and the City of Mexico.

General characters.—Largest species of *Myotis* known to occur in Mexico or the United States. Length 90 to 105, forearm 40 to 47. Calcar slender, without well-developed lobe. Free border of uropatagium naked. Ears short, reaching tip of nose. Wings from metatarsus.

Ears.—The ears are short and pointed; laid forward they reach to or just beyond nostril. Auricle concave on both sides immediately below the narrowly rounded off tip (most strongly so on the posterior border). Anterior border straight or very slightly convex through the basal two-thirds of its length, then concave or almost straight to tip; posterior border strongly concave directly below tip, then still more strongly convex to basal notch, the widest part of the ear at about mid height. Basal notch well defined, isolating a prominent basal lobe, which is slightly notched on the lower side and joins the side of the face in a line which if continued would coincide with the margin of the upper lip.

Tragus moderately long and broad, the anterior edge straight or very slightly convex toward the tip; posterior border with a well-developed lobe at base; just above the lobe the tragus attains its greatest width; the two borders are usually parallel for a short distance, after which the posterior border bends rapidly forward to the tip, below which it may be either straight or very slightly concave.

Membranes.—The membranes are, for an American *Myotis*, rather thick and opaque. The uropatagium is sparsely haired both dorsally and ventrally on its proximal fourth; the free border, which is distinctly shorter than the calcar, wholly naked. Wing from point between ankle and base of toes, but nearer the latter. When drawn away perpendicularly from the leg, the wing appears to be attached to the ankle.

Feet.—Feet (Pl. II, fig. 6) large and strong, half as long as tibiæ. Toes (without claws) slightly longer than sole, scarcely united by membrane at extreme base, all sprinkled with long, stiff hairs. Calcar long, slender, usually terminating indistinctly, but sometimes with a more or less well defined lobule at tip.

Fur and color.—There is nothing peculiar about the distribution of the fur to distinguish this bat from other American members of the genus.

In color the fur is dull sepia throughout, paler on the belly, the hairs everywhere dusky slate at base. Individual variation is trifling and is mostly confined to the belly. This is usually dull broccoli brown, but in some specimens by admixture of yellow it becomes more nearly isabella color.

Skull.—Skull stronger and more heavily built than in any other *Myotis* found in Mexico or the United States, but not actually larger than that of *M. thysanodes.* Greatest length (5 specimens) 16 to 16.4; zygomatic breadth, 10 to 11; interorbital constriction, 4 to 4.2; width of rostrum at anterior root of m 1, 6 to 6.2; length of mandible, 12 to 13. When viewed from above, the brain case is subcircular in outline but truncate posteriorly and slightly longer than broad. Forehead moderately elevated above muzzle; occiput high and compressed, with well-developed ridges. Distance from posterior border of last upper molar to tip of hamular equal to or less than distance between alveoli of posterior molars.

Teeth.—Upper incisiors diverging at tips, the inner tooth of each pair much the larger. First and second premolars in the tooth row or second displaced slightly inward and partly concealed by the anterior edge of the third, the relative size of the two teeth variable, but first always the larger. The second premolar is always much shorter than the first, but the cross section of the crown is sometimes nearly equal in the two teeth. On the other hand, in rare cases the area of cross section in the first is nearly double that of the second. Third upper premolar triangular in outline, posterior margin longest, the outer margin abruptly convex anteriorly, the anterior and posterior borders slightly concave; inner apex of triangle bluntly rounded and not reaching to level of inner margins of molars. Crowns of first and second upper molars trapeziform in outline, the anterior edge longest, and the posterior, outer, and inner edges successively shorter. Anterior edge slightly convex, posterior edge slightly concave. Crown of first molar considerably shorter in proportion to its width than second (fig. 14 *d*, p. 61). Inner mandibular incisors smallest, their crowns compressed and trifid; middle incisors similar but larger; outer incisors about as large as the two others together, their crowns irregularly terete, and with four indistinctly developed tubercles, one of which is much larger than the others. First and second premolars perfectly in line, the first considerably larger than the second, though not much wider in cross section. Third premolar as broad as long, trapeziform, the posterior margin longest.

Measurements.—In the following table average measurements are given of 20 specimens of *Myotis velifer* from six localities.

Average measurements of 20 specimens of Myotis velifer from 6 localities.

Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
Michoacan: Patzcuaro	5	99	44.8	18.5	9.5	45	7.2	73.4	16	10.6	9
Hidalgo: Tulancingo	3	97	42	18.3	8.9	43.6	7.2	71.3	16.1	10.3	8.5
Mexico: Ixtapalapa	1 ♂	94	40	17.6	8.6	42	6.4	71	15.4	11	9
Arizona: San Bernardino Ranch	4	98.8	42	16.5	9	41.5	6.4	69	......	......	7.8
Texas: San Antonio	1[1]	95.2	44.4	18	8.4	43	7	62	......	......	......
San Antonio	4	93.3	41.3	18.1	9.3	43	6.9	67	......	......	......
Missouri: Marble Cave	3	93.6	39.6	17.9	9.8	42.6	7	69.3	15.6	10.1	8.1

[1] Type of '*incautus*.'

Specimens examined.—Total number 46, from the following localities:

Arizona: San Bernardino Ranch (Monument 77, Mex. Bound. Line), 5 (skins).
Hidalgo: Tulancingo, 4 (1 skin).
Indian Territory: Fort Reno, 3.
Jalisco: Guadalajara, 2 (skins, Merriam Coll.); Santa Cruz del Valle, 3 (skins, Am. Mus. Nat. Hist.); Hacienda San Marcos, Tonila, 1 (skin, Am. Mus. Nat. Hist.).
Mexico: Lerma, 1; Ixtapalapa, 1; City of Mexico, 1 (skin).
Michoacan: Patzcuaro, 11 (3 skins).
Missouri: Marble Cave, Stone County, 3.
San Luis Potosi: Ahualulco, 1.
Texas: Mouth of Pecos River, 4; New Braunfels, 1; San Antonio, 4 (skins, Am. Mus. Nat. Hist., including type of '*incautus*').
Vera Cruz: Las Vigas, 1.

General remarks.—Through the kindness of Dr. J. A. Allen, I have been able to examine two of the original specimens of *Myotis velifer* from Santa Cruz del Valle, Guadalajara, Jalisco, and four specimens (including the type) of '*Vespertilio incautus*' from San Antonio, Texas. After comparing the specimens of '*incautus*' with seven *M. velifer* from various parts of Mexico, I can find no characters to separate the two even subspecifically. In size as well as in cranial and dental characters they agree perfectly, while the difference in color is too slight to be described by words. As the specimens from Mexico were all taken in midsummer and those from Texas were killed in October the variation in color is probably seasonal.

The large size of this bat distinguishes it at a glance from all other Mexican or United States species except *M. thysanodes*. From the latter the darker color, slender calcar, naked free border of interfemoral membrane, and shorter ears and tragus separate it without difficulty.

Myotis velifer, while totally different from all other bats found in Mexico or the United States, is doubtfully distinct from the South American *M. albescens*. Mr. Oldfield Thomas, who has compared for me specimens of the former with the *albescens* in the British Museum so named by Dobson after examination of the type, writes that *M. velifer* and *M. albescens* are practically identical. It is best, however, to retain the name *velifer* for the bat occurring in Mexico and the United States until the South American species has been positively identified.

Dr. Harrison Allen refers to this bat in his recent monograph as *Vespertilio albescens velifer*. Under the same name he mentions a specimen of *M. thysanodes* from 'Dalyura' (=Dulzura), Cal.; while the Texan specimens of *velifer* in the Biological Survey collection he has labeled '*V. albescens?*'

MYOTIS LUCIFUGUS (Le Conte). Little Brown Bat.

1831. *Vespertilio lucifugus* Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, Append., p. 431. (Southern Georgia.)
1856. *Vespertilio subulatus* Le Conte, Proc. Acad. Nat. Sci. Phila. (1854–55), p. 435.
1864. *Vespertilio affinis* H. Allen, Monogr. N. Am. Bats, p. 53.
1864. *Vespertilio lucifugus* H. Allen, Monogr. N. Am. Bats, p. 55.

1878. *Vespertilio carolii* Dobson, Catal. Chiroptera Brit. Mus., p. 325.
1893. *Vespertilio gryphus* Var. (a) *Vespertilio gryphus lucifugus* H. Allen, Monogr Bats N. Am., p. 78.
1893. *Vespertilio albescens affinis* H. Allen, Monogr. Bats N. Am., p. 93.
1897. *Vespertilio lucifugus austroriparius* Rhoads, Proc. Acad. Nat. Sci. Phila., p. 227, May 1897. (Tarpon Springs, Florida.)

Type locality.—Georgia, probably southern Liberty County.

Geographic distribution.—The whole of North America north of the southern boundary of the United States, except in the Rocky Mountains and on the Pacific coast of California, Oregon, Washington British Columbia, and southern Alaska.

General characters.—Size medium; length 80 to 90; forearm 36 to 40; tibia 14.6 to 16.6. Calcar slender, indistinct, about equal in length to free border of uropatagium, usually terminating in a faintly indicated lobule; keel very slightly developed, if at all. Free border of uropatagium naked. Ears short, laid forward they reach about to nostril.

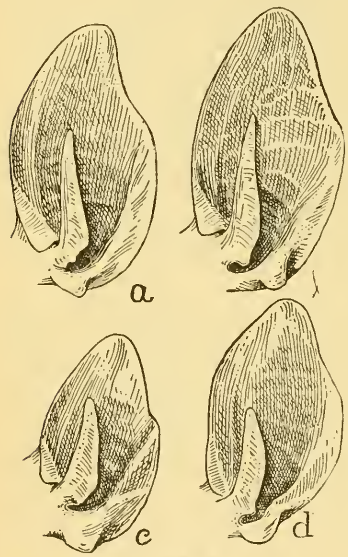

FIG. 13.—Ear of (*a*) *Myotis subulatus*, (*b*) *M. keenii*, (*c*) *M. lucifugus*, and (*d*) *M. alascensis* (× 2).

Ears.—The ears (fig. 13, *c*) are short and pointed, reaching when laid forward barely to tip of nose. The anterior border is straight from base through lower third, then for a short distance strongly convex, and finally straight to narrowly rounded off tip. Posterior border gently concave from just below tip to about middle, where it becomes convex and continues so to basal notch. Basal notch moderately developed, isolating a broad but not conspicuous basal lobe. Tragus short, blunt, bent slightly forward. Anterior border straight or slightly concave from base to tip. Posterior border straight or slightly convex immediately below tip, then more strongly convex to notch above large and prominent basal lobe. Greatest width of tragus through basal lobe or at about middle height, according to convexity of posterior border.

Membranes.—Membranes rather thick and leathery, entirely naked except where fur of body extends in a narrow line at the base of the wings and uropatagium. On the latter the fur occupies about the basal fourth on the dorsal side, rather less ventrally. The wings are attached at the base of the toes.

Feet.—The feet are large and strong, slightly more than half length of tibiæ. Toes longer than sole, joined by membrane at base to a point slightly beyond middle of proximal phalanges. The membrane extends farther on first digit than on fifth.

Fur and color.—The distribution of the fur in *Myotis lucifugus* is in no way peculiar. The hairs are everywhere dusky slate at base. General color dull brown with a distinct gloss in certain lights, the ventral surface paler and more yellowish. The exact shades are variable. Thus in three specimens taken at Washington, D. C., in June, the color of the back is respectively wood brown, raw umber, and sepia, the belly in each pale wood brown tinged to a varying degree with gray. In the majority of individuals the color tends toward sepia. Seven skins from Elk River, Minn., and three from Kadiak Island, Alaska, are indistinguishable in color from those taken at Washington. Ears and membranes light brown.

Skull.—The skull of *Myotis lucifugus* is characterized by the broad

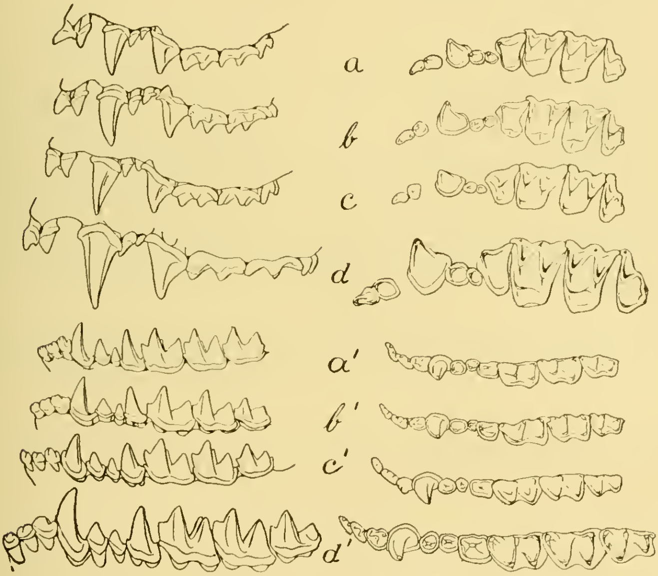

FIG. 14.—Teeth of (*a*) *Myotis yumanensis*, (*b*) *M. lucifugus*, (*c*) *M. lucifugus longicrus*, and (*d*) *M. velifer* (× 5).

muzzle and palate and gradually sloping forehead. In most specimens the face line begins to rise almost from the tip of the muzzle; in others, however, there is a short flat area back of the nasal opening. The brain case is broad and inflated at the back, less so in front, producing in many individuals a wedge-shaped outline. Distance from posterior molar to tip of hamular less than distance between posterior molars.

The skull of *Myotis lucifugus* differs from that of *M. subulatus* in its slightly smaller size, broader palate and muzzle, and less abruptly elevated face line.

Teeth.—Upper incisors diverging at tips (fig. 14 *b*). Crown of first bicuspidate, and, when viewed from below, nearly rectangular and about twice as long as broad. Larger cusp placed at extreme anterior end; the smaller one on the inner edge near posterior border. Crown of second incisor subterete, unicuspidate. Crown of first premolar longer than second when viewed from the side, slightly larger, or in rare cases very much larger than the latter in cross section; the two teeth in line, or second slightly displaced inward. There is nothing characteristic in the form of the third premolar or of the molars. Maxillary incisors as usual in the genus, the middle pair and the next compressed and trifid, the outer much larger and subterete. First maxillary premolar with crown longer than the second when viewed from the side, and one-fourth to one-third larger in cross section; the two teeth perfectly in line, or second slightly displaced inward. Third premolar subquadrate, nearly as broad as long. The lower molars show no distinctive characters.

As compared with *M. subulatus*, the species with which it is most likely to be confused, *Myotis lucifugus* shows numerous differences in dental characters. The tooth row, as a whole, is shorter, and the individual teeth relatively smaller. The first and second premolars in each jaw are actually smaller, and in most specimens more nearly equal in size in cross section. In *M. subulatus* the premolars are so large that the second is often crowded inward from the tooth row, a condition rarely seen in *M. lucifugus*. The form of the third lower premolar is very different in the two species. When viewed from the side, this tooth is conspicuously broader in proportion to its heigh in *M. subulatus*. When viewed from above, the tooth is much larger in *M. subulatus*, and distinctly longer than broad, while in *M. lucifugus* it is nearly as broad as long.

Measurements.—See table, page 65.

Specimens examined.—Total number 562, from the following localities:

Alabama: Greensboro, 1 (skin, Merriam coll.).
Alaska: Kadiak Island, 9.
Connecticut: 1 (Merriam coll.).
District of Columbia: Washington, 20 (majority in Merriam coll.).
Florida: Tarpon Springs, 7 (two skins, Rhoads coll., type and topotypes of '*austroriparius*').
Illinois: Warsaw, 141; West Northfield, 2.
Kentucky: Mammoth Cave, 218.
Maine: Eastport, 1.
Maryland: Seneca River, 1.
Massachusetts: Woods Hole, 1.
Minnesota: Elk River, 7; Fort Snelling, 4.
Newfoundland: Bay St. George, 4 (skins, Bangs coll.).
New York: Adirondacks, 1 (Merriam coll.); Big Moose Lake, 1 (Merriam coll.); Catskill Mountains, 2; Howes Cave, 25 (Merriam coll.); Lake George, 1; Locust Grove, 9 (Merriam coll.); Lyons Falls, 4 (Merriam coll.); Oneida Lake, 63 (Miller coll.); Peterboro, 1 (Merriam coll.); Sing Sing, 1 (Merriam coll.); West Point, 1.
North Carolina: Roan Mountain, 1.
Nova Scotia: Halifax, 1.

Ontario: Gravenhurst, 1 (Miller coll.); James Bay, 2; North Bay, Lake Nipissing, 1 (Miller coll.).
Pennsylvania: Bradford, 1; Center County, 19.
Quebec: Godbout, 1 (Merriam coll.); Ottawa, 2 (Merriam coll.).
South Carolina: Beaufort, 3.
Virginia: Riverton, 1.

General remarks.—*Myotis lucifugus* resembles *M. velifer* more closely than it does any other North American species. From the latter it is, however, readily distinguishable by its much smaller size. From *M. subulatus*, the only species of the genus with which it is associated in the eastern United States, it may be at once recognized by its shorter ear and shorter, less acuminate tragus.

This bat is the *Vespertilio gryphus lucifugus* of Dr. Harrison Allen's recent monograph. Dr. Allen's 'northern form of *Vespertilio gryphus*' is *M. subulatus*.

Through the kindness of Mr. S. N. Rhoads I have examined the type and six topotypes of *Vespertilio lucifugus austroriparius* from Tarpon Springs, Fla. I can find no characters by which these specimens may be distinguished from those taken at other parts of the range of *Myotis lucifugus*. The two skins, one of which is the type, are those of partly grown individuals whose immaturity is clearly indicated by the soft, papery skulls in which the nasal sutures are still clearly visible, and by the imperfectly formed joints of the fingers (see fig. 1, p. 9). These specimens differ from northern adults in smaller size, shorter fur, and duller, browner color. Three adult topotypes in alcohol show only one of these peculiarities—the shortness of fur—and in the fourth this also is absent. The fifth alcoholic specimen is immature. That the adult specimens of *Myotis* from Tarpon Springs are not smaller than *M. lucifugus* from other localities is clearly shown by the table of measurements on page 65. The short fur of three of the adults is evidently a seasonal character, since all showing this peculiarity are in worn, ragged coat, while the only one in fresh pelage (killed September 12) has fur of the ordinary length. The fur of all these specimens, after nearly five years immersion in alcohol, has lost the warm, glossy appearance characteristic of freshly killed individuals. It can be perfectly matched, however, among the series of alcoholic specimens collected in Center County, Pa., during the winter of 1893.

MYOTIS LUCIFUGUS ALASCENSIS subsp. nov.

Type from Sitka, Alaska. Adult ♀ (in alcohol), No. 77416, U. S. National Museum (Biological Survey collection). Collected August 5, 1895, by C. P. Streator. Collector's number, 4754.

Geographic distribution.—Humid coast district of southern Alaska and northern British Columbia.

General characters.—More like typical *lucifugus* than like *longicrus*, but darker in color and with longer ears.

Ears.—As shown in the table of measurements on page 65 the ears of this form average distinctly larger than those of the typical subspecies. I can not see, however, that they differ appreciably in form (fig. 13*d*).

Fur and color.—The fur is distributed as in true *lucifugus.* In color it is evidently darker than that of the typical form, but the exact differences can not be determined from specimens in alcohol. Ears and membranes blackish.

Measurements.—See table, page 65.

Specimens examined.—Total number 16, from the following localities:

Alaska: Fort Wrangel, 1 (skin, Merriam coll.); Loring, 4 (1 skin); Sitka, 8 (3 skins).

British Columbia: Massett, Queen Charlotte Islands, 3.

General remarks.—*Myotis lucifugus alascensis* is distinguishable from both typical *M. lucifugus* and *M. lucifugus longicrus* by its longer ears and darker color. From *M. lucifugus longicrus* it differs further in its much shorter tibia.

MYOTIS LUCIFUGUS LONGICRUS (True).

1886. *Vespertilio longicrus* True, Science, VIII, p. 588, Dec. 24, 1886.
1893. *Vespertilio nitidus longicrus* H. Allen, Monogr. Bats N. Am., p. 103.
1893. *Vespertilio albescens* (melanic phase) H. Allen, Monogr. Bats N. Am., p. 92 (part).

Type locality.—Puget Sound.

Geographic distribution.—Boreal and Transition zones from Puget Sound east to Wyoming; south at least to Arizona and southern California, and probably much farther.

General characters.—Similar to typical *Myotis lucifugus*, but larger (length, 94 to 102; forearm, 37 to 40; tibia, 17.8 to 19), and with longer tibia and proportionally shorter ear and forearm.

Ears.—The ears are more rounded and proportionally slightly shorter than in typical *M. lucifugus*, the inner side of the conch usually more hairy. Tragus as in *M. lucifugus*.

The membranes and feet differ in no way from those of the true *M. lucifugus*, except that the feet appear shorter in proportion to the tibiæ.

Fur and color.—The fur shows no peculiarities in distribution. In color it is darker and duller than in the typical subspecies (especially in specimens from northern California), but the difference is apparently never very striking, while two skins from Arizona are indistinguishable from specimens of *lucifugus* taken at Washington, D. C.

Skull.—The skull of *Myotis lucifugus longicrus* does not differ appreciably in size or form from that of true *lucifugus*.

Teeth.—In dental characters *Myotis lucifugus longicrus* agrees closely with typical *M. lucifugus*. While there appear to be no constant and important differences between the teeth of the two forms, the third upper premolar averages slightly larger in *longicrus*, and there are usually trifling differences in the relative sizes of the lower premolars (fig. 14*c*).

Measurements.—See table, on page 65.

Specimens examined.—Total number 97, from the following localities:

Arizona: San Francisco Mt., 2; Chiricahua Mts., 1 (skin).
California: Nevada City, 4; Nicasio, 72; Owens Lake, 1; Point Reyes, 1; San Emigdio, 1; Walker Pass, 2.
Chihuahua: San Francisco Water Canyon, San Luis Mts., 1.
Colorado: Grand Junction, 1.
Nevada: Cottonwood Range, 1 (skin); Panaca, 1.
New Mexico: Santa Fe, 1.
Oregon: East base Cascade Mts., near Mt. Thielson, 1 (skin); Beaverton, 2 (Miller Coll.).
Washington: Cape Flattery, 1; Colville, 1; Geyser Basin, 1; Port Townsend, 1.
Wyoming: Lake Fork, 1.

General remarks.—*Myotis lucifugus longicrus* is a well-marked geographical race of *M. lucifugus*, replacing the typical form of the latter in the western United States throughout the region west of the Great Plains. The northern and southern limits of its range can not at present be determined.

A single skin from Cofre de Perote, Vera Cruz, is probably referable to *M. lucifugus longicrus*. The tibia, however, is slightly shorter than in true *longicrus*, and more material from southern localities may show the necessity of recognizing another geographic race.

Myotis lucifugus longicrus is the bat to which the 'melanic form of *Vespertilio albescens*' of Dr. Allen's recent monograph for the most part refers. Under this name, however, Dr. Allen also included dark-colored specimens of *M. californicus*.

Measurements of subspecies of Myotis lucifugus.

Subspecies.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
lucifugus	Florida: Tarpon Springs	4	89.5	40	16	8.7	38.8	6.2	63.7	13.7	9.4	7.1
	District of Columbia: Washington.	2 ♀ ♀	86.5	37.5	....	9	38.9	6.7	....	12.2	9.4	7.5
	Pennsylvania: Centre County	6	85.3	37.6	15.5	7.3	37.6	5.6	60.2	13.3	9.7	7.2
	New York: Howes Cave	10	86.3	38.4	16.5	8.7	38	6.6	61.5	13.2	9.1	8
	Newfoundland: Bay St. George	4 ♀ ♀	87.7	37.2	15.5	9	36.7	6.1	61.2	....	....	....
alascensis	Alaska: Kadiak Island	6	88.6	38.3	16.1	9.1	36.1	....	....	13.6	8.5	7
	Sitka	1 ♀ [1]	91	39	16	9	38	6.4	60	16	10.6	8
	Sitka	8 ♀ ♀	86.3	38.6	16	8.4	36.6	6.2	59	15.2	9.5	7.6
	Loring	3	80	35	15	8	34.6	6.2	57.6	14.8	8.9	7
longicrus	British Columbia: Massett	3	85.6	37.6	16.9	8.9	37	6.2	60	14.9	9.9	7
	Washington: Puget Sound	1 ♀	97	44	19	8	38.5	6	65	12	10	7
	California: Nicasio	10	95.3	43.6	18.7	7.7	37.6	5.5	65.3	12	9.8	7.3
	Nevada City	1 ♀	102	46	19.6	8	39.6	6	71	13	9.8	7.4
	Owens Lake	1 ♀	96	45	17.8	8.4	....	6	69	12.6	9	7.4
	Walker Pass	2 ♀ ♀	97	44.6	18.5	7.4	39.6	6	69	12.6	10	7.4
	San Emigdio	1 ♀	100	45	18.8	7.6	40	5	69	13.4	9.6	7.4
	Wyoming: Lake Fork	1 ♂	97	45	19	8	38	7	71	12.6	9	7.4
	Nevada: Panaca	1 ♂	94	43	18.4	8	39.6	5.6	68	12	9	7.4
	Arizona: San Francisco Mountain	2	93.5	41	17.3	7.7	38.5	6.2	68	13.5	9.5	8.2

[1] Type.

MYOTIS YUMANENSIS (H. Allen).

1864. *Vespertilio yumanensis* H. Allen, Monogr. N. Am. Bats, p. 58.
1866. *Vespertilio macropus* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 288, (nec Gould, 1854).
1893. *Vespertilio nitidus* (pedomorphic variety) H. Allen, Monogr. Bats N. Am., pp. 72, 73.
1893. *Vespertilio albescens* H. Allen, Monogr. Bats N. Am., p. 87, (part, nec Geoff., 1805).
1893. *Vespertilio nitidus macropus* H. Allen, Monogr. Bats N. Am., p. 100.

Type locality.—Old Fort Yuma, California.

Geographic distribution.—Austral zones and lower edge of Transition zone from the southwestern United States to San Luis Potosi and Michoacan, Mexico.

General characters.—Size small; length 74–88; forearm 32–37; calcar distinct, considerably longer than free border of interfemoral membrane, terminating in a well-marked lobule; free border of uropatagium naked; ears moderate; wings from base of toes, but on account of extent of web between toes apparently from side of metatarsus; feet very large and strong as compared with other small American species.

Ears.—The ears (Pl. I, fig. 2) are moderately long; laid forward they reach just beyond the tip of the nose. The anterior border is straight for a short distance at base, then strongly convex, and finally straight or even slightly concave just below tip. The tip is narrow and abruptly rounded off. The posterior border is concave from the tip to the widest part of the auricle, just below mid height, then strongly convex to basal notch, which isolates a well-marked rounded lobe.

Tragus slender, acutely pointed. Anterior border slightly concave at base, then straight or very faintly concave to tip. Posterior border crenulate, straight or slightly concave from tip to broadest point at about lower third. A very large lobe at base; this lobe so large that the greatest breadth of the tragus is often through it.

Membranes.—The membranes, especially the uropatagium, are, for so small a bat, thick and leathery. The interfemoral membrane (Pl. II, fig. 2) is furred at the base, both dorsally and ventrally, but otherwise is naked except for a sprinkling of short hairs along the veins. Wings from base of toes, but on account of the conspicuous webbing of the latter the membrane appears to be attached to the side of the metatarsus.

Feet.—The feet (Pl. II, fig. 2) are, for so small a bat, very large, broad, and strong, more than half as long as the short tibiæ, the whole leg and foot suggesting a small *Nycticeius* rather than a *Myotis.* Toes (without claws) as long as sole, united by membrane at base to distal fourth of proximal phalanges. Calcar strong and distinct, much longer than free border of uropatagium, usually terminating in a distinct lobule. Keel on posterior edge very slightly developed.

Fur and color.—The fur shows no peculiarities in distribution. On the middle of the back it averages about 6 mm. in length.

Color pale wood brown, varying to broccoli brown; belly dirty whitish; the fur everywhere light plumbeous at base; ears and membrane very light brown; the uropatagium and wing membranes edged with whitish.

Specimens from the type locality are the palest that I have seen. Those from Fort Verde, Arizona, and apparently also alcoholic specimens from Tulare and other localities in southern California, are slightly darker, but still very different from *M. yumanensis saturatus*.

Skull.—The skull of *Myotis yumanensis* resembles that of *M. lucifugus* in form, but is distinguished from the latter by its smaller size, and shorter, broader palate. The brain case is broader and flatter than in *M. lucifugus*. From the skull of *M. californicus* that of *M. yumanensis* is readily distinguished by its slightly larger size and very much broader, more robust form, the rostrum in particular being noticeably broader.

Teeth.—The teeth of *Myotis yumanensis* (fig. 14 *a*) more closely resemble those of *M. lucifugus* than any other species. They are, however, smaller, and the crowns of the molars are longer in proportion to their width. The crown of the third lower premolar is only slightly longer than broad, thus resembling the corresponding tooth in *M. lucifugus*, and differing from *M. californicus*, which, like *M. subulatus*, has the crown of this tooth very distinctly longer than broad.

Measurements.—See table, page 69.

Specimens examined.—Total number 142, from the following localities:

Arizona: Fort Verde, 6 (skins); White Mountains, 1 (skin, Am. Mus. Nat. Hist.).

California: Fort Reading, 1; Fort Yuma, 5 (skins); Fresno, 8; Horse Shoe Bend, Colorado River, 1; Keeler, 7; Lone Pine, 2; Mount Whitney, 1; Nevada City, 2; Nicasio, 1; Owens Lake, 5; Owens Valley, 1; Old Fort Tejon, 13; San Luis Rey, 8; Tulare, 45; Walker Pass, Kern County, 1.

Michoacan: Patzcuaro, 13.

Nevada: Pyramid Lake, 1.

San Luis Potosi: Jesus Maria, 7; Hda. La Parada, 3; Ahualulco, 9.

Utah: Provo City, 1.

General remarks.—*Myotis yumanensis* needs comparison with *M. californicus* only. From the latter it is readily distinguished by its much larger foot and longer calcar. More detailed comparison of the two will be found under *M. californicus*.

This is the species to which Dr. Harrison Allen's recent account of *Vespertilio albescens* for the most part refers. His so-called larger melanic form of *albescens* is *Myotis lucifugus longicrus* (True). Specimens of *Myotis californicus*, *M. thysanodes*, and *M. velifer* in the Biological Survey collection have been labeled by Dr. Allen *V. albescens*, the last two, however, with a query. This bat is also the *Vespertilio macropus* and *V. nitidus macropus* of Dr. Allen. The name *macropus*, however, is preoccupied by *Vespertilio macropus* Gould, 1854.[1]

Myotis yumanensis is a much smaller bat than *M. albescens*, and does

[1] Mammals of Australia (*fide* Dobson).

not agree with the descriptions of the latter given by Geoffroy or Dobson. Mr. Oldfield Thomas, after comparing specimens of *M. yumanensis* with the *M. albescens* identified by Dobson in the British Museum, writes me that the two are in no way closely related.

Lack of an adequate series of skins prevents any determination of the extent of individual color variation in this species. Specimens taken at Fort Verde, Arizona, in May and August, are slightly darker than those killed at the type locality in April, while two July skins from Patzcuaro, Michoacan, are nearly as dark as the lightest examples of *M. yumanensis saturatus.*

MYOTIS YUMANENSIS SATURATUS subsp. nov.

Type from Hamilton, Washington. Adult ♂ (skin), No. $\frac{17399}{24306}$, U. S. National Museum (Biological Survey collection). Collected September 13, 1889, by T. S. Palmer. Collector's number, 392.

Geographic distribution.—Transition zone in Oregon, Washington, and British Columbia.

General characters.—Similar to typical *Myotis yumanensis*, but fur longer and color much darker.

Fur and color.—Fur distributed as in the typical subspecies. On the middle of the back it averages about 9 mm. in length. Back dark glossy yellowish brown (the exact shade usually between the 'sepia' and 'mummy brown' of Ridgway's Nomenclature of Colors, Pl. III); belly isabella color; chin, throat, and sides darker than belly; fur everywhere deep blackish plumbeous at base; ears and membranes blackish.

Measurements.—See table, page 69.

Specimens examined.—Total number 19, from the following localities:

British Columbia: Kamloops, 1 (skin); Kultus Lake (near Chilliwack), 1 (skin, Miller coll.); Mount Lehman, 1 (skin, Am. Mus. Nat. Hist.); Port Moody, 1 (skin); Shuswap, 1 (skin); Sumas, 3 (skins, Miller coll.).

Oregon: Crooked River, 1[1]; Lone Rock, 2[1]; Twelve Mile Creek, 1[1].

Washington: Chelan, 3[1]; Hamilton, 2 (skins); Lake Cushman, 1 (skin); Neah Bay, 1.

General remarks.—*Myotis yumanensis saturatus* is readily distinguishable from true *yumanensis* by its much darker color. In this character, however, it closely approaches the typical form of *M. lucifugus*, from which it differs chiefly in smaller general size and much smaller skull. From *M. lucifugus longicrus* it differs very noticeably in its shorter tibia as well as in other characters.

[1] These specimens may be nearer true *yumanensis* than *saturatus*. In alcohol, however, their color appears much too dark for the typical subspecies.

Measurements of subspecies of Myotis yumanensis.

Subspecies.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
yumanensis	California: Fort Yuma	4	83.7	35.5	14.1	8.7	32.7	5.2	56.5	....	....	....
	Tulare	10	80.5	36.6	15	8.7	34.2	6	56.4	14.2	9	7.4
	Arizona: Fort Verde	4	79.2	36.7	15.7	8.8	33.9	....	55.5	14	8.2	7
	San Luis Potosi: Jesus Maria	5 ♀♀	81	34.9	15.5	7.9	34.4	6.5	57.8	14.4	9.1	7.6
	Michoacan: Patzcuaro	8	80.6	36.3	14.6	8.3	34.1	5.7	57	14.2	9	7.6
saturatus	British Columbia: Sumas	3	82.3	36.5	14	8.6	34.6	5.3	57	....	....	....
	Washington: Chelan	3	77	35	15	8.3	35.3	6	59.3	14.3	8.9	7
	Hamilton	1 ♂ [1]	77	30	15	8.6	33	5	....	....	....	....

[1] Type.

MYOTIS CALIFORNICUS (Aud. & Bach.).

1842. *Vespertilio californicus* Aud. & Bach., Journ. Acad. Nat. Sci. Phila., p. 280 (California).
1862. *Vespertilio nitidus* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 247 (Monterey, California).
1864. *Vespertilio nitidus* H. Allen, Monogr. N. Am. Bats, p. 60.
1864. *Vespertilio oregonensis* H. Allen, Monogr. N. Am. Bats, p. 61 (Cape St. Lucas and Fort Tejon).
1866. *Vespertilio obscurus* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 281 (Lower California).
1866. *Vespertilio volans* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 282 (Cape St. Lucas).
1866. *Vespertilio exilis* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 283 (Cape St. Lucas).
1866. *Vespertilio tenuidorsalis* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 283 (Cape St. Lucas).
1866. *Vespertilio yumanensis* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 283 (nec H. Allen, 1864).
1878. *Vespertilio nitidus* Dobson, Catal. Chiroptera Brit. Mus., p. 318.
1890. *Vespertilio melanorhinus* Merriam, North American Fauna, No. 3, p. 46, Sept. 11, 1890 (San Francisco Mt., Arizona).
1893. *Vespertilio albescens melanorhinus* H. Allen, Monogr. Bats N. Am., p. 91.
1893. *Vespertilio nitidus* H. Allen, Monogr. Bats N. Am., p. 91.
1893. *Vespertilio nitidus henshawi* H. Allen, Monogr. Bats N. Am., p. 103 (Wingate, N. Mexico).
1893. *Vespertilio nigricans* H. Allen, Monogr. Bats N. Am., p. 97 footnote (nec Maximilian 1826).

Type locality—'California.'

Geographic distribution.—Austral zones and lower part of Transition zone throughout the western United States and Lower California, east to Wyoming and Texas. South limit of range not known.

General characters.—Smallest species of *Myotis* known to occur in the United States. Length, 76 to 87; forearm, 30 to 36. Calcar about as long as free border of uropatagium, very slender but distinct and with a more or less well developed lobule at tip, outer edge with a distinct keel. Legs slender, the small feet reaching when extended backward to within about 5 mm. of tip of tail. Free border of uropatagium naked.

Ears moderate, reaching just beyond tip of nose. Wings from base of toes. Fur on back distinctly darker at base than at tip.

Ears.—The ears are moderately long (Pl. I, fig. 2), reaching when laid forward 1 to 3 mm. beyond tip of nose. The anterior border of the auricle is straight or slightly convex at the base, then strongly convex to a point somewhat beyond the middle, after which it is straight or even a little concave to the narrowly rounded off tip. Posterior border concave from tip to point slightly below the middle, after which it is convex to basal notch. Basal lobe strongly developed and notched on its lower border.

Tragus varying much in shape, but with anterior border usually straight, or nearly so, and posterior border strongly convex and with small basal lobe.

Membranes.—The membranes are thin and delicate. Uropatagium (Pl. II, fig. 1) furred on basal third, otherwise naked, except for a few hairs along the veins. Wings from base of toes, naked, except for a narrow strip along side of body.

Feet.—The feet are small and weak (Pl. II, fig. 1), distinctly less than half as long as tibia. Calcar slender but distinct, shorter than free border of uropatagium, usually terminating in a distinct lobule. The posterior border is provided with a keel beginning abruptly about 2 mm. from the base and fading away gradually at about middle of calcar. This keel is supported by 1 to 3 cartilaginous outgrowths from the calcar.

Fur and color.—The fur is soft, full, and long, that on middle of back averaging about 8 mm. in length.

Color light yellowish gray, paler on the belly, the fur everywhere dark plumbeous at base. Membranes, ears, lips, and muzzle blackish.

Skull.—The skull of *Myotis californicus* is smaller and more lightly built than that of any other North American *Myotis.* The brain case is moderately rounded, and the long narrow muzzle fades gradually into the gently sloping forehead. The skull is thus very different from that of *M. yumanensis*, the only species with which *M. californicus* is likely to be confused. In form it resembles the skulls of *M. evotis* and *M. thysanodes*, but the latter are among the largest of the species found in the region inhabited by *M. californicus.*

Teeth.—The teeth of *Myotis californicus* (fig. 15, *a*) are, like the skull, small and delicate. In general they closely resemble the teeth of *M. subulatus*, and differ from those of *M. yumanensis* in numerous details, as in the shape of the third upper molar and third lower premolar, the former being distinctly narrower and the latter longer in proportion to its width than in *M. yumanensis.*

Measurements.—See table, page 74.

Specimens examined.—Total number 152, from the following localities:

Arizona: Camp Grant, 2; Oracle, 5; Prescott, 1 (skin, Am. Mus. Nat. Hist.); Santa Catalina Mountains, 1 (skin); Tinajas Altas, Yuma County, 3; White Mountains, 1 (skin, Am. Mus. Nat. Hist.).

California: Amargosa River, Mohave Desert, 1; Banning, 1; Cahto, 1; Colorado Desert, 1; Death Valley, 14 (including Bennett Wells, 1; Funeral Mountains, 1; Saratoga Springs, 6); Dulzura, 15 (6 skins, Miller coll.); East Fork Kaweah River, 3; Fort Crook, 1; Fort Tejon, 11; Old Fort Yuma, 1; Jacumba, San Diego County, 1; Kern River (25 miles above Kernville), 1; Monterey, 1; Mount Shasta, 1; Nicasio, 7; Petaluma, 1; Point Reyes, 5; San Clemente Island, 3; Santa Barbara, 1; Santa Ysabel, San Diego County, 23; Tejon Pass, 1; Tres Pinos, 1; Twin Oaks, San Diego County, 1; Witch Creek, San Diego County, 7.

Chihuahua: East side of San Luis Mountains, 3.

Lower California: Cape St. Lucas, 2 ('*V. obscurus*' H. Allen); San Fernando, 3 (Miller coll.).

Nevada: Colorado River, 2; Cottonwood Range, 4; Gold Mountain, Esmeralda County, 2; Pahrump Valley, 1; Panaca, Lincoln County, 1; Vegas Valley, Lincoln County, 1.

New Mexico: Fort Defiance, 1; Fort Wingate, 2; Silver City 1 (skin).

Oregon: Elgin, 1; John Day River, 3; Twelve Mile Creek, 2.

Texas: Paisano, 1.

Washington: Almota, Whitman County, 1; Blue Creek, 1; Chelan, 1.

Wyoming: Bitter Creek, Sweetwater County, 2 (skins, Am. Mus. Nat. Hist.); Bull Lake, 1.

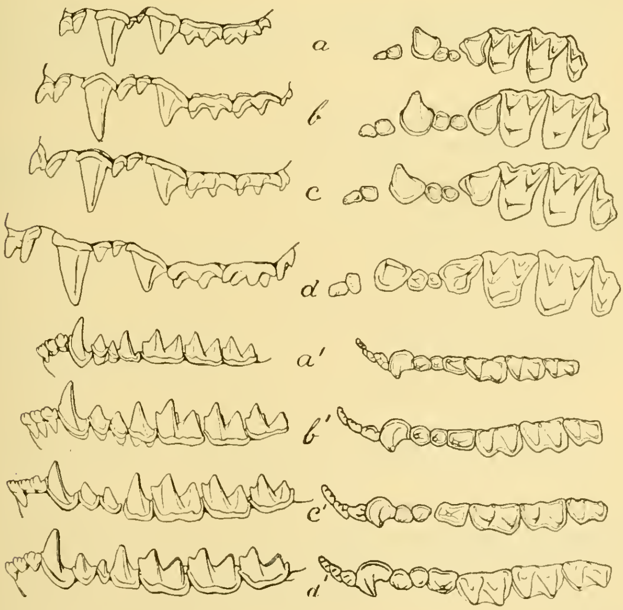

FIG. 15.—Teeth of (*a*) *Myotis californicus*, (*b*) *M. subulatus*, (*c*) *M. evotis*, and (*d*) *M. thysanodes* (× 5.)

General remarks.—Typical *Myotis californicus* varies considerably in color, size, and proportions, but may always be recognized among North American and Mexican species by its small size, slender form, delicate membranes, long tail and legs, small feet, and pale yellowish color. *Myotis yumanensis*, the only other species of equally small size, has conspicuously shorter legs, larger feet, shorter tail, and thicker mem branes. The species resembling *M. californicus* in form are all conspicuously larger.

In his recent monograph Dr. Harrison Allen uses the name *Vespertilio nitidus* for *Myotis californicus*. As subspecies of *californicus* he includes *M. yumanensis* (=' *Vespertilio nitidus macropus*'), *M. californicus ciliolabrum*, and *M. lucifugus longicrus* (=' *Vespertilio nitidus longicrus*'). *Vespertilio melanorhinus*, a synonym of *M. californicus*, he, however, refers to ' *V. albescens*' (=*M. yumanensis*) as a subspecies, ' *Vespertilio albescens melanorhinus*.'

MYOTIS CALIFORNICUS CAURINUS subsp. nov.

Type from Massett, Queen Charlotte Islands, British Columbia. Adult, ♂ (in alcohol), No. 72219, U. S. National Museum (Biological Survey collection). Collected in 1895 by J. H. Keen.

Geographic distribution.—The humid coast district of British Columbia, Washington, and Oregon (possibly also of northern California).

General characters.—Similar to typical *M. californicus*, but very much darker in color.

Ears, membranes, feet, and fur.—As in typical *californicus*.

Color.—Very deep, frequently almost blackish sepia throughout, slightly yellowish on belly, the fur everywhere blackish plumbeous at base.

Measurements.—See table, page 74.

Specimens examined.—Total number, 14, from the following localities:

British Columbia: Port Moody, 1; Massett, 9.
Oregon: Marmot, 1 (skin).
Washington: Fort Steilacoom, 1; Puget Sound, 1; Tenino, 1.

General remarks.—In color *Myotis californicus caurinus* closely resembles dark specimens of *M. californicus mexicanus*. It is readily distinguishable from the latter, however, by its much smaller size.

MYOTIS CALIFORNICUS CILIOLABRUM (Merriam).

1886. *Vespertilio ciliolabrum* Merriam, Proc. Biol. Soc. Washington, IV, p. 1.
1893. *Vespertilio nitidus ciliolabrum* H. Allen, Monogr. Bats N. Am., p. 101 (part).

Type locality.—Trego County, Kansas.

Geographic distribution.—Trego County, Kansas, and central South Dakota. Limits of range wholly unknown.

General remarks.—Similar to typical *M. californicus*, but very much paler in color.

Ears.—In form the ears of *Myotis californicus ciliolabrum* are as in typical *M. californicus*. They average, however, slightly larger.

Membranes.—The membranes are thin and translucent. Wings from base of toes, and entirely naked except a narrow line close to the body. Uropatagium thinly haired on proximal fifth ventrally and on proximal half dorsally, otherwise naked, but with a few hairs along the veins.

Feet.—The feet are moderately large, about half the length of the tibia, the toes longer than the sole. A distinct wart at heel. Calcar slender, distinct, about equal to free border of interfemoral membrane, terminating in a small but distinct lobule and noticeably keeled along posterior edge. The keel is supported by 1 to 3 cartilaginous processes.

Fur and color.—Except for its unusual extension on the back of the uropatagium the fur shows no peculiarities in distribution.

In color the fur is pale yellowish white throughout. The ears, muzzle, and chin are dark brown in strong contrast. Membranes light brown with pale edges.

Measurements.—See table, page 74.

Specimens examined.—Total number 13, from the following localities:

Kansas: Trego County, 6.
South Dakota: Carroll Draw, Pine Ridge Indian Reservation. 7 (skins Am. Mus. Nat. Hist.).

General remarks.—*Myotis californicus ciliolabrum* is a pale, whitish, race of *M. californicus*, presenting the opposite extreme from *M. c. caurinus.* Except in color, I can not find that it differs in any constant characters from typical *californicus.* The specimens from Grant County, N. Mex., referred to in the original description of *M. c. ciliolabrum* are undoubtedly true *californicus*, as are those from Death Valley referred to this subspecies by Dr. Harrison Allen.

MYOTIS CALIFORNICUS MEXICANUS (Saussure).

1860. *Vespertilio mexicanus* Saussure, Revue et Mag. de Zool., 2e ser., XII, p. 282.
1866. *Vespertilio agilis* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 282 (Mirador, Mex.).

Type locality.—Unknown, but probably Vera Cruz, Puebla, or Oaxaca.

Geographic distribution.—Austral and Transition zones in central and southern Mexico (San Luis Potosi, Michoacan, and Oaxaca). Limits of range not known.

General characters.—Slightly larger than typical *Myotis californicus*, and averaging somewhat darker and yellower in color.

Ears, membranes, feet, and fur.—As in typical *californicus.*

Color.—Dull yellowish brown, slightly paler on the belly. Membranes and ears in dry skins blackish. Two immature specimens from Reyes, Oaxaca, are considerably darker than any of the adults, but otherwise a series of thirteen skins shows very little individual variation.

Skull and teeth.—As in typical *californicus.*

Measurements.—See table, page 74.

Specimens examined.—Total number 51, from the following localities:

Michoacan: Patzcuaro, 44 (8 skins).
Oaxaca: Cuicatlan, 1; Reyes, 5 (skins).
San Luis Potosi: Hacienda La Parada, 1.

Average measurements of subspecies of Myotis californicus.

Subspecies.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
californicus	California: Saratoga Springs	5 ♂ ♂	80	39	14.2	5.4	31.3	4	58	14.2	9.9	8
	Death Valley	5	77.8	38.8	13.9	5.7	31	4.1	55.4	12.9	9.9	8.3
	Arizona: Oracle	5 ♀ ♀	82	39	14.4	6	32	4.2	57	14	10	7.5
caurinus	British Columbia: Massett	1 ♂ [1]	75	34	14	7	32	5	54	12.8	8	7
	Massett	9	77	34.5	13.8	6.1	32.1	4.3	54.1	13.2	9.5	7.1
ciliolabrum	Kansas: Trego County	1 ♀ [1]	75	34	15	7	33	6	59	14	9	8.8
	Trego County	5	80.2	36.7	14.6	6.8	32.8	5.4	57	14.6	10	8.5
mexicanus	Michoacan: Patzcuaro	10	81.5	38.3	4.2	5.9	34.1	4.4	60	14	9.6	7.2

[1] Type.

MYOTIS NIGRICANS (Maximilian).

1826. *Vespertilio nigricans* "Schinz, Thierreich u. s. w., B. I, p. 179" Maximilian, Beiträge zur Naturgesch. v. Brasilien, II, p. 266.
1878. *Vespertilio nigricans* Dobson, Catal. Chiroptera Brit. Mus., p. 319.
1893. *Vespertilio nigricans* H. Allen, Monogr. Bats N. Am., p. 96.

Type locality.—Fazenda de Aga, near the Iritiba River, southeastern Brazil.

Geographic distribution.—Tropical America, north to extreme southern Mexico (Chiapas). Limits of range not known.

General characters.—About the size of typical *Myotis californicus*, but with slightly larger foot and smaller ears; fur on back not distinctly darker at base than at tip.

Ears.—The ears are slightly smaller than in *M. californicus*, but not different in form.

Membranes.—As in *M. californicus.*

Feet.—The feet are relatively larger than in *M. californicus*, but smaller than in *M. yumanensis.* Calcar about as long as free border of uropatagium, terminating in a small but distinct lobe; keel obsolete.

Fur and color.—Fur short, that on middle of back averaging a little less than 6 mm. in length, nearly unicolor on back but distinctly bicolor on belly. Back clove brown (lighter than No. 2 on Pl. III of Ridgway's Nomenclature of Colors), the hairs just perceptibly darker at base and with glossy tips, which in certain lights produce a slightly grizzled appearance. Belly light broccoli brown, the basal half of the hairs deep plumbeous. Ears and membranes blackish in dry skins. A series of ten skins from Huehuetan, Chiapas, shows no variation in color.

Skull.—The skull of *Myotis nigricans* (figs. 11*c* and 12*a*) is slightly smaller than that of *M. californicus*, and has a shorter rostrum and less frontal concavity in the dorsal outline. The differences are slight, but very evident when series are compared.

Teeth.—The teeth of *Myotis nigricans* do not differ appreciably from those of *M. californicus.*

Measurements.—The average measurements of 10 specimens of *Myotis igricans* from Huehuetan, Chiapas are given in the following table:

Average measurements of 10 specimens of Myotis nigricans.

Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
hiapas, Huehuetan.........	10 ♀ ♀	76.7	35	13.6	6.9	33.5	4.4	57	12.7	8.6	6.6

Specimens examined.—Total number, 34; all from Huehuetan, Chiapas ltitude about 300 feet).

General remarks.—*Myotis nigricans* differs from *M. californicus* in numerous characters, each of which is trivial in itself but which with he others goes to make up a sum quite different from that shown by ny other North American bat. The constancy in color of the 10 skins y which this species is represented in the Biological Survey collection s very remarkable.

MYOTIS SUBULATUS (Say). Say's Bat.

823. ? *Vespertilio subulatus* Say, Long's Exped. to Rocky Mts., II, p. 65, footnote (Arkansas River, near La Junta, Colorado).

864. *Vespertilio subulatus* H. Allen, Monogr. N. Am. Bats, p. 51.

878. *Vespertilio subulatus* Dobson, Catal. Chiroptera Brit. Mus., p. 324.

893. *Vespertilio gryphus* var. (b), Northern form of *Vespertilio gryphus*, H. Allen, Monogr. Bats N. Am., p. 80.

897. *Vespertilio gryphus* var. *septentrionalis* Trouessart, Catal. Mamm. t. Vivent. q. Foss., p. 131. (Only name undoubtedly based on this animal.)

Type locality.—Arkansas River, near La Junta, Colorado.

Geographical distribution.—North America east of the Rocky Mountains.

General characters.—Size medium; length 80 to 90; forearm 34 to 7. Calcar slender, slightly longer than free border of uropatagium, erminating indistinctly or with a slightly developed lobule; keel rudimentary or absent. Free border of uropatagium naked. Ears long, eaching 2 to 5 mm. beyond tip of nose. Wings from base of toes.

Ears.—The ears (fig. 13*a*) are long and slender, reaching when laid orward, 2 to 5 mm. beyond tip of nose. Anterior border straight from base to near middle, then for a varying distance moderately convex, nally straight to narrowly rounded off tip. Posterior border concave rom point immediately below tip to about middle, where it becomes onvex and continues so to basal notch. Basal notch strongly marked, solating a narrow and very conspicuous lobe.

Tragus slender, straight, or slightly bent backward. Anterior border straight throughout or slightly convex near tip. Posterior border traight or evenly and slightly concave from tip to widest point, which s opposite or slightly above level of anterior base. Basal lobe small, width of tragus through lobe always much less than width at base o anterior edge.

Membranes.—The membranes are thin and translucent, naked excep for a narrow line close to the body. On the uropatagium the furre region occupies the basal fourth dorsally, rather less ventrally, other wise the membrane is naked except for scattered hairs along the veins Wings from base of toes.

Feet.—The foot is moderately large, about half as long as tibia. Toe longer than sole, united by membrane at base to a little beyond middl of proximal phalanges, and sprinkled with coarse hairs on dorsal sur face. Calcar slender, equal to or slightly longer than free edge of inter femoral membrane, terminating indistinctly or with an ill-defined lobe Keel rudimentary or absent.

Fur and color.—The fur is full and soft, but shows no peculiaritie in distribution. In color it apparently does not differ from typical *M lucifugus;* but too few skins are now available to determine the limit of variation.

Skull.—The skull of *Myotis subulatus* resembles that of *M. evotis* s closely that it is impossible to distinguish with certainty between th two. In *M. subulatus* the skull is very slightly smaller, but the diffe ence is trifling and intangible. The skull of *M. subulatus* does no closely resemble that of *M. lucifugus.*

Teeth.—The teeth of *Myotis subulatus* (fig. 15 *b*) agree in form an relative size with those of *M. evotis*, and I am unable to find any diffe ences by which to separate them. They differ, however, in man details from the teeth of *M. lucifugus.*

Measurements.—See table on page 77.

Specimens examined.—Total number 53, from the following localities

Alberta: Near Red Deer, 1 (skin, Miller coll.).
Illinois: Chicago, 1.
Indiana: Brookville, 1; Wheatland, 1.
Kentucky: Eubanks, 2.
Maine: Eastport, 2.
Maryland: Forest Glen, Montgomery County, 2 (Miller coll.).
Massachusetts: Woods Hole, 1.
Minnesota: Elk River, 2.
Missouri: Marble Cave, 9.
New York: Hammondville, 12 (Merriam coll.); Hemlock Lake, 1; Highlan Falls, 1; Lake George, 3; Peterboro, 2 (Miller coll.).
Ontario: Mount Forest, 1 (skin, Miller coll.); North Bay, 1 (Miller coll.).
Pennsylvania: Meadville, 1.
Quebec: Godbout, 1 (Merriam coll.); Ottawa, 3 (Merriam coll.).
Tennessee: Bellamys Cave, 1.
Virginia: Alexandria, 1.
West Virginia: Aurora, 2 (Merriam coll.).
Wisconsin: Bayfield, 1.

General remarks.—*Myotis subulatus* may be distinguished from *M lucifugus*, the only species with which it is likely to be confused, by it narrower skull, longer ears, and longer, more sharply pointed tragus

MYOTIS SUBULATUS KEENII (Merriam).

1895. *Vespertilio subulatus keenii* Merriam, American Naturalist, XXIX, p. 860, September 1, 1895.

Type locality.—Massett, Queen Charlotte Islands, British Columbia. Type in U. S. National Museum (Biological Survey collection). Adult ♀, No. 72922 (in alcohol).

Geographic distribution.—*Myotis subulatus keenii* is at present known from the type locality only. It doubtless occurs throughout most of the humid northwest coast district.

General characters.—About the size of typical *Myotis subulatus*, but with longer tail and ears; color much darker than in true *subulatus*.

Ears.—The ears of *M. subulatus keenii* (fig. 13 *b*) average distinctly longer than those of typical *subulatus* from the eastern United States, but do not differ in form.

Fur and color.—The fur appears to be longer than in true *srbulatus*, and considerably darker in color, but with alcoholic specimens only for comparison it is impossible to determine the degree of difference between the two forms. Membranes and ears blackish.

Measurements.—See table below.

Specimens examined.—Total number 3, all from the type locality.

General remarks.—*Myotis subulatus keenii* is a well-marked race, characterized, like the other bats of the humid northwest coast district, by darkness of color. In addition to its color differences it has longer ears than its eastern representative, in this respect showing much the same variation as *M. lucifugus alascensis*.

Measurements of subspecies of Myotis subulatus.

Subspecies.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
subulatus	New York: Hammondville	10	85.6	38.8	17.2	7.5	35.7	6.3	61	16.3	10.2	9.7
	Quebec: Godbout	2 ♂♂	80	36.8	16.4	7.5	33.8	6.5	58	15.6	9.8	[illegible]
	Missouri: Marble Cave	8	85.3	38.5	17.1	8	35.3	6.2	61	16.7	10.7	9.3
keenii	British Columbia: Massett	1 ♀ [1]	86	41	16.4	8.8	36	6	60	17.4	11	9.6
	Massett	3	84.3	40.6	16.3	8.3	35.3	6	58	17.8	10.8	9.8

[1] Type.

MYOTIS EVOTIS (H. Allen). Long-eared Bat.

1864. *Vespertilio evotis* H. Allen, Monogr. Bats N. Am., p. 48.
1878. *Vespertilio evotis* Dobson, Catal. Chiroptera Brit. Mus., p. 324.
1893. *Vespertilio albescens evotis* H. Allen, Monogr. N. Am. Bats, p. 89.
1896. *Vespertilio chrysonotus* J. A. Allen, Bull. Am. Mus. Nat. Hist., VIII, p. 240, November 21, 1896. Kinney Ranch, Sweetwater County, Wyoming.

Type locality.—Not stated, and no type designated. In the original description specimens are mentioned from the upper Missouri River, and the Pacific coast from Puget Sound to Cape St. Lucas. Monterey, Cal. (one of the localities given), may be selected as the type locality.

Geographic distribution.—Austral and Transition zones from the Pacific Coast to the eastern edge of the Rocky Mountains; south to Vera Cruz.

General characters.—Size large; length 85 to 92; forearm 36 to 43. Calcar longer than free border of uropatagium, slender, distinct, and with a more or less well-developed lobule at the tip. Free border of uropatagium naked or very indistinctly ciliate. Ears very long, reaching 7 to 10 mm. beyond tip of nose. Wing from base of toes.

Ears.—The ears (Pl. I, fig. 6) are long and slender; laid forward they reach considerably (7 to 10 mm.) beyond tip of nose. Anterior border of auricle regularly convex from base to a point slightly beyond middle, thence straight or nearly so to the tip. Posterior border slightly concave immediately below tip of ear, then gradually and moderately convex to base. Basal lobe strongly developed, and notched on the lower border. The auricle is usually marked with three or four distinct cross ridges.

Tragus long, slender, and pointed. The anterior border straight or slightly concave from base to about mid height, then moderately convex, the terminal third or fourth usually straight. Posterior border with a small but distinct lobe at base. Above this lobe the margin bends abruptly outward for a varying distance, sometimes forming a sharp and conspicuous angle with the lower end of the concavity which extends downward from the tip of the tragus, in other cases separated from the latter by a region of varying extent in which the posterior and anterior borders are parallel. These variations bring about striking contrasts in the form of the lower part of the tragus in different individuals, and suggest the existence of more than one species or race. Specimens from approximately the same region, however, show both extremes and intermediate conditions.

Membranes.—The membranes are thin and light. Uropatagium hairy on basal fifth, otherwise naked except for a few hairs along the nerves and on the free border. Wing from base of toes (Pl. II, figs. 3 and 4).

Feet.—The feet are moderately large, slightly less than half as long as tibiæ. Toes (without claws) distinctly longer than sole and united by membrane through basal third of proximal phalanges. Whole dorsal surface of foot sprinkled with stiff hairs. Calcar distinct, equal to or longer than free border of uropatagium, terminating in a lobule of varying distinctness. Posterior border never distinctly keeled.

Fur and color.—The fur is full, soft, and not peculiar in distribution. It is light yellowish-brown, paler ventrally, the hairs everywhere dusky slate at base. The absence of a series of skins of this bat makes it impossible to describe the color accurately or compare it in detail with that of its allies, *M. thysanodes* and *M. subulatus*. A skin from Shuswap, British Columbia, has the fur of the back dull, pale raw umber, the dusky bases of the hairs showing through along the sides. The belly is light broccoli brown. In front of the shoulder and just below it is a small tawny olive area which contrasts strongly with the color of the belly. In another specimen (No. 1382, collection of Dr. C. Hart Merriam, San Bernardino Mountains, California, August 14, 1885, F. Stephens) the color is similar but a shade paler and yellower throughout, the dark bases of the hairs nowhere showing through. No dark shade in front of shoulder. This specimen is practically indistinguishable in color from the palest examples of *M. thysanodes*, but the fur is much darker at base and the general color is slightly clearer yellow, with the tips of the hairs more glossy. Other skins are duller and less yellow.

Skull.—The skull of *Myotis evotis* equals that of *M. thysanodes* in length and mastoid breadth, but is narrower across zygomata and has the occiput less elevated. The occipital outline is rounded as in *M. thysanodes*, and the occipital crest is very slightly developed. Forehead rising above the muzzle gradually, in this respect also resembling *M. thysanodes.* Rostrum more slender than in *M. velifer* or *M. thysanodes.* Pterygoids and posterior part of palatines as in *M. thysanodes.*

The skull of *Myotis evotis* is easily distinguished from that of all other North American species except *M. subulatus.* From the latter, however, it differs merely in very slightly larger size.

Teeth.—In dental characters *Myotis evotis* does not differ essentially from *M. thysanodes.* The premolars apparently show less tendency to crowding, but I can find no tangible difference in form or relative size (fig. 15 *c*).

Measurements.—The measurements of 8 specimens of *Myotis evotis* from eight localities are given in the following table:

Measurements of 8 specimens of Myotis evotis from 8 localities.

Locality.	Sex.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
Washington: Easton	♂	85	41	19	8	36	7	62	19.4	11.8	10.8
Wyoming: Kinney Ranch	♀[1]	......	......	18	8.6	40	7	64	......	......	......
California: Inyo Mountains	♂	89	43	20	7	38	8	63	23	14.6	13
Owens Lake	♀	91	43	17.6	8	38	6.4	63	22	13.4	12.4
San Joaquin River	♂	92	43	19	8	38	6	62	22	13.6	12
Twin Oaks	♀	90	42	18.6	8	37	6.4	62	21	13	11
Nevada: Pahranagat Valley	♀	85	40	18	7.6	36.6	7	62	22	14.6	12
Vera Cruz: Perote	♂	91	42	20	9	40.4	6	67	20	12	11

[1] Type of *Vespertilio chrysonotus* J. A. Allen.

Specimens examined.—Total number 32, from the following localities:

Arizona: Chiricahua Mountains, 1 (skin, Am. Mus. Nat. Hist.); San Francisco Mountain, 1; Springerville, 2 (skins); White Mountains, 2 (skins, Am. Mus. Nat. Hist.).
British Columbia: Shuswap, 1 (skin).
California: Dulzura, 3 (2 skins, Miller coll., 1, Am. Mus. Nat. Hist.); Inyo Mountains, 1; Owens Lake, 1; San Bernardino Mountains, 1 (skin, Merriam coll.); North Fork San Joaquin River, 1; Twin Oaks, San Diego County, 1.
Chihuahua: San Luis Mts., 1 (skin).
Colorado: Loveland, 4 (2 skins, Miller coll.).
Montana: Hot Springs, 1.
Nevada: Cottonwood Range, 1; Pahranagat Valley, 1.
New Mexico: Vermejo River, 1 (skin).
Oregon: Blue Creek, 1; Harney, 1; Twelve Mile Creek, 1.
Vera Cruz: Perote, 1.
Washington: Easton, 1; Colville, 1.
Wyoming: Bull Lake (east of Fremont Peak), 1; Kinney Ranch, Sweetwater County, 1 (skin, Am. Mus. Nat. Hist., type of *V. chrysonotus* J. A. Allen).

General remarks.—*Myotis evotis* is so totally distinct from all other bats occurring in Mexico or the United States that no detailed comparison with any is needed. The only species with which it could be confused are *M. thysanodes* and *M. subulatus*. The ears, however, are much larger than in either of these, and the free border of the uropatagium is never densely haired, as in *M. thysanodes*.

Through the kindness of Dr. J. A. Allen, I have before me the type of *Vespertilio chrysonotus* from Kinney Ranch, Wyoming. I am unable to find that it differs in any way from *Myotis evotis*. The tail is mutilated so that it gives no characters. The forearm is only 2 mm. longe than in the largest *evotis* from the United States that I have seen, a difference too trivial to be taken into account. In color the type of *chrysonotus* is a barely perceptible shade yellower than skins of *evotis* from the San Bernardino Mountains, California, and Vermejo River, New Mexico, but the difference is wholly inconsequential.

MYOTIS THYSANODES sp. nov. Fringed Bat.

1893. *Vespertilio albescens velifer* (variety) H. Allen, Monogr. Bats N. Am., p. 93. Dulzura, California.

1893. *Vespertilio albescens evotis* H. Allen, Monogr. Bats N. Am., p. 90 (part, specimen No. 29827, from old Fort Tejon, California).

Type from Old Fort Tejon, California. Adult ♀ (in alcohol). No. 29827, U. S. National Museum (Biological Survey collection). Collected July 5, 1891, by T. S. Palmer. Original number, 235.

Geographic distribution.—Lower Sonoran zone from near the southern border of the Western United States to San Luis Potosi and Michoacan.

General characters.—In size nearly equal to *Myotis velifer*. Length, 85 to 95; forearm, 40 to 46. Calcar thick and distinct, usually terminating in a well-marked pointed projection. Free border of uropatagium thickened and densely haired. Ears moderately long; laid forward they reach 3 to 5 mm. beyond nostril. Wings from point between ankle and base of toes, but nearer latter.

Ears.—The ears (Pl. I, fig. 5) are moderately long and obtusely pointed; laid forward they reach 3 to 5 mm. beyond the tip of the nose. Anterior border of auricle straight or slightly convex through basal half, then more convex for a short distance, after which it is nearly straight to the rounded tip; posterior border at first straight or slightly concave, sloping rapidly backward to the widest point at about mid-height, below which the border becomes convex and continues so to the well-marked basal notch. Basal lobe distinct and moderately large.

Tragus long and slender, the anterior border straight or slightly concave at base, then straight or slightly convex to near the tip, just below which the border is always convex. Posterior border with a well-developed lobe at base, widest part of tragus through this lobe or immediately above it. A more or less developed notch above the lobe. Beyond this notch the border is at first strongly convex, then slightly concave below the tip, which is thus always bent backward. Posterior border indistinctly crenulate.

Membranes.—The membranes are moderately thick and dark colored. Uropatagium noticeably more leathery than wing membranes, distinctly thickened at free edge, sparsely haired on proximal fourth both above and below, the rest of the membrane with a few scattered hairs, which become more abundant toward the free border, where they form a conspicuous fringe both above and below (Pl. II, fig. 5). Wing from side of foot, just below base of toes.

Feet.—Feet (Pl. II, fig. 5) large and strong, half as long as tibiæ. Toes (without claws) slightly longer than sole, scarcely united by membrane at extreme base; all sparsely haired. Calcar distinct and thick, considerably longer than free border of interfemoral membrane, terminating distinctly, but usually without well-developed lobule.

Fur and color.—There is nothing peculiar in the distribution of the fur in this species, except the thickly haired border of the uropatagium.

In color the fur is everywhere light, dull, yellowish brown, distinctly paler ventrally, the hairs everywhere dusky slate at base. The color is subject to considerable individual variation in shade. The palest specimens are yellowish wood brown inclining to clay color; the darkest specimens dull raw umber. The belly varies from clear gray scarcely tinged with yellow to a strong yellowish gray, and in other specimens to dull brownish gray. The exact shades are very variable and impossible to describe accurately.

Skull.—Skull (fig. 11 *b*, and fig. 12 *b*) large, exactly the same size as that of *M. velifer*, but more lightly built. Brain case oval in outline, abruptly rounded posteriorly, occipital region inflated and lacking well-formed ridges. Forehead moderately elevated above muzzle. Distance from posterior border of last upper molar to tip of hamular greater than width between alveoli of posterior molars.

Although the skull of this species and that of *M. velifer* are equal in size, that of the former is easily distinguished by its more inflated brain case, forehead more abruptly elevated above muzzle and rounder less angular occiput. When viewed from above, the posterior margin of the brain case is rounded in *M. thysanodes*, truncate in *M. velifer*. When viewed from behind, the brain case in *M. thysanodes* is broader in proportion to its height than in *M. velifer* and lacks the conspicuous occipital crest of the latter. The posterior part of the palate, from the last molars to the tips of the hamulars, is shorter in proportion to the distance between the hindermost molars in *M. velifer* than in *M. thysanodes*.

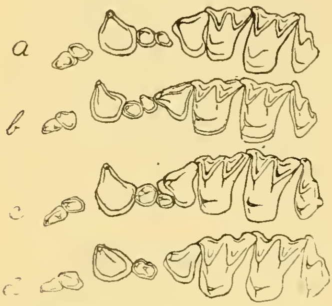

FIG. 16.—Maxillary teeth of four specimens of *Myotis thysanodes*, showing individual variation in form and position of premolars: *a*, specimen from Patzcuaro, Michoacan; *b*, *c*, and *d*, from Hacienda La Parada, San Luis Potosi (×5).

Teeth.—Upper incisors diverging at the tips. First and second upper premolars very variable in relative position and size. The first is always much longer than the second and has the crown at least one-fourth larger in cross section. The cross section of the first may, however, be nearly twice that of the second. In some specimens these two small premolars are perfectly in the line of the tooth row, the first in contact with the canine, the second touching the first, but separated from the third by a distinct space. In others the second premolar while perfectly in line is in contact with the third as well as with the first. Rarely the second premolar lies slightly external to the tooth row, while very commonly it is displaced to a varying degree inward, so much so in some cases as to be almost hidden from the outer side by the close approximation of the first premolar and the anterior edge of the third. These variations are independent of age and sex. The extremes with intermediates of all degrees occur among a dozen of the females collected by Mr. Nelson at Hacienda La Parada, San Luis Potosi, August 16, 1892; while specimens with teeth much worn or wholly unworn may have the premolars indifferently greatly crowded and displaced or wholly in the tooth row (fig. 15 *d*, fig. 16, and fig. 17.)

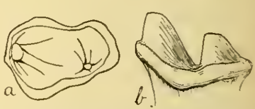

FIG. 17.—Abnormal premolar of *Myotis thysanodes* (No. 52228): *a*, crown; *b*, side (×20).

Third premolar triangular in outline, the outer border abruptly convex in front, and equal to posterior border; anterior and posterior borders concave; inner apex rounded, not extending back to level of inner margins of molars. First and second molars trapeziform, the anterior edge longest, the posterior outer and inner margins successively shorter. Anterior border straight to near inner edge, where it is bent abruptly backward, posterior border very slightly concave. First molar shorter and broader than second, and with anterior border nearly straight.

Central lower incisors with crowns compressed and trifid, the next pair similar but larger, the outer incisors still larger and with crowns indistinctly terete and quadrituberculate. First and second mandibular premolars variable in position and in relative size, the first always the larger. The second is shorter than the first, but in some specimens its crown has a cross section nearly equal to that of the latter. The first is always in contact with the canine and usually with the second premolar also, but may be separated from the latter by a narrow space. The second premolar is either wholly in the line of the tooth row and not touching the third, in line and touching the latter, or more or less displaced inward. Third premolar trapeziform, slightly broader than long.

In dentition *Myotis thysanodes* shows many points of difference from *M. velifer*. One of the most striking of these is the great variability in the size and position of the first and second upper premolars (figs. 16 and 17), which in *M. velifer* are comparatively constant. Other differences may be seen in the form of the third upper and third lower premolars. The crowns of the upper molars are proportionally broader in *M. velifer* than in *M. thysanodes*.

Measurements.—Average measurements of 23 specimens of *Myotis thysanodes* from four localities are given in the following table:

Average measurements of 23 specimens of Myotis thysanodes from 4 localities.

Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
California: Old Fort Tejon.....	[1]1	87	36	18	8	41	6	69	18	12	11
Old Fort Tejon.....	10	87	37	17.6	8	41.2	6.3	69.2	17.6	11.8	10.5
Michoacan: Patzcuaro..........	3	89	37	16.7	8.9	41.8	6.7	71.5	18.3	11.9	10.8
San Luis Potosi: Hda. La Parada	10	90.4	36.9	17.4	8.9	42.7	6.7	73.6	18.5	12.2	10.5

[1] Type.

Specimens examined.—Total number 88, from the following localities:

California: Dulzura, 1 (skin, Miller coll.); Old Fort Tejon, 16.
Chihuahua: East side San Luis Mountains, 2 (skins).
San Luis Potosi: Hacienda La Parada, 62 (6 skins).
Michoacan: Patzcuaro, 5 (2 skins).
Jalisco: La Laguna, Sierra de Juanacatlan, 1 (skin); Sierra Nevada de Colima, 1 (skin, Am. Mus. Nat. Hist.).

General remarks.—*Myotis thysanodes* needs no close comparison with any other species occurring in Mexico or the United States. Its large size separates it from all others but *M. velifer*, while from the latter the ciliated free border of the uropatagium, peculiar thickened calcar, larger ears and paler color together with the cranial and dental characters readily distinguish it.

In certain respects *M. thysanodes* resembles *M. evotis*. The color is very much the same, while the ears in these two species reach their maximum development among the species of this genus found in North America. The free border of the interfemoral membrane in *M. evotis* shows a slight tendency to the ciliation so conspicuous in *M. thysanodes*. *Myotis evotis* is, however, a smaller animal and has ears proportionally longer than in *M. thysanodes*, while the free border of the interfemoral membrane is never distinctly ciliate.

That this species is the same as the South American *Myotis albescens* is exceedingly unlikely. Dobson, who has seen the type of the latter, gives for it the following characters, which do not in the least apply to the present species: "Ears shorter than the head; laid forward, the tips do not reach to the end of the muzzle; calcaneum feeble, termination indistinct; above dark brown." Moreover, Mr. Oldfield Thomas, who has compared specimens of *Myotis thysanodes* with the *albescens* in the British Museum, writes me that the two do not in the least resemble each other, and that *M. albescens* is allied rather to *M. velifer*. For further discussion of the question, see under the latter species.

In Dr. Harrison Allen's recent monograph (p. 93) a specimen of this species in my collection, taken at Dulzura, [misspelled Dalyura], Cal., is recorded as a variety of '*V. albescens velifer*.' A specimen from Old Fort Tejon, California, in the Biological Survey collection, is labeled by Dr. Allen '*V. subulatus*,' while fifteen others of the same species from the same locality are marked '*V. albescens?*.' One of the latter (No. 29827), however, is recorded as '*V. albescens evotis*' (p. 90).

Dr. T. S. Palmer has kindly furnished me with the following account of the colony from which the type of *Myotis thysanodes* was taken:

In July, 1891, while one of the parties of the Death Valley Expedition was collecting at Old Fort Tejon, California, several species of bats were observed. The most abundant was a small *Vespertilio* [=*Myotis*], which could be seen at dusk flying about the oak trees near the old barracks in great numbers, and passing in and out of the ruined buildings. A long two-story adobe building, with the roof still intact, seemed to be the center of attraction, and about sundown bats could be seen streaming forth from a window in one of the gables. On the morning of July 5 an examination was made of the attic of this building, and the bats were found clinging to the ridgepole and the rafters, literally by thousands. Individuals of all ages, from recently born young to adults, were hanging together in bunches as big as a bushel basket. Others found concealment in cracks and crevices, but very few were flying about. Evidently the colony had occupied the attic for several years, but it was too dark to see whether more than one species was present.

A sack was carried along under the ridgepole and specimens swept into it from several of the larger bunches. In this way more than a hundred bats were collected in a few minutes. As soon as they were disturbed they uttered a peculiar squeaking note and flew about in a confused manner in their efforts to escape. The sack was carried out under one of the oak trees and the specimens examined; 160 had been captured, and of these 25 were preserved[1] and the remainder allowed to escape. Some of the bats which had been given their liberty attempted to fly back to their retreat, but dazed by the sunlight took refuge in the branches of the nearest tree;

[1] Sixteen proved to be *Myotis thysanodes;* the others were *M. yumanensis.*

others made no attempt to escape, except to crawl up the trunks of the trees, where they remained until dark. Some of the young ones failed to find their way back to the building, and remained about the spot for several days.

Genus LASIONYCTERIS Peters.

1864. *Scotophilus* H. Allen, Monogr. N. Am. Bats, p. 27 (part, not *Scotophilus* Leach, 1821).
1865. *Lasionycteris* Peters, Monatsber. K. Akad. Wiss. Berlin, p. 648. Type *Vespertilio noctivagans* Le Conte.
1870. *Cnephaiophilus* Fitzinger, Sitzungsber. K. Akad. Wissensch., Wien, LXII, Abth., I, p. 8 (part).
1875. *Vesperides* Coues in Coues' and Yarrow's Zoology of Wheeler's Exped., p. 83. Type *Vespertilio noctivagans* Le Conte.
1878. *Vesperugo* Dobson, Catal. Chiroptera Brit. Mus., p. 183 (part).
1893. *Lasionycteris* H. Allen, Monogr. Bats N. Am., p. 104.

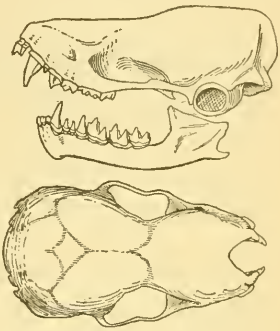

FIG. 18.—Skull of *Lasionycteris noctivagans* (×2.)

Type species.—*Lasionycteris noctivagans* (Le Conte).

Geographic distribution.—The range of the genus *Lasionycteris* is the same as that of the type and only known species.

Generic characters.—Dental formula: $i, \frac{2\text{-}2}{3\text{-}3}$; $c, \frac{1\text{-}1}{1\text{-}1}$; $pm, \frac{2\text{-}2}{3\text{-}3}$; $m, \frac{3\text{-}3}{3\text{-}3}=36$. Skull (fig. 18), flattened; rostrum very broad in proportion to brain case, strongly concave on each side back of the nasal aperture; dorsal profile of skull nearly straight and sloping gradually from external nares to occiput, which is scarcely angular, and always without sagittal crest. Ears short, nearly as broad as long; when laid forward, reaching barely to nostril; basal lobe very large. Tragus short, straight, and bluntly rounded at tip, width much more than half length of anterior margin. Back of interfemoral membrane furred on basal half. Mammæ, 2.

FIG. 19.—Teeth of *Lasionycteris noctivagans* (×5).

General remarks.—Among the American *Vespertilionidæ* the genus *Lasionycteris* is readily distinguished by its dental formula, combined with its short, broad ears, broad tragus, and partially furred uropatagium.

The genus *Lasionycteris* is peculiar to North America, where it is represented by one widely distributed species whose characters are remarkably constant throughout its range.

LASIONYCTERIS NOCTIVAGANS (Le Conte). Silver-haired Bat.

1831. *Vespertilio noctivagans* Le Conte, McMurtrie's Cuvier's Animal Kingdom, I, p. 31, June, 1831.

1831. *Vespertilio auduboni* Harlan, Monthly Amer. Journ. Geol. and Nat. Hist., I, p. 220, Pl. II, November, 1831 (Philadelphia, Pa.).

1835. *Vespertilio pulverulentus* Temminck, Monogr. de Mammalogie, II, p. 325 (Missouri River).

1864. *Scotophilus noctivagans* H. Allen, Monogr. N. Am. Bats, p. 39.

1865. *Lasionycteris noctivagans* Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin, p. 648.

1878. *Vesperugo noctivagans* Dobson, Catal. Chiroptera Brit. Mus., p. 238.

1893. *Lasionycteris noctivagans* H. Allen, Monogr. Bats N. Am., p. 105.

Type locality.—Eastern United States.

Geographic distribution.—North America, from Atlantic to Pacific; probably not breeding south of the Transition Zone.

General characters.—See generic characters given on page 85.

Color.—The fur is deep, blackish, chocolate brown throughout, many of the hairs on the back, belly, and furred part of interfemoral membrane tipped with silvery white. The white tips are most numerous on middle of back. They are absent, or nearly so, from face, crown, and throat.

Skull and teeth.—The cranial and dental characters of *Lasionycteris noctivagans* have been sufficiently described in the diagnosis of the genus.

Measurements.—The average measurements of 21 specimens of *Lasionycteris noctivagans* from eight localities are given in the following table:

Average measurements of 21 specimens of Lasionycteris noctivagans from 8 localities.

Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
New York: Sing Sing	10	105.8	42.4	17.1	7.9	41.1	5.3	73.4	15.9	14.1	6.7
Montana: Flathead Lake	2♀♀	100.5	41	16.2	7.5	42	4.5	75	15.6	14.1	6.2
Colorado: Rifle	1♂	97	38	16	8	39	4.6	68	16	12	6
Nevada: Badger	2♀♀	95.5	32.5	16	8.4	40	6.2	......	15.8	11.8	6
Oregon: Blue Mountains	1♂	97	39	16.4	8	41	6	......	15.4	11	5.6
Crooked River	1♂	95	41	17	7	41.4	5	......	16	12	6
Elgin	3	101	43	16.3	8.9	43	4.3	......	16	13.3	5.7
Harney	1♂	98	44	15	8.6	41	6	......	16	13	6

Specimens examined.—Total number 105, from the following localities:

Alberta: Henry House 2 (skins).
British Columbia: Sumas, 1 (skin, Miller coll.).
California: Nevada City, 1; Nicasio, 2.
Colorado: Rifle, 1.
Massachusetts: Nantucket, 1; North Truro, 6 (skins, Miller coll.).
Montana: Flathead Lake, 2.

Nebraska: Platte River, 1.
Nevada: Badger, 2.
New York: Lake George, 6 (2 skins); Leyden, 14; Locust Grove, 4; Lyons Falls, 4; Sing Sing, 47 (26 young).
North Carolina; Magnetic City, 1 (skin).
Oregon: Beaverton, 1 (skin, Miller coll.); Blue Mountains, 1; Crooked River, 1; East base Cascade Mountains, near Mount Thielson 1 (skin); Elgin, 3; Harney, 1; Salem, 1.
Pennsylvania: Carlisle, 1.

General remarks.—*Lasionycteris noctivagans* is one of the most easily recognized of North American bats. Its peculiar color alone is sufficient to distinguish it from all others found in the region where it occurs.

Genus PIPISTRELLUS Kaup.

1829. *Pipistrellus* Kaup, Skizzirte Entwick.-Gesch.,u. Natürl. Syst. d. Europ. Thierw., Th. I, p. 98. Type *Vespertilio pipistrellus* Schreber.
1839. *Vesperugo* Keyserling & Blasius, Wiegmann's Archiv f. Naturgesch., 5ter Jahrg., Bd. 1, p. 312 (part).
1856. *Nannugo* Kolenati, Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge II, 131, 169–172. Based on *nathusii*, *pipistrellus*, and *kuhlii*.
1856. *Hypsugo* Kolenati, Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 167–169. Included the species *maurus* and *krascheninikowii*.
1864. *Scotophilus* H. Allen, Monogr. N. Am. Bats, p. 27 (part, not *Scotophilus* Leach).
1878. *Vesperugo* Dobson, Catal. Chiroptera Brit. Mus., p. 183 (part).
1893. *Vesperugo* H. Allen, Monogr. Bats N. Am., p. 121.

Type species.—*Pipistrellus pipistrellus* (Schreber).

Geographic distribution of genus.—The greater part of the Eastern Hemisphere, and throughout the southern half of North America. Exact limits of distribution not known.

Generic characters.—Dental formula:

$$i, \frac{2-2}{3-3}; \; c, \frac{1-1}{1-1}; \; pm, \frac{2-2}{2-2}; \; m, \frac{3-3}{3-3} = 34.$$

Skull (figs. 21 and 22) small and lightly built, varying somewhat in form among the different species. Braincase usually more inflated than in *Vespertilio* and *Lasionycteris*, but rostrum proportionally as broad as in these genera. Ears (fig. 20) distinctly longer than broad and tapering to a narrowly rounded tip. Tragus straight or slightly curved forward. Back of interfemoral membrane sprinkled with hair on basal third. Mammæ, 2.

General remarks.—The members of the genus *Pipistrellus* may be recognized by their dental formula and small size. The bats of the European genus, *Pterygistes*[1] (*Pterygistes noctula* and *P. leisleri*), which have the same dental formula, are large, heavily built, and altogether different in appearance.[2]

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[1] *Pterygistes* Kaup, Skizzirte Entwick.-Gesch. u. Naturl. Syst. d. Europ. Thierw., Th. I, p. 100, based on *Vespertilio proterus* Kuhl (= *V. noctula* Schreber) and *V. leisleri* Kuhl

[2] For remarks on the generic characters of '*Noctulinia*' (=*Pterygistes*), see H. Allen, Proc. U. S. Nat. Museum, 1893, p. 30.

In America the genus is represented by three species, all of which are strictly congeneric with *Pipistrellus pipistrellus*. Of the American species *P. subflavus* resembles *P. pipistrellus* most closely, but is distinguishable at a glance by its much longer thumb.

KEY TO AMERICAN FORMS OF PIPISTRELLUS.

Tragus blunt with tip bent forward:
- Forearm about 31 mm.; colors very pale .... *hesperus* (p. 88)
- Forearm about 28 mm.; colors darker .... *australis* (p. 90)

Tragus tapering and straight:
- Forearm 30 to 32 .... *veracrucis* (p. 93)
- Forearm 33 to 36—
  - Color yellowish brown .... *subflavus* (p. 90)
  - Color drab brown .... *obscurus* (p. 93)

PIPISTRELLUS HESPERUS (H. Allen).

1864. *Scotophilus hesperus* H. Allen, Monogr. N. Am. Bats, p. 43.
1878. *Vesperugo hesperus* Dobson, Catal. Chiroptera Brit. Museum, p. 228.
1886. *Vesperugo merriami* Dobson, Ann. & Mag. Nat. Hist., 5th ser., XVIII, p. 124.
1893. *Vesperugo hesperus* H. Allen, Monogr. Bats N. Am., p. 128.

Type locality.—Fort Yuma, Cal. Type No. 5406, U. S. National Museum.

Geographic distribution.—Lower Austral zone in the Western United States from western Texas to the Pacific Coast. Limits not known.

General characters.—Size very small (forearm about 26); thumb short (about one-eighth of forearm); ear shorter and more bluntly rounded than in other American members of the genus, reaching barely to nostril when laid forward; tragus blunt and distinctly bent forward at tip; feet very small, about half as long as tibia; barely 1 mm. of tip of tail free from membrane; color very pale.

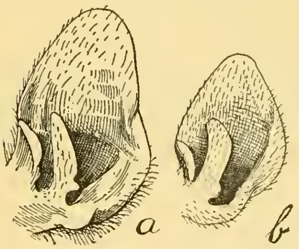


FIG. 20.—Ear of (*a*) *Pipistrellus subflavus* and (*b*) *P. hesperus* (×2).

Ears.—The ears (fig. 20 *b*) are short, reaching barely to nostril when laid forward. The anterior border of auricle is strongly convex from well developed basal notch to region about middle, where it becomes straight and remains so almost to narrowly rounded tip. Posterior border concave immediately below tip, then strongly convex to basal notch. Basal lobe well developed, separated from auricle by a deep notch and joining face at point below line of lips, and slightly behind posterior corner of eye. The fur of the head extends over dorsal surface of ear to slightly beyond the basal third. Otherwise the ear is naked except for a sprinkling of fine hairs on inner surface.

Tragus less than half length of ear, broadest just below tip; anterior border straight throughout greater part of its length, but strongly concave immediately below tip; posterior border strongly convex from tip almost to notch above well developed basal lobe.

Membranes.—The membranes are thin and delicate. Uropatagium very sparsely furred at extreme base, otherwise naked except for a few scattered hairs which are most numerous on the basal half. Wing membranes attached at base of toes. Uropatagium extending almost to extreme tip of tail.

Feet.—Foot small, distinctly less than half as long as tibia, naked or with a few almost invisible whitish hairs on dorsal surface. Calcar about as long as tibia, scarcely keeled on posterior edge, terminal lobe absent or very indistinct.

Fur and color.—The fur extends on basal third of ears, but barely reaches extreme base of interfemoral membrane, and on wing membranes invades merely a very narrow strip close to body.

Color light yellowish gray or whitish gray, the fur everywhere deep plumbeous at base. In some specimens the hairs on the back have faint dark subterminal areas which, however, are visible on close inspection only. Ears, muzzle, face, and membranes black. A narrow whitish border on wing membrane between foot and fifth finger.

This species is apparently much more constant in color than *P. subflavus*, but the absence of a good series of skins leaves the range of individual variation in color a matter of uncertainty.

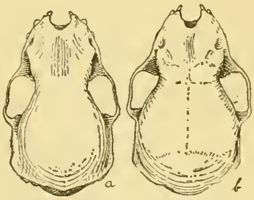


FIG. 21.—Top view of skull of (*a*) *Pipistrellus hesperus* and (*b*) *P. subflavus* (×2.)

Skull.—The skull of *Pipistrellus hesperus* (figs. 21 *a*, and 22 *b*) is very small, thin, and papery. That of an adult male from Fort Bowie, Arizona, measures 11.4 mm. in occipitonasal length, 6 mm. in zygomatic breadth, and 4 mm. in occipital depth. The dorsal outline is nearly straight from external nares to occiput, though there is a slight concavity between the orbits and a slight convexity over the brain case. Muzzle broad and nearly flat, slightly concave on each side of median line. In general the skull of *Pipistrellus hesperus* suggests a miniature of that of *Lasionycteris.*

Teeth.—The teeth of *Pipistrellus hesperus* (fig. 23 *a*) do not differ materially from those of *P. subflavus.* The anterior upper premolar is minute (much smaller than the smaller upper incisor) and usually thrown out of the tooth row by the second premolar, the anterior edge of which is generally in contact with the canine.

Measurements.—See table, page 95.

Specimens examined.—Total number 127, from the following localities:

Arizona: Beaverdam, 1; Fort Bowie, 1 (skin); Grand Cañon, 2; Guadalupe Cañon, Cochise County, 4 (skins); Little Colorado, 2; Dos Cabezas, 1 (skin); Keam Cañon, Navajo County, 1 (skin); New River, Maricopa County, 1; Yuma, 2.

California: Borax Flat, Mohave Desert, 3; Colorado Desert, 1 (skin); Death Valley, 4; Funeral Mountains, Inyo County, 1; Furnace Creek, Death Valley, 1; Grapevine Spring, Death Valley, 1; Independence, 1; Hot Springs Valley, Inyo County, 2; Jacumba, San Diego County, 2 (skins); Keeler, 1; Kern River, 3; Kernville, 1; Lone Pine, 3; Owens Lake, 1; Palm Springs, 3; Panamint Valley, Inyo County, 6; Panamint Mountains, 4; Poso Creek, Kern County, 1 (skin); Saline Valley, Inyo County, 1; San Emigdio, 1; Santa

Ysabel, San Diego County, 18; Three Rivers, 7; Twin Oaks, 2; Vallecitas, San Diego County, 3; Whitewater, 1 (skin); Yosemite Valley, 1; Old Fort Yuma, 1 (type).

Colorado: Grand Junction, 4.

Lower California: San Fernando, 7 (Miller coll.).

Nevada: Gold Mountain, Esmeralda County, 1; Pahranagat Valley, 1; Vegas Mountains, 1; Vegas Valley, Lincoln County, 1.

New Mexico: Dog Spring, Grant County, 7 (skins); Fort Wingate, 1; Grant County, 1 (skin).

Texas: Chinate Mountains, 1; El Paso, 4 (1 skin); Paisano, 5; Pecos River, 1.

Utah: St. George, 2.

Washinton: Almota, 1.

General remarks.—*Pipistrellus hesperus* is readily distinguishable among North American bats by its dental formula, small size, blunt tragus, and pallid color. It needs no comparison with any other species. At the southernmost extremity of its known range a subspecies slightly different from that occurring farther north has been differentiated. Otherwise the species is remarkably constant in all its characters.

PIPISTRELLUS HESPERUS AUSTRALIS subsp. nov.

Type from Barranca Ibarra, Jalisco, Mexico; altitude about 3,000 feet. Adult ♀ (in alcohol), No. 52112, U. S. National Museum (Biological Survey collection). Collected May 14, 1892, by E. W. Nelson. Original number, 2614.

General characters.—Slightly smaller than true *Pipistrellus hesperus;* fur shorter; color apparently darker and browner.

Ears, membranes, and feet.—As in the typical subspecies.

Fur and color.—The fur is shorter than in specimens of true *hesperus* taken in April and May, but in distribution it shows no peculiarities.

Color darker and browner than in specimens of true *hesperus* that have been immersed in alcohol for a similar length of time. Until skins of the southern animal are examined the actual color differences between the two forms can not be determined.

Measurements.—The measurements of the type and the averages of four specimens from the type locality are given in the table of measurements on page 95.

Specimens examined.—Four, all from the type locality.

General remarks.—*Pipistrellus hesperus australis* is a fairly well marked subspecies characterized by slightly smaller size, shorter fur, and darker color than in the typical form. The material by which it is represented is so poor, however, that all the characters can not be determined with certainty.

PIPISTRELLUS SUBFLAVUS (F. Cuvier). Georgian Bat.

1832. ?*Vespertilio georgianus* F. Cuvier, Nouv. Ann. Mus. d'Hist. Nat., Paris, p. 16. (Not determinable.)

1832. *Vespertilio subflavus* F. Cuvier, Nouv. Ann. Mus. d'Hist. Nat., Paris, p. 17. (Description good.)

1835–41. *Vespertilio erythrodactylus* Temminck, Monogr. de Mamm., II, 13me Monogr., p. 238.

1864. *Scotophilus georgianus* H. Allen, Monogr. N. Am. Bats, p. 35.

1878. *Vesperugo georgianus* Dobson, Catal. Chiroptera Brit. Mus., p. 235.
1893. *Vesperugo carolinensis* H. Allen, Monogr. Bats N. Am., p. 121 (not *Vespertilio carolinensis* Geoff.).

Type locality.—Eastern United States; probably Georgia.

Geographic distribution.—Austral zones and casually parts of Transition zone in the Eastern United States, from the Atlantic Coast west to Iowa and eastern and southern Texas.

General characters.—Size small (forearm, about 34); thumb long (about $\frac{1}{5}$ forearm); ear when laid forward reaching slightly beyond nostril; tragus straight, tapering to a broadly rounded tip; feet small, slightly more than half as long as tibia; terminal 2 mm. of tail free from membrane; hairs on back mostly distinctly tricolored; general color light yellowish brown, undulated with darker brown.

Ears.—The ears (fig. 20 *a*) are considerably longer than in *P. hesperus*, reaching, when laid forward, just beyond nostril. In general form the ear is much as in *P. hesperus*, but the auricle is slightly narrower, and the basal lobe is smaller and separated from auricle by a slight notch only. On dorsal surface of ear the fur of head extends scarcely to basal third. Otherwise the ear is naked except for a sprinkling of fine hairs on inner surface.

Tragus about half length of ear, broadest opposite anterior base and thence tapering gradually upward to bluntly rounded tip which is turned slightly backward. Anterior border slightly concave at base, then gently convex to tip. Posterior border slightly concave immediately below tip, then strongly convex almost to notch above well developed basal lobe.

Membranes.—The membranes are thin and delicate. Uropatagium thinly furred on basal fourth, otherwise naked except for a few scattered hairs along veins on lower side. Wing membranes attached at base of toes. Uropatagium attached at base of terminal caudal vertebra.

Feet.—Foot large, distinctly more than half as long as tibia, covered with conspicuous light-brown hairs on dorsal surface. Calcar distinctly longer than tibia, scarcely keeled on posterior edge, terminal lobe absent or very indistinct.

Fur and color.—The fur extends on base of ears and interfemoral membrane and on wing membranes to line joining knee and middle of forearm.

Color light yellowish brown, uniform on the ventral surface, but on the back clouded to a varying degree with darker brown. The hairs on the back appear to be of two kinds. The main body of the fur is made up of short hairs (about 6 mm. in length), which are deep plumbeus from base to a little below middle, then yellowish brown almost to extreme tip, which is dark brown. Intermixed with these shorter hairs are others which are much longer (about 10 mm. in length) and clear yellowish brown to extreme tip.

Typical *Pipistrellus subflavus* presents a wide range of individual variation in color. This is due to the extent of the terminal dark bands on the hairs of the back, and also to the exact shade of the yellowish subterminal bands. The yellowest specimens that I have seen were taken at Washington, D. C., during May and June.

Skull.—The skull of *Pipistrellus subflavus* (figs. 21 *a* and 22 *b*) is larger than that of *P. hesperus*. That of an adult male from Washington, D. C., measures 13 mm. in occipito nasal length, 8 mm. in zygomatic breadth, and 5 mm. in occipital depth. The dorsal outline is nearly straight from the anterior nares to a point immediately behind the orbits, then strongly convex to occiput. Muzzle narrow and arched, the concavities on each side nearly obsolete. In general the skull of *Pipistrellus subflavus* suggests a miniature of that of the smaller forms of *Vespertilio*.

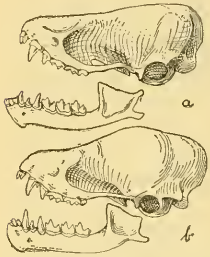


FIG. 22.—Side view of skull of (*a*) *Pipistrellus hesperus* and (*b*) *P. subflavus* (×2).

Teeth.—The teeth of *Pipistrellus subflavus* (fig. 23 *b*) are larger than those of *P. hesperus* but essentially similar in form. The anterior upper premolar is large (about the size of the larger upper incisor) and generally fully in the tooth row.

Measurements.—See table, page 957.

Specimens examined.—Total number, 213, from the following localities:

Alabama: Greensboro, 2.
District of Columbia: Washington, 17 (11 skins).
Indian Territory: Stilwell, 13.
Louisiana: Mer Rouge, 10; Houma, 2 (skins).
Maryland: Marshall Hall, 5 (skins); St. Georges Island, 2 (skins).
Mississippi: Washington, 8.
Missouri: Marble Cave, Stone County, 70.
New York: Sing Sing, 33.
North Carolina: Raleigh, 7 (skins); Bertie County, 2 (skins).
Pennsylvania: Carlisle, 7 (1 skin).
Tennessee: Hickman County, 1 (skin); Arlington, 3; Big Sandy, 10; Danville, 4.
Texas: Clear Creek, Galveston County, 1; Brownsville, 1.
Virginia: Cedarville, 6 (skins, Miller coll.); Fredericksburg, 6 (skins); Hampshire County, 1 (skin); Wytheville, 2.

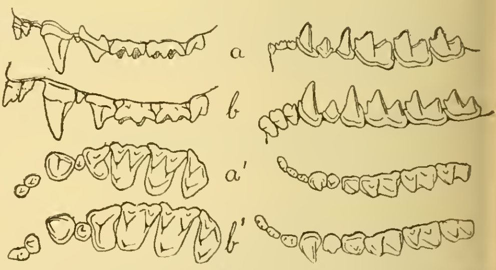


FIG. 23.—Teeth of (*a*) *Pipistrellus hesperus* and (*b*) *P. subflavus* (×5).

General remarks.—The Georgian bat, *Pipistrellus subflavus*, is so readily distinguished among the species of the region it inhabits that detailed comparisons are scarcely necessary. Its dental formula, small size, relatively large thumb, distinctly tricolored fur and general yellowish color are unmistakable characters.

PIPISTRELLUS SUBFLAVUS OBSCURUS subsp. nov.

Type from Lake George, Warren County, N. Y. Adult ♀ (skin) No. 67723, U. S. National Museum (Biological Survey collection). Collected September 6, 1894, by Walter K. Fisher. Original number, 198.

General characters.—Size and proportions as in typical *subflavus*, but color duller and less yellow, and dark tips of shorter hairs on back more conspicuous.

Ears, membranes, feet, and fur.—As in typical *subflavus*.

Color.—Fur everywhere blackish slate at base. Middle band on shorter hairs of back dull, pale, wood brown or isabella color. Tips of these hairs dusky brown, and much more conspicuous than in true *subflavus*. Long hairs of back pale wood brown. Belly uniform isabella color, in some specimens inclining toward wood brown, but seldom showing any approach to the bright yellowish brown of true *subflavus*.

A melanistic specimen is dark chocolate brown throughout. Two others are rich reddish brown. In all three of these abnormal individuals the characteristic variegation of the fur of the back still persists.

Skull and teeth.—I can find no cranial or dental characters to distinguish *Pipistrellus subflavus obscurus* from the typical subspecies.

Measurements.—See table, page 95.

Specimens examined.—Thirty four (seven skins), all from the type locality.

General remarks.—*Pipistrellus subflavus obscurus* is readily distinguishable from true *subflavus* by its darker, duller, less yellow color. The difference is especially noticeable on the ventral surface, which is generally a rich yellowish wood brown in typical *subflavus*, dull isabella color in *obscurus*. The darker hue of the back in *obscurus* is due partly to differences in the color of the long hairs, and of the middle bands of the short hairs, and partly to the more extended dark tips of the short hairs. Like the typical form, *Pipistrellus subflavus obscurus* varies considerably in color, so that individual specimens of either subspecies, especially those that are not fully adult, are sometimes difficult to identify. When series are compared, however, the differential characters at once become apparent.

PIPISTRELLUS VERÆCRUCIS (Ward).

1891. *Vesperugo veræcrucis* Ward, Am. Naturalist, XXV, p. 745, August, 1891.

Type locality.—Las Vegas, Jalapa, Vera Cruz.

Geographic distribution.—This species is known from the type locality only.

Characters.—As I have seen no specimens of *Pipistrellus veræcrucis*, I copy the original description.

All six specimens were indistinguishable one from another in point of color. The following color-description is taken from a dried skin, whereas all the rest of the description is taken from a specimen preserved in alcohol.

Hairs of back clove-brown for basal half, followed by two equal zones respectively broccoli-brown and clove-brown; some of hairs furthermore tipped with light Vandyke-brown, giving a decidedly "rusty" tone to the back. Ventral surface; bases of hair slightly lighter than those of back, followed by light-hair brown, producing a grayish or smoky effect.

Wing membranes naked, except a very limited area on upper surface along sides of body, not exceeding 3 or 4 mm. in width; and on lower surface, the area included between a line passing from the middle of humerus to the knee and the side of the body is scantily haired.

Interfemoral membrane with a small, triangular patch of hair on its upper surface, covering base of tail, and extending to one-fourth of its length.

Legs and arms naked. Wing extending from base of outer toe. Antebrachial membrane losing itself at middle of radius. Two caudal vertebræ free from membrane.

Black glandular prominences between eyes and nostrils well developed, fringed with longish hairs on both upper and lower edges, and with three or four long, black, bristly hairs growing from its upper surface.

Inner edge of ear conch evenly convex. Outer edge coming up in an even, sweeping curve from angle of mouth to level of tip of tragus, where it meets a slightly concave line leading up to the obtusely rounded tip. A nearly semi-circular antitragus is developed from that part of the conch passing below the tragus. Bone of inner margin of tragus concave, thus throwing this organ forward, followed by a straight margin. Bone of outer margin with a subtriangular lobe, followed by a deep notch, above which the greatest width is quickly reached. From here a nearly straight line leads to the tip, which is obtusely rounded.

Measurements in millimeters: Length of head and body, from tip of nose to base of tail, 37.5; length of tail, 36; length of tail beyond membrane, 3; length of head, 15; height of ear, from notch between antitragus and conch to tip, 10; height of tragus, inner margin, 4.5; height of tragus, outer margin, 6; greatest width of tragus, 2; length of antitragus, 2; height of antitragus (approximately), .75; length of forearm, 31; length of thumb, including claw and excluding metacarpus, 7.5. Second digit—metacarpal, 29. Third digit—metacarpal, 30.5; first phalanx, 11.5; second phalanx, 11; cartilaginous tip, 5. Fourth digit—metacarpal, 29; first phalanx, 10; second phalanx, 7; cartilaginous tip, 2.5. Fifth digit—metacarpal, 28; first phalanx, 8.5; second phalanx, 5; cartilaginous tip, 1. Interspace between tips of third and fourth digits, 16; interspace between tips of fourth and fifth digits, 37; interspace between tip of fifth digit and juncture of membrane with foot, 42; extent of outstretched wings, 212; length of tibia, 13.5; length of foot, 9; length of calcaneum, about 8.

Teeth, $\frac{2-2}{3-3}, \frac{1-1}{1-1}, \frac{2-2}{2-2}, \frac{3-3}{3-3} = 30$ [34].

Middle upper incisors separated by 1.5 mm., inclined forwards and inwards; a large internal cusp on posterior-external edge halfway up from base to tip. Outer incisors simple, conical, inclined parallel to their respective inner mates, separated from canines by about .75 mm. Lower incisors tri-lobate, evenly spaced. Upper canines long, simple, slightly recurved. Lower canines straight, with basal cusps on forward edge only. First upper premolar interior to tooth line, visible from the exterior. Second upper premolar longer than any of its corresponding molars.

A prominent conical excrescence is on the lower gum, opposite the space between the premolars, in front of which the point of the upper canine passes. Two much less prominent excrescences are on the upper gum immediately above this lower one. Type No. 527 ♂, Las Vegas, V[era Cru]z, February 19, 1891. Collectors, H. L. Ward and C. M. Teran.

General remarks.—Pipistrellus veraecrucis differs from *P. subflavus* in its smaller size, relatively longer thumb, and browner, less yellow color.

No specimens of this species have been obtained by the field agents of the Biological Survey, nor are any known to be in American museums.

Average measurements of North American forms of Pipistrellus.

Name.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
hesperus	Washington: Almota	[1]1♀	77	32	12	6	30	4	52	12.4	9	5.4
	California: Fort Yuma	[1]1♂	70	28	11	5	28	3.8	48	10	8.6	4.6
	Santa Ysabel	10	72.8	32	11.5	5.5	31.6	4	51.4	11.6	8.7	5.2
	Colorado: Grand Junction	4	74.6	31	12	5.5	31.3	4	52	12.1	9.3	5.4
	Texas: Paisano	3	79	34.5	12.8	5.4	32.5	4	55.5	12.4	9.6	5.1
australis	Jalisco: Barranca Ibarra	[1]1♀	64	28	11.4	5	29	4	47	10.4	8.4	5
	Barranca Ibarra	4	63.2	26.8	10.7	5.1	28.6	3.9	45	10.7	8	4.5
veræcrucis	Vera Cruz: Las Vegas, Jalapa	[1]1	73.5	36	13.5	9	31	7.5	58	....	....	6
subflavus	Louisiana: Mer Rouge	10♀♀	85.1	40.7	15.3	7.9	34.6	6.8	60.8	14.2	9.8	6.6
	Missouri: Marble Cave	10	84.6	39.8	16.1	8.1	33.7	6.8	60	13.9	9.5	6.4
	District of Columbia: Washington	5♀♀	84	37.8	15.2	7.8	34	6.8	62.8	14	9.6	6.6
obscurus	New York: Lake George	10	84.8	38.9	15.2	8	36	6.8	60.6	14	10	6.8

[1] Type; measurements by original describer.

Genus VESPERTILIO Linnæus.

1758. *Vespertilio* Linnæus, Systema Naturæ, 10th ed., I, pp. 31–32. Type by elimination *Vespertilio murinus* Linnæus (not *V. murinus* Schreber, 1775).

1820. *Eptesicus* Rafinesque, Annals of Nature, p. 2. Type *Eptesicus melanops* Rafinesque (=*Vespertilio fuscus* Beauvois).

1829. *Cnephæus* Kaup, Skizzirte. Entw.-Gesch. u. Natürl. Syst. d. Europ. Thierw., I, p. 103. Type *Vespertilio serotinus* Schreber.

1839. *Vesperugo* Keyserling & Blasius, Wiegmann's Archiv f. Naturgesch., 5ter Jahrg., Bd. 1, p. 312 (part).

1839. *Vesperus* Keyserling & Blasius, Wiegmann's Archiv f. Naturgesch., 5ter Jahrg., Bd. 1, p. 313. Based on the 32-toothed species of '*Vesperugo*.'

1841. *Noctula* Bonaparte, Iconografia Fauna Italica, I, fasc. XXI, under *Vespertilio alcythoe*. Type '*Vesperugo*' *serotinus*.

1856. *Cateorus* Kolenati, Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 162–163. Type '*Vesperugo*' *serotinus*.

1856. *Meteorus* Kolenati, Allgem. Deutsch. Naturhist. Zeitg., Dresden, Neue Folge, II, pp. 131, 167–169 (included *nilssoni, discolor, savii, leucippe, aristippe*).

1864. *Scotophilus* H. Allen, Monogr. N. Am. Bats, p. 27 (part).

1878. *Vesperugo* Dobson, Catal. Chiroptera Brit. Mus., p. 183 (part).

1892. *Adelonycteris* H. Allen, Proc. Acad. Nat. Sci. Phila. (1891), p. 466, Jan. 19, 1892. (Proposed as a substitute for *Vesperus*, preoccupied in Entomology).

1893. *Adelonycteris* H. Allen, Monogr. Bats, N. Am., p. 111.

Type species.—*Vespertilio murinus* Linnæus (=*V. discolor* Natterer)—not *V. murinus* Schreber.

Geographic distribution.—Boreal, Austral and parts of Tropical regions in both hemispheres.

Generic characters.—Dental formula: $i, \frac{2\text{-}2}{3\text{-}3}; c, \frac{1\text{-}1}{1\text{-}1}; pm, \frac{1\text{-}1}{2\text{-}2}; m, \frac{3\text{-}3}{3\text{-}3} = 32.$ Skull (figs. 24 and 25) large and heavily built; rostrum broad in proportion to brain case (less so than in *Lasionycteris*), scarcely concave at sides back of nasal aperture; dorsal profile nearly straight, rising gradually from external nares to occiput, which in the adult is strongly angular and provided with a conspicuous sagittal crest. Ears short, considerably narrower than long, basal lobe well developed, but not excessively large. Tragus straight, short, directed slightly forward, broadest near the middle and tapering to a moderately sharp point. Back of interfemoral membrane wholly naked except for a sprinkling of hairs on basal fourth. Mammæ, 2.

General remarks.—The genus *Vespertilio* contains the largest American species of the Vespertilionine group. Aside from the dental formula, the large size of *Vespertilio fuscus*, the only known North American species, is sufficient to distinguish the genus among those occurring in the region now under consideration.

The North American species is separable into at least five tolerably well-marked subspecies as follows:

KEY TO THE SUBSPECIES OF VESPERTILIO FUSCUS.

Size small (total length, 96 to 107; forearm, 40 to 45; longest finger, 68 to 77).
- Breadth of muzzle greater than half length of head .... *propinquus* (p. 100)
- Breadth of muzzle less than half length of head .... *bahamensis* (p. 101)

Size large (total length, 105 to 122; forearm, 43 to 52; longest finger, 77 to 96).
- Membranes and ears thick and leathery, the ears distinctly thickened along anterior border .... *fuscus* (p. 96)
- Membranes and ears thin, the ears scarcely thickened along anterior border.
  - Forearm, 47 to 50; longest finger, 85 to 89 (average 86) .... *cubensis* (p. 102)
  - Forearm, 50 to 52; longest finger, 85 to 96 (average 90) .. *miradorensis* (p. 99)

VESPERTILIO FUSCUS Beauvois. Brown Bat.

1796. *Vespertilio fuscus* Beauvois, Catal. Peale's Museum, p. 14. (Philadelphia, Pa.).
1806. *Vespertilio carolinensis* Geoffroy, Ann. Mus. d'Hist. Nat., Paris, VIII, p. 193. (Carolina.)
1818. *Vespertilio phaiops* Rafinesque, Am. Monthly Mag., III, p. 445. (Kentucky.)
1820. *Eptesicus melanops* Rafinesque, Annals of Nature, p. 2. (Kentucky.)
1823. *Vespertilio arquatus* Say, Long's Expedition to Rocky Mountains, I, p. 167, footnote.
1835. *Vespertilio ursinus* Temminck, Monogr. de Mammalogie, II, p. 235.
1843. *Scotophilus greenii* Gray, List Spec. Mamm. Brit. Mus., p. 30 (nomen nudum).
1864. *Scotophilus fuscus* H. Allen, Monogr. N. A. Bats, p. 208.
1878. *Vesperugo serotinus* var. *Vesperus fuscus* Dobson, Catal. Chiroptera Brit. Mus., p. 193.
1893. *Adelonycteris fuscus* H. Allen, Monogr. Bats N. A., p. 112.

Type locality.—Philadelphia, Pa.

Geographic distribution.—Austral, Transition, and (lower edge of) Boreal zones throughout the United States and adjoining British provinces.

General characters.—Size large; total length, 110 to 112; tail vertebræ, 41 to 52; forearm, 43 to 46; longest finger, 77 to 84; ear, 11.6 to 14;

ears and membranes thick and leathery; crowns of upper molars narrow; color variable, but seldom very dark.

Ears.—Ears short, reaching barely to nostril when laid forward, furred on basal third above and sprinkled with hairs on most of inner surface, but especially near an terior border. The membrane of the ear is heavier and more leathery than in the southern subspecies, and the anterior edge is distinctly thickened.

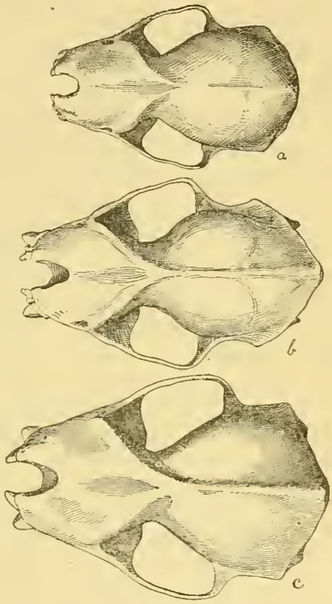


FIG. 24.—Top view of skull of (*a*) *Vespertilio bahamensis*, (*b*) *V. fuscus*, and (*c*) *V. serotinus* (×2).

Membranes.—Membranes naked, broad and ample, that of wings attached to foot a little beyond base of toes. Free edge of interfemoral membrane a little shorter than calcar and terminating at base of penultimate caudal vertebra. The flight membranes, like the ears, are thicker and less membranaceous than in the subpecies occurring in or near the tropics.

Feet.—Foot about half length of tibia; calcar slightly longer than foot, keeled on outer edge, and terminating indistinctly or in a faintly defined lobe. Dorsum of toes with a few short bristle-like hairs.

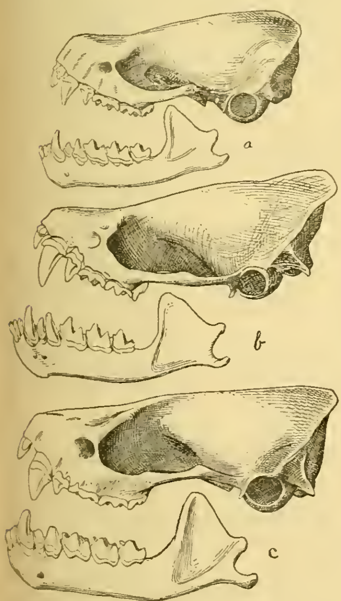


FIG. 25.—Side view of skull of (*a*) *Vespertilio bahamensis*, (*b*) *V. fuscus*, and (*c*) *V. serotinus* (×2).

Fur and color.—On middle of back the fur is about 12 mm. long. The fur extends along the sides in a line about 10 mm. wide on wing membranes both above and below. The proximal third or fourth of uropatagium is furred. Otherwise the membranes are naked except for a few scattered hairs on the under side of the interfemoral membrane and on the under side of the wings close to the humerus and forearm.

Color brown throughout, but always paler on belly than on back. The exact shade varies considerably, but is usually a clear bister or sepia. Sometimes, however, it approaches cinnamon. Ears and membranes blackish in dry specimens.

Skull.—The skull of typical *Vespertilio fuscus* (figs. 24 *b*, 25 *b*) averages about 18.5 mm. in occipito-nasal length and 12.5 mm. in zygomatic breadth; mandible, 14 mm. It has no tangible characters to distinguish it from the skulls of the other large subspecies.

Teeth.—The teeth of typical *Vespertilio fuscus* (fig. 26 *a*) do not differ appreciably in form or size from those of the other large continental subspecies. They average slightly smaller, however, than in *V. fuscus miradorensis*, and the crown of the middle upper molar is usually narrower.

Measurements.—See table, page 103.

Specimens examined.—Total number, 336, from the following localities:

Alabama: Greensboro, 1.

Arkansas: Fort Towson. 1.

Arizona: Apache, 4; Santa Catalina Mountains, 3 (skins); Chiricahua Mountains, 1 (skin); Guadalupe Cañon, Cochise County, 2 (skins); Fort Verde, 2 (1 skin); Fort Huachuca, 9; Huachuca Mountains, 4 (skins); New River, 2; San Francisco Mountain, 6; Yuma, 1.

British Columbia: Ashcroft, 2 (skins).

California: Bear Valley, San Bernardino County, 2; Cassel, 2; Cloverdale, 1; Dulzura, 3 (1 skin); Horse Corral Meadows, Fresno County (altitude, 8,000 feet), 1; Kern Lakes, North Fork Kern River (altitude, 7,000 feet), 1; Kern River, 6; Kernville, 1; South Fork Kings River, 2; Lone Pine, 7; Little Kern River, 3; Mount Shasta, 2 (skins); Mount Whitney, 2; Nevada City, 6; Nicasio, 63; Owens Lake, 1; Old Fort Tejon, 1; Pine Valley, 4 (skins); Poso Creek, Kern County, 1 (skin); Round Valley, 1; Raymond, 2; Santa Barbara, 2; Sequoia National Park, 9; Sherwood, 1; Twin Oaks, San Diego County, 3; Three Rivers, 1; Tehachapi, 1; Visalia, 2; Walker Basin, Kern County, 4; Yosemite Valley, 2.

Colorado: Loveland, 6 (skins, Miller coll.).

Connecticut: Norfolk, 2.

District of Columbia: Washington, 53 (33 skins).

Georgia: Riceboro, 1.

Idaho: Fort Sherman, 1.

Illinois: Richland County, 1; Warsaw, 4.

Kansas: Fort Riley, 2; Neosho Falls, 1 (skin).

Maine: Eastport, 4.

Massachusetts: Cambridge, 4; Wilmington, 6 (skins).

Mississippi: Bay St. Louis, 2.

Missouri: Marble Cave, Stone County, 5; St. Louis, 1.

Montana: Big Snowy Mountains, 1; Prospect Creek, 2; Kalispell, 2; Milk River, 1.

Nevada: Pyramid Lake, 4; Carson Valley, 1.

New Hampshire: Charlestown, 1.

New York: Hammondville, 6; Sing Sing, 13.

Ontario: Toronto, 1 (skin).

Oregon: Anna Creek, 3; Des Chutes River, 4 (skins); Fort Klamath, 2.

Pennsylvania: Carlisle, 1; Center County, 2 (skins).

South Dakota: Smithville, 5; Custer, 1; Cheyenne River, 1; Fort Pierre, 1; Fort Meade, 1.

Texas: Brazos River, 1.

Utah: Cache County, 1; Laketown, 1; Ogden, 5; St. George, 4.

Washington: Spokane Bridge, 2; Geyser Basin, 1.

General remarks.—In size and general appearance typical *Vespertilio fuscus* occupies a somewhat intermediate position among the North American subspecies. It is considerably smaller than *miradorensis* and much larger than *propinquus* and *bahamensis*. Very pallid specimens are occasionally taken in the Southwestern United States, but the number of skins available for comparison is so small that it is impossible to determine the status of the form which these aberrant individuals represent.

Vespertilio fuscus and *V. serotinus* have been considered by many writers as races of a circumpolar species. Six specimens of the serotine—four from Budapest, Hungary, and two from Berne, Switzerland—kindly sent me by Mr. Oldfield Thomas, of the British Museum, prove conclusively that this view of the relationship of the two animals is untenable. The differences between the American and European forms are so great that, taken in connection with the complete geographic isolation which undoubtedly exists, they leave no doubt of the necessity of recognizing each as a distinct species. *Vespertilio serotinus* is a large and heavily built animal, approached in size by *V. fuscus miradorensis* alone among the races of *V. fuscus*. The adult females from Budapest measure, respectively: Total length, 131 and 134; tail vertebræ, 52 and 53; tibia, 22.8 and 22.6; foot, 10 and 11; forearm, 52 in each; thumb, 8.4 and 8; longest finger, 93 and 96; ear from meatus, 20 in each; width of ear, 13 and 14; tragus, 9 and 8.6. In addition to its large general size *V. serotinus* has relatively much larger skull and teeth than any of the races of *V. fuscus* (see figs. 24, 25, and 26). The skull of an adult female from Budapest (No. 4489, Miller coll.) measures: Occipito-nasal length, 21.4; zygomatic breadth, 15; mandible, 17; upper tooth row (exclusive of incisors), 8; lower tooth row, 10. The skull is considerably broader in proportion to its length than in *V. fuscus*, and the audital bullæ are relatively smaller. The teeth are much larger than those of *Vespertilio fuscus*, and the inner lobes of the upper molars are broader, in this respect approaching *V. fuscus cubensis*. The upper incisors are separated from the canines by a wider space than in *fuscus*, and this space subtends a distinct groove on the surface of the premaxilla between the roots of the canine and incisors. The paroccipital processes are much more strongly developed in *V. serotinus* than in any of the races of *V. fuscus*.

VESPERTILIO FUSCUS MIRADORENSIS (H. Allen).

1866. *Scotophilus miradorensis* H. Allen, Proc. Acad. Nat. Sci., Phila., p. 287.

Type locality.—Mirador, Vera Cruz, Mexico. Type in the United States National Museum, but now mislaid or lost.

Geographic distribution.—Costa Rica, Guatemala, and southern Mexico. Limits of range not known.

General characters.—Size larger and color darker than in the more northern form. Feet and distribution of fur as in true *fuscus*; ears and membranes thinner and more membranaceous.

Color.—In color *Vespertilio fuscus miradorensis* averages darker than true *fuscus*, thus agreeing with the other southern forms, *propinquus* and *cubensis*.

Skull.—The skull of *Vespertilio fuscus miradorensis* is slightly larger and somewhat less flattened than that of true *fuscus*. The skull of an adult male from Tehuacan, Puebla, measures: Occipito-nasal length, 19.5 mm.; zygomatic breadth, 13; mandible, 14.5. The occiput, although developing even more strongly marked ridges than in the typical subspecies, appears less sharply 'peaked' behind when viewed from the side.

Teeth.—The teeth are heavier than in true *fuscus*, and the crown of the middle upper molar is broader on its inner side, but no tangible dental characters can be established to separate the large subspecies.

Measurements.—See table, page 103.

Specimens examined.—Total number, 17, from the following localities:

Costa Rica: San José, 1.
Guatemala: Zuñil, Quezaltenango, 1.
Mexico: Valley of Toluca, 2 (skins); Ixtapalapa, 2.
Oaxaca: Cerro San Felipe, 1; Oaxaca, 1.
Puebla: Tehuacan, 3 (1 skin).
Tlaxcala: Mt. Malinche, 1.
Vera Cruz: Jico, 1; Las Vigas, 2; Tuxpango, 2 (skins).

VESPERTILIO FUSCUS PROPINQUUS (Peters).

1872. *Vesperus propinquus* Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin, p. 262.
1878. *Vesperugo propinquus* Dobson, Catal. Chiroptera Brit. Mus., p. 203.

Type locality.—Santa Ysabel, Guatemala.

Geographic distribution.—In addition to the type the only known specimen of *Vespertilio fuscus propinquus* is from Greytown, Nicaragua.

General characters.—Size very small (total length, 96 to 105; tail vertebrae, 37 to 45; longest finger, 68; ear, 14 to 15); breadth of muzzle distinctly more than half length of head; colors dark.

Ears.—The ears in *Vespertilio fuscus propinquus* are proportionally shorter and broader than in typical *fuscus*, and the tips are distinctly more broadly rounded. They are haired in exactly the same manner as in true *fuscus*. The ear membranes are thin and membranaceous, like those of the other southern races.

Membranes and feet.—Except for their smaller size, the membranes and feet are exactly as in true *fuscus*, though the membranes, like the ears, are thinner and less leathery.

Fur and color.—The fur is shorter than in true *fuscus*, averaging only about 7 mm. on back. There is nothing peculiar in its distribution. In the single alcoholic specimen that I have seen the color is about as in *V. fuscus miradorensis*. Peters, however, describes the color of the type specimen as rust red.[1] This is much brighter than the Greytown specimen, but the color may be due to staining while in alcohol.

Measurements.—See table, page 103.

Specimens examined.—I have seen only one specimen of *Vespertilio fuscus propinquus*. This was collected by Mr. Charles W. Richmond at Greytown, Nicaragua (♀ ad., No. 52790, U. S. National Museum, Dept. of Agriculture collection).

[1] "Oben rostroth, die Haare an der Basis schwarzbraun, Bauchseite blasser, indem die an der Basis schwarzbraunen Haare hier mehr rostgelbe Spitzen haben."

General remarks.—Among the races of *Vespertilio fuscus*, *V. fuscus propinquus* differs most widely in size and in form of head from its nearest geographical ally, *V. fuscus miradorensis*. It combines the small size of the West Indian *bahamensis*, the broad muzzle of true *fuscus*, and the delicate ears and membranes of the southern races in general. Additional material may show that it is specifically distinct.

VESPERTILIO FUSCUS BAHAMENSIS subsp. nov.

Type from Nassau, New Providence, Bahamas. Adult ♂ (in alcohol) No. 76537, U. S. National Museum (Biological Survey collection). Collected in the spring of 1894 by C. J. Maynard.

Geographic distribution.—This form is known from the type locality only.

General characters.—Size about as in *V. fuscus propinquus*; breadth

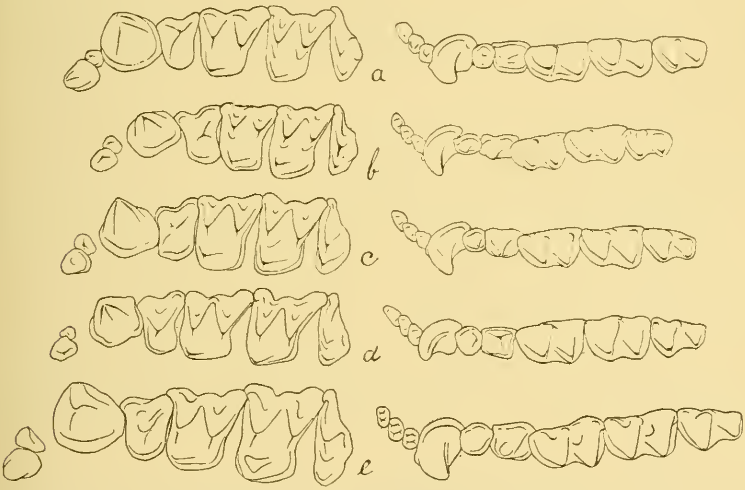


FIG. 26.—Teeth of (*a*) *Vespertilio fuscus*, (*b*) *V. bahamensis*, (*c*) *V. cubensis*, (*d*) *V. miradorensis*, and (*e*) *V. serotinus* (× 5).

of muzzle less than half length of head; ears narrower than in *propinquus*, about as in typical *fuscus*.

Ears.—Ears smaller than in typical *fuscus*, but of essentially the same shape, thus narrower than in *propinquus*. The ear membrane is thinner and more membranaceous than in true *fuscus*, in this respect resembling that of the other southern races.

Membranes and feet.—The membranes and feet are as in typical *fuscus*, allowance being made for the smaller size of *bahamensis*, and the difference in texture of the membranes common to all the southern races.

Fur and color.—The fur is shorter than in true *fuscus*, averaging only about 8 mm. in length on the back. It is distributed exactly as in the typical subspecies. So far as can be determined from specimens preserved in alcohol, the color is considerably darker and duller than in true *fuscus*.

Skull.—The skull of *Vespertilio fuscus bahamensis* is much smaller and more lightly built than that of typical *fuscus* (figs. 24*a* and 25*a*). The skull of a fully adult male measures: Occipito-nasal length, 16.5; zygomatic breadth, 11; mandible, 12.6. In form it differs from that of true *fuscus* in its narrower, deeper, more cylindric brain case and less sharply 'peaked' occiput.

Teeth.—The teeth, like the skull, are smaller than those of true *fuscus* (fig. 26*b*). In a fully adult male the upper tooth row (exclusive of incisors) measures 6.4 mm.; the mandibular tooth row, 7.8 mm. In form the teeth differ slightly from those of true *fuscus* in the greater breadth of the inner (lingual) side of the first and second upper molars.

Measurements.—See table, page 103.

Specimens examined.—Total number 90, all from the type locality.

General remarks.—*Vespertilio fuscus bahamensis* needs no comparison with typical *fuscus* or with *V. fuscus cubensis*, from both of which it differs widely in size. Its superficial resemblance to *V. fuscus propinquus* is closer. Unlike the latter, it has a very narrow muzzle.

VESPERTILIO FUSCUS CUBENSIS (Gray).

1839. *Scotophilus cubensis* Gray, Ann. Nat. Hist., IV, p. 7.

1840. *Vespertilio dutertreus* Gervais, in Ramon de la Sagra's Hist. de l'Ile de Cuba, Mammifères, p. 6.

1892. *Vesperugo fuscus cubensis* Chapman, Bull. Am. Mus. Nat. Hist., IV, p. 316.

Type locality.—Cuba.

Geographic distribution.—Cuba.

General characters.—Externally similar to *Vespertilio fuscus miradorensis*, but slightly smaller in general size, and with much smaller ears. Skull about as large as in true *fuscus*, thus much smaller than in *miradorensis*.

Ears.—The ears are delicate and papery, like those of the other southern races. They are smaller than in either *fuscus* proper or *miradorensis*. In form they differ markedly from those of true *fuscus* in their general narrowness, and especially in their more pointed tips. The characters of the ears have already been described by Mr. Chapman.

Membranes.—In form the membranes do not differ from those of the other subspecies. In texture they agree with the southern forms.

Fur and color.—The fur is distributed exactly as in the other subspecies. In color the specimens, after five years' immersion in alcohol, are darker and redder, especially on the whole ventral surface, than any others that I have seen. They even surpass *V. fuscus miradorensis* in darkness and richness of color.

Skull.—The skull of *Vespertilio fuscus cubensis* is about the size of that of true *fuscus* or a little smaller, thus distinctly smaller than that of *V. fuscus miradorensis*, the form to which *cubensis* bears the closest superficial resemblance, and much larger than that of *bahamensis*, its nearest geographical ally. In form the skull is similar to that of true *fuscus* but the brain case is slightly less flattened. The sagittal crest is well developed as in the other large subspecies.

Teeth.—The teeth of *Vespertilio fuscus cubensis* (fig. 26 *c*) differ from those of true *fuscus* in the greater breadth of the inner (lingual) sides of the maxillary molars. These teeth are also distinctly shortened in their transverse diameter. These peculiarities are exaggerations of the conditions found in *miradorensis* and *bahamensis.*

Measurements.—See table below.

Specimens examined.—Total number, 11, from the following locality:

Cuba: Trinidad, 10[1]; ———, 1.

General remarks.—*Vespertilio fuscus cubensis* is a fairly well marked insular form apparently most closely related to *V. fuscus miradorensis* of southern Mexico. It differs much less from this large continental subspecies than from *V. fuscus bahamensis*, its nearest geographical ally.

Average measurements of subspecies of Vespertilio fuscus.

Subspecies.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
fuscus	Massachusetts: Cambridge	2	116	47.5	19.5	10.4	45	6.8	81	18	13.3	8.3
	New York: Sing Sing	10	113.9	44.3	19.1	9.7	45.3	7	80	19.5	12.7	8.3
	District of Columbia: Washington.	5	110.8	46.5	19.1	9.7	44.8	6.5	80.5	18.1	12.8	8
	Mississippi: Bay St. Louis	2	108.5	42	19.5	10	47	6.7	79.5	17.5	12.5	7.8
	California: Nicasio	10	113	47	19.7	9.6	46.4	6	82	17.8	12.7	8.1
	Lone Pine	5	108.6	46	19.6	9.2	44.8	6.1	79.4	17	12.4	8.1
miradorensis	Vera Cruz: Mirador	[2]1	......	57	....	10.6	50	8.3	....	....	....	8.3
	Jico	1 ♂	118	48	22	10	50	8	91	19.4	13	10
	Las Vigas	1 ♀	120	50	22	10	51	7	85	18	13.6	9
	Tlaxcala: Mt. Malinche	1 ♂	120	50	21.6	11.4	52	6.4	96	19	13	8.8
	Puebla: Tehuacan	2 ♀♀	119	50.5	20.7	9.8	50.5	7	90	19	13.3	9
	Guatemala: Zuñil	1 ♂	110	....	20	10.4	50	6.4	....	18.6	12	3
	Costa Rica: San José	1	118	49	22	10	52	6.8	93	20	13.6	9
propinquus	Guatemala: Sta. Ysabel	[2]1	105	45	18	10	40	9.5	....	15	11.4	[illegible]
	Nicaragua: Greytown	1 ♀	96	37	17	7.8	40	5	68	14	11	7.8
bahamensis	New Providence: Nassau	[2]1 ♂	103	44	18	8	42	6	77	16.8	11	[illegible]
	Nassau	10	101.7	42.6	17.9	8.6	42.7	6	74	15.6	11.3	7.6
cubensis	Cuba: Trinidad	10	110.7	48.5	19.9	9	48.4	6.6	86	16.7	12.6	8.4

[1]For the opportunity of examining these specimens I am indebted to Dr. J. A. Allen of the American Museum of Natural History.

[2]Type.

[NOTE.—The following species is not represented in any of the extensive collections of bats recently made in Mexico. As I have never seen the animal and hence can form no opinion as to the weight of its characters, I have not attempted to include it in the synopsis of the North American forms of *Vespertilio*. Dobson's description, based on an examination of the type, may be introduced here, however, as an aid to the recognition of the species.]

VESPERTILIO ALBIGULARIS (Peters).

1872. *Vesperus* (*Marsipolæmus*) *albigularis* Peters, Monatsber. K. Akad. Wiss., Berlin, p. 260.

1878. *Vesperugo albigularis* Dobson, Catal. Chiroptera Brit. Mus., p. 207.

"Ears very broad and broadly rounded off above; the lower half of the outer margin of the ear-conch broadly folded backwards, as in *V. noctula*, separated in front from the angle of the mouth by a wart, *but terminating below and internal to it under the lower jaw by a small internal prolongation;* tragus broad above, attaining its greatest width above the middle of the inner margin, which is slightly concave, narrowest opposite the base of the inner margin, a prominent triangular lobe at the base of the outer margin. Nostrils rather wide apart, opening sublaterally; muzzle broad and obtuse; crown of the head scarcely elevated above the face-line.

"Wings from the base of the toes; postcalcaneal lobe long and narrow; last caudal vertebra free.

"Fur dark brown above, the extreme tips hoary, as in *V. noctivagans*, paler beneath, the *chin and throat*, as far back as a line connecting the posterior margins of the ears, *pure white*.

"Upper inner incisors long and broad and slightly bifid at their extremities: outer incisors very short, shortly exceeding the cingulum of the inner ones in vertical extent; the single upper premolar close to the canine; lower incisors in the direction of the jaws; first lower premolar half the size of the second, which exceeds the molars in vertical extent.

"Length (of the type specimen, an adult ♂), head and body 2''.35 [59.7 mm], tail 1''.5 [38 mm], head 0''.7 [17.8 mm], ear 0''.65 × 0''.13 [16.5 mm × 5.8 mm], forearm 1''.65 [41.9 mm], thumb 0''.35 [8.9 mm], third finger 2''.75 [69.8 mm], fifth finger 2'' [50.8 mm], tibia 0''.6 [15.2 mm], foot 0''.35 [8.9 mm].

"*Hab.*—Mexico. Type in the collection of the Berlin Museum.

"This species may be at once distinguished from all other species of *Vespertilionidæ* by the very peculiar manner in which the outer margin of the ear-conch terminates under the jaw, which has caused the describer, Dr. Peters, to make it the type of a new subgenus, *Marsipolæmus*. In the prolongation of the ear-conch, in the form of the tragus, and in dentition it resembles the African species of *Chalinolobus*."

General remarks.—This species is very different from any of those recently collected in Mexico, and is probably well worthy of subgeneric or even generic separation from *Vespertilio*. Its characters are so remarkable and Mexico has recently been so thoroughly explored that doubt is thrown on the accuracy of Peters' information concerning the type locality.

Genus LASIURUS Gray.

1831. *Lasiurus* Gray, Zoological Miscellany, No. 1, p. 38 (based on the American hairy-tailed bats).
1864. *Lasiurus* H. Allen, Monogr. N. Am. Bats, p. 14.
1870. *Atalapha* Peters, Monatsber. K. Akad. Wiss., Berlin, p. 907. (Not *Atalapha* Rafinesque, 1814.)
1878. *Atalapha* Dobson, Catal. Chiroptera Brit. Mus., p. 267. (Not *Atalapha* Rafinesque, 1814.)
1893. *Atalapha* H. Allen, Monogr. Bats N. Am., p. 141. (Not *Atalapha* Rafinesque, 1814.)

Type species.—Lasiurus borealis (Müller).

Geographic distribution of genus.—The whole of North America and South America, the West Indies, Sandwich Islands, and Galapagos Islands.

Generic characters.—Dental formula: $i. \frac{1\text{-}1}{3\text{-}3}$; $c. \frac{1\text{-}1}{1\text{-}1}$; $pm. \frac{2\text{-}2}{2\text{-}2}$; $m. \frac{3\text{-}3}{3\text{-}3}=32$; upper incisor in contact with canine; a minute upper premolar at base of canine on inner (lingual) side; dental formula otherwise as in *Dasypterus*, *Nycticeius*, and *Rhogeëssa;* skull (figs. 28, 29, 31) broad, short and deep, very different in form from that of any other North American genus of *Vespertilionidæ* except *Dasypterus;* ear (fig. 27) broad, blunt, and rounded at tip, hairy on most of dorsal surface; dorsal surface of interfemoral membrane furred nearly to extreme edge; mammæ, 4.

The members of the genus *Lasiurus* are recognizable among North American bats by their thickly furred interfemoral membranes. Two distinct species are known to occur north of Panama; one of these is divisible into at least five well-marked geographic races.

KEY TO NORTH AMERICAN FORMS OF LASIURUS.

Size large (forearm more than 50 mm.) ....*cinereus* (p. 112)
Size small (forearm 36–44).
  Underside of wing membrane very sparsely haired along forearm. *mexicanus* (p. 111)
  Underside of wing membrane thickly furred immediately back of forearm.
    Ear small and with slightly developed external basal lobe.... *teliotis* (p. 110)
    Ear large and with well-developed external basal lobe.
      Color mahogany brown ....*seminolus* (p. 109)
      Color varying from deep rich cherry red through orange and yellow to light yellowish gray.
        Color deep rich cherry red, forearm 42–44 ....*pfeifferi* (p. 110)
        Color varying from yellowish gray to light red, forearm 36–43 ....*borealis* (p. 105)

LASIURUS BOREALIS (Müller). Red Bat.

1776. *Vespertilio borealis* Müller, Natursyst. Suppl., p. 21.
1777. *Vespertilio noveboracensis* Erxleben, Syst. Regni Anim., I, p. 155.
1781. *Vespertilio lasiurus* Schreber, Säugthiere, Abth. I. Taf. LXII B (published with Abth. IV Heft 4. See Sherborn, Proc. Zool. Soc. London, 1891, p. 589).
1785. *Vespertilio noveboracus* Boddaert, Elenchus Animalium, I, p. 71.
1785. *Vespertilio lasurus* Boddaert, Elenchus Animalium, I, p. 71.
1796. *Vespertilio rubellus* Palisot de Beauvois, Catal. Peale's Museum, p. 204.

1814. *Atalapha americana* Rafinesque, Précis des découv. somiol., p. 12 (nomen nudum).[1]
1815. *Vespertilio rubra* Ord, Guthrie's Geography, 2d Am. ed., II, p. 291.
1818. *Vespertilio tesselatus* Rafinesque, American Monthly Mag., III, p. 445.
1818. *Vespertilio monachus* Rafinesque, Am. Monthly Mag., III, p. 445.
1820. *Vespertilio rufus* Warden, Description des États-Unis de l'Amérique Septentrionale, V, p. 606.
1863. *Lasiurus noveboracensis* H. Allen, Monogr. N. Am. Bats, p. 15.
1870. *Lasiurus funebris* Fitzinger, Sitzungsber. k. Akad. Wissensch. Wien, LXII, p. 46.
1878. *Atalapha noveboracensis* Dobson, Catal. Chiroptera Brit. Mus., p. 269.
1893. *Atalapha noveboracensis* H. Allen, Monogr. Bats N. Am., p. 142.
1894. *Atalapha borealis* Rhoads, American Naturalist, XXVIII, p. 523.

Type locality.—New York.

Geographic distribution.—The typical form of *Lasiurus borealis* ranges through the Boreal, Transition, and Austral zones in eastern North America from Canada to Florida and Texas, west at least to Indian Territory and Colorado. Southern and western limits of range not known. Probably breeds throughout its known range.

General characters.—Size small (forearm, 38 to 43; longest finger, 78 to 88); forearm with no distinct tuft of fur near proximal end; color very variable, ranging from bright yellowish red or fawn color to yellowish gray; a whitish area in front of shoulder.

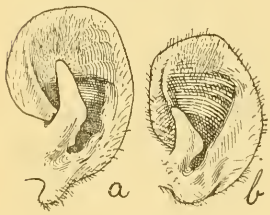


FIG. 27.—Ear of (*a*) *Lasiurus borealis* and (*b*) *L. teliotis* (×2).

Ears.—The ears of typical *Lasiurus borealis* (fig. 27*a*) when laid forward reach a little more than halfway from angle of mouth to nostril. The anterior border is strongly but irregularly convex from free point of anterior basal lobe to tip, a distance through which it forms almost a semicircle. The posterior border is slightly concave immediately below tip, then evenly convex to basal lobe. The convex portion of the outline of the posterior border forms the arc of a circle with considerably longer radius than that of the anterior border. Posterior basal lobe strongly developed and deeply notched on anterior border. Inner side of ear naked except for a few scattered hairs, which are especially numerous along anterior and posterior borders. Outer side densely furred throughout basal two thirds, naked at tip.

Tragus triangular in general outline. Anterior border straight from base to slight concavity just below tip; posterior border straight from tip to widest point (opposite anterior base), where there is a strong angle, below which the margin is straight to slightly developed basal lobe.

[1] Rafinesque says: "J'ai observe cette espèce [*A. sicula* Raf.] en Sicile, elle diffère de l'*Atalapha americana* (*Vespertilio noveboracensis* Lin.), autre espèce du même genre, par ses deux premiers et son dernier caractère."

Membranes.—The flight membranes are attached at base of toes, the uropatagium at extreme tip of tail.

Feet.—The foot is small, less than half as long as tibia. Dorsal surface of toes thickly furred. Calcar about twice as long as foot and considerably shorter than free border of interfemoral membrane. It is slightly developed, indistinctly keeled, and seldom lobed at tip.

Fur and color.—The fur is everywhere full and soft. On middle of back it is about 7 mm. in length and on neck about 10 mm. It covers the basal two-thirds of dorsal side of ear, the whole dorsal side of the interfemoral membrane, and the dorsal side of the flight membrane to a line running from ankle to middle of humerus. There is a narrow strip of fur running along basal third of fifth metacarpal and a squarish clump at base of thumb. Near base of forearm (in position occupied by strip of fur in *L. cinereus*) there are numerous fine scattered hairs, which are so inconspicuous as readily to escape notice. On the ventral surface the fur reaches about to middle of uropatagium and on flight membranes to line joining knee and elbow. Beyond elbow a sparse growth of hairs covering an area 10 mm. or more in width extends along forearm to bases of fingers, where it becomes much more dense. The antebrachial membrane is covered with a sparse coating of hairs on the ventral surface.

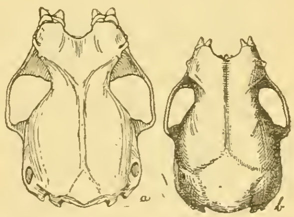


FIG. 28.—Top view of skull of (*a*) *Lasiurus borealis* and (*b*) *L. teliotis* (2).

In color typical *Lasiurus borealis* varies very extensively, but never shows the mahogany brown of *seminolus* or the intense red of the tropical races. Red specimens are rufous red throughout (the exact shade somewhere between rufous and burnt sienna), paler and more fawn-colored on the belly, the hairs of the back usually with distinct grayish tips, those on the throat and chest tipped with whitish. A yellowish white patch in front of each shoulder. Frequently the white on chest tends to connect the shoulder patches by a whitish collar. The individual hairs on the back are blackish at base, then light rufous to the narrow subapical band which gives the characteristic color to the back, and, finally, grayish white at extreme tips. Gray specimens are yellowish gray on the back and buffy on the belly. The red usually persists as a faint salmon suffusion.

Skull.—The skull of typical *Lasiurus borealis* (figs. 28 *a*, 29 *b*) has the broad rostrum and flaring zygomata of *L. cinereus*. The dorsal profile of the skull is nearly straight from external nares to highest point of occiput. The skull of an adult female from Washington, D.C., measures: Greatest length, 13.8; zygomatic breadth, 10.2; breadth of rostrum at posterior edge of large premolar, 6; mandible, 10; upper tooth row, 5.4; lower tooth row, 6.4.

Teeth.—The teeth (fig. 30 *b*) are large, the upper molars broad on the inner (lingual) side, and the lower molars wide in their transverse diameter.

Measurements.—See table, page 115.

Specimens examined.—Total number, 387, from the following localities:

Alabama: Mobile Bay, 3; Greensboro, 9 (2 skins, Merriam coll.).
Arkansas: Fort Smith, 1.
District of Columbia: Washington, 20 (6 skins).
Florida: Old Town, 1 (skin, Miller coll.); St. Marys, 1.
Georgia: Riceboro, 8.
Illinois: Mount Carmel, 1 (skin); Olney, 3; Warsaw, 2; West Northfield, 1 (skin).
Indian Territory: Hartshorne, 1 (skin); Redland, 3.
Kansas: Cedar Vale, 1.
Kentucky: Hickman, 2.
Louisiana: Lafayette, 1; New Orleans, 2; Pineville, 1; Shreveport, 1.
Massachusetts: Nantucket, 1.
Mississippi: Hancock County, 1 (skin, Miller coll.): Washington, 10.
Missouri: Golden City, 1; Marble Cave, Stone County, 1.
New York: Greene, 1; Hartford, 1 (skin); Oyster Bay, 1 (skin); Sing Sing, 86.
North Carolina: Fort Macon, 1 (skin); Magnetic City, 1 (skin); Roan Mountain, 1 (skin).
Oklahoma: Ponca, 2.
Ontario: North Bay, 2 (Miller coll.); Toronto, 1 (skin).
Pennsylvania: Bainbridge, 1; Carlisle, 1 (skin); Kenneth Square, Chester County, 1.
South Carolina: Mount Pleasant (near Charleston), 7 (skins, Miller coll.)
Tamaulipas: Matamoras, 2.
Tennessee: Alexandria, 1; Arlington, 2; Big Sandy, 11; Clarksville, 1; Danville, 1.
Texas: Arthur, 3; Brownsville, 158 (3 skins); Clarksville, 1; Corpus Christi, 2; Fort Clark, 1; Nueces Bay, 1; Paris, 3; Waco, 1 (skin, Miller coll.); Wichita Falls, 1.
Virginia: Amelia Court-House, 1; Berryville, 1 (skin); Dismal Swamp, 2; Gainesville, 1.

General remarks.—Typical *Lasiurus borealis* presents a wide range of individual variation, but may always be distinguished from the other subspecies by fairly constant characters. It never shows the mahogany brown coloring of *L. borealis seminolus* and seldom approaches the brilliant cherry red of *L. borealis pfeifferi*. From *L. borealis teliotis* it differs in its larger ear with well-developed, strongly-notched external basal lobe.

Specimens from Brownsville, Tex., where the animal breeds, are slightly smaller than those from New York, and the ear is proportionally shorter (see table of measurements, p. 115). In this respect they are intermediate between true *borealis* and *teliotis*, though the ear is formed exactly as in the typical subspecies. Specimens from Oklahoma and Indian Territory, on the other hand, are indistinguishable from northeastern specimens.

LASIURUS BOREALIS SEMINOLUS (Rhoads).

1895. *Atalapha borealis seminola* Rhoads, Proc. Acad. Nat. Sci. Phila., p. 32.

Type locality.—Tarpon Springs. Fla.

Geographic distribution.—Lower Austral and Tropical zones from South Carolina to southern Texas.

General characters.—In size and proportions similar to typical *Lasiurus borealis;* general color mahogany brown, slightly frosted with grayish.

Ears, membranes, feet, and distribution of fur.—In all external characters except color *Lasiurus borealis seminolus* agrees with typical *borealis.*

Color.—General color rich mahogany brown throughout, the back (especially between the shoulders) slightly frosted with gray and the throat and chest varied with whitish. A distinct whitish area in front of shoulder as in true *borealis.* Muzzle, backs of ears, and fur bordering forearm, yellowish brown. Clump of fur at base of thumb whitish or yellowish. On middle of back the fur is about 12 mm. in length. In this region the colors on the individual hairs are arranged in four bands as follows: Basal band deep blackish plumbeous (this band usually broader than in true *borealis*), middle band light gray, subapical band rich mahogany, extreme tip grayish white.

Color variation in *Lasiurus borealis seminolus* is much less than in typical *borealis*, and is chiefly noticeable in the amount of red in the mahogany brown, in the amount of white on the throat and chest, and in the shade of gray in the broad middle band on the hairs of the back. This is often strongly suffused with yellowish.

Skull and teeth.—As in typical *borealis.*

Measurements.—See table, page 115.

Specimens examined.—Total number, 19, from the following localities:

Florida: Old Town, 3 (skins, Miller coll.); Lake Harney, 2.
Georgia: Nashville, 1.
Louisiana: New Orleans, 5.
Mississippi: Bay St. Louis, 3.
South Carolina: Mount Pleasant (near Charleston), 4.
Texas: Brownsville, 1.

General remarks.—*Lasiurus borealis seminolus* appears to be a well-marked subspecies confined to the Austroriparian fauna. The single specimen taken at Brownsville, Texas (No. 59976, U. S. National Museum) was killed on September 8, 1891, and may have been a migrant. No intermediates between *seminolus* and true *borealis* has yet come to light, but the perfect agreement of the two forms in all charaters except color makes me unwilling to recognize them as species. The possibility that *seminolus* and true *borealis* are dichromatic phases of one species lacks weight on account of the total absence of intermediate specimens, and also from the fact that both forms have not yet been found breeding at any one locality.

LASIURUS BOREALIS PFEIFFERI (Gundlach).

1861. *Atalapha pfeifferi* Gundlach, Monatsber. K. Preuss Akad. Wiss., Berlin, p. 152.
1878. *Atalapha noveboracensis* var. *β* (*Atalapha pfeifferi*) Dobson, Catal. Chiroptera Brit. Mus., p. 271.
1892. *Atalapha noveboracensis pfeifferi* Chapman, Bull. Am. Mus. Nat. Hist., IV, p. 316.

Type locality.—Cuba.

Geographic distribution.—Cuba. Jamaica? Bahamas?

General characters.—Slightly larger than typical *Lasiurus borealis*, but similar in proportions; color brighter and more intense.

Ears, membranes, feet, and distribution of fur.—As in the typical subspecies.

Color.—I have seen no skins of the Cuban red bat, and am therefore unable to give a detailed description of the animal's color. The two specimens collected by Mr. Chapman in 1892 have now been in alcohol for five years. Hence their color furnishes no trustworthy basis for comparison with that of continental material. When compared with alcoholic specimens from the eastern United States they are appreciably brighter.

Measurements.—See table, page 115.

Specimens examined.—Two from Trinidad, Cuba (Am. Mus. Nat. Hist.).

A skull from Nassau, Bahamas (Miller coll.), and an imperfect skin from Spanishtown, Jamaica, may be referable to this race, but it is not possible to identify them with certainty.

General remarks.—*Lasiurus borealis pfeifferi* is a tolerably well-marked insular form, distinguished from typical *borealis* by its slightly larger size and brighter color.

LASIURUS BOREALIS TELIOTIS (H. Allen).

1891. *Atalapha teliotis* H. Allen, Proc. Am. Philos. Soc., XXIX, p. 1.
1893. *Atalapha teliotis* H. Allen, Monogr. Bats N. Am., p. 153.

Type locality.—Unknown, probably some part of California (type in U. S. National Museum).

Geographic distribution.—This form is known from a few localities in California and Lower California from the head of the Sacramento Valley south to Comondu.

General characters.—Slightly smaller than typical *Lasiurus borealis*; ear proportionally much shorter than in the typical subspecies, and with external basal lobe greatly reduced in size; color averaging brighter than in the typical form.

Ears.—The ear (fig. 27*b*) is similar in form to that of typical *borealis*, except that the tip is slightly narrower and the external basal lobe is reduced in size, indistinctly marked off from the rest of the ear, and scarcely, if at all, notched on its anterior border.

Membranes, feet, and distribution of fur.—The external form, with the exception of the size and shape of ears, is as in true *borealis*.

Color.—I have seen only four skins of the Californian red bat. In these the color is uniformly slightly darker and redder than in ordinary red specimens of true *borealis*. The difference is especially noticeable on the interfemoral membrane, rump, and lumbar region. One skin (♂) from Dulzura, Cal., almost lacks the grayish tips to the hairs on the back. Another (also ♂) taken at the same place on the same day (November 5, 1891) shows the gray tips very distinctly on the neck and fore part of the back.

Skull.—The skull of *Lasiurus borealis teliotis* (figs. 28 *b*, 29 *a*) is distinguishable from that of typical *borealis* by its smaller size, narrower rostrum, and less flaring zygomata. That of an adult male from Dulzura, Cal., measures: Greatest length, 12.4; zygomatic breadth, 9; breadth of rostrum at posterior edge of large premolar, 5.2; upper tooth row, 4.6. The mandible of this specimen is lost. That of another adult male from the same locality measures: Length, 9; lower tooth row, 5.4.

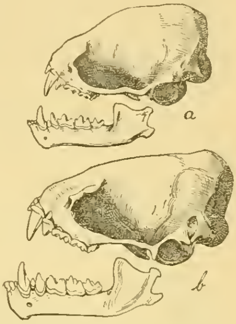


FIG. 29.—Side view of skull of (*a*) *Lasiurus teliotis* and (*b*) *L. borealis* (×2).

Teeth.—The teeth are smaller than in the typical subspecies, the upper molars are narrower on the inner (lingual) side, and the mandibular teeth are narrower in their transverse diameter (fig. 30 *a*.)

Measurements.—See table, page 115.

Specimens examined.—Total number, 10, from the following localities:

California: Exact locality unknown, 1 (type); Bakersfield, 1; Berryessa, Santa Clara County, 1 (skin); Dulzura, 2 (skins, Miller coll.); Fresno, 1; Santa Ysabel, San Diego County, 1; Tehama, 1; Three Rivers, 1.
Lower California: Comondu, 1 (skin).

FIG. 30.—Teeth of (*a*) *Lasiurus teliotis* and (*b*) *L. borealis* (×5).

General remarks.—*Lasiurus borealis teliotis* is readily distinguishable from typical *borealis* by its smaller ear, with less developed and entire external basal lobe, smaller skull, with narrower rostrum, and weaker dentition. From *L. borealis mexicanus* it differs in completely furred dorsum of interfemoral membrane and more hairy under side of wing.

LASIURUS BOREALIS MEXICANUS (Saussure).

1861. *Atalapha mexicana* Saussure, Revue et Mag. de Zool., 2e sér., XIII, p. 97, Mars., 1861 (southern Mexico).

1871. *Atalapha frantzii* Peters, Monatsber. K. Preuss. Akad. Wiss., Berlin (1870), p. 908, 1871 (Costa Rica).

1878. *Atalapha noreboracensis* var. α (*Atalapha frantzii*) Dobson, Catal. Chiroptera Brit. Mus., p. 271.

Type locality.—Not stated, but without doubt in some one of the States of southern Mexico, probably Vera Cruz, Puebla, or Oaxaca.

Geographic distribution.—Central America and southern Mexico. Limits of range unknown.

General characters.—Apparently most like *Lasiurus borealis teliotis*, but feet, interfemoral membrane, and under side of wings much less hairy.

Ears.—In dried specimens the ears appear to be essentially as in *L. borealis teliotis*, though the external basal lobe may be slightly more developed.

Membranes and feet.—These show no distinctive characters.

Fur and color.—On the body the fur shows no peculiarities as compared with the other subspecies. On the interfemoral membrane it extends thickly to about the middle, then becomes more sparse, and finally disappears, leaving the edge of the membrane bare. The backs of the feet are scarcely furred. On the under side of the wings, the area behind the forearm which is densely furred in the other subspecies, is merely sprinkled with inconspicuous hairs: these are, however, more dense at the bases of the fingers. The antebrachial membrane is also very sparsely furred.

Color as in *L. borealis teliotis*.

Measurements.—See table, page 115.

Specimens examined.—Total number, 8, from the following localities:

Jalisco: ———, 6.
Tehuantepec: Guichicovi, 1 (skin).
Vera Cruz: Pennela (near Cordova), 1 (skin).

General remarks.—From the unsatisfactory material at my disposal it appears that *Lasiurus borealis mexicanus* is a well-marked race, most like *teliotis*, but differing from this, as well as from all the other known subspecies, in the restricted peripheral distribution of the fur.

LASIURUS CINEREUS (Beauvois). Hoary bat.

1796. *Vespertilio linereus* Palisot de Beauvois, Catal. Peale's Museum, Philadelphia, p. 14. (Obvious misprint for *cinereus*.)
1823. *Vespertilio pruinosus* Say, Long's Exped. to Rocky Mts., I, p. 167 (footnote).
1864. *Lasiurus cinereus* H. Allen, Monogr. N. Am. Bats, p. 21.
1878. *Atalapha cinerea* Dobson, Catal. Chiroptera Brit. Mus., p. 272.
1893. *Atalapha cinerea* H. Allen, Monogr. Bats N. Am., p. 155.

Type locality.—Philadelphia, Pennsylvania.

Geographic distribution.—Boreal North America from Atlantic to Pacific. The hoary bat breeds within the Boreal zone, but in autumn and winter it migrates south to the southern border of the United States and probably much farther.

General characters.—Size, large (forearm, over 50 mm.); prevailing color, gray; ears with black rims; forearm with distinct patch of fur near base.

Ears.—The ears of *Lasiurus cinereus* are in general similar to those of *L. borealis*, but are broader in proportion to their length (see table of measurements, p. 115). The external basal lobe is less developed than in *borealis* and without trace of notch on anterior border. Margin of ear membrane dark brown or blackish. Outer side of ear densely furred to a little beyond middle. Inner side with conspicuous patch of yellowish hairs above and in front of middle and a border of similar hairs along lower part of anterior edge.

Tragus shaped as in *L. borealis*, covered with sparse coating of hairs on outer side.

Membranes.—In form and attachment the membranes are as in *L. borealis.*

Feet.—Foot about half as long as tibia; dorsal side thickly furred. Calcar twice as long as foot and slightly shorter than free border of interfemoral membrane. It is distinctly though narrowly keeled on posterior edge, and usually lobed at tip. The terminal lobe is very variable, and may be well developed on one side and absent on the other.

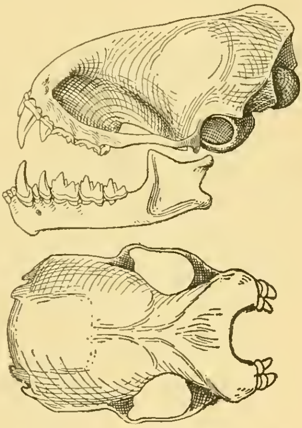


Fig. 31.—Skull of *Lasiurus cinereus* (×2).

Fur and color.—The fur is distributed much as in *L. borealis.* As in that species, it is distinctly longer on neck than on back, thus forming a ruff. On the neck it averages about 15 mm. in length, on the back 11 mm. General color, a mixture of light yellowish brown, deep umber brown, and white, the yellowish brown clear and unmixed on throat, head, and under side of membranes, the umber brown predominating on back and dorsal surface of interfemoral membrane, where, however, the hairs are mostly tipped with silvery white, sometimes to so great an extent as nearly to conceal the dark tints beneath. Lips, chin, and cheeks sprinkled with short blackish hairs. Ventral surface with white predominating on belly, between which and yellow of throat is a band in which the umber brown is more conspicuous than elsewhere on the under parts. Tufts of fur at bases of thumb, fifth finger, and forearm, light yellowish brown, like fur on under side of wing membranes. On middle of back the individual hairs are colored as follows: Deep plumbeous at base; light yellowish brown (shading toward umber distally) through middle half; umber brown subapically; silvery white at tip.

Color variation is considerable, but never enough to obscure the characters of the species. It appears to be wholly independent of locality, as skins from such widely separated localities as Minnesota and southern California are practically indistinguishable.

One skin from the Santee River, South Carolina, has the dusky tints throughout the pelage so intensified and extended as to suggest melanism. Another from Eureka, California, is in a similar phase, though not so extreme.

Skull.—The skull (fig. 31) resembles that of *Dasypterus intermedius* and *Lasiurus borealis*, but is intermediate between the two in size. The rostrum is broad and short and the zygomatic arches broadly flaring. The skull of an adult female from Santa Ysabel, California, measures: Greatest length, 16.4; zygomatic breadth, 12; breadth of rostrum at posterior border of large premolar, 8; mandible, 12.6; upper-tooth row, 6.4; lower-tooth row, 8. That of an adult female from Fort Snelling, Minnesota, measures: Greatest length, 17; zygomatic breadth, 12; breadth of rostrum at posterior edge of large premolar, 8; mandible, 13.6; upper-tooth row, 7; lower-tooth row, 8.

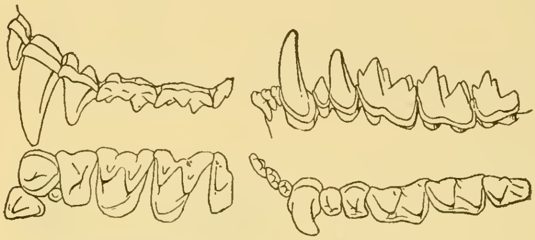


FIG. 32.—Teeth of *Lasiurus cinereus* (· 5).

Teeth.—The teeth of *Lasiurus cinereus* (fig. 32) are large and strong, but the minute upper premolar is proportionally smaller than in *L. borealis*.

Measurements.—See table, page 115.

Specimens examined.—Total number, 56, from the following localities:

Alabama: Mobile Bay, 1.
Alberta: Eight miles NW. of Red Deer, 1 (skin, Miller coll.).
Arizona: Tempe, Maricopa County, 1.
California: Berryessa, Santa Clara County, 1; Cloverdale, 1; Eureka, 1 (skin); Kern River, 1; Monterey, 1; Nicasio, 1; Panamint Mountains, 2; Santa Ysabel, 1 (skin).
Chihuahua: San Luis Mountains, 1.
Colorado: Larimer County, 3 (skins, Miller coll.).
District of Columbia: Washington, 1.
Georgia: Savannah River, 1.
Illinois: Warsaw, 1.
Kansas: Little Blue River, 1; North Falls, 1.
Louisiana: Pineville, 1.
Maryland: Laurel, 1.
Massachusetts: North Truro, 6 (skins, Miller coll.).
Minnesota: Fort Snelling, 1.
Nebraska: Fort Pierre, 1; Fort Union, 2; Loup Fork, 1.
Nevada: Vegas Valley, 1.
New Mexico: Dog Spring, Grant County, 2; Doña Ana, 1.
New York: Westville, Long Island, 1; Locust Grove, 4.
Nova Scotia: Halifax, 1.
Tamaulipas: Matamoras, 1.
Texas: Brownsville, 9 (1 skin, Miller coll.).
Washington: Almota, 1; Fort Walla Walla, 1.

Average measurements of North American forms of Lasiurus.

Name.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
borealis	Ontario: North Bay	2♂♂	106	47.5	19.5	7.2	39	6.7	79.5	11.8	11.4	6.5
	New York: Sing Sing	10	110.4	50.9	19.6	7.8	39.7	7	81.7	11.9	11	7
	District of Columbia: Washington.	4	103	47.5	19.2	7.4	38.5	6.3	79.3	11.2	10.1	6.5
	Mississippi: Washington	10	105.6	49.1	19.2	7.4	40.1	7.3	80.4	11.8	10.1	6.7
	Texas: Brownsville	10	108.9	52.7	18.6	7.9	40.6	6.4	82.8	10.5	9.8	6.1
seminolus	South Carolina: Charleston.	2♂♂	100	46	19	6.9	40	7	81	12.7	10.7	6.9
	Florida: Lake Harney	2♂♂	97.5	45	19.3	7	40	7	79	11.3	10	6.5
	Mississippi: Bay St. Louis	3♀♀	104.3	50	19.3	7.6	40.2	7.4	83	12	11	6.5
	Texas: Brownsville	1♀	115	54	20	9	42	7	87	12.6	11.4	7
pfeifferi	Cuba: Trinidad	2♂♂	106.5	50.5	21.8	7	44	6.8	89.5	12.5	10.7	6.8
teliotis	California: ? (type)	1	....	....	20	6.6	39	7	79	9	7.6	5.4
	Three Rivers	1♂	96	47	....	8	37	6.6	74	9.8	9.8	6.4
	Tehama	1♂	107	57	20	8	39	6.4	82	9.4	9.6	6
	Bakersfield	1♀	100	45	19.6	8.6	40	7	76	10	9	6
mexicanus	Jalisco	6	113.3	57	20.2	8.1	41.2	7.4	86.5	13	10.2	6.5
cinereus	New York: Locust Grove	4	134.5	57.5	23.2	10	50.2	10.6	107	18	17.2	9.5
	California: Panamint Mts.	2♀♀	136	58.5	23.5	9	54	10	109	17.5	17.7	9
	Cloverdale	1♂	130	52	23	10	46	10.4	101	17	15	9
	Monterey	1♂	138	57	24	9	55	10	110	17	16	9
	Kern River	1♂	140	58	23	9	51	10	103	18	17.6	9

Genus DASYPTERUS Peters.

1864. *Lasiurus* H. Allen, Monogr. N. Am. Bats, p. 25 (part).
1871. *Dasypterus* Peters, Monatsber. K. Akad. Wiss., Berlin (1870), p. 912 (subgenus).
1878. *Atalapha* Dobson, Catal. Chiroptera Brit. Mus., p. 267. (Part—not *Atalapha* Rafinesque, 1814.)
1893. *Dasypterus* H. Allen, Monogr. Bats N. Am., p. 137 (genus).

Type species.—*Dasypterus intermedius* H. Allen.

Geographic distribution of type species.—Gulf States and northeastern Mexico.

Geographic distribution of genus.—The range of the genus is the same as that of the only known species.

Generic characters.—Dental formula:

$$i, \frac{1-1}{3-3}; \; c, \frac{1-1}{1-1}; \; pm, \frac{1-1}{2-2}; \; m, \frac{3-3}{3-3}=30;$$

upper incisor in contact with canine; skull (fig. 33) easily distinguishable from that of any other American genus of *Vespertilionidæ*, except *Lasiurus*, by its extreme shortness, depth, and breadth; ear considerably higher than broad, somewhat tapering at tip, naked on half of dorsal surface; dorsal surface of interfemoral membrane furred on basal half only; mammæ, 4.

General remarks.—Without seeing the South American species originally associated with *D. intermedius* by Peters, it is impossible to determine whether these belong in the genus as now understood.

DASYPTERUS INTERMEDIUS H. Allen.

1863. *Lasiurus intermedius* H. Allen, Proc. Acad. Nat. Sci. Phila. (1862), p. 146.
1864. *Lasiurus intermedius* H. Allen, Monogr. N. A. Bats, p. 25.
1878. *Atalapha intermedia* Dobson, Catal. Chiroptera Brit. Mus., p. 274.
1893. *Dasypterus intermedius* H. Allen, Monogr. Bats N. Am., p. 137.

Type locality.—Matamoras, Tamaulipas, Mexico.

Geographic distribution.—Gulf States and northeastern Mexico.

General characters.—Size, large (forearm, 45–56); color, light brown.

Ears.—The ears are short, reaching barely to nostril when laid forward. The dorsal surface is densely furred on basal half, but otherwise the ear is naked except for a sprinkling of hairs on inner side, especially along anterior edge. Beginning at lower edge of basal lobe the anterior margin is first strongly convex, then nearly straight for a distance of about 6 mm., then abruptly convex (or even angular), after which it continues nearly straight to narrowly rounded off tip. Posterior border slightly concave immediately below tip, then gently and evenly convex to notch above posterior basal lobe. Posterior basal lobe well developed, slightly notched on lower side, and joining face about 5 mm. behind angle of mouth.

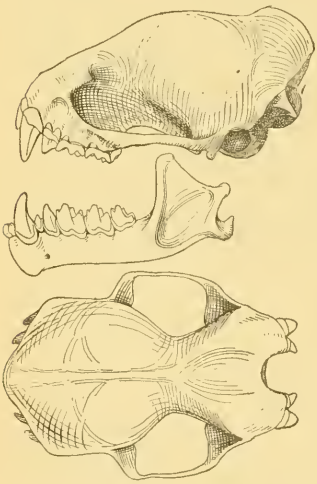


Fig. 33.—Skull of *Dasypterus intermedius* (×2.)

Tragus blunt and bent forward, anterior border nearly straight to slight concavity just below tip. Posterior border convex immediately below tip, then straight to point opposite anterior base. Here a sharp angle is formed, below which the margin is irregularly crenulated to base.

Feet.—The foot is moderate in size, a little less than half as long as tibia. Calcar slightly shorter than tibia, very indistinctly keeled and terminating obscurely or in an ill-defined lobe.

Membranes.—Membranes thick and leathery. Wing membrane attached at base of toes, uropatagium near tip of last caudal vertebra. Free border of uropatagium slightly longer than calcar.

Fur and color.—The fur is full and soft. On the middle of the back it is about 12 mm. in length. The fur of the back extends on basal half of outer side of ear, basal half of dorsal surface of interfemoral membrane, and base of wing membranes. On the latter it occupies a strip about 10 mm. in width. There is a slight tuft of hair at the base of the thumb, and in many specimens a faintly indicated tuft near proximal end of forearm. On the ventral surface the fur barely reaches the uropatagium except along the basal fourth of tail. A thin coating of fur occupies the under side of the wing membrane to a line joining elbow and knee. Beyond this it extends in a strip about 10 mm. wide along posterior edge of forearm to bases of fingers. The greater part of the propatagium is thinly furred.

Color light yellowish brown of variable shade, the hairs throughout the body with narrow dark plumbeous bases and those of the back with faintly dusky tips. The general effect is suggestive of the color of *Pipistrellus subflavus*.

Skull and teeth.—The skull (fig. 33) and teeth (fig. 34) have been sufficiently described under generic characters. The skull of an adult

FIG. 34.—Teeth of *Dasypterus intermedius* (×5).

female from Brownsville, Tex. (No. 52540, U. S. National Museum), measures: Greatest length, 19.6; zygomatic breadth, 15; breadth of rostrum at posterior edge of premolar, 9; mandible, 15; upper tooth row, 8; lower tooth row, 9. The skull of an adult male from Houma, La., measures: Greatest length, 18; zygomatic breadth, 13; breadth of rostrum at posterior edge of premolar, 8; mandible, 14; upper tooth row, 7; lower tooth row, 8.6.

Measurements.—Average measurements of 18 specimens of *Dasypterus intermedius* from five localities are given in the following table:

Average measurements of 18 specimens of Dasypterus intermedius from 5 localities.

Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
Texas: Brownsville	10♀♀	145	65.9	24.9	10	55	8.9	111	18.8	14.4	8.8
Louisiana: Lafayette	2♀♀	126.5	52	20	8.7	48	7	96	18.5	15.5	9.3
Houma	2♂♂	130	61	18.9	9	46	6	95.5	18	15	9.4
Florida: Old Town	3	127	63.5	20	9	45.5	......	......	......	......	......
Mullet Lake	1♂	120	54	18	8	47	7	95	17	14	8

Specimens examined.—Total number 72, from the following localities:

Florida: Davenport, 1 (skin); Mullet Lake, 1; Old Town, 3.
Louisiana: Lafayette, 2; Houma, 2 (1 skin).
Mississippi: Hancock County, 1 (skin).
Tamaulipas: Matamoras, 3 (2 skeletons).
Texas: Brownsville, 57 (2 skins); Padre Island, 1; Cameron County, 1.

General remarks.—Aside from its generic characters *Dasypterus intermedius* is distinguishable among North American bats by its large size, small ears, and yellowish brown color.

Specimens from Louisiana, Mississippi, and Florida average distinctly smaller than those from Brownsville, Tex. (which are essentially topotypes). More extensive material than that now available may show the necessity of recognizing two subspecies, a larger Tamaulipan (typical) form, and a smaller Austroriparian form.

Genus NYCTICEIUS Rafinesque.

1819. *Nycticeius* Rafinesque, Journ. de Physique, LXXXVIII, June, 1819, p. 417.
1827. *Nycticeus* Lesson, Man. de Mamm., p. 98.
1827. *Nycticejus* Temminck, Monographies de Mamm., I, p. xviii.
1830. *Nycticeyx* Wagler, Natürl. System der Amphibien, p. 13.
1831. *Nycticea* Le Conte, McMurtrie's Cuvier, Animal Kingdom, p. 432.
1864. *Nycticejus* H. Allen, Monogr. N. Am. Bats, p. 11.
1878. *Nycticejus* Dobson, Catal. Chiroptera Brit. Mus., p. 266.
1893. *Nycticejus* H. Allen, Monogr. Bats N. Am., p. 131.

Type species.—*Nycticeius humeralis* Rafinesque.

Geographic distribution of type species.—Austral zones in the Eastern United States.

Geographic distribution of genus.—Austral zones in the Eastern United States. Cuba.

Generic characters.—Dental formula:

$$i, \frac{1-1}{3-3};\ c, \frac{1-1}{1-1};\ pm, \frac{1-1}{2-2};\ m, \frac{3-3}{3-3} = 30;$$

upper incisor distinctly separated from canine; lower incisors scarcely crowded; outer lower incisor tricuspidate and not smaller than others; skull low and narrow; uropatagium furred at extreme base only; tragus blunt and bent forward; tip of tail free from membrane; mammæ, 2.

The genus *Nycticeius* as thus defined is peculiar to America, where it is represented by one species. It differs in dental formula from all other genera of American *Vespertilionidæ* except *Dasypterus* and *Rhogeëssa*. From the former it is distinguishable by its differently shaped skull, wide space between upper incisor and canine, and essentially naked uropatagium. From *Rhogeëssa* it is separated by details in the structure of teeth and skull, as well as by external characters.

NYCTICEIUS HUMERALIS Rafinesque. Rafinesque's Bat.

1818. *Vespertilio humeralis* Rafinesque, American Monthly Mag., III, p. 445.
1819. *Nycticeius humeralis* Rafinesque, Journ. de Physique, LXXXVIII, p. 417.
1831. *Nycticea crepuscularis* Le Conte, McMurtrie's Cuvier, Animal Kingdom, I, p. 432.

1864. *Nycticejus crepuscularis* H. Allen, Monogr. N. Am. Bats, p. 11.
1878. *Nycticejus crepuscularis* Dobson, Catal. Chiroptera Brit. Mus., p. 266.
1891. *Nycticejus humeralis* Thomas, Ann. & Mag. Nat. Hist., 6th ser., VII, p. 528.
1893. *Nycticejus humeralis* H. Allen, Monogr. Bats, N. Am., p. 132.

Type locality.—Kentucky.

Geographic distribution.—Austral zones in the eastern United States west to Arkansas and southern Texas.

General characters.—Size, medium (total length, 88 to 95; forearm, 34 to 38); color, dull brownish, slightly paler beneath.

Ears.—The ears are small and for their size remarkably thick and leathery. They are naked throughout except at extreme base above. Lower anterior half of inner surface with a few short scattered hairs. Anterior border strongly convex immediately above small but distinct anterior basal lobe, then very slightly convex to narrowly rounded off tip. Posterior border gently concave from immediately below tip to a little below middle, then convex to slightly developed external basal lobe.

Tragus short, broad, and blunt, bent slightly forward; posterior base with distinct lobule.

Membranes.—The membranes, like the ears, are thick and leathery. Wing membranes attached at base of toes, uropatagium at middle of terminal caudal vertebra.

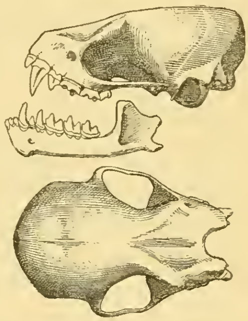


FIG. 35.—Skull of *Nycticeius humeralis* (×2).

Fur and color.—The fur is sparse and short, that on middle of back averaging about 6 mm. in length. It is closely confined to the body, barely reaching extreme base of uropatagium and flight membranes.

Color dull umber brown above, paler below, the fur everywhere plumbeous at extreme base, but the dark basal color less well defined than in other species with which *Nycticeius* is found associated. The exact shade varies slightly, but is usually burnt umber or mummy brown on the back and raw umber or hair brown on the belly. One skin from Hickman County, Tenn. (No. 30637, U. S. National Museum), is dark sepia above, broccoli brown below.

Skull.—The skull (fig. 35) is short, broad, and low. That of an adult female from Sans Souci, N. C. (No. 43037, U. S. National Museum), measures 14 mm. in greatest length and 10 mm. in zygomatic breadth; greatest length of mandible, 10.6. Dorsal profile nearly straight from external nares to occiput, but slightly convex over front part of brain case. Occiput never developing strongly marked ridges. Length of bony palate behind molars (exclusive of central spine), about half width of interpterygoid fossa.

Teeth.—The teeth (fig. 36) are not so large as might be expected from the massiveness of the skull. Upper tooth row of adult female from Sans Souci, N. C., 6; lower, 6.8. Upper incisor close to canine, but separated from it by a space less than half as great as the diameter of the incisor. Upper molars much narrower on the inner side than on the outer side. Outer lower incisor with transverse diameter of crown slightly greater than that of second or third.

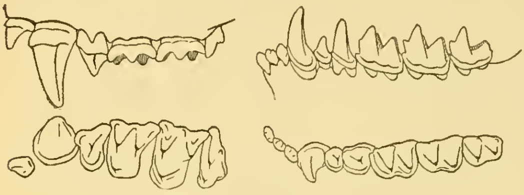


FIG. 36.—Teeth of *Nycticeius humeralis* (× 5).

Measurements.—In the following table average measurements are given of 35 specimens of *Nycticeius humeralis* from the United States, and for comparison, Gundlach's measurements of a dry specimen of *N. humeralis cubanus*.

Average measurements of 36 specimens of Nycticeius.

Name.	Locality.	Number of specimens.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
humeralis	Pennsylvania: Carlisle	10	93.5	36.9	13.8	6.7	36.2	5.4	64.5	13.9	10	6.1
	Virginia: Dismal Swamp.....	5	91.4	35.8	13.4	7.7	35.8	5.6	63.4	13.5	10.5	6.2
	Tennessee: Big Sandy........	10	92.2	36.3	13.7	7.3	34.3	5.5	63.4	13.1	9.9	5.9
	Texas: Brownsville	10	92.3	37.2	13.6	7.2	36.4	5.3	65.2	12.7	8.8	5.1
cubanus	Cuba	1	....	29	11	6.7	30	5.5	55	....	....	....

Specimens examined.—Total number 154, from the following localities:

Arkansas: Fort Smith, 5.
District of Columbia: Washington, 2.
Florida: Titusville, 1; Chattahoochee, 1.
Georgia: Riceboro, 3.
Indian Territory: Redland, 4.
Kentucky: Hickman, 7.
Louisiana: Mer Rouge, 19; Pineville, 1.
Mississippi: Bay St. Louis, 17; Washington, 2.
North Carolina: Bertie County, 9; Sans Souci, 4 (skins).
Pennsylvania: Carlisle, 12.
Tamaulipas: Matamoras, 1.
Tennessee: Big Sandy, 13; Danville, 2; Warner, 1; Arlington, 4; Hickman County, 1 (skin).
Texas: Brownsville, 32; Paris, 3; Arthur, 1; Lomita Ranch, 2; Hidalgo, 1.
Virginia: Dismal Swamp, 5; near Riverton, 1 (skin, Miller coll.).

NYCTICEIUS HUMERALIS CUBANUS (Gundlach).

1861. *Vesperus cubanus* Gundlach, Monatsber. K. Preuss. Akad. Wiss., Berlin, p. 150.
1877. *Nycticeius cubanus*, Gundlach, Contribucion á la Mamalogia Cubana, p. 33.

Type locality.—Cuba.

Geographic distribution.—Cuba.

Characters.—I have not seen specimens of *Nycticeius* from Cuba, but Gundlach's careful description of the animal leaves no doubt that it is distinct from the form occurring on the mainland. It is distinguished from the latter by smaller size and apparently also by paler color. A translation of Gundlach's second and more perfect account of the animal is as follows: "Pelage above light tawny (the fur blackish at base), beneath pale reddish tawny (the base of the fur likewise blackish). Face and flight membranes blackish brown. The nose appears somewhat divided by the projecting nostrils; between the nose and the eyes there is on each side a protuberance with bristly hairs. Ears oval, lengthened (8 mm. high in front). The anterior base rounded and spreading outward; the posterior at the angle of the mouth forms a semicircle. This semicircle, which bends inward to the tragus, forms another rounded enlargement. Tragus oblong, scarcely narrowed throughout, somewhat bent in the form of a sickle forward and provided with a tooth-shaped lobule at the base of the exterior border. Nails tawny.

"The measurements of a dry specimen are as follows: Width between extremities of wing, 0.180 m.; total length of body, 0.045; length of tail, 0.029; length of head, 0.016; length of ear, 0.012; length of forearm, 0.030; length of thumb, 0.005½; length of second or index finger, 0.029½; length of third finger, 0.055; of fourth finger, 0.046; of fifth finger, 0.040; length of tibia, 0.011; length of foot to the end of nails, 0.006¾; length of calcar, 0.013.

"This is a rare species. I have only observed it at Habana (Cerro) in a house where it lived in a crack above the window, and in the field near Cárdenas, where I killed it while flying about at dusk. A female contained two embryos in May."[1]

[1] Pelaje, por encima pálido-pardo (los pelos con la base negruzca), por debajo pálido bermejízo-pardo (la base de los pelos también negruzca). Cara y membranas voladoras, morenas. La nariz aparece algo dividida por las ventanas saltonas; entre la nariz y los ojos hay en cada lado un rollo con pelos tiesos. Orejas ovales, alargadas (por delante con 8 mil. de alto). La base anterior, redonda y extendida hácia fuera; la posterior, pelada en el ángulo de la boca y extendida en un semicírculo, que inclinado hácia dentro hasta la orejuela, forma una segunda ampliación redonda. Orejuela oblonga, adelgazándose apénas, algo encorvada en forma de hoz hácia delante, y provista en la base del borde exterior con un lóbulo dentiforme. Uñas pardas.

Las medidas, tomadas de un ejemplar disecado, son:

Anchura entre las puntas del ala, 0.180 mil.; longitud hasta el fin del cuerpo, 0.045; longitud del rabo, 0.029; longitud de la cabeza, 0.016; longitud de la oreja, 0.012; longitud del antebrazo, 0.030; longitud del pulgar, 0.005½; longitud del segundo dedo ó índice, 0.029½; longitud del tercero dedo, 0.055; longitud del quarto dedo, 0.046; longitud del quinto dedo, 0.040; longitud de la tibia, 0.011; longitud del pié hasta el fin de les uñas, 0.006¾; longitud del espolón, 0.013.

Es especie rara. La he observado solamente en la Habana (Cerro) en una casa donde vivia, en las rendijas sobre una ventana, y en el campo cerca de Cárdenas, donde la maté al oscurecer volando. Una ♀ tenia en mayo dos embriones.

Genus RHOGEËSSA H. Allen.

1866. *Rhogeëssa* H. Allen, Proc. Acad. Nat. Sci., Phila., p. 285 (genus).
1873. *Rhogöessa* Marschall, Nomenclator Zoologicus, Mamm., p. 11.
1878. *Rhogeëssa* Dobson, Catal. Chiroptera Brit. Mus., p. 245 (subgenus of '*Vesperugo*').
1893. *Rhogeëssa* H. Allen, Monogr. Bats N. Am., p. 132 (genus).

Type species.—*Rhogeëssa tumida* H. Allen.

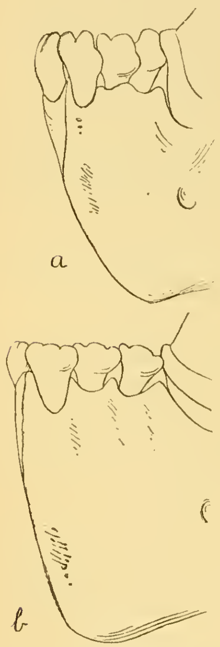


FIG. 37.—Left mandibular incisors of (*a*) *Rhogeëssa* and (*b*) *Nycticeius* (×20).

Geographic distribution.—Tropical Mexico, Central America, and probably northern South America (known from Margarita Island, Venezuela).

Generic characters.—Dental formula:

$$i, \frac{1-1}{3-3}; \quad c, \frac{1-1}{1-1}; \quad pm, \frac{1-1}{2-2}; \quad m, \frac{3-3}{3-3} = 30;$$

lower incisors crowded, the outer cusp of first and second obsolete; third lower incisor greatly reduced in size, unicuspidate (figs. 37 *a* and 38 *a*); upper incisor very close to canine or in contact with it; skull small, light, and papery, narrow and deep; external form variable, but tragus always straight or bent backward, and tail included to tip in interfemoral membrane.

Remarks.—The genus *Rhogeëssa* has received varying treatment. It was originally described as a full genus whose relationships were supposed to be with *Nycticeius* and *Nyctinomus*. In 1878 Dobson referred it to '*Vesperugo*' as a subgenus. This view has been adopted by most subsequent writers except Mr. Oldfield Thomas and Dr. Harrison Allen, both of whom have recognized *Rhogeëssa* as a full genus related more closely to *Nycticeius* than to any of the genera usually included under the name '*Vesperugo*.' Mr. Thomas has pointed out characters in which *Rhogeëssa* resembles *Antrozous*. These characters, the reduced size of the outer lower incisor and slightly crenulate posterior border of tragus, seem to be instances of parallel development rather than indications of genetic relationship. The genus *Rhogeëssa* is closely related to *Nycticeius*, but the peculiarities of the lower incisors and the general form of the skull are enough to warrant its recognition.

FIG. 38.—Crowns of incisors of right mandible of (*a*) *Rhogeëssa* and (*b*) *Nycticeius* (×20).

KEY TO SPECIES OF RHOGEËSSA.

Lateral mandibular incisor scarcely one-twentieth as large as central incisors .... *alleni* (p. 128)
Lateral mandibular incisor one-half to two-thirds as large as central incisors.
  Ear laid forward, reaching about 6 mm. beyond tip of nose ..... *gracilis* (p. 126)
  Ear laid forward, reaching about to tip of nose.
    Fur grayish brown at base.................................. *parvula* (p. 125)
    Fur yellowish throughout.
      Forearm about 30 mm .... *tumida* (p. 123)
      Forearm about 25 mm .... *minutilla* (p. 125)

RHOGEËSSA TUMIDA H. Allen.

1866. *Rhogeëssa tumida* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 286.
1877. *Vesperugo parvulus* Dobson, Catal. Chiroptera Brit. Mus., p. 245.

Type locality.—Mirador, Vera Cruz, Mexico.

Geographic distribution.—Central America and southern Mexico.

General characters.—Size small; length, 70 to 75; tail, 30 to 33; forearm, 27.4 to 30. Calcar strong, distinct, slightly longer than free border of uropatagium, terminating in a small but evident lobule conspicuously keeled on the posterior border. Free border of uropatagium naked. Ears moderate, laid forward they reach about to tip of nose. Wings from base of toes. Legs and feet short and strong, the feet when outstretched reaching to within 5 mm. of tip of tail. Fur yellowish, the hairs on the back with dusky tips.

Ears.—The ears (Pl. I, fig. 8) are moderately long, reaching, when laid forward, about to tip of nose; the substance of the conch thick and leathery. Anterior border strongly concave from base to a little past middle, then straight to narrowly rounded-off tip. Posterior border concave just below tip, then gently and evenly convex to base. No indication of basal notch.

Tragus directed slightly forward; the anterior edge nearly straight, but slightly concave at base, and curved a little backward at tip. Posterior edge faintly crenulate, concave below tip, then concave to slightly developed basal lobe. Greatest width of tragus at about middle of posterior border.

Membranes.—The membranes, especially the uropatagium, are remarkably thick and leathery for so small a bat. Throughout they are wholly naked except close to the body and along the veins on the interfemoral membrane. Wings from base of toes. Uropatagium (Pl. I, fig. 13) attached at tip of terminal caudal vertebra.

Feet.—The feet and legs (Pl. I, fig. 13) are short and strongly built, in this respect resembling *N. humeralis*. The foot is scarcely one-half as long as the tibia, and the toes are slightly longer than the sole. The toes are not united by membrane at base. Calcar distinct and strong, slightly longer than free border of uropatagium. Lobule at tip of calcar small but distinct. Keel well developed and supported by one or two cartilaginous outgrowths.

Fur and color.—There is nothing peculiar in the distribution of the fur. It extends in a very narrow line on the wings along the side of the body both dorsally and ventrally, and on the uropatagium covers the basal fourth dorsally but scarcely reaches the membrane on the ventral side.

In color the fur is dull yellowish brown throughout, scarcely paler ventrally, the hairs dusky at tip. Ears and membranes dark brown.

Skull.—In general appearance the skull of *Rhogeëssa tumida* (fig. 39) stands between that of *Nycticeius humeralis* and *Pipistrellus subflavus*. The skull of an adult female from Santo Domingo, Oaxaca (No. 73267, United States National Museum, Biological Survey collection), measures: Greatest length, 13; zygomatic breadth, 8.4; breadth of rostrum at anterior edge of first molar, 5; mandible, 9;[1] upper tooth row, 5.6; lower tooth row, 6. That of an adult female from Patuca, Honduras (No. 21017, United States National Museum), measures: Greatest length, 12.4; zygomatic breadth, 8; breadth of rostrum at anterior edge of first molar, 4; mandible, 9.4; upper tooth row, 5; lower tooth row, 6. The rostrum is relatively narrower than in *Nycticeius* and the occiput is more elevated. The muzzle is distinctly concave in front of orbits instead of flat or almost convex as in *Nycticeius*.

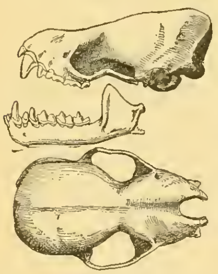


FIG. 39.—Skull of *Rhogeëssa tumida* (×2).

Teeth.—Upper incisor usually in contact with canine, though occasionally separated by a narrow space (fig. 40*a*). Maxillary teeth essentially as in *Nycticeius*, but premolar relatively larger and posterior molar narrower in proportion to its length.

Lower incisors greatly crowded, the outer cusp of *i* 1 and *i* 2 much smaller than middle and inner cusp. Outer lower incisor unicuspidate, about one-half the size of *i* 1 or *i* 2. Other mandibular teeth essentially as in *Nycticeius*, but premolars more crowded.

Measurements.—See table, page 129.

Specimens examined.—Total number, 10, from the following localities:

Colima: Colima, 3.
Costa Rica: ———, 1.
Guatemala: Huehuetan, 1.
Guerrero: Amula, 1 (Merriam coll.).
Honduras: Patuca, 2.
Oaxaca: Santo Domingo, 1.
Vera Cruz: Mirador, 1.

General remarks.—*Rhogeëssa tumida* needs comparison with *R. parvula* and *R. minutilla* only. From the former it is distinguished by its clear yellowish fur without darker base, and from the latter by its considerably larger size.

[1] As the mandible is imperfect, this measurement is only approximately correct.

Dobson and most subsequent authors have wrongly applied the specific name *parvula* to this species. So far as known *R. parvula* is restricted to the Tres Marias Islands.

[The following species is not North American, but is introduced here to complete the account of the genus *Rhogeëssa*.]

RHOGEËSSA MINUTILLA Miller.

1896. *Vesperugo parvulus* Robinson, Proc. U. S. National Museum, XVIII, p. 651 (not *Rhogeëssa parvula* H. Allen).

1897. *Rhogeëssa minutilla* Miller, Proc. Biol. Soc. Washington, XI, p. 139, May 13, 1897.

Type locality.—Margarita Island, Venezuela. (Type in U. S. National Museum, No. 63216.)

Geographic distribution.—This species is probably confined to Margarita Island.

General characters.—Similar to *Rhogeëssa tumida*, but considerably smaller (forearm, only 25 mm.).

Ears.—The ears of the type (when relaxed by soaking in water) appear to be smaller and narrower than in *R. tumida*, but otherwise not peculiar.

Membranes, feet, and distribution of fur.—As in *R. tumida.*

Color.—Fur everywhere light yellowish brown to base, the hairs on the back tipped with chestnut. The color appears to differ slightly from that of *R. tumida.* but I have too few skins to make an adequate comparison.

Skull.—The skull of the type and only known specimen is so much injured that its characters can not be determined with certainty, but it appears to be smaller and relatively narrower than that of *R. tumida.* Greatest length, 11.8; length of mandible, 9; upper tooth row, 5; lower tooth row, 5.6.

Teeth.—The teeth are essentially as in *R. tumida.*

Measurements.—The measurements of the type specimen are given in the table on page 129.

Specimens examined.—One, the type.

General remarks.—*Rhogeëssa minutilla* is a small insular form most closely related to *R. tumida*, but apparently perfectly distinct. So far as I know the genus *Rhogeëssa* has not yet been recorded from the mainland of South America, where, however, it doubtless occurs.

RHOGEËSSA PARVULA H. Allen.

1866. *Rhogeëssa parvula* H. Allen, Proc. Acad. Nat. Sci. Phila., p. 285

Tpye locality.—Tres Marias Islands, Mexico.

Geographic distribution.—Tres Marias Islands.

Characters.—As I have seen no specimens of this species, I quote the original description entire. It is as follows:

"Ear sub-acute at tip; lips whiskered; eyes very small, each furnished with a wart above; similar growth seen beneath chin. Fur above silky, not thick, of a light greyish-brown at basal third, fawn-chestnut-brown at apical two-thirds; that of head same color, running on to the ears one-half their height. Beneath, basal third inclined to greyish; apical two-thirds grayish fawn. Membranes almost black, naked, excepting basal fourth of interfemoral membrane behind, which is furnished with a small, short patch of glistening fur.

"*Measurements*—7841.

"Height of auricle 6″ [12.7 mm.]; height of tragus 3″ [6.4]; length of head 7″ [14.8]; length of body 10″ [21.1]; length of tail 1′ 2″ [30.5]; length of forearm 1′ 1″ [27.4]; length of longest finger 1′ 11″ [48.5]; length of thumb 2″ [4.2]; length of tibia 5″ [10.6]; length of foot 2½″ [5.3]; expanse 6′ 7″ [16.7].

"Two individuals, ♂ and ♀; Nos. 7841, 7842, Museum of Smithsonian Institution. Alcohol.

"Tres Marias, Mexico, Col. Grayson."

RHOGEËSSA GRACILIS sp. nov.

Type from Piaxtla, Puebla. Adult ♂ (in alcohol). No. 70694, U. S. Nat. Museum, Biological Survey collection. Collected Nov. 24, 1894, by E. W. Nelson and E. A. Goldman. Collector's number, 7099.

Geographic distribution.—Southern Mexico (Puebla and 'Isthmus of Tehuantepec').

General characters.—Size, medium; length, 79 to 82; tail, 38.6 to 41; forearm, 32 to 33. Calcar slender but distinct, a little shorter than free border of uropatagium, terminating in a small lobule, distinctly keeled on the posterior border. Free border of uropatagium naked. Ears long; when laid forward extending about 6 mm. beyond tip of nose. Wings from base of toes. Feet and legs long and slender, the outstretched feet reaching to within about 10 mm. of tip of tail.

Ears.—The ears (Pl. I, fig. 7) are long, and at the same time broad; laid forward they reach about 6 mm. beyond tip of nose; the substance of the conch thin and translucent. Anterior border strongly convex from base to a little below middle, then straight or very slightly convex to the rather broadly rounded off tip. Posterior border concave below tip to about middle, where it bends abruptly outward, then gradually convex to base. A very faintly indicated basal notch and basal lobe. About 5 mm. above the crown and an equal distance from the tip of the ear conch in the male is developed a conspicuous, flattened-pyriform, glandular thickening with the large end toward the anterior margin of the ear and the main axis nearly perpendicular to that of the auricle. The thickened mass is 5 mm. in length, 4 mm. wide at the broad end, 2 mm. at the narrow end, and 1 mm. thick. It is most conspicuous on the dorsal side of the ear, where, although not different in color from the rest of the ear, it is noticeably raised above the surface, and the boundaries are sharply marked. On the inner side of the ears the thickenings are less definite in outline, but are noticeably paler than the surrounding integument. When these structures are examined with a lens it is seen that they are thickly covered on the outer side with pores lying mostly at the bases of the fine hairs with which the surface is beset. The thickened masses are of exactly the same size and shape in the two ears and are placed symmetrically with respect to the outlines of the conchs.

Tragus slender and taper pointed, slightly bent backward at the tip, and broadest opposite anterior base. The anterior border is slightly concave at base, then evenly convex to tip. The posterior border is strongly concave from tip to a point slightly above the middle, where the tragus attains a width nearly equal to that at level of anterior base. From this point to the basal lobe the posterior border is nearly straight and about parallel with the lower part of the anterior border. Basal lobe small but prominent. Posterior border of tragus crenulate, especially near the middle, where there are five or six minute sharply projecting points, from the bases of which thickened processes may be traced a short distance into the substance of the tragus when the latter is held to the light.

Membranes.—The membranes are thin and semitransparent, the uropatagium not different in texture from the wings. Throughout they are entirely naked, except for a narrow line of hair on the wings extending along sides of body about to a line drawn halfway between knee and elbow. On the uropatagium there is also a narrow hairy area close to body and a sprinkling of fine hairs along the veins. Wings from base of toes. Uropatagium (Pl. I, fig. 12) attached at tip of terminal caudal vertebra.

Feet.—The feet are small and weak, distinctly less than half as long as the slender tibiæ (Pl. I, fig. 12). Toes longer than sole, cleft to base. Calcar slender but very distinct, about as long as free border of uropatagium and terminating in a small and ill-defined lobule. Keel remarkably well developed, extending from near tip of calcar almost to base and supported by four cartilaginous processes.

Fur and color.—The fur is long, that on middle of back averaging about 9 mm. It extends farther on the membranes than in *R. parvula*, but otherwise shows no peculiarities. In color it is everywhere light sepia at base, then dull yellowish brown, that on the back tipped with chestnut. As this description is from a specimen that has been immersed in alcohol for nearly two years and a half, it can not be more than approximately accurate.

Skull.—The skull of *Rhogeëssa gracilis* is longer and more slender than that of *R. tumida*, and the forehead appears to be more abruptly raised above the face line. The zygomata are less widely flaring in front. Apparently the occiput is considerably narrower than in *R. tumida*. From the material at hand it is, however, impossible to determine the cranial characters with accuracy, since of the skull of the female topotype there remains only the mandible and rostral portion, while the skull of the type is so much injured that it would not hold together if removed from the skin and cleaned.

Teeth.—The teeth of *Rhogeësa gracilis* (fig. 40) differ from those of *R. tumida* in numerous details. The crowns of the upper molars are much narrower on the lingual side and the posterior upper molar is considerably broader. The front lower premolar is slightly larger than in *R. tumida*, but otherwise the mandibular teeth show no distinct differences.

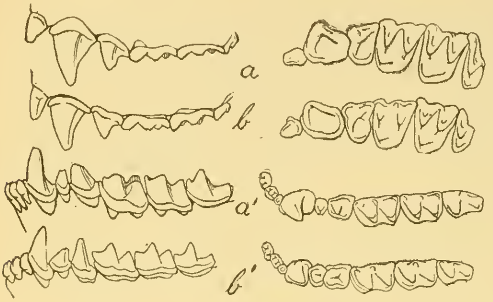


FIG. 40.—Teeth of (*a*) *Rhogeësa tumida* and (*b*) *R. gracilis* (× 5).

Measurements.—See table, page 129.

Specimens examined.—Total number, 3, from the following localities:

Isthmus of Tehuantepec, 1.
Puebla: Piaxtla, 2.

General remarks.—*Rhogeëssa gracilis* is so readily distinguished from the other species of the genus by its slender form and very large ears that no detailed comparisons are necessary.

This is the only species of North American *Vespertilionidæ* in which I have found any sexual differences in cutaneous structures.

RHOGEËSSA ALLENI Thomas.

1892. *Rhogeëssa alleni* Thomas, Ann. & Mag. Nat. Hist., 6th ser., X, p. 477, December, 1892.

Type locality.—Santa Rosalia, near Autlan, Jalisco, Mexico. Type in British Museum.

Geographic distribution.—*Rhogeëssa alleni* is known from the type locality only.

Characters.—As I have not seen the type and only known specimen of this bat, I copy Mr. Thomas's original description:

"Decidedly larger than *Rh. parvula;* muzzle obliquely truncate as in that species. Ears large, laid forward they reach about 1 or 2 millim. beyond the nostrils; their inner margin very convex forwards below, straight or even slightly concave above; tip narrowly rounded off; outer margin concave below the tip, then straight, becoming slightly convex below, outer basal lobe but little marked. Tragus long, its broadest point opposite to base of its inner edge; inner edge straight or slightly concave, tip rounded, outer margin slightly convex, the edge indistinctly crenulate, somewhat as in *Antrozous pallidus;* a marked lobule at the base of the outer margin, above and below which there is a concavity. Thumb very short and thick, no longer than in *Rh. parvula.* Posterior edges of wing-membrane bordered with white, bifid tip to fourth finger unusually distinct; wings from the base of the fifth toe; post-calcareal lobe small and narrow; tip of calcar projecting slightly from the back of the membrane; tail included in membrane to the extreme tip."

"*Teeth.*—Upper incisors one on each side, long, slender, unicuspid; upper premolars large, quite close to the canines; no trace of a minute anterior premolar. Lower incisors six, the four median ones broad, tricuspid; the outer ones unicuspid, exceedingly minute, practically invisible from in front, and scarcely one-twentieth of the size in cross section of the median incisors; far smaller therefore both absolutely and relatively than in *Rh. parvula.*

"Dimensions of the type (an adult female in spirit):—

"Head and body 47 millim; tail 41; ear above head 12.2, from notch 16; tragus, inner margin 7; forearm 35; thumb 5; metacarpal of third finger 33.5; lower leg 15.5; hind foot 7.1; calcar 15.

"Skull of a second specimen: Occiput to gnathion 14.7; greatest breadth 9.5; distance from front of canine to back of $\underline{\text{m. 3}}$ 5.4."

Measurements of specimens of Rhogeëssa.

Name.	Locality.	Number.	Sex and age.	Total length.	Tail vertebræ.	Tibia.	Foot.	Forearm.	Thumb.	Longest finger.	Ear from meatus.	Width of ear.	Tragus.
tumida	Vera Cruz: Mirador	8195	♂ ad.	65.5	25.4	10.4	5.1	29.5	4.8	57.2	....	....	7.3
	Colima: Colima	52102	♀ ad.	75	34	12	5	29.8	4	52	12.8	9.6	7
	Colima	52065	♂ ad.	70	33	11.4	5.4	20	4	52	12.4	9.4	7.4
	Colima	52066	♂ ad.	70	30	11	5.4	28	4	51	12.6	9	7
	Oaxaca: Santo Domingo.	73269	♀ ad.	....	....	12	7	33	4.4	63	13.6	9.6	7.2
	Guatemala: Huehuetan.	78600	♂ ad.	75	33	11.4	6	30	4.6	56	14	9	7
	Honduras: Patuca	21016	♀ ad.	73	30	12	6	30	4	55	12.6	9	7
	Patuca	21017	♀ ad.	75	31	12.4	5.6	30	4	57	13	9	7
parvula	Tres Marias Islands.....	7841	[1]♂ ad.	65.5	29.5	10.4	5.3	27.4	4.1	48.5	....	....	6.4
minutilla	Venezuela: Margarita Island.	63216	[2]♂ ad.	....	25	11	5	25	3.6	51	11.8	8	6.4
gracilis	Puebla: Piaxtla.........	70691	♀ ad.	79	38.6	14	6	32	4	60	17	11	10
	Piaxtla.........	70694	[2]♂ ad.	82	41	14.6	5	33	4.4	61	16.6	11.8	10
	Isthmus of Tehuantepec.	11240	♀ ad.	77	37	13	5	30	4	58	16	11	9
alleni	Jalisco: Autlan...............		[3]♀ ad.	....	41	....	7.1	35	5	....	....	....	7

[1] Type, measurements from H. Allen. [2] Type. [3] Type, measurements from Thomas.

INDEX TO GENERIC AND SPECIFIC NAMES.

[Names in italics are here recognized as valid.]

PLATE I.

[One and one-half times natural size.]

FIG. 1. *Myotis velifer* (J. A. Allen). Patzcuaro, Michoacan, Mexico.
(No. 52179, U. S. Nat. Mus.)

2. *Myotis californicus* (Audubon & Bachman). Nicasio, Cal.
(No. 1512, Merriam collection.)

3. *Myotis yumanensis* (H. Allen). Tulare, Cal.
(No. 30709, U. S. Nat. Mus.)

4. *Nycticeius humeralis* Rafinesque. Brownsville, Tex.
(No. 52613, U. S. Nat. Mus.)

5. *Myotis thysanodes* Miller (topotype). Old Fort Tejon, Cal.
(29824, U. S. Nat. Mus.)

6. *Myotis evotis* (H. Allen). Bull Lake, Wyoming.
(No. 55846, U. S. Nat. Mus.)

7. *Rhogeëssa gracilis* Miller (type). Piaxtla, Puebla, Mexico.
(No. 70694, U. S. Nat. Mus.)

8. *Rhogeëssa tumida* H. Allen. Colima, Mexico.
(No. 52065, U. S. Nat. Mus.)

9. *Corynorhinus macrotis townsendii* (Cooper). Gold Beach, Oregon.
(No. 88542, U. S. Nat. Mus.)

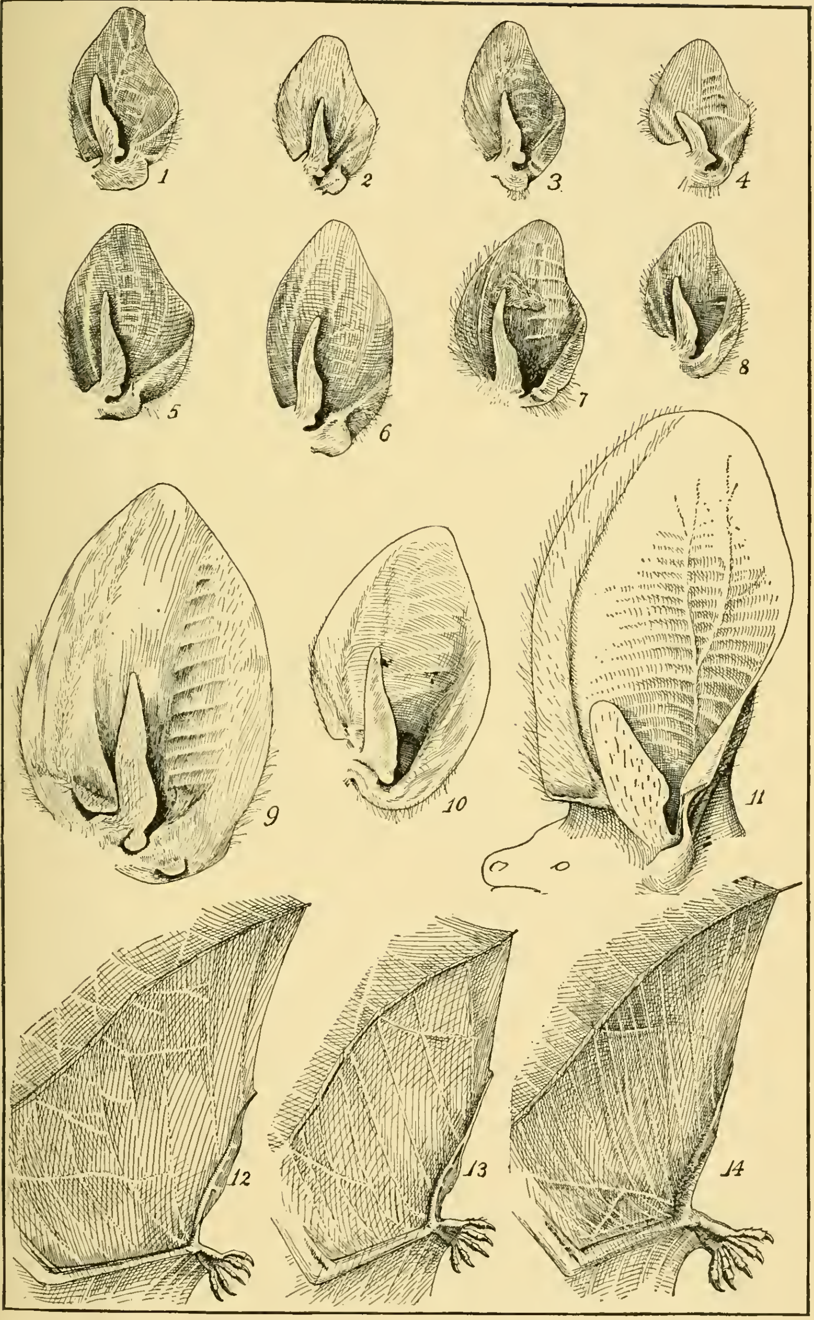
10. *Antrozous pallidus* (Le Conte). Sycamore Creek, Texas.
(No. 24155, U. S. Nat. Mus.)

11. *Euderma maculatum* (J. A. Allen) (type). Ventura County, Cal.
(No. $\frac{3920}{2991}$, Am. Mus. Nat. Hist., N. Y.)

12. *Rhogeëssa gracilis* Miller (type). Piaxtla, Puebla, Mexico.
(No. 70694, U. S. Nat. Mus.)

13. *Rhogeëssa tumida* H. Allen. Colima, Mexico.
(No. 52065, U. S. Nat. Mus.)

14. *Nycticeius humeralis* Rafinesque. Brownsville, Tex.
(No. 52613, U. S. Nat. Mus.)



1. *Myotis velifer.*
2. *Myotis californicus.*
3. *Myotis yumanensis.*
4. *Nycticeius humeralis.*
5. *Myotis thysanodes.*
6. *Myotis evotis.*
7. *Rhogeëssa gracilis.*
8. *Rhogeëssa tumida.*
9. *Corynorhinus macrotis townsendi.*
10. *Antrozous pallidus.*
11. *Euderma maculatum.*
12. *Rhogeëssa gracilis.*
13. *Rhogeëssa tumida.*
14. *Nycticeius humeralis.*

PLATE II.

[One and one-half times natural size.]

FIG. 1. *Myotis californicus* (Audubon & Bachman). Nicasio, Cal. (No. 1512, Merriam collection.)

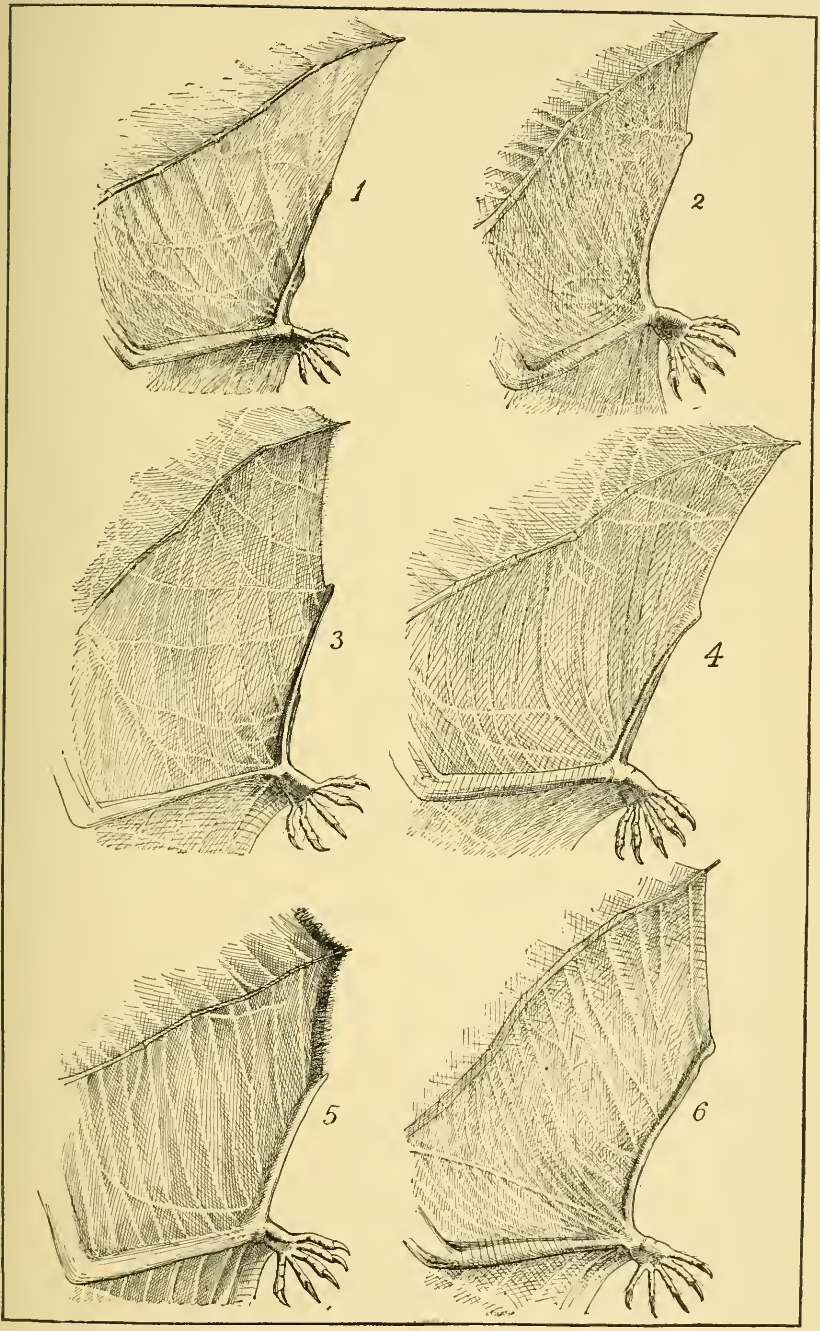
2. *Myotis yumanensis* (H. Allen). Tulare, Cal. (U. S. Nat. Mus.)

3. *Myotis evotis* (H. Allen). Bull Lake, Wyoming. (No. 55846, U. S. Nat. Mus.)

4. *Myotis evotis* (H. Allen). Perote, Vera Cruz, Mexico. (No. 88541, U. S. Nat. Mus.)

5. *Myotis thysanodes* Miller (type). Old Fort Tejon, California. (No. 29827, U. S. Nat. Mus.)

6. *Myotis velifer* (J. A. Allen). Patzcuaro, Michoacan, Mexico. (No. 52282, U. S. Nat. Mus.)



1. *Myotis californicus.*
2. *Myotis yumanensis.*
3. *Myotis evotis* (Bull Lake, Wyo.).
4. *Myotis evotis* (Perote, Mexico).
5. *Myotis thysanodes.*
6. *Myotis velifer.*

PLATE III.

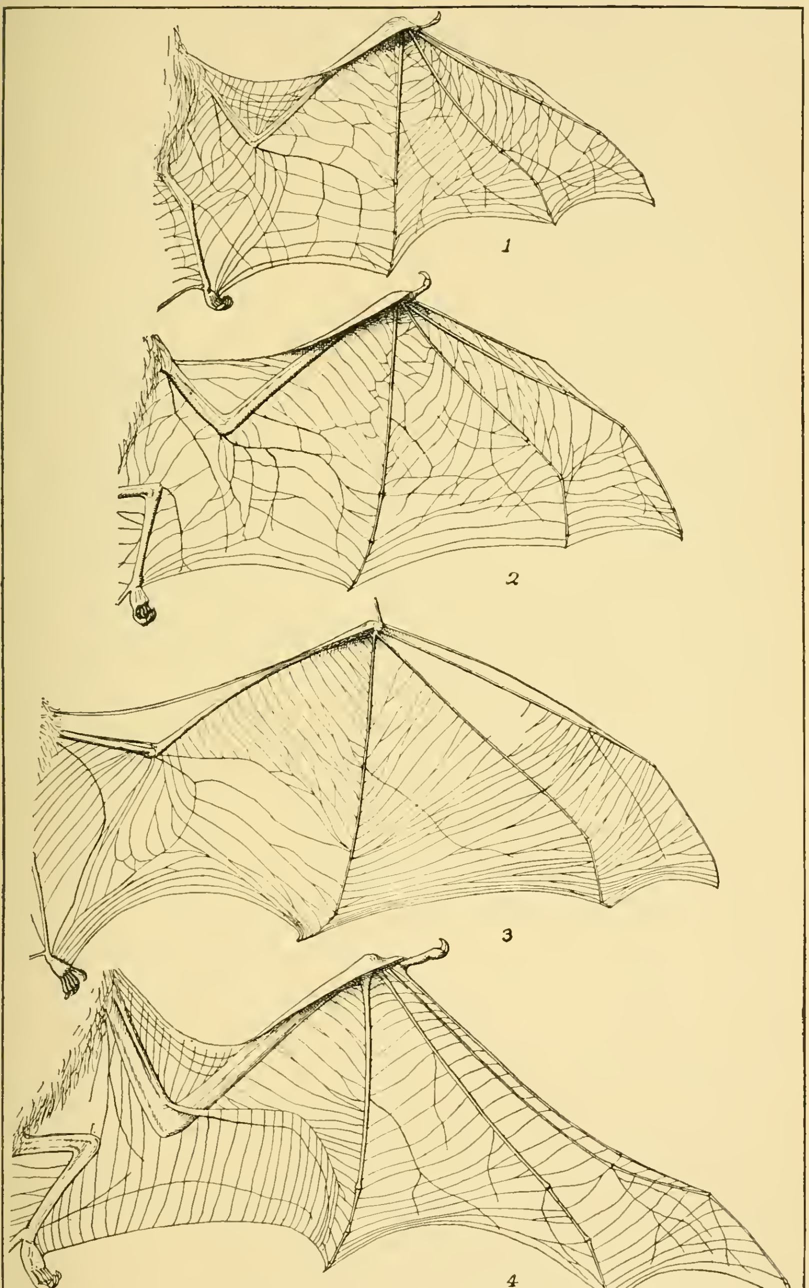
[Two-thirds natural size.]

FIG. 1. *Plecotus auritus* (Linn.). Höllsteig, Baden, Germany.
(No. 4495, Miller collection.)

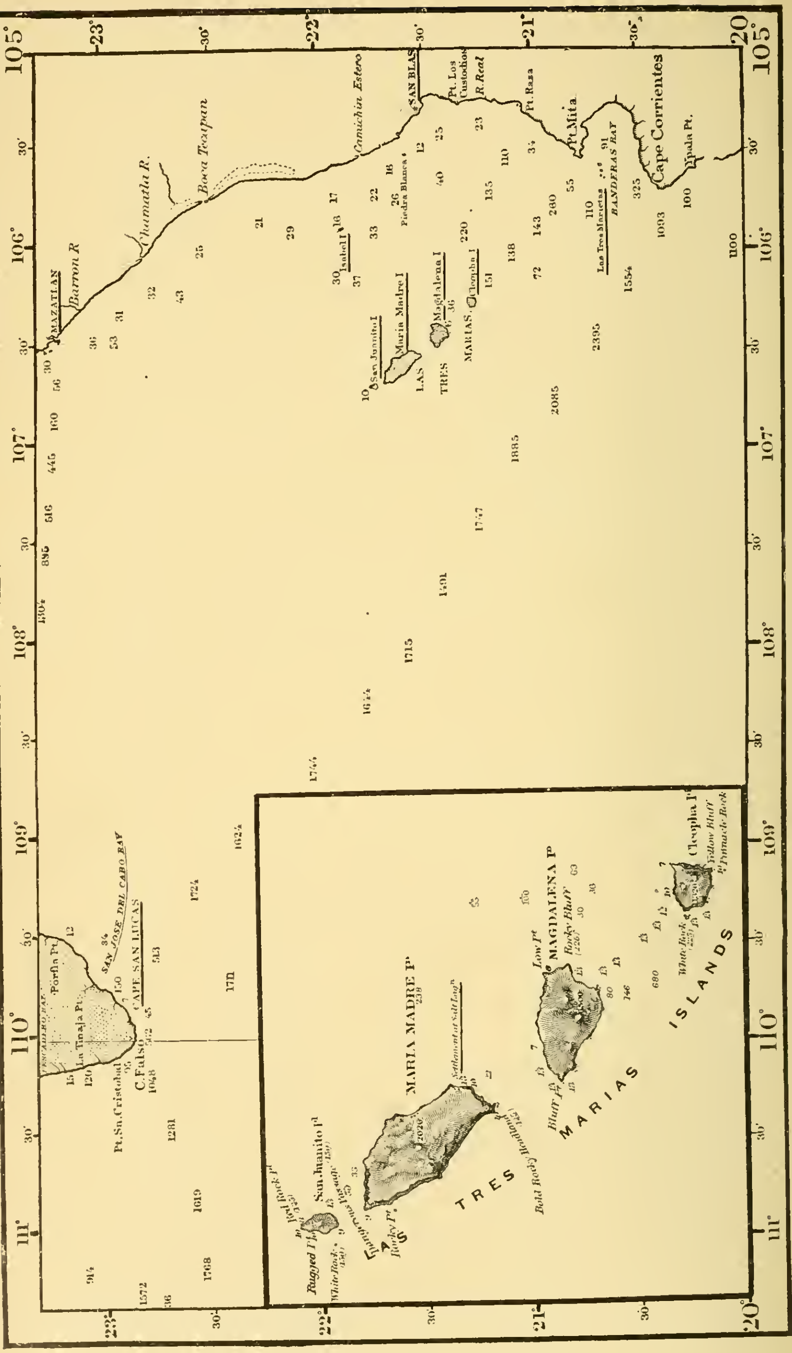
2. *Corynorhinus macrotis pallescens* Miller. Owens Lake, Cal.
(No. 28954, U. S. Nat. Mus.)

3. *Euderma maculatum* (J. A. Allen) (type). Ventura County, Cal.
(No. $\frac{3920}{2991}$, Am. Mus. Nat. Hist., N. Y.)

4. *Lasiurus cinereus* (Beauvois). Vegas Valley, Nevada.
(No. 27976, U. S. Nat. Mus.)



1. *Plecotus auritus.*
2. *Corynorhinus macrotis pallescens.*
3. *Euderma maculatum.*
4 *Lasiurus cinereus.*



MAP OF THE TRES MARIAS ISLANDS, MEXICO.

(From charts of the U. S. Hydrographic Office. Elevations are in feet; soundings in fathoms.)

U. S. DEPARTMENT OF AGRICULTURE
DIVISION OF BIOLOGICAL SURVEY

NORTH AMERICAN FAUNA

No. 14

[Actual date of publication, April 29, 1899]

NATURAL HISTORY OF THE TRES MARIAS ISLANDS, MEXICO

General Account of the Islands, with Reports on Mammals and Birds. By E. W. Nelson
Reptiles of the Tres Marias. By Leonhard Stejneger
Notes on Crustacea of the Tres Marias. By Mary J. Rathbun
Plants of the Tres Marias. By J. N. Rose
Bibliography of the Tres Marias. By E. W. Nelson

Prepared under the direction of
Dr. C. HART MERRIAM
CHIEF OF DIVISION OF BIOLOGICAL SURVEY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1899

Supt. Documents.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Biological Survey,
Washington, D. C., January 25, 1899.

Sir: I have the honor to transmit herewith for publication as North American Fauna No. 14 a report by E. W. Nelson on the natural history of the Tres Marias Islands, Mexico. These islands are the largest off the west coast between Cape St. Lucas and the Isthmus of Panama, but have seldom been visited, and very little is known of their fauna or flora. For several years Mr. Nelson has had charge of the field work of the Biological Survey in Mexico, and in May, 1897, visited the Tres Marias. During the course of this visit he made a thorough collection of birds and mammals and also secured specimens of reptiles, fishes, mollusks, crustaceans, and plants, so that his report contains a fairly complete account of the natural history of the islands. In working up the material collected, Mr. Nelson has had the assistance of several well known naturalists in the United States National Museum and United States Fish Commission, who have prepared reports on special groups, as credited in detail on page 13.

Mention should be made also of the unfailing courtesy and interest of the Mexican Government in the investigations conducted by the Biological Survey in Mexico. Letters have been furnished by officials in the City of Mexico, and by the late Mexican minister in Washington, Señor Don Matias Romero, which greatly facilitated the work in various ways, and on the occasion of the visit to the Tres Marias enabled Mr. Nelson to borrow a large boat at San Blas and secure comfortable quarters on the islands.

Several attempts at agriculture have been made on the Tres Marias Islands, but the results have thus far been unsuccessful, owing to the dry climate and the scarcity of permanent water. Corn and beans have been grown on a small scale, but the crops suffer from the severe storms which occur at certain seasons. Experiments have been made with a view to utilizing the native species of agave for fiber and mescal, and the cultivation of cotton has also been tried without success. Recently it has been proposed to establish an American colony on one of the islands for the purpose of growing coffee, bananas, Australian chestnuts, and date palms, and to engage in the manufacture of banana and chestnut flour. Such a scheme, Mr. Nelson tells me, could only result in failure, as the islands are entirely unsuited to growing these products. It therefore seems desirable to publish at once all the information in the possession of the Department, for the purpose of making it available to those who may be interested in the islands or their products.

Respectfully,

C. HART MERRIAM,
Chief, Biological Survey.

Hon. JAMES WILSON,
Secretary of Agriculture.

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GENERAL DESCRIPTION OF THE TRES MARIAS ISLANDS, MEXICO.

By E. W. Nelson.

INTRODUCTION.

The Tres Marias islands are situated off the west coast of Mexico, about 65 miles west from the port of San Blas. These islands have been known since early in the history of the New World, and in 1532 were named Las Islas de la Magdalena by Diego de Mendoza. Many of the early explorers sailed about them, and Dampier states that they were familiar to the buccaneers who visited these shores. They are mentioned by several of the later voyagers, especially the English exploring expeditions which visited the west coast of Mexico in the first half of the present century. During all this time, however, they remained uninhabited and nothing definite was known or published concerning their character or products. It is said at San Blas that the first men who lived upon the islands were bandits, who took refuge there, and had a secure retreat from which they harried the mainland settlements for several years. Finally, the abundance of Spanish cedar became known, a settlement of woodcutters was established on Marie Madre, and this island has since been continuously inhabited.

Col. A. J. Grayson, a naturalist who lived for many years on the west coast of Mexico, was the first to publish any detailed information about the islands.[1] Most of this information is contained in the various papers embodying the results of his three trips to the Tres Marias in 1865, '66, and '67, published by himself, George N. Lawrence, and W. E. Bryant. In 1881 Alphonse Forrer, a natural history collector, spent some time on Maria Madre collecting specimens for the British Museum, but no detailed account of his work has been published. No other naturalist is known to have visited the islands until the spring of 1897. In April of that year Mr. E. A. Goldman and I visited the port of San Blas for the

[1] Mr. John Xantus, who spent several years subsequent to 1859 on the west coast of Mexico, was supposed to have visited the islands, on account of several specimens of birds which he sent to the Smithsonian Institution, labeled "Tres Marias Islands, 1861." But as no one else has collected any of these species, and as Xantus sent in no birds which have been taken by others on the islands, it is safe to conclude that he did not visit the Tres Marias.

purpose of outfitting an expedition to the Tres Marias. A letter to the collector of customs at San Blas, kindly furnished me by the Mexican Minister in Washington, the late Don Matias Romero, proved of the greatest service. The collector of customs rendered every assistance in his power, including the loan of a large open boat 25 feet long, and a letter to his deputy which secured us very pleasant quarters in the custom house on Maria Madre. While preparations for the trip were in progress a party from Socorro, N. Mex., consisting of Prof. C. L. Herrick, his son Harry, and Dr. T. S. Maltby arrived at San Blas, also bound for the Tres Marias, and we made the trip together. On the evening of April 28 the boat crept out of the lagoon, and by the aid of a faint land breeze edged slowly off shore. The islands came in sight the next morning, but it was impossible to reach them for several days, owing to calms, head winds, and the lack of a keel to the boat. The stock of water was on the point of exhaustion when Maria Madre was finally reached, three days later, on the afternoon of May 2.

The landing was made at the settlement at the head of a shallow bay on the east side of the island. Our letters secured a cordial welcome from the customs inspector and the agent of the owner of the islands. In a couple of hours the outfit was snugly installed on the broad upper verandas of the custom house, where our headquarters were located. Collections were made near this place, the island traversed both on foot and horseback, and on May 20 a boat trip was made to the north end of the island and across to San Juanito. On May 23 the party returned to the settlement, and two days later proceeded to Maria Magdalena, where camp was made near the beach for four days. On May 29 we crossed to Maria Cleofa, where we remained two days, and then started, May 31, on the return to the mainland. The wind was fair, and a quick trip was made, San Blas being reached on the evening of June 1.

When Colonel Grayson visited the islands, in 1865, he found a settlement on Maria Madre, but the other islands uninhabited. In the spring of 1897 there was a branch custom-house, with three inspectors, at the main settlement on Maria Madre, which had supervision of the shipment of salt and Spanish cedar. The settlement contained about twenty-five families, all of whom, except the customs inspectors, were in the service of the owner of the islands, Señora Gil de Azcona, who lived in the city of Tepic, on the mainland. In May and June the workmen are employed in salt-making at a lagoon near the south point of the island, where there is a small group of houses. The rest of the year they are occupied in cutting cedar and hauling it to the beach for shipment. The available supply of this valuable timber is now approaching exhaustion. Subsequent to Grayson's visit a settlement of woodcutters was made on the northeast side of Maria Magdalena, and a number of houses were built and a field cleared. We found the place deserted, the houses in ruins, and the field overgrown with thorny bushes.

The amount of land suitable for agriculture upon the islands is very limited and forms but a small percentage of the total area. A few cattle are raised on Maria Madre, but the scanty herbage and great scarcity of water during the long dry season limit this industry to the most insignificant proportions. There is a small field near the settlement, where coarse grass is grown for stock. Attempts have been made to grow corn and beans to supply the residents, but the fierce summer storms of wind and rain, called 'chubascos,' which beat the crops to the ground, have rendered these efforts futile. At present all food supplies are brought from the mainland. A number of years ago a house was built and a field cleared and fenced near the north end of the island for the purpose of growing cotton. A warehouse was also built at the main settlement, but after a trial the owner was forced to abandon the industry, the field and house were deserted, and the place is now overgrown with bushes. Subsequently it was proposed to utilize the agaves, which grow abundantly near the north end of the island, for fiber and for distilling from their fleshy bases the alcoholic product known as 'mescal.' Machinery was obtained, but the owner died before the industry was exploited.

In winter the weather is dry and pleasant, and small coasting steamers stop every now and then to take on wood for fuel, and sailing vessels call for Spanish cedar or, in spring, for salt. In May the inhabitants are obliged to lay in a stock of provisions sufficient for several months, as they are practically cut off from communication with the mainland during summer, when the islands are avoided on account of the storms that sweep over them. Many objects drift out from the Gulf of California after storms and are cast up on the shores. In September, 1896, a great tornado of wind and rain swept over northern Sinaloa and the Gulf of California; the coast lowlands were devastated by the flooded rivers, and crops and forests were alike overwhelmed and swept to sea. In May, 1897, the shore of Maria Madre was still strewn with cornstalks, driftwood, and other wreckage that had been stranded after this storm.

Our obligations to the collector of customs at San Blas and his agent on Maria Madre have already been mentioned, and acknowledgments are due also to the owner of the islands, Señora Gil de Azcona, whose letter procured us the use of horses and other courtesies.

PHYSIOGRAPHY.

The Tres Marias are situated between latitude 21° and 22° and longitude 106° and 107° (see frontispiece). Between the islands and the mainland, 20 miles offshore, lies Isabel Island, only about a mile long and 150 feet high. The soundings in the channel between the mainland and the islands gradually deepen to less than 300 fathoms, but just west of the group the sea bottom drops rapidly to more than 1,500 fathoms. The absence of a deep channel shows that they are continental islands, as distinguished from the oceanic Revillagigedo group, farther west.

The Tres Marias group comprises four islands, San Juanito, Maria Madre, Maria Magdalena, and Maria Cleofa, arranged in a northwest and southeast direction. Maria Madre, the largest, measures about 8 by 15 miles, and rises over 2,000 feet above the sea. North of this, and separated from it by a channel 4 miles wide and 5 or 6 fathoms deep, is San Juanito, an islet 3 or 4 miles in diameter and about 100 feet high. Next southeast of Maria Madre is Maria Magdalena, roughly triangular in outline and 7 or 8 miles across, with its central summit rising to an altitude of about 1,500 feet. A shallow channel 8 miles wide separates it from Maria Madre. Southeast of Maria Magdalena lies Maria Cleofa, the last of the group. It is irregularly rounded in outline, about 3 miles across, and its altitude is apparently much less than 1,320 feet, as given on the charts. The channel between the two last-named islands is about 12 miles wide and much deeper than the others.

With the exception of San Juanito, which is nearly flat with a narrow border of low bluffs along the north shore, the islands are mountainous and rise in successive slopes from the shore to the culminating point near the center. The interior of Maria Madre is occupied by a mountainous ridge extending almost the entire length of the island, but descending to a gently sloping area near each end. The eastern side of the island has the longer slope, while the westward or seaward face is much more abrupt, thus corresponding with the formation of the mountains parallel to the coast on the adjacent mainland. Both slopes of the island are scored at intervals with canyons which usually descend in a nearly direct line to the sea. Maria Magdalena and Maria Cleofa are occupied by a central mountainous elevation, from which canyons descend in all directions to the sea. The northeastern points of both these islands are low, flat, sandy areas of limited extent, and the western faces are rocky and precipitous. Permanent fresh water is very scarce on all the islands. There are three little streams on Maria Madre, which sink several miles from the sea during the dry season, and one each on Maria Magdalena and Maria Cleofa.

The relative situation of the islands, with the narrow, shallow channels between them, shows conclusively that at one time they formed a single island at least 45 or 50 miles long, and at a still earlier stage they must have been connected with the mainland. One of the strongest proofs of this former connection is shown by the correspondence between the fauna and flora. The breaking down of the original island into several smaller ones and the evident continuous encroachment of the sea appear to indicate that the subsidence is still in progress. The country back of the coast on the mainland was, within a comparatively recent period, the scene of great volcanic activity, and the Tres Marias bear evidence of having undergone various oscillations in level. On Maria Madre there are great beds of marine deposits, hundreds of feet above sea level, containing quantities of shells and corals of species now living along the shore. Isabel Island, near the mainland, is of volcanic origin and exhibits similar evidence of having once been a much larger island which is now sinking. Apparently it consists mainly of the remains of an old volcano, and a small crater still occupies the center of the island. Although no craters were seen on the Tres Marias, yet there are lavas and other volcanic rocks on all the islands, but a large part of the formation is made up of other rocks elevated by the volcanic uplift.

FAUNA.

The Tres Marias, like the adjacent coast, lie within the Arid Tropical life zone. The evidence furnished by the fauna of the former connection of the Tres Marias with the mainland is as follows: Six species of land shells were obtained, which, according to Dr. William H. Dall, are widely distributed on the mainland. These species are *Polygyra ventrosula* Pfr., *Orthalicus undatus* Brug., *Orthalicus undatus melanocheilus* Val., *Lamellaxis* ——— ?, *Opeas subula* Pfr., and *Glandina turris*, Pfr. A fresh-water fish taken on Maria Magdalena and Maria Cleofa has been identified by Prof. B. W. Evermann as *Agonostomus nasutus* Günther, a common species on the mainland. In fresh-water pools on Maria Magdalena two or three individuals of another small fish were seen, which were very similiar to common mainland species of *Awaous*, and undoubtedly belong to this or a closely allied genus. Six of the seven species of lizards inhabit the mainland, and only one is peculiar to the islands; the mud turtle and crocodile are also found on the mainland, as are the eight species of snakes. Concerning the reptilian fauna Dr. Stejneger remarks: "Thus most of the species are common on the opposite mainland and generally distributed over tropical Mexico and Central America. Then again it seems as if the species are practically identical on all the islands of the group. This would indicate a comparatively recent severance of these islands from each other, as well as from the opposite mainland of Mexico."

The birds and mammals seem to have been more susceptible to modifying influences than other forms of life. Thirty-six species of resident land birds were found on the group, of which twelve are identical with those on the mainland, and twenty-four can be distinguished specifically or subspecifically. We found ten species of indigenous mammals, seven of which, acccording to Dr. Merriam, are peculiar to the islands, but closely related to species living on the mainland.

ANIMALS PECULIAR TO THE TRES MARIAS.

So far as known, the following species and subspecies (with the exception of *Compsothlypis insularis*) are peculiar to the islands:

MAMMALS.

Marmosa insularis Merriam.
Oryzomys nelsoni Merriam.
Peromyscus madrensis Merriam.
Lepus graysoni Allen.
Procyon lotor insularis Merriam.
Rhogeëssa parvula H. Allen.
Glossophaga mutica Merriam.

BIRDS.

Columba flavirostris madrensis Nelson.
Leptotila capitalis Nelson.
Buteo borealis fumosus Nelson.
Polyborus cheriway pallidus Nelson.
Psittacula insularis Ridgway.
Trogon ambiguus goldmani Nelson.
Dryobates scalaris graysoni Baird.
Nyctidromus albicollis insularis Nelson.
Amazilia graysoni Lawrence.
Iache lawrencei Ridgway.
Platypsaris aglaiæ insularis (Ridgway).
Myiopagis placens minimus Nelson.
Icterus graysoni Cassin.
Cardinalis cardinalis mariæ Nelson.
Piranga bidentata flammea (Ridgway).
Vireo flavoviridis forreri (Von Madarasz).
Vireo hypochryseus sordidus Nelson.
Compsothlypis insularis (Lawrence). Occurs also on the mainland near San Blas.
Granatellus francescæ Baird.
Thryothorus lawrencii (Ridgway).
Thryothorus lawrencii magdalenæ Nelson.
Melanotis cærulescens longirostris Nelson.
Myadestes obscurus insularis Stejneger.
Merula graysoni Ridgway.

REPTILES.

Cnemidophorus mariarum Günther.

FLORA.

The islands were visited near the end of the long dry season, when most of the herbaceous plants were withered and lifeless, but representatives of 136 species, largely shrubs and trees, were secured.

The general appearance of the vegetation was the same as that in similar situations on the mainland. Among the most notable plants were the Spanish cedar (*Cedrela*), three species of wild fig (*Ficus*), two of *Pithecolobium*, five of *Solanum*, two of *Ipomœa*, a *Passiflora*, cassias, euphorbias, a large agave, a large cereus, and two opuntias.

On San Juanito the vegetation is largely made up of bushes and scrubby trees 8 to 15 feet high, with many agaves on the sandy southern end. Agaves are very numerous also on the northern end of Maria Madre. On the latter island the forest is rather low and scrubby near the shore, but increases in luxuriance farther up the slopes, especially along the bottoms and sides of the canyons, where Spanish cedars, wild figs, and several other trees attain a large size. In its primeval condition, before the advent of woodcutters, it must have presented a fine example of tropical forest growth. Now, only a few specimens remain to show what the original condition must have been. Along the summit of the island the dense forest is made up of slender-trunked trees, called 'palo prieto' by the natives, which I was unable to identify. On Maria Magdalena the conditions were similar to those on Maria Madre, but a larger percentage of the original forest still remains intact, although the Spanish cedars are mainly gone. Maria Cleofa is more rocky and sterile, and the trees are stunted and brushy. Several species found on the other islands appeared to be wanting here. The report on the plants shows that the flora of the islands is very similar to that of the mainland, and the fact that several new species were found may be due to our imperfect knowledge of the mainland flora.

PLANTS DESCRIBED FROM THE TRES MARIAS.

Ægiphila pacifica Greenman.
Beloperone nelsoni Greenman.
Buxus pubescens Greenman.
Cordia insularis Greenman.
Erythrina lanata Rose sp. nov. (also on mainland).
Euphorbia nelsoni Millspaugh.
Euphorbia subcærulea tresmariæ Millsp. var. nov.
Gilibertia insularis Rose sp. nov.
Pilocarpus insularis Rose sp. nov.
Ternostroemia maltbya Rose sp. nov. (also on mainland).
Zanthoxylum insularis Rose sp. nov.
Zanthoxylum nelsoni Rose sp. nov.

SUMMARY.

The following statement shows the number of species of animals and plants now known from the Tres Marias:

Land mammals	11
Birds	83
Reptiles	18
Fresh-water fish	2
Fresh-water shrimp	1
Land mollusks	6
Plants	136

ACKNOWLEDGMENTS.

Much of the value of this report is due to the cordial cooperation of several eminent specialists. Through the courtesy of Mr. F. V. Coville, curator of the National Herbarium, Dr. J. N. Rose, assistant curator, was enabled to prepare the report on the plants. Dr. Leonhard Stejneger, curator of the division of reptiles of the National Museum, Dr. William H. Dall, honorary curator of the division of conchology, and Miss Mary J. Rathbun, assistant in the division of invertebrates, reported on the Tres Marias material; and Prof. B. W. Evermann, ichthyologist of the United States Fish Commission, kindly identified the collection of fishes from the islands and the adjacent mainland. Finally, I wish to express my great indebtedness to Mr. Robert Ridgway, curator, and Dr. Charles W. Richmond, assistant curator, of the division of birds in the National Museum, for having so freely placed at my disposal, not only the material in their charge but also their knowledge of tropical American birds.

MAMMALS OF THE TRES MARIAS ISLANDS.

By E. W. Nelson.

Mammals are not numerous either in species or individuals upon the Tres Marias. So far as known, they number but eleven species, of which seven are peculiar to the islands; one is introduced, and the other three are widely ranging bats. A sea lion and two species of porpoise were found near the shores, and whales were reported to occur during certain seasons. As with the birds, one of the most unaccountable features of the mammal fauna is the absence of a number of species that are common on the adjacent mainland. Considering the primitive condition of the islands, it is difficult to explain the presence of field mice, the pigmy opossum, rabbit, and raccoon, while the large gray opossum, nasua, skunk, fox, coyote, deer, peccary, squirrel, and various small rodents of the adjacent mainland remain unrepresented. The Tres Marias mouse was rather common above 200 feet on all of the larger islands; the rabbit was very numerous near the north end of Maria Madre, on San Juanito, and in some places on Maria Magdalena, and two species of bats were abundant in caves on Maria Madre. Aside from these species, mammals were uncommon and difficult to find. One cause of their general scarcity may be the very limited supply of permanent fresh water, and the absence of small species from a broad belt near the shore was easily accounted for by the abundance of carnivorous crabs.

The mammals obtained by our party have been identified by Dr. C. Hart Merriam, who has described the new forms and given critical notes on other species.[1] Of the land mammals taken, five were new and two, *Lepus graysoni* and *Rhogeëssa parvula*, had been previously described. We failed to secure two species of bats (*Myotis nigricans* and *Lasiurus borealis mexicanus*) which were taken by Mr. Forrer. Notwithstanding the fact that collections were made in several branches of natural history, I feel confident that representatives of all the resident land mammals were secured, but it is quite possible that future work may add other bats to the present list.

ANNOTATED LIST OF SPECIES.

Marmosa insularis Merriam. Tres Marias Pigmy Opossum.

Marmosa insularis Merriam. Proc. Biol. Soc., Washington, XII, pp. 14-15, Jan. 27, 1898. Type from Maria Madre Island.

These pretty little opossums were not found except in the high interior of Maria Madre, between 1,200 and 1,800 feet above sea level, where

[1] Proc. Biol. Soc. Washington, XII, pp. 13-19, 1898.

they were apparently rather common about the wild fig trees in the forest and were feeding upon the figs. They may occur also on the other islands, especially upon Maria Magdalena. Two men living on the island described the nests of these animals as globular masses of dry leaves and small plant stems, lined with shreds of softer vegetable matter. The nests are built in the forks of bushes, from 3 to 8 feet from the ground, and have the entrance on the lower side. One of the men found a nest situated as described and about 3 feet from the ground. He saw the owner peering out of a hole near the lower side, but as he approached the head vanished, and the entrance was suddenly closed by the opossum drawing some of the nest material across it. The nest was quickly thrust into a game bag, and when examined was found to contain a female opossum and a number of young clinging to her fur with their feet and tails twined closely about hers. The weight of the young was so great that the parent could only walk very slowly.

Oryzomys nelsoni Merriam. Nelson's Rice Rat.

Oryzomys nelsoni Merriam. Proc. Biol. Soc. Washington, XII, p. 15, Jan. 27, 1898. Type from Maria Madre Island.

This rice rat is probably a rare species, as only a few specimens were secured after much trapping. They were found only in damp places near springs about the summit of Maria Madre, about 1,800 feet above sea level. This seemed the most suitable location for them on account of the juicy herbaceous vegetation mingled with the undergrowth.

Peromyscus madrensis Merriam. Tres Marias Mouse.

Peromyscus madrensis Merriam. Proc. Biol. Soc. Washington, XII, p. 16, Jan. 27, 1898. Type from Maria Madre Island.

This is the mostly widely distributed and probably the most numerous rodent. Specimens were taken on the three large islands, but its occurrence on San Juanito, where land crabs are very numerous, is doubtful. They were generally distributed over the forest-grown slopes bordering the shore, above the belt infested by crabs. On Maria Madre they were most common about the wild fig trees near the summit (1,500 to 1,800 feet), where the pigmy opossums were secured. Here their burrows entered the ground under logs or projecting roots, but elsewhere these mice were found living beneath rocks and small ledges. They are apparently restricted to the forest, and while nowhere so abundant as were the rabbits in one place near the north end of Maria Madre, yet they were much more generally distributed.

Mus rattus Linn. Black Rat.

These rats were found in small numbers about the houses and distributed over the forested parts of Maria Madre and, as on the mainland of western Mexico, we found only the gray form.

Lepus graysoni Allen. Tres Marias Cottontail.

Lepus graysoni Allen, Mon. N. Am. Rodentia, pp. 347–348, 1877. Type from Tres Marias Islands (undoubtedly from Maria Madre).

The cottontail is abundant in some places on San Juanito, Maria Madre and Maria Magdalena, and was reported to occur on Maria

Cleofa. They were very numerous about a deserted ranch on the north side of Maria Magdalena, but were rather scarce elsewhere on that island. We found them extraordinarily abundant and surprisingly tame about old fields on an abandoned ranch at the northern end of Maria Madre. Some were killed with stones near camp, and it would have been easy to kill over a hundred in a morning. They would sit in their forms among the bushes while one peered at them from a distance of a few feet, and when driven out into an open space they often sat quietly while the camera was brought up and focussed within a short distance. The old fields at this ranch had been long abandoned and were covered with a scattered growth of bushes, which seemed more suitable for the rabbits than the forested areas, where they occurred much more sparingly. The cottontails frequented the wood roads leading from the shore up over the forested slopes, and after 3 o'clock in the afternoon could be found sitting quietly in little open places in the undergrowth waiting for the nearer approach of sunset before coming out into the roads.

The skin of these rabbits was surprisingly delicate, and it was difficult to skin them without tearing it in many places. It was found almost impossible to carry a specimen by the hind legs even a short distance without having the skin tear and slip where it had been grasped by the hand.

It is strange that the rabbits are not more abundant on the islands, considering the fact that the raccoon is the only predatory mammal, and that the few red-tailed hawks and caracaras are the only birds that prey upon them.

Procyon lotor insularis Merriam. Tres Marias Raccoon.

Procyon lotor insularis Merriam. Proc. Biol. Soc. Washington, XII, p. 17, January 27, 1898.

The raccoon was rather common on Maria Madre and Maria Magdalena, but no signs of them were seen on Maria Cleofa, where, however, they may occur. In May they were feeding on wild figs and other fruits and on the crabs, which were very abundant near the shore. Every morning freshly made raccoon tracks were seen in trails leading from the seashore to higher parts of the islands, but the animals usually passed our traps without paying the slightest attention to the bait. They were semi-diurnal in habits and several were seen in the woods in broad daylight. One afternoon one was seen crossing the bed of a dry wash near the northern end of Maria Madre, and instead of trying to escape through the woods it climbed a wild-fig tree on the bank and stood looking down from a horizontal branch until shot.

Zalophus californianus (Lesson). Sea Lion.

A large seal or sea lion, called 'lobo marino' or sea wolf by the Mexicans, was reported to occur at several places on the rocky shores of Maria Magdalena and Maria Cleofa. We first heard of them before leaving San Blas and again upon reaching the islands. It was evident that the sea lions had been hunted for sport by previous visitors until they had become comparatively scarce and are now in a fair way to become extinct. After learning the location of the most frequented places on both islands, we visited them under the guidance of a tortoise-shell hunter who was very familiar with the shore, but we saw only a single sea lion. It was on a rocky islet off the shore of Maria Cleofa, and took to the water and disappeared before we could get a shot. Our guide said that sometimes the sea lions leave the islands for a few days, and this may account for the failure to find them about their usual haunts. The consensus of opinion among the residents of Maria Madre was that these animals are now very scarce. Formerly they were found in many places; but at present a rocky point on the north-west side and a jutting reef on the south side of Maria Magdalena and some islets west of Maria Cleofa are the only landing places used.

It is possible that the Guadalupe Island fur seal (*Arctocephalus townsendi* Merriam) may also occur at times about the islands.

Rhogeëssa parvula H. Allen. Tres Marias Rhogeëssa.

Rhogeëssa parvula H. Allen. Proc. Acad. Nat. Sci. Phila., 1866, p. 285. Type from the Tres Marias.

These little bats were rather common on Maria Madre, where they live in the forest and fly at dusk along the trails and about small open places. At times they appear in such situations in broad day. Two were killed while flying up and down a trail in the brilliant sunshine in the middle of the forenoon, and I saw one hawking for insects among the tree tops along a trail two hours before sunset. As a rule, however, they only come out when it is too dark for one to see more than an indistinct form as they flit about among the trees. A few were also seen on Maria Magdalena.

Myotis nigricans (Maximilian). Maximilian's Black Bat.

According to Mr. Oldfield Thomas, a specimen of this bat was taken on the Tres Marias by Mr. Forrer.[1] We took none, and they probably occur on the island only as stragglers.

Otopterus mexicanus (Saussure). Big-eared Bat.

A colony of over a hundred big-eared bats was living in an old warehouse at the settlement on Maria Madre, and others were found in several caves situated in various parts of the island. The warehouse where these bats were found had a large open window and wide cracks, so that it was quite light inside, yet they were found hanging from the ceiling and roof, in plain view, and evidently had lived there a long time. The specimens were mostly females heavy with young.

Glossophaga mutica Merriam. Tres Marias Glossophaga.

Glossophaga mutica Merriam. Proc. Biol. Soc. Washington, XII, pp. 18–19, January 27, 1898. Type from Maria Madre Island.

This was by far the most numerous bat on Maria Madre, where it was found in every cave sufficiently deep to be dark. One cave was among

[1] Biologia Centrali-Americana, Mammalia, 206, 1881 (under *Vespertilio nigricans*).

some huge projecting rocks lying at the water's edge, near the settlement. Many of the females collected contained large embryos. These bats were feeding on the fruit of the wild fig.

As surmised by Dr. Merriam,[1] the record of *Chœronycteris mexicana* from these islands, given by Mr. Thomas in the Biologia, proves to be referable to the present species. In reply to a letter of inquiry, Mr. Thomas states that he discovered the mistake in identification too late to correct it in the Biologia, and agrees with Dr. Merriam in referring his specimen to *G. mutica*.

Lasiurus borealis mexicanus (Saussure). Mexican Red Bat.

Forrer added this species to the fauna of the Tres Marias as recorded by Mr. Thomas.[2] We did not see any red bats, and I doubt their being found on the islands except as stragglers from the mainland. Bats are such wide-ranging animals it is to be expected that several additional species will eventually be found to occur on the islands.

? **Phocæna communis** (Lesson). Common Porpoise.

Porpoises supposed to belong to this species were common around the shores of the Tres Marias and also in bays and mouths of streams or lagoons along the coast of the mainland. They were always seen in the belt of shallow discolored water within a short distance of the shore. As soon as blue water, with a depth of over 40 fathoms, was reached, the other porpoise (*Prodelphinus longirostris*) was encountered. The common porpoise was seen in schools of 10 to 30 or 40 individuals swimming in loose order. At Maria Madre they came into the shallow bay in front of the settlement in the early morning and followed close along shore.

Prodelphinus longirostris (Gray). Long-nosed Porpoise.

In the blue water between the mainland and the islands these porpoises were very abundant in schools of from 100 to 200 individuals. They are much slenderer and more graceful animals than the preceding species. While swimming about their feeding places at sea they were accompanied by swarms of terns, gannets, and shearwaters. On one occasion, while crossing to the islands, a school of about 200 porpoises came directly toward us and passed under and on all sides of the boat. While they were passing, the water was broken into foam on every hand by their glistening black bodies, and overhead swarmed a shrieking crowd of sea birds. Mr. Goldman made a fortunate rifle shot and killed two of them, but one sank before it could be harpooned.

[1] Proc. Biol. Soc. Washington, XII, pp. 13–19, footnote, January, 1898.
[2] Biologia Centrali-Americana, Mamm., p. 205, footnote.

BIRDS OF THE TRES MARIAS ISLANDS.

By E. W. Nelson.

The present paper is based mainly upon the birds found on the Tres Marias, but for the sake of completeness the results of our work on Isabel Island have also been introduced.[1] The situation of Isabel Island between the mainland and the Tres Marias renders its bird life of peculiar interest in the present connection. Mr. Xantus sent specimens of birds to the National Museum labeled 'Tres Marias, 1861,' but only one of these can be an authentic island species, and it seems almost certain that Xantus did not visit the islands.

Colonel Grayson's notes on his three visits to the group and his trip to Isabel Island were published by George N. Lawrence in the 'Proceedings' and 'Memoirs of the Boston Society of Natural History,' while the descriptions of new birds in his collections appeared in various publications and are mentioned in the bibliography (see pp. 93–94). Grayson constantly refers to the 'Tres Marias Islands,' but the internal evidence of his writings, in addition to the information given me by the inhabitants, indicates that all of his work was done on Maria Madre.

Mr. A. Forrer visited Maria Madre in 1881, but the publication of *Vireo flavoviridis forreri* by Von Madarasz and a few notes in the 'Biologia Centrali-Americana' and in some of the British Museum Catalogues are all we know of his work there.

As already stated in the general introduction, our work was done on Isabel Island on April 22 and 23, on Maria Madre from May 2 to 25, and six days were spent working about Maria Magdalena and Maria Cleofa. It is quite certain that the bird fauna of Maria Madre is now fairly well known, and it will be advisable for anyone visiting this group in the future to give attention chiefly to the two smaller islands. It is certain that a large proportion of the birds found on Maria Madre occur also on Maria Magdalena, but some of the species living in the dense forest at higher altitudes on these islands probably do not occur in the more scanty forest of Maria Cleofa.

At present 83 species and subspecies of birds are known from the Tres Marias, and further observations will, no doubt, add to the list various stragglers from the mainland. The bird fauna may be grouped under the following headings: Resident land birds, 36 species or sub-

[1] The notes in the following pages refer to Isabel Island only when so stated.

species. Visitant land birds, 26 species or subspecies. Resident water fowl, 13 species. Visitant water fowl, 8 species.

Of the 36 resident species or subspecies of land birds all but 5 were observed by Colonel Grayson. These exceptions are: *Melopelia leucoptera*, *Tyrannus melancholicus couchi*, *Ornithion imberbe*, *Vireo flavoviridis forreri*, *and Thryothorus lawrencii magdalenæ.*

Twenty-four of the 36 resident land birds are specifically or subspecifically distinct from their mainland representatives. Of this number 12 were described from Grayson's collections, 1 from Forrer's, and 11 from our own. A study of our collections from the islands, and near San Blas on the mainland, brings out the interesting fact that several species from the latter district show a decided approach to their island representatives. This is very marked in *Compsothlypis* which is very nearly the same at San Blas as on the islands. The *Polyborus* and *Platypsaris* from that locality seem to be intermediate between the island races and the birds of the mainland. Specimens of *Thryothorus felix* from the same part of the coast are much nearer *T. lawrencii* than they are to typical *T. felix*.

Among the 24 species or subspecies of land birds peculiar to the islands 15 are larger than their relatives of the nearest mainland. These are *Columba f. madrensis*, *Leptotila capitalis*, *Psittacula insularis*, *Dryobates s. graysoni*, *Nyctidromus a. insularis*, *Amazilia graysoni*, *Icterus graysoni*, *Cardinalis c. mariæ*, *Piranga b. flammea*, *Vireo f. forreri*, *Vireo h. sordidus*, *Compsothlypis insularis*, *Granatellus francescæ*, *Thryothorus lawrencii* and *Merula graysoni*.

Six of the island birds average smaller than their mainland representatives. These are *Polyborus c. pallidus*, *Iache lawrencei*, *Platypsaris a. insularis*, *Myiopagis p. minimus*, *Melanotis c. longirostris*, and *Trogon a. goldmani*. The two first named are generally smaller, but *Platypsaris a. insularis* has a longer tarsus, *Myiopagis p. minimus* a longer bill and tarsus, *Melanotis c. longirostris* a longer bill, and *Trogon a. goldmani* a longer bill and tarsus.

Although *Compsothlypis insularis* also occurs in a limited area along the coast, I have considered it as a typical island species. The difference in size between island birds and their mainland representatives varies greatly, being slight in some and very well marked in others. *Nyctidromus a. insularis* is a larger bird than *albicollis* proper, but has a shorter bill and tarsus. Among the birds peculiar to the islands *Thryothorus lawrencii magdalenæ* and *Myadestes o. insularis* are almost the only ones which do not show more or less well-defined differences in size from their nearest mainland relative; a series of the first named, however, may show that it also differs.

One of the most puzzling features of the fauna of these islands is the absence of various land birds found on the adjacent mainland. Although the physical conditions appear so much like those of the mainland, yet some change must have occurred to upset nature's fine balance and render these isolated areas unsuitable for many species.

The death by starvation of the Louisiana Tanagers on Maria Madre Island (p. 52) is an example of the manner in which the island fauna may be maintained in its present state. As the climatic conditions on the islands and on the mainland are very similar and the vegetation nearly alike, this paucity of species presents one of the curious problems of distribution.

It would be hard to find an equal area of similar country on the mainland, near San Blas, where so few species of land birds could be found. The only reasonable explanation seems to be the scarcity of water and the long, dry season, which combine to reduce the food supply and perhaps render the country unsuited to some species. It was very surprising to find a total absence on the islands of such common and widely spread mainland genera as *Conurus*, *Momotus*, *Piaya*, *Campephilus*, *Melanerpes*, *Myiozetetes*, *Cissolopha*, *Cyanospiza*, *Pipilo*, *Pyrgisoma*, *Saltator*, and others. The absence of *Pipilo* is especially unexpected, for this genus is represented on Socorro Island, which lies very much farther at sea off the same part of the coast.

ANNOTATED LIST OF SPECIES.

? **Brachyrhamphus brevirostris** (Vigors.) Short-billed Murrelet.

Brachyrhamphus brevirostris was described from San Blas and *B. hypoleucus* from Cape St. Lucas. Colonel Grayson mentions having seen 'guillemots' at Isabel Island (Mem. Boston Soc. Nat. Hist., II, p. 318, 1874) and off the Tres Marias group (Proc. Boston Soc. Nat. Hist., XIV, p. 288, 1871). This led me to anticipate finding at least one of the species there, and it is with some disappointment that I have to record our failure to see either species about the islands, although I watched for them constantly. From this experience I am inclined to think that they breed only along the coast of Lower California, and visit these islands sporadically.

Larus argentatus smithsonianus Coues. American Herring Gull.

A single immature specimen was taken on San Juanito Island May 22, and a few others were seen. These birds were flying back and forth along a strip of beach where a large colony of blue-footed gannets were breeding, and the gulls probably had an eye on the nesting ground for the purpose of capturing any unprotected eggs. They were noted singly a few times along the shores of the Tres Marias and at Isabel Island. No fully adult individuals were seen.

Larus heermanni Cassin. Heermann's Gull.

On April 23 a fine adult bird of this species was shot on the shore of Isabel Island. In company with its mate it had harried a blue-footed gannet into disgorging a number of small fish upon a rock at the edge of the water, and was picking up the spoils by a series of little downward swoops and hoverings. The gannet had shuffled into the water and was making off, with backward glances at its tormentor, when I drew near. These gulls are bold and noisy aggressors when they wish to take advantage of the gannets, and about the breeding places of the latter they feed largely at the public expense. But few of them were seen about the islands—two or three pairs at Isabel and half a dozen pairs about the Tres Marias. A nest, which had been occupied earlier in the season, was seen on the ledge of a rocky islet off the shore of Maria Cleofa May 30, and full grown young of the year were also seen on the rocks.

Sterna maxima Boddaert. Royal Tern.

None were seen at Isabel Island, although they were not uncommon during April along the mainland coast. During May they were seen in small parties about the shores of all the Tres Marias group, where they probably breed in very limited numbers. The only specimen saved was taken May 31 from a flock of six which was coasting along the beach at Maria Cleofa.

Sterna elegans Gambel. Elegant Tern.

Sterna galericulata Lawr., Mem. Boston Soc. Nat. Hist., II, p. 317 (1874).

Colonel Grayson found these terns on Isabel Island, but none were seen by us.

Sterna fuliginosa crissalis (Lawr.). Pacific Sooty Tern.

Haliplana fuliginosa var. *crissalis* Lawr. (ex Baird MS.), Proc. Boston Soc. Nat. Hist., XIV, pp. 285, 301, June, 1871; Mem. Boston Soc. Nat. Hist., II, p. 318, 1874.

These handsome terns are common about Isabel Island where Colonel Grayson found them breeding. My observations from the last of April to the first of June led me to believe that at this season Isabel Island is their central roosting point. During the week we were cruising about Isabel and the Tres Marias islands many flocks were seen. From about noon until the middle of the afternoon or later the flocks were generally flying directly toward Isabel at an altitude of from 50 to 200 yards above the water. This was noted also near the islands, while we were crossing the straits between the Tres Marias, and off the mainland near San Blas. Many of the birds were perched along the top of an inaccessible rock just off Isabel, and were also seen alighting on the cliffs of the northern and northeastern side of the island, but the boat was too unwieldy for us to venture near enough to closely examine these haunts. The birds have a peculiar shrill cry which they often utter while feeding and when flying about at night. The night before we landed on Isabel Island it was necessary to anchor about midway between the island and the shore. The wind blew strongly in the afternoon but fell at sunset, a dead calm ensued, and heavy clouds overspread the sky. During the day only a few sooty terns had been seen, but from about 9 p. m. until near daybreak they were evidently much more numerous, for their cries were heard at short intervals. Several times the notes were uttered directly overhead and the birds seemed to be scarcely higher than the top of the mast, where they apparently paused and hovered while they examined the boat with great curiosity. As they were heard every night while we were at sea, it is evident that they were both diurnal and nocturnal in habits.

They feed well out at sea, and were not found anywhere along shore, except when they came to their roosting place on Isabel Island. There were no signs of their roosting about the Tres Marias, although they may roost on some of the outlying rocky islets. Grayson found them in small numbers farther west, about the Revillagigedo Islands. During our trip to the Tres Marias many schools of large fish were encountered swimming close to the surface and constantly breaking, often with such force and rapidity that the water boiled and foamed over considerable areas. These schools of fish were commonly accompanied by flocks of sooty terns and gannets, which appeared to be animated by the wildest excitement. The terns hovered over the foaming sea, uttering shrill cries and darting down into the water, evidently after food; and in the midst of the turmoil the blue-footed gannets swam about, beating the water with their wings and adding to the noise made by the terns and leaping fish. While on Maria Madre I saw a flock of terns some distance off shore, and taking a canoe, managed to get out to them, and directly in the course of the school of fish they were accompanying. Letting the boat drift, I stood up and watched the swarm go by. Thousands of large fish and hundreds of terns and gannets passed the boat on every side, amid loud cries from the terns, a rushing sound from the fish and gannets, and a bewildering complexity of motion in sea and air that was intensely exciting. This novel sight was so interesting that I came near losing the chance to secure some of the birds.

These terns were seen also following schools of porpoises off shore—in the latter case accompanied by the wedge-tailed shearwater. In the passage between Maria Magdalena and Maria Cleofa a flock of sooty terns was seen soaring in wide circles high overhead and finally starting off for their roosting place on Isabel Island.

The 'variety *crissalis*,' named in manuscript by Professor Baird and published by Mr. Lawrence, was characterized as "having the under tail coverts tinged with ashy, instead of being pure white." A series of 17 specimens from the west coast of Mexico, and from widely scattered islands of the Pacific and Indian oceans, agree in having the posterior part of flanks, under wing coverts, and entire crissum distinctly ashy, not a single individual being white on these parts, as is commonly the case with birds from the Atlantic and Gulf coasts of North America. Unfortunately the series of Atlantic birds at hand is very small, but there is little doubt that *crissalis* is a valid subspecies. Birds from the west coast of Mexico, the Galapagos Islands, and Hawaii agree in having an average shorter bill and tail than those from elsewhere. Specimens from the Indian Ocean have even a longer bill and tail than those from the Atlantic, but are ashy below, like those from western Mexico. Specimens from Ascension Island, off the west coast of Africa, also have a light ashy shade on the lower tail coverts.

The following average measurements show the sizes of these birds from various parts of their range:

*Table of measurements of Sterna fuliginosus and Sterna f. crissalis.**

Name.	Locality.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Sterna fuliginosus..	East coast of North America and west coast of Africa.	7	288.1	151	42.8	23.5
Sterna fuliginosus crissalis.	West coast of Mexico, Hawaii, and Galapagos Islands.	10	288.6	143.5	41.8	23.6
Sterna fuliginosus crissalis.	Krusenstern Islands (west of Hawaii).	2	292.5	203.5	39.5	24.2
Sterna fuliginosus crissalis.	Glorioso Island (Indian Ocean).......	3	292.6	192	43.3	23.8

* All measurements are in millimeters.

In the foregoing measurements the length of the tail is unreliable, owing to its variability, on account of wear and other causes.

Anous stolidus ridgwayi Anthony. Pacific Noddy Tern.

Anous stolidus Lawr., Mem. Boston Soc. Nat. Hist., II, p. 318, 1874.

Anous stolidus ridgwayi Anthony, Auk, XII, p. 36, 1898.

Common the last of April on Isabel Island, and a few seen off the Tres Marias during May. Between San Blas and the islands a number of these birds were seen. We usually saw one or two individuals at a time, and did not find them in flocks anywhere except when congregated on the rocks at their roosting places. At sea they usually flew close along the surface of the waves with long, graceful wing strokes. From their dark color and habit of keeping close to the water they were several times mistaken for black petrels.

They were found in considerable numbers on the ragged faces of cliffs and rocks along the northeastern point of Isabel Island, and were very unsuspicious, permitting us to approach quite near in the boat. While perched on the black lava cliffs, their dark color blended so closely with the background that it was very difficult to distinguish them, even when within fair gunshot. The day we left the island we visited their resting place and fired a dozen or more shots while they were on the rocks or flying about, but the noise of the reports did not seem to give them much alarm. They would circle out a short distance, and, after hovering for a few moments over their killed or wounded companions floating in the water, would return to the same part of the cliff from which they had just been startled. They were not heard to utter any notes, and the silence with which they would suddenly appear out of the cliff and then return and vanish again in its gloomy face produced an uncanny effect.

Colonel Grayson found them nesting on the north end of Isabel Island in April, 1869, and states that they were breeding in communities on shelving rocks beneath overhanging cliffs. The nests were placed close together, but were inaccessible. A single egg was procured, however, which was white, with scattering brownish blotches, most numerous about the larger end. This is undoubtedly the tern which Colonel Grayson reports as replacing the sooty tern on the Revillagigedo Islands, and which he described as being black, with a hoary forehead.

Puffinus cuneatus Salvin. Wedge-tailed Shearwater.

Puffinus cuneatus Salvin, Ibis, 5th ser., VI, p. 353, July, 1888.

Puffinus knudseni Stejn., Proc. U. S. Nat. Mus., XI, p. 93, Nov. 8, 1888.

During our trip to and from the islands we saw 100 or 200 wedge-tailed shearwaters. They were usually seen singly skimming along over the sea, at an elevation af a few yards, making widely sweeping circuits and pausing occasionally to pick up bits of food. When about midway between Isabel Island and the Tres Marias we encountered several schools of small porpoises of 150 or more individuals, which traveled in close array, frequently gamboling about and playfully leaping high in the air. A swarm of sooty terns followed the porpoises, and twice when they passed near us I saw considerable numbers of these shearwaters among the terns. Judging from the numbers, they must be rather common in these waters, but none were seen near the islands.

This species was first described from specimens taken on the Krusenstern Islands, in the Marshall Group, and Mr. A. W. Anthony made the first record of its occurrence on the American side of the Pacific, at the Revillagigedo Islands, during the summer of 1897 (Auk, XV, Jan., 1898, p. 39). As it is a species new to North America, a detailed description of our specimen is given, in order to facilitate identification in case other examples should be taken.

Description.—No. 156678, U. S. Nat. Mus., Dept. of Agriculture Coll. Ad. ♂, off Maria Mandre Island, May 2, 1897. Collected by E. W. Nelson and E. A. Goldman.

Top and sides of head and neck grayish-brown; forehead, lores, and space from latter area back beneath eyes and along sides of neck paler or more ashy, thus edging the darker area of the crown and upper neck with lighter. Back, including rump and upper tail coverts, mainly dark brown, but mixed with numerous feathers of a decidedly grayish, almost ashy, shade. These latter feathers undoubtedly indicate the color of dorsal surface in fresh-plumaged birds. Wings and tail blackish-brown. Entire lower surface of body white, shaded with dingy ashy, darkest on sides and palest along median portion. Under tail coverts mixed dark brown and grayish-brown. Border of the wing along under side brown or grayish-brown; under coverts white with a little flecking of pale gray on some feathers. In the flesh this specimen had a horn-blue bill with flesh-colored feet and tarsi.

Dimensions.—Wing, 293; tail, 135 (length of middle pair of tail feathers beyond lateral pair, 47); culmen, 42; tarsus, 50; middle toe, with claw, 59.

Habitat.—The range of this species is now known to extend across the middle North Pacific from Japan to the west coast of Mexico.

Oceanodroma melania (Bonap.). Black Petrel.

Common between Isabel and the Tres Marias. Black petrels were by far the most numerous of the petrels seen, and outnumbered all the others two to one. Three, and possibly four, other species were seen on the way to and from the islands, but this was the only one secured. They circled about in all directions, sometimes coming very near, but nothing peculiar in their habits was observed. They were quick to see little fragments of fat thrown overboard while we were skinning other waterfowl, and when the morsels were small enough ate them greedily.

Phæthon æthereus Linn. Red-billed Tropic Bird.

Tropic birds are readily distinguished on the wing by their graceful ternlike flight and long filamentous tail feathers. Many of them breed on Isabel Island and in suitable places on rocky islets near San Blas and about the Tres Marias. The last of April fresh eggs and nearly grown young were found on Isabel, and by the last of May the young on the Tres Marias had taken wing and few were to be seen, although we were told by the tortoise shell hunters that many breed there earlier in the season.

Soon after landing on Isabel, a tropic bird was found sitting on its solitary egg at the end of a little hole in the rock close to the beach. The hole was only about 15 or 18 inches across and about 3 feet deep, so that there was no difficulty in taking the bird by hand after a little maneuvering to avoid its sharp beak. During a stay of about twenty-four hours on this island at least 20 nests containing eggs or young were examined. A single egg is laid directly on the rough rock or loose dirt forming the floor of the nesting site, which is always located under the shelter of over arching rock, but varies greatly in situation. The inner ends of holes in cliffs facing the sea were favorite places, but as the number of such situations was limited, the birds were forced to utilize small caves and even rock shelters. In one locality five or six nests were placed on loose earth at the bottom of rock shelters so situated that I could walk directly up to them and pick up the birds. Whenever a nest was approached the parent screamed and fought viciously, ruffled its feathers and looked very fierce, but made no attempt to escape. They protested with beak and voice when pushed about, but as soon as I went away a few yards they would shuffle back to resume their former position over the egg. The young, even when quite small, were equally fierce in resenting any intrusion. One nest was found on the beach under the edge of some great rocks that had fallen from the adjacent cliff. It was only 5 or 6 feet above high tide and would have been overlooked but for the angry cries of the old bird when she heard me walking over the roof of her habitation. At sunrise the old birds were found sitting side by side at the mouths of their nesting places waiting to enjoy the first rays of sunlight. Half an hour later one of each pair started out to sea while the other resumed its place on the nest. When disturbed on the nest their cries are very shrill and strident, consisting of a series of short, harsh, clicking or rattling sounds something like the noise of an old-fashioned watchman's rattle. The young are covered at first with fluffy white down. Before they are one-third grown the first plumage begins to appear, and is very similar to that of the adults, except that the black barring on the back is broader.

Sula websteri Rothschild. Webster's Booby.

Sula bassana Grayson, Proc. Boston Soc. Nat. Hist., p. 302, 1871.

Sula websteri Rothschild, Bull. Brit. Orn. Club, VII, No. LIV, p. LII, 1898.

This booby is no doubt the *Sula bassana* reported from Isabel Island by Grayson but not seen by us. Mr. Anthony found it the most abundant species breeding on the Revillagigedo Islands during the summer of 1898.

Sula brewsteri Goss. Brewster's Booby.

Sula brewsteri Goss, Auk V, p. 242, 1888.

Brewster's boobies were very numerous on a small hill at one side of the little bay where we landed on Isabel Island April 22, but there were no signs of their breeding. They came in from sea during the first half of the afternoon and sat about on rocky parts of the shore until nightfall. Scattered individuals were also seen about the ledges and tops of the cliffs facing the sea. The following morning at daybreak they were congregated on the little hill already mentioned which is probably their regular roosting place. About half an hour after sunrise they began to start out to sea singly and by twos and threes until all were off on the day's fishing expedition. A few were seen about the rocks just off San Blas, and were said to breed on the large rock (Piedra Blanca) midway between Isabel and San Blas. Only a few of these boobies were seen about the Tres Marias until an islet was visited off the northwest shore of Maria Cleofa. This islet rises from 150 to 200 feet above the sea, with cliffs on all sides. The summit is mainly rolling, with an elevated, sloping bench on one end At this time, May 30, many thousands of boobies were breeding on the bare top of this rock. The eggs were laid directly on the surface, with no sign of a nest. The sun was intensely hot and heated the rocks so that they were uncomfortably warm to the touch. The birds did not sit upon the eggs during the hottest hours, but while standing to avoid contact with the heated rocks kept in such position that the eggs or young were shaded from the sun, and thus had their vitality preserved. While trying to secure photographs of this breeding ground a few of the old birds flew away and it was surprising to see how quickly the newly hatched young succumbed to the heat when the parents left them exposed to the rays of the sun. The nests were spaced at intervals of 4 or 5 feet, so that the old birds were safely out of reach of one another. Although so gregarious in their breeding habits, they appeared to have but little regard for one another. It was amusing to see the savage way in which the nest owners assisted intruders of their own kind out of their territory. While we were walking among them some of the birds would often waddle off to one side, and in so doing necessarily trespassed on their neighbors. The latter at once raised a hoarse shrieking and set upon the outsiders with wicked thrusts of their beaks, which continued until the victims took wing and escaped.

We were also subjects of this proprietary rage, and had our legs nipped every now and then, despite all efforts to walk circumspectly. Our progress over the breeding ground was accompanied by a wave of hoarse, nasal cries that sometimes became almost deafening. Many of the birds were valiant upholders of their rights and sturdily refused to leave their nests, which they defended vigorously, all the time uttering loud cries of rage.

These birds show very little individual variation in color. As the species is not well known the following descriptions are appended from specimens taken on Isabel and Maria Cleofa.

Adult male.—Nearly entire head white, shading gradually on posterior portion into drab of neck and then insensibly into dark, sooty brown of back. On lower side of neck the drab becomes darkest at posterior border, where it ends abruptly against the pure white of lower parts. Bill light horn color; gular pouch in life livid blue; feet greenish yellow—the latter varying in intensity.

Male in immature plumage.—Dorsal surface uniform dark brown, slightly paler than back of adult; entire lower surface still paler and more dingy brown. Feathers over much of body, especially about head, neck, and lower parts, narrowly edged with grayish brown, giving a faint wavy barring. Bill bluish horn color, with darker shade of same about base and on gular pouch; feet and tarsi dull fleshy yellow; iris greenish gray.

Adult female.—Head, neck all around, and back sooty brown; ventral surface below neck white. Bill light horn color; a spot of leaden bluish on lores; base of bill, gular pouch, feet, and tarsi grayish yellow; iris pale grayish.

Average measurements of these birds from Isabel Island are as follows: ♂ (5 specimens), wing 384.4; tail 189.6; culmen 93.6; tarsus 45.4; ♀ (5 specimens), wing 416.6; tail 192.8; culmen 96.6; tarsus 48.8.

Nestlings a few days old are covered with fluffy white down. A male bird of the previous year, which still retained the immature plumage, was taken at Isabel on April 23, and several others were seen.

Sula nebouxii Milne-Edwards. Blue-footed Booby.

Sula piscator Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 302, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 316, 1874.

Sula nebouxii Milne-Edwards, Ann. Sci. Nat., Paris (Zool.), 6ème sér., XIII, Art. 4, p. 37, pl. 14, 1882 (Chile).

Sula gossi Goss (ex Ridgway MS.), Auk, V, p. 241, July, 1888 (Gulf of Calif.).

Sula nebouxii is the most abundant species of booby occurring on Isabel and the Tres Marias. On April 22 they were breeding abundantly on the beaches and on a low flat area that covers a part of the former island. They were common on the grassy beach at the landing and thence back among the scrubby trees and bushes which form a scanty growth over the flat. They were most numerous on the open beach a little above high-water mark, but dozens of them were seen with their eggs farther back among the bushes. Like the preceding species, they fought and screamed savagely when approached. The males usually flew away, but the females remained to give battle over the nests, which were mere hollows in the earth, sand, or gravel. Not a single young one was seen in the hundreds of nests on Isabel.

The sun was excessively hot the morning of our arrival, and while the men were landing the outfit, ropes were fastened between the tops of some scrubby trees close to the beach and a piece of canvas spread for an awning, under which the baggage was placed. An old booby had her eggs in the sand within 3 feet of the edge of the sheltered area and stood her ground unflinchingly while the men were at work, keeping a wary eye on their movements and making vicious dabs whenever a leg came incautiously within reach. Having arranged camp, I went out exploring for an hour or so and returned with various specimens, including the egg of a tropic bird, and found that one of the boatmen had driven off the booby and thrown away her eggs. Wishing to test the bird's discrimination, I placed the reddish-brown egg of the tropic bird in the hollow where the two greenish-white eggs of the booby had been, and sitting under the awning began to prepare specimens. In the course of half an hour the owner of the despoiled nest returned and alighted 10 or 15 steps away near another deserted nest, gave a look at the eggs in it, walked to still another, looked at it, and then proceeded directly to her own nest and stopped. She looked about and then down at the nest. The presence of the single reddish-colored egg appeared to surprise her; she looked at it with one eye and then with the other as if in doubt. An instant later the feathers on her head and nape ruffled up and with a loud squawk of rage she suddenly dashed her beak again and again into the strange egg, breaking it to fragments in a moment. As soon as the egg was demolished she took wing and disappeared out to sea. There was no intention to sacrifice the tropic bird's egg in this experiment, so the booby carried off the honors.

About 10 o'clock the following night a visit was paid to the nesting boobies. The night was calm, and taking a lighted candle I walked out a short distance to an opening in the bushes where there were twenty or thirty nests. The females were found on their eggs with the males standing close beside them. When the strange visitor appeared in their midst the birds set up a continuous series of hoarse cries and, like so many moths, seemed to become fascinated by the light. They started up on all sides, and trooping within the circle of bright light, began to run around me in a ring about 20 feet in diameter. They ran in single file from right to left and presented a most ludicrous sight. Occasionally one fell on its breast, whereupon the others scrambled over the fallen bird until it regained its feet and rejoined the procession. One of the number was suddenly possessed with a desire to run around one of my legs, and, although seized by the head several times and tossed out among its companions, persisted in returning to the same place and continuing its gyrations. The next morning at daybreak the birds were seen standing in pairs by their eggs and remained in this position until about sunrise, or a little after, when all of the males went out to sea—usually in little parties of two to five or six. They returned between 1 and 3 o'clock in the afternoon, and a number of them flew directly to their mates and disgorged numerous small fishes which the females ate greedily. These observations seemed to show that the females did the incubating and the males provided the food. As the neighboring waters do not abound in small fishes, the boobies have to go in many cases from 10 to 30 miles to obtain their daily supply. During a visit to San Juanito Island, the latter part of May, many blue-footed boobies were found breeding on sandy beaches at the south end of the island; many of the young were hatched and some were more than half grown. Like the young of the tropic birds, the young boobies uttered angry cries and fought savagely when approached.

This species is found in Chile, on the Galapagos Islands, and north to the island of San Pedro Martir in the Gulf of California. The type of *Sula nebouxii* was obtained on the coast of Chile, and the type of *S. gossi* came from San Pedro Martir.

The sexes are alike in color, but when standing together the males may be readily distinguished by their smaller size and slenderer form. In life the bill is leaden horn color, with its base and the gular pouch leaden blue; the feet are bright blue. The downy young are pure white. Four specimens measure as follows: ♂ (1 specimen), wing, 410; tail, 219; culmen, 108; tarsus, 51. ♀ (average of 3 specimens), wing, 438; tail, 219; culmen, 109.6; tarsus, 56.

Phalacrocorax sp. Cormorant.

Two or three cormorants seen at a distance were the only ones noted during the trip. None were seen near Isabel nor on the rocks near San Blas.

Pelecanus californicus Ridgway. California Brown Pelican.

A few pairs of brown pelicans were breeding on Isabel Island the last of April. The nests were made of sticks and placed in the dense tops of the scrubby trees growing on the rocky inner slopes of the island. They were found about all of the Tres Marias, but usually occurred singly and were nowhere common. Two or three were seen fishing in the breakers alongshore at the north end of Maria Madre.

Fregata aquila (Linn.). Man-o'-war Bird.

Hundreds of man-o'-war birds were breeding on Isabel in April, and on approaching the island many were seen soaring over the rocky summit. The first shot caused hundreds of others to take wing, and in a few moments the air was swarming with them. They soared in constantly intersecting circles, until the sky seemed covered with their silhouetted outlines. So few had been seen alongshore near San Blas that it was an interesting and unexpected sight. Upon landing, numerous large, oval, and brilliantly red objects were seen in the tops of the dark-green bushes along the slopes. These proved to be the gular pouches of old male man-o'-war birds inflated to the size of a man's head, the brilliant red color of the distended membrane making them very conspicuous objects. It appeared to be a common custom of the birds to sit quietly on the top of a tree for a long time with the pouches thus distended and evidently serving as sexual ornaments. A few birds were seen circling high overhead with their pouches fully inflated, but as a general rule, when soaring, the pouches were closed.

The nests were built of sticks and placed in the tops of low trees and stout bushes from near sea level to the summit of the island. Three or four of these platform-like structures were found together in some of the larger bushes. Many of the young were hatched and, when able to stand alone, would do their best with voice and beak to resent our approach. The young are covered with white down until nearly half grown.

A few of these birds were also seen about the Tres Marias, and are said to breed on San Juanito, but were not common.

Ardea herodias Linn. Great Blue Heron.

A few solitary individuals were seen at various times during May along the beaches, and it is probable that a few pairs may breed on the islands. They were also noted by Colonel Grayson.

Ardea egretta Gmel. American Egret.

The American egret is another species noted by Colonel Grayson, which we did not see. It must occur merely as a straggler from the mainland.

Ardea candidissima Gmel. Snowy Heron.

Recorded by Colonel Grayson as a straggler, but not seen by us.

Nycticorax violaceus (Linn). Yellow-crowned Night Heron.

A dozen or more night herons were noted and a young bird was shot on a rock close to Isabel Island, where it must have strayed from the mainland. As Colonel Grayson found them on the islands and took specimens in immature plumage, it is very probable that they breed there in small numbers.

Totanus flavipes (Gmel.). Yellow-legs.

A single specimen was shot by Prof. C. L. Herrick on Maria Madre the middle of May.

Actitis macularia (Linn.). Spotted Sandpiper.

A few were seen along the shore on all of the islands, where they probably breed.

Several small flocks of another sandpiper were seen along shore on the islands; but although considerable energy was expended in their pursuit we failed to secure a specimen.

Ægialitis semipalmata Bonap. Semipalmated Plover.

Colonel Grayson took a single specimen of this plover. It was not seen by us and must occur only as a straggler.

Hæmatopus palliatus Temminck. American Oyster-catcher.

Rather common on the shores of the Tres Marias and Isabel, as well as along the coast of the mainland near San Blas. A series of ten oyster-catchers were secured and have been compared with four specimens of *Hæmatopus galapagensis*, one of *H. frazari*, and a number of typical *H. palliatus* (from the Atlantic coast of the United States and the West Indies).

All of the birds from the Tres Marias, Isabel Island, and the adjacent mainland were found to be surprisingly close to typical *palliatus*. As the Tres Marias are not far south of Lower California, the birds from the islands might naturally be expected to be nearly typical representatives of *H. frazari*. In reality about the only sign of gradation toward the latter form is the mixed black and white across the lower border of the black neck area. Some specimens from a single small flock on Maria Cleofa had the line of demarkation between the black and white areas on the breast as sharply defined as in *palliatus*, while others had the mixed black and white areas, as in *frazari* and *galapagensis*. Some of the birds have a white spot on the under eyelid, which is absent in others, but otherwise the color is the same as in typical *palliatus*. Birds from the Tres Marias and the mainland coast to the south have an average shorter bill and tarsus than true *palliatus*, and in this character approximate *frazari* and *galapagensis*. Mr. Ridgway has already called attention to the close general similarity existing between the two latter species. The series from the Tres Marias and adjacent coast agree with specimens in the National Museum from various points along the Pacific coast of Mexico, Central, and South America in being very close to typical *palliatus*, thus showing pretty conclusively that this is the resident bird along the coast and adjacent islands south of Lower California.

So far as can be judged from specimens at hand, *H. galapagensis* is distinct from *frazari*, although the birds resemble one other more closely than they do representatives of *palliatus* from the adjacent mainland. A series of specimens from the southern end of Lower California will probably show intergradation between *palliatus* and *frazari*. The following measurements show the comparative sizes of birds from various localities:

Measurements of Hæmatopus palliatus, H. frazari, and H. galapagensis.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Hæmatopus palliatus..	Atlantic coast, United States and West Indies.	♀	3	260	102.3	90	63
Hæmatopus palliatus..	Tres Marias and Isabel Islands.	♂	6	256	100.1	75.8	58.1
Hæmatopus palliatus..	Tres Marias and adjacent coast.	♀	5	262.2	104	83.8	58.4
Hæmatopus palliatus..	Peru and Chile................	♀	2	263	97.5	84	61
Hæmatopus frazari....	Coast of Lower California ..	?	4	250.2	116.8	74.4	56.9
Hæmatopus galapagensis.	Galapagos Islands	♂	2	253	98	83.5	54.5
Hæmatopus galapagensis.	Galapagos Islands...........	?	3	246.6	101.6	82	57

Columba flavirostris madrensis Nelson. Tres Marias Pigeon.

Columba flavirostris Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 274, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 304, 1874.

Columba flavirostris madrensis Nelson, Proc. Biol. Soc. Washington, XII, p. 6, 1898.

These handsome birds were rather common on Maria Madre and Maria Magdalena, ranging to the summits of the islands, and they probably live also on Maria Cleofa. On Maria Madre they were most numerous along the wooded sides of a canyon some distance back from the coast, where they usually perched among the higher branches of the trees or were seen flying about by twos and threes. Early in the morning a few could be found among the smaller trees on the bases of the foothills near the settlement, but later in the day they retired farther inland to the more heavily wooded slopes. On Maria Magdalena they were numerous in some trees near a group of deserted houses and in old clearings a short distance back from the shore. They came to these trees to feed upon the ripening fruit, but were rather shy. When one becomes startled and takes wing it makes a loud flapping noise that alarms its companions, and then all dash swiftly away. They were less confiding than most of the birds on the islands, but were not so shy as their representatives on the mainland. Wild figs and the small fruit of a tree, probably a species of *Psidium*, or wild guava, were favorite articles of food. Their loud cooing note is uttered at short intervals and is one of the characteristic sounds in the forests they frequent. They are essentially arboreal in habits and are rarely seen near the ground.

Zenaidura macroura (Linn). Mourning Dove.

A single mourning dove was taken on May 5, on Maria Madre, and a few others were seen on the island during the first half of the month. They were found for a short time about an old field near the shore, and, like several other species, were probably stray migrants.

Leptotila fulviventris brachyptera (Salvadori). White-fronted Dove.

There is a typical specimen of this bird in the National Museum collection, which was taken on the Tres Marias by Colonel Grayson. It was undoubtedly a straggler from the mainland, as it shows no approach toward the characters distinguishing the resident insular species.

Leptotila capitalis Nelson. Tres Marias Dove.

Leptoptila albifrons Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 274, 1871 (part); Lawr., Mem. Boston Soc. Nat. Hist., II, p. 305, 1874 (part).

Leptotila capitalis Nelson, Proc. Biol. Soc. Washington, XII, p. 6, 1898.

Very common on Maria Madre and Maria Magdalena, and probably occurs also on Maria Cleofa. They run about on the ground under the shade of the forest with motions like those of a quail. During the morning and evening hours quiet trails leading through the forest are their favorite resorts. When walking along these trails one sees them for a moment, sometimes running and sometimes on the wing close to the ground, as they disappear around the next bend. If one is walking slowly the birds will frequently keep ahead for some distance, but if pressed they either run or fly to one side into the sheltering woods. They have a loud cooing note, which is heard at short intervals wherever the birds are common. During the hot hours of the day they retire to the shadiest recesses of the forest and usually perch in some thick-topped tree. While resting in these retreats they have the pretty custom of uttering mellow call notes, as if in response to one another. During the breeding season they are seen in pairs, keeping close together, but at other times are solitary. When forced to take wing, they do so with a loud whirring sound and dart away through the intricate mazes of the dense forest with wonderful quickness. Their agility in flying at full speed among the network of trunks and branches is extraordinary and equalled by few birds If they take wing without being alarmed, their flight is almost noiseless.

Melopelia leucoptera (Linn). White-winged Dove.

White-winged doves were rather common residents on both Maria Madre and Maria Magdalena, and a few were seen on Maria Cleofa.

Colonel Grayson does not mention having seen this bird during any of his visits to the islands. It seems quite improbable that so conspicuous a species should have been present and overlooked, and I am inclined to believe that it has become a resident of the islands since his visits. It is now a conspicuous and widely spread species and one of the two resident land birds found by us that are not in Grayson's list. In habits and appearance the white-winged doves of the islands are identical with those on the mainland, where the species is very numerous. Two specimens were taken on Maria Madre, May 7, and a single specimen was shot on Isabel Island, April 22; the latter was undoubtedly a straggler from the mainland, since Isabel is a waterless island.

Columbigallina passerina pallescens (Baird). Mexican Ground Dove.

These pretty little doves were common on Maria Madre and Maria Magdalena, but were most numerous about old fields and in the settlement on the former island. The series of specimens taken on Maria Madre appears to be identical with the birds of the adjacent mainland; seven males from the islands average as follows: Wing, 87.4; tail, 61.8; culmen, 11.6; tarsus, 16.6.

Cathartes aura (Linn.). Turkey Vulture.

Generally distributed, and very common about the settlement on Maria Madre.

Buteo borealis fumosus Nelson. Tres Marias Red-tailed Hawk.

Buteo borealis var. *montana* Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 268, 1871 (part).

Buteo borealis var. *calurus* Lawr., Mem. Boston Soc. Nat. Hist., II, p. 301, 1871 (part).

Buteo borealis fumosus Nelson, Proc. Biol. Soc. Washington, XII, p. 7, 1898.

Colonel Grayson records this as a common species. We found a few living along the canyons that score the slopes of Maria Madre. They were very sparsely distributed and only some twelve or fifteen individuals were noted; two or three were seen on Maria Magdalena and none on Maria Cleofa. They were not at all shy, and whenever found perched on a tree were readily approached within gunshot. They feed mainly upon iguanas and rabbits, both of which are common on the two larger islands. Nothing distinctive was noted about the habits of these hawks. They are uniform in color, and differ more from the mainland forms than does *B. borealis socorroensis*, although the latter is from an island much farther out at sea.

The adult female of *fumosus* has some heavy shaft streaks of dark brown on the chest, but these are not heavy enough to form a well-defined dark area as is often the case in *calurus*.

Description of an immature male (?) from Maria Madre: Upper surface almost uniform blackish brown; tail mainly of same color, but crossed by nine narrow, irregular lighter bands; a light area on the throat, where the feathers have narrow blackish shaft lines and broad, dull white borders; breast and sides of neck dull, dark brown, with dull, rusty edgings to feathers on latter area; middle of breast paler; feathers on lower breast and flanks blackish brown, with irregular whitish spots; abdomen and lower tail coverts dull brownish, paler than flanks, with pale buffy barring; some feathers of tibia buffy or heavily barred with buffy, but mostly like those of lower breast.

Below are averages showing the relative size of the two island forms:

Measurements of Buteo borealis fumosus and Buteo b. socorroensis.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Depth of bill.	Tarsus.
Buteo borealis fumosus.	Maria Madre Island.	Ad. ♂	3	373.3	207.3	26	18.5	81.3
Buteo borealis fumosus.	.... do	Ad ♀	1	412	214	30	20	84
Buteo borealis socorroensis.	Socorro Island......	Ad. ♂	2	387.5	207.5	25	17.5	80
Buteo borealis socorroensis.	.....do	Ad. ♀	1	425	221	30	20	86

Falco peregrinus anatum (Bonap.). Duck Hawk.

Falco peregrinus var. *nigriceps* Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 268, 1871.

A single duck hawk was taken by Colonel Grayson, who mentions that it was shot while in close pursuit of a sparrow hawk. We did not see this species during our visit to the islands.

Falco sparverius Linn. Sparrow Hawk.

The sparrow hawk was recorded from the islands by Colonel Grayson, but we did not see a single individual, and it probably occurs merely as a straggler.

Falco columbarius Linn. Pigeon Hawk.

Colonel Grayson records this species as very common upon the islands. Not a single individual was seen by us, and it probably occurs only as a winter visitant or stray migrant.

Falco albigularis Daudin. White-throated Falcon.

Hypotriorchis rufigularis Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 269. 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 301, 1874.

Colonel Grayson took a specimen of this fine little falcon on the islands. None were seen by us, and it must, no doubt, be classed as one of the numerous accidental visitants from the mainland.

Polyborus cheriway pallidus Nelson. Tres Marias Caracara.

Polyborus audubonii Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 268, 1871, (part).

Polyborus tharus var. *auduboni* Lawr., Mem. Boston Soc. Nat. Hist., II, p. 303, 1874, (part).

Polyborus cheriway pallidus Nelson, Proc. Biol. Soc. Washington, XII, p. 8, 1898.

Very abundant about the settlement on Maria Madre and rather commonly distributed elsewhere over the island. They were also rather common on the other islands, including San Juanito. The old log roads and dry bottoms of the canyons on Maria Madre were favorite resorts. The birds were met in many unexpected places, and were frequently seen perched in tree tops in the midst of the unbroken forest. Iguanas were excessively numerous, and furnished the main supply of food for the caracaras; the birds were on the alert, however, for anything in the form of carrion that turned up along shore or in the forest.

Pandion haliaëtus carolinensis (Gmel.) American Osprey.

Several ospreys were seen along the shores of all the islands, where they probably nest. Colonel Grayson found a nest on a rock adjacent to the northern shore of Maria Madre and another in a large cactus. Mr. Forrer obtained an immature bird during his visit to this island.

Strix pratincola Bonap. American Barn Owl.

Colonel Grayson states that he heard the well-known hissing scream of this bird at night on the Tres Marias. We were told of the presence of barn owls on the islands, but did not see them, and failed to learn whether they occur as residents or stray migrants.

Speotyto cunicularia hypogæa (Bonap.) Burrowing Owl.

Colonel Grayson says of the burrowing owl, "A few individuals of this species inhabit the Marias Islands, perhaps wandered from the mainland." We neither saw nor could learn anything of them, and those seen by Colonel Grayson were probably winter stragglers.

?**Micropallas** Sp.

The first evening after landing on Maria Madre, Mr. Goldman saw and heard a little owl about the size of *Glaucidium phalænoides* on an old log road in the forest. It was very near, and when he had moved back far enough to shoot without destroying the bird it became too indistinct to see and so escaped. Its notes were not like those of the ferruginous owl. This was the only one seen or heard during our stay. If a resident, it is very uncommon, for special but unsuccessful efforts were made to find others.[1]

Amazona oratrix Ridgway. Double Yellow-headed Parrot.

Chrysotis levaillantii Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 271, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 296, 1874.
Amazona oratrix Ridgway, Man. N. Am. Birds, p. 594, 1887.

The yellow-headed parrot is a common resident and always nests in holes high up in large trees in the forest. Half-grown young were found the middle of May. The birds were usually seen flying about the forest in pairs, but congregated in flocks of from six to twenty or more at their feeding places. They feed upon the fruits of various trees, and during May the fleshy pods of *Pithecolobium dulce* formed their staple article of diet. These low trees, from 15 to 35 feet high, were growing around the houses of the settlement on Maria Madre and were scattered thence along the coast, especially about the borders of

[1] During the visit to Maria Magdalena Island a larger owl was seen in the forest along the bottom of a steep canyon, but was not sufficiently near to identify, and escaped before it could be obtained. This was probably *Ciccaba squamulata* (Bonap.), a species which is not rare on the mainland.

old clearings and in scrubby second growth on the lower slopes. A number of yellow-headed parrots came down every day to feed in the trees, even among the houses, and did not pay the slightest attention to passing people. As these birds readily learn to talk, they are highly prized as pets, and are sold to visitors, or sent to towns on the mainland; the birds taken while young being most highly prized on account of their docility. The men search for their nests, and when one is located the hunter strikes the base of the tree several sharp blows with a stone or ax, and then places his ear against the trunk and listens. He can tell whether the young are old enough to remove, by the strength of the cries they utter in reponse to the blows on the tree. Being satisfied of the presence of his game, the hunter climbs the tree, and if necessary cuts into the nest with his machete. Each brood contains two young, which are carried to the ground inside the hunter's shirt. By means of a noose on the end of a long cane, like a fishing rod, many old parrots are captured while feeding. An old woman had twenty birds which she had taken in this manner while they were feeding in the top of a small *Pithecolobium* tree by her door. The hunters search for regular feeding places in the forest and wait under the trees for the birds to come. When the birds arrive, the end of the rod is slowly and cautiously pushed up through the branches, the noose slipped over the bird's head and drawn about its neck with a quick jerk, after which the victim is hauled down and thrust into a cage. A favorite resort for the parrots on Maria Madre was a group of trees about half a mile from the settlement. The birds were very unsuspicious, and one could walk up within 20 or 25 yards in full view and watch them without their paying much attention. The parrots were constantly chattering, and the greatest good comradeship seemed to prevail. Mates kept close together and showed their attachment by caressing and feeding one another at short intervals. The proficiency in speaking which some of these birds attain is remarkable. The daughter of the customs inspector on Maria Madre had one which afforded much amusement by the variety of its remarks and their frequently absurd appropriateness. Colonel Grayson supposed these birds to be peculiar to the Tres Marias, as he did not chance to find them on the mainland. In reality, they are widely distributed on both coasts of Mexico.

After comparing the series taken on the islands with specimens from both coasts of the Mexican mainland certain slight differences are noticeable, but are too poorly defined to be worthy of subspecific recognition. The island birds are usually apple green on the dorsal surface, and mainland specimens are more of an oil green; the ventral surface has a more decided bluish wash; there is also tendency to a richer suffusion of orange and orange red on the yellow feathers about the necks of old birds.

The following measurements show that the island birds are a little larger than those of the mainland, with proportionately smaller bill and shorter tarsus. Averages of 9 specimens from the islands (both sexes): Wing, 233.3; tail, 133.6; culmen, 34.3; tarsus, 24.7. Averages of 7 specimens from both coasts of the mainland (both sexes): Wing, 222.5; tail, 120.1; culmen, 34.4; tarsus, 24.5.

Some old residents on Maria Madre reported that they had occasionally seen stray individuals of another parrot which was a little smaller than the yellow head, probably *Amazona finschi*, which is abundant on the mainland.

Psittacula insularis Ridgway. Tres Marias Lovebird.

Psittacula cyanopyga Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 271, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 297, 1874 (part).

Psittacula insularis Ridgway, Proc. U. S. Nat. Museum, X, 1887, p. 541 (Aug. 1888).

Psittacula cyanopygia Salvadori, Cat. Birds Brit. Mus., XX, p. 249, 1891 (part).

Lovebirds, or 'catarinas,' as they are called by the Mexicans, are common on Maria Madre and Maria Magdalena, and probably occur on Maria Cleofa, although none were seen on the latter island. They were usually seen in flocks, from a few pairs up to 30 or 40 individuals, and in May were feeding on small, sweet, wild figs, common on the lower slopes. While feeding they keep up a constant chattering, which notifies one of their presence. When flying over the top of the forest they keep in compact flocks and move steadily forward with rapid wing beats, suggesting a flock of cedar birds. They are very gentle, affectionate little creatures and quickly become tame and greatly attached to their owners.

Salvadori considers *Psittacula insularis* a synonym of *P. cyanopyga*. The series of eight adults from the islands and seven from the mainland show that the island birds can be readily distinguished. The two series show no signs of intergradation in color, and their specific distinctness is well defined, although the average measurements show but slight differences in size.

Description of Psittacula insularis, ♂ ad., Maria Madre, May, 1897:	*Description of Psittacula cyanopyga, ♂ ad., Tepic, Mexico, April, 1897:*
Cheeks, lores, forehead, and crown, back to line between orbits, rich green, decidedly clearer than in *cyanopyga*, and much more sharply contrasted with surrounding colors.	Cheeks, lores, and forehead bright green, more yellowish than in *insularis*, and shading gradually into surrounding colors.
Middle of crown green, shading abruptly into dull bluish green, which extends thence over neck, middle of back, scapulars, tertials, and lesser wing coverts.	Crown, from between orbits, neck, middle of back, scapulars, tertials, and lesser wing coverts, dark green without bluish.
Rump patch, axillars, and greater wing coverts vivid cobalt blue.	Rump patch, axillars, and greater wing coverts bright turquoise blue.
Upper tail coverts brighter green than middle of back, but darker than in *cyanopyga*.	Upper tail coverts clearer green than back.
Upper surface of tail dark green, darker than in *cyanopyga*.	Upper surface of tail rich green.

Secondaries and outer vanes of primaries near base, dark blue; primaries with outer vanes along distal half and at tips edged with dark green; inner webs of primaries brown.

Exposed under surface of primaries and secondaries dull blue.

Lower parts, back to crissum, dingy blue with a dull greenish wash; blue brightest on abdomen, and contrasting abruptly with green of crissum.

Crissum rich dark green.

Secondaries and outer vanes of inner primaries dark blue; rest of outer vanes and tips of primaries dark green; inner webs of primaries brown.

Exposed under surface of primaries and secondaries dull bluish green.

Lower parts, back to crissum, dull green, richest on abdomen and shading insensibly into color of crissum.

Crissum brighter green.

Description of Psittacula insularis, ♀ ad., Maria Madre, May, 1897.

Entire dorsal surface dingy green; brightest on sides of head, forehead, rump, and upper tail coverts, with a dull bluish shade on middle of back and wings.

Lower surface dull green, back to crissum; the latter brighter green.

Description of Psittacula cyanopyga, ♀ ad., from Tepic, Mexico, April, 1897.

Dorsal surface dark green; brightest on forehead, rump, and upper tail coverts, with an olive shade on middle of back and wings.

Lower surface nearly uniform light green, with a yellowish shade; crissum nearly the same.

Average measurements of Psittacula insularis and P. cyanopyga.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Psittacula insularis	Maria Madre Island	ad. ♂	6	91.8	45.8	13.9	12.9
Psittacula insularis	do	ad. ♀	2	91.5	46.5	13.5	13
Psittacula cyanopyga	Tepic and Jalisco	ad. ♂	3	90.6	45.6	12.8	13.1
Psittacula cyanopyga	do	ad. ♀	4	89.2	41.5	13.1	12.7

Coccyzus minor (Gmel.) Mangrove Cuckoo.

This bird is rather common among the mangroves and other trees bordering the salt lagoons near San Blas. A single specimen was taken on May 8 near the shore of Maria Madre, but no others were seen, and it probably occurs there only as a straggler.

Trogon ambiguus goldmani Nelson. Goldman's Trogon.

Trogon ambiguus Grayson Proc. Boston Soc. Nat. Hist., XIV, p. 272, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 290, 1874 (part).

Trogon ambiguus goldmani Nelson, Proc. Biol. Soc. Washington, XII, p. 8, 1898.

Goldman's trogon was common in the more heavily wooded parts of Maria Madre and Maria Magdalena, and occurs no doubt on the less heavily wooded Cleofa. On Maria Madre they were found from the coast up nearly to the summit in suitable timber and especially along the sides and bottoms of heavily wooded canyons. Their habits were similar to those of the mainland bird. They sit quietly for a time on a branch and then fly, with an undulating motion, to another tree in the vicinity. Their notes are limited to a short succession of unmusical sounds, which are frequently heard. They were reported to nest in hollow trees. Unlike most of the birds of these islands, the trogons were nearly as shy as their representatives on the mainland. In life they have light yellow bills and bright red eyelids.

Ceryle alcyon (Linn.). Belted Kingfisher.

Colonel Grayson records that during each of his visits one or two belted kingfishers were observed sitting on rocks along the seashore. None were seen by us.

Dryobates scalaris graysoni (Baird). Grayson's Woodpecker.

Picus scalaris var. *graysoni* Baird, Hist. N. Am. Birds, II, pp. 515, 517, 1874; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 294, 1874.

This is the only woodpecker found on the Tres Marias. It is common on all of the islands and generally distributed, except in the most heavily wooded areas. It seems to prefer second-growth thickets and other places where shrubs and scrubby trees form low and rather thin forests, and was usually seen hunting for food along the trunks of large shrubs or small trees. It was a common practice for them to alight on tree trunks near the ground and work slowly to the top, and after remaining there quietly for a time to make a short flight to another tree. Like its relative of the mainland, it is a very quiet bird, rarely uttering any call notes and making little noise while searching for food. From its habit of peering into crevices of the bark and doing only a small amount of pecking it is evident that it finds most of its food on or near the surface. Old nesting sites were seen in the trunks of both living and dead trees and in the flower stems of large magueys. The holes were usually between 5 and 10 feet from the ground. Colonel Grayson found a nest about 12 feet from the ground in the green flower stem of a large maguey (*Agave*) near the seashore in April.

A comparison of a series of these island woodpeckers with other forms shows that the dorsal surface, including the crest of the males, is most like typical *D. scalaris* from the plains of Puebla. On the ventral surface it may be distinguished from all the other races by its whiter color and scantier and smaller black markings along the sides. These markings are usually in the form of small rounded spots instead of more or less elongated streaks, as in the other races, and the white markings on the greater and lesser wing coverts are decidedly larger and more conspicuous. *D. s. graysoni* averages a little smaller than *D. s. scalaris*. The darker dorsal surface and unmarked bases of outer tail feathers distinguish it from *D. s. bairdii*. It has a shorter, stouter bill than *D. s. lucasanus*, with considerably more barring on the outer tail feathers. From *D. s. sinaloensis* it is distinguished mainly by its larger size, darker dorsal surface, and paler, less marked lower surface. The following averages show the relative size of *graysoni* and *sinaloensis:*

Measurements of Dryobates s. graysoni and Dryobates s. sinaloensis.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Dryobates scalaris graysoni.	Maria Madre Island	ad. ♂	6	98.7	59.6	22.1	18.6
Dryobates scalaris graysoni.	do	ad. ♀	3	96.6	57	19.5	17.5
Dryobates scalaris sinaloensis.	Sinaloa and Tepic	ad. ♂	3	94.6	53.6	19.8	17.1

An adult female in the National Museum collection from Mazatlan, while having the normal bill and tarsus of *sinaloensis*, agrees with birds from the Tres Marias in its long wings and tail. Its measurements are as follows: Wing, 96; tail, 60; culmen, 18.5; tarsus, 16.5.

Nyctidromus albicollis insularis Nelson. Tres Marias Parauque.

Nyctidromus albicollis Grayson, Proc. Boston Soc. Nat. Hist. XIV, p. 273, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 291, 1874.

Nyctidromus albicollis insularis Nelson, Proc. Biol. Soc. Washington XII, p. 9, 1898.

On the mainland the parauques are rarely seen while the sun is above the horizon, but when night falls they come out of the dense thickets where they have passed the day and sit in dusty trails and other open places. On Maria Madre they were among the commonest birds frequenting old log roads through the forest and shady canyon bottoms until late in the morning and coming out again at 3 or 4 o'clock in the afternoon. Of late years these places have been so completely given over to solitude that when a human being chances to stray into them he is looked upon with little fear. The wood folk seem to consider him harmless and only a strange creature of their own kind.

Parauques were among the most confiding birds found in these quiet retreats and permitted a close approach before taking wing and moving away. In the early dusk they were frequently seen hawking for insects among the low trees Several came about camp at the north end of Maria Madre just after sunset, and flew very swiftly back and forth with the same erratic course and vigorous wing strokes that are so characteristic of the night-hawk. In fact, I mistook one of these birds for a night-hawk until it was secured. Their notes remind one slightly of the whip-poor-will's, but are not so loud and far-reaching. The regular call is made up of two and sometimes three syllables, besides which they have various little clucking and purring notes.

Curiously enough the parauques of the Tres Marias bear a much greater resemblance, in size and color, to *N. albicollis merrilli* of the Rio Grande Valley than to the ordinary birds of the adjacent mainland.

Chordeiles acutipennis texensis (Lawr.) Texas Nighthawk.

A single specimen was taken May 5 on Maria Madre, and several others were seen during the first half of the month, after which time they disappeared. These birds were probably stray migrants, for there was nothing to indicate that they were residents.

Amazilia graysoni Lawr. Grayson's Humming Bird.

Amazilia graysoni Lawr., Ann. Lyc. Nat. Hist., N. Y., VIII, p. 404, 1867.
Pyrrhophæna graysoni Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 283, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 292, 1874.

Very common on the islands. They were seen almost everywhere darting about the less luxuriant parts of the forest hunting for flowers, and now and then stopping on a twig in some low tree top to rest or arrange their plumage. They were among the numerous feathered visitors to the little flower garden at the custom-house on Maria Madre where they were very confiding, and would carry on their search for food among the flowers quite indifferent to one's presence. These humming birds are very pugnacious, as the following incident recorded by Colonel Grayson well illustrates: "Sometimes combats between them become of a desperate nature. One day while watching a number of them in active motion around some tobacco flowers (of which they seem to be very fond) two fine males, after darting at each other for some time, at length came to a deathly struggle, high above my head; they finally clinched each other, each having one of the mandibles of the other in his mouth, at the same time scratching with their little claws, and using their wings with the greatest force, and in this situation, whirling round and round, they fell to the ground near my feet. During this terrible conflict, in which passion and desperation were exhibited, I observed them for a few seconds and then gently placed my hat over both. Even after they were thus captured, and I held one in each hand, they evidenced a desire to continue the war."

The same author records having seen these hummers dart upon and capture little flies in the manner of a flycatcher, and found their crops full of minute insects. This I can corroborate from my own observations.

Upon comparing a series of 8 specimens of *Amazilia graysoni* with an equal number of *A. cinnamomea* the general style of coloration is seen to be very similiar, yet the differences between the two forms are so constant it seems advisable to consider them specifically distinct. The dorsal surface of *A. graysoni* is a more dingy green with less coppery iridescence than in *cinnamomea;* the bronze tips of the tail feathers are less uniform, and the extreme points sometimes terminate with a little cinnamon spot; the cinnamon of the lower surface is considerably darker. There is also a well marked and constant difference in size—*graysoni* being the larger, as shown by the following averages:

Measurements of Amazilia graysoni and A. cinnamomea.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.
Amazilia graysoni	Maria Madre Island	ad. ♂	4	68.8	42.6	25
Amazilia graysoni	do	ad. ♀	4	65.9	43.4	25.4
Amazilia cinnamomea	Western Mexico	ad. ♂	7	57.9	36.6	22
Amazilia cinnamomea	do	ad. ♀	1	53	32.5	23

Iache lawrencei Ridgway. Lawrence's Humming Bird.

Circe latirostris Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 282, 1871.

Iache lawrencei (Berlepsch, Ms.) Ridgway, Man. N. Am. Birds, p. 320, 1887.

Like the preceding species this is a common and generally distributed bird, and was found on all the islands. Like Grayson's humming birds, they were common about the flower garden at the custom house on Maria Madre. Colonel Grayson found its nest on Maria Madre and describes it as follows: "The elegant little structure I found attached to a slender twig, and shaded with its leaves, about 5 feet from the ground. The situation was fronting the sea, but a few paces from the water's edge, where the first beams of the morning sun dissolved the dews. Its form is cup-shaped, and composed of the down of the silk cotton tree (*Eriodendron*) intermingled with the down of other plants and spider webs, the whole exterior neatly studded with diminutive lichens; it contained two newly hatched young, but little larger than flies."

In general appearance *Iache lawrencei* closely resembles *I. latirostris.*[1] The dorsal surfaces of the males are nearly the same color, but the upper tail coverts of *lawrencei* are grayish instead of green, as in *latirostris;* their lower surface is a darker, duller green; the blue-throat patch is nearly obsolete and replaced by an extension of the green of the neck; the under-tail coverts are darker brown.

The females of *lawrencei* differ mainly from those of *latirostris* in the clearer, brighter green of the dorsal surface and darker under-tail coverts. As the differences between the two birds seem to be fairly constant, although not very striking, it is perhaps advisable to treat them as species until more material proves the contrary.

The type of *I. latirostris* formed part of the Bullock collection and probably came from the southern end of the table-land near the Valley of Mexico. The following measurements show the differences in size:

[1] *Iache latirostris* undoubtedly occurs on the islands as a straggler. About midway on our return to the coast a hummer passed close to the side of the boat, coming from the direction of San Blas and heading in a direct line for the islands. As this wanderer passed I had a close view and identified it as *I. latirostris.*

Measurements of Iache lawrencei and I. latirostris.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.
Iache lawrencei	Maria Madre Island	ad. ♂	3	52.3	32.6	18.8
Iache lawrencei	do	ad. ♀	4	51.2	29.2	20.2
Iache latirostris	Southern table-lands, Mexico	ad. ♂	5	54.2	33	21.9
Iache latirostris	do	ad. ♀	1	52	33	23

Platypsaris aglaiæ insularis (Ridg.) Grayson's Becard.

Hadrostomus aglaiæ var. *affinis* Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 279, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 289, 1874.

Platypsaris insularis Ridgway, Man. N. Am. Birds, p. 325, 1887.

The rose-throated becard was not common and only three specimens were taken, all on Maria Madre. They were found in the heavier forest on the slopes well back from the coast, and nothing unusual was noted in regard to their habits. They probably occur on Maria Magdalena and perhaps on Maria Cleofa. A considerable series of specimens from various parts of Mexico shows that a single species of rose-breasted becard ranges over a large part of Mexico and has developed four geographical subspecies. The ranges of these four forms may be defined as follows:

Platypsaris aglaiæ (Lafr.). Eastern Mexico from northern Tamaulipas south along basal slopes of the Cordillera of Vera Cruz and Tabasco to arid parts of Yucatan. (Type from vicinity of Jalapa, Vera Cruz.)

Platypsaris aglaiæ sumichrasti Nelson. Humid lowlands of Vera Cruz, and thence southward in similar country nearly or quite to Guatemala. (Type from Otatitlan, Vera Cruz.)

Platypsaris aglaiæ albiventris (Lawr.). West coast of Mexico from the Isthmus of Tehauntepec to southern Arizona, ranging along river valleys into the interior of western Mexico. (Type from Plains of Colima.)

Platypsaris aglaiæ insularis (Ridg.). Tres Marias Islands. (Type from Maria Madre Island.)

Typical specimens of *insularis* are much darker than typical examples of *albiventris*. Specimens from the coast lowlands about San Blas are intermediate in color. The island birds, however, may usually be distinguished by their smaller bills. Back from the coast of Tepic, especially in the arid river canyons at Bolaños and near Guadalajara, only typical specimens of *albiventris* were found. On the eastern side of Mexico these two forms are paralleled by the pale bird of the foot hills and adjacent interior (*aglaiæ*) and the darker one of the coast lowlands (*sumichrasti*). The color of extreme specimens of *albiventris* is very different from that of *aglaiæ* and *insularis*, but among the series from western Mexico, where *albiventris* has its home, are various intermediate stages, some specimens approaching very closely to both the forms just named. Some specimens of *insularis* are much nearer typical *aglaiæ* in color than *albiventris*. Females of *insularis* are more distinct from those of *aglaiæ* than the males, owing to their generally grayer backs, but even this is not a constant character. The only character of *insularis* that is fairly constant is the smaller bill; a curious development, since there is a general tendency to an increase in size of bill among Tres Marias birds.

Measurements of Platypsaris aglaiæ and its races in Mexico.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Platypsaris aglaiæ	Eastern Mexico	ad. ♂	3	94.3	72.3	16	21.8
Platypsaris aglaiæ sumichrasti.	Otatitlan, Vera Cruz	ad. ♂	3	89.6	68.3	16.3	22
Platypsaris aglaiæ albiventris.	Plains of Colima and Bolaños, Jalisco.	ad. ♂	4	90.5	67.5	15.8	21.6
Platypsaris aglaiæ insularis.	Maria Madre Island	ad. ♂	3	87	66.8	14.3	22.1
Platypsaris aglaiæ insularis.	do	ad. ♀	3	88	66.6	15	22.3
Intermediates between P. a. albiventris and P. a. insularis.	Coast near San Blas, Tepic	ad. ♂	3	89.8	64.3	15.3	22.3

Tyrannus melancholicus couchi (Baird.) Couch's Kingbird.

On Maria Madre Island ten or a dozen of these birds were seen and appeared to be resident. Two or three were noted on Maria Magdalena, and others on Maria Cleofa, where they were most numerous. They were always found near the seashore. The specimens obtained seem to be identical with those from the adjacent mainland. As a rule birds from northeastern Mexico, the type locality, are lighter than those from western Mexico, but this difference is not constant.

Myiarchus mexicanus magister Ridgway. Arizona Crested Flycatcher.

Although resident on all the islands, birds from the Tres Marias are almost identical with those from the mainland, and nothing distinctive was noted in their habits. They frequent the thinner parts of the scrubby forests which cover most of the slopes, but were most numerous within a mile or two of the sea. They kept among the low trees, usually perching on tops of bushes or on branches within 10 or 15 feet of the ground, where they watched for passing insects.

Myiarchus lawrencei olivascens Ridgway. Olivaceous Flycatcher.

This was much more abundant than the preceding species, and one of the commonest and most generally distributed resident birds on the islands. Like the preceding, it was most numerons in the scrubby forest within a mile or two of the seashore and kept among the branches of trees and bushes within 10 or 15 feet of the ground. Its habits were the same as on the mainland.

A careful comparison of series from the islands and the mainland shows but little difference. The island birds are slightly grayer on the back, the bills average a little longer and wider, and the tarsus is longer, but these differences are too slight to warrant subspecific recognition. Unfortunately the type of this subspecies is based on a winter specimen from Santa Efigenia, Oaxaca, near the border of Chiapas. This leaves the summer range of typical birds in doubt.

Below are averages of specimens from the islands and the mainland:

Measurements of Myiarchus lawrencei olivascens.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus
Myiarchus lawrencei olivascens.	Tres Marias Islands	ad. ♀	7	76.3	74.8	16.8	19.7
Myiarchus lawrencei olivascens.	Northwest Mexico, southern Arizona.	ad. ♀	7	76.8	74.7	16.1	18.8

Contopus richardsonii (Swains). Western Wood Pewee.

During the first ten days of May these birds were not uncommon in some of the denser growths of small trees along the lower slopes of Maria Madre. None were seen on the other islands and they all disappeared a little later, showing that they were merely stray migrants. The single specimen taken is identical with others from the western United States.

Empidonax difficilis Baird. Western Flycatcher.

These birds were very sparingly distributed on the Tres Marias. They were seen on Maria Madre soon after our arrival, and on May 27 one was taken on Maria Magdalena. They were usually found in dense thickets and along shady canyons. Colonel Grayson records them as common, but they undoubtedly occur only as winter visitants and migrants.

Ornithion imberbe (Sclater). Beardless Flycatcher.

Two specimens were taken and a few others seen early in May on Maria Madre; none were seen later, and they probably occur merely as stragglers during migration. They move about like small vireos in the tops of low trees and in large bushes, searching the outer twigs for insects and flying out every now and then to capture one on the wing.

A series of specimens from various localities on both coasts and the interior of Mexico, the Tres Marias Islands, and southern Arizona fails to show any tangible characters to distinguish *O. imberbe ridgwayi* from typical *O. imberbe.*

Myiopagis placens (Sclater). Golden Crowned Flycatcher.

In the National Museum collection is a typical specimen of *M. placens*, taken by Colonel Grayson in January, 1865, on the Tres Marias Islands, which agrees perfectly in size and color with the large dark birds from the mountains of Jalisco, on the adjacent mainland. Eight specimens of both sexes from various localities in Mexico and Central America average as follows: Wing, 68.2; tail, 65.8; culmen, 11.2; tarsus, 19.1.

Myiopagis placens minimus Nelson. Little Golden Crowned Flycatcher.

Elainea placens Lawr., Proc. Boston Soc. Nat. Hist., XIV, p. 279, 1871; Mem. Boston Soc. Nat. Hist., II, p. 286, 1874.

Myiopagis placens minimus Nelson, Proc. Biol. Soc. Washington, XII, p. 9, 1898.

Early in May a few of these birds were seen in the low scrubby forest near the shore on Maria Madre, but by the middle of the month they had retired to the heavily wooded canyons and slopes above 600 or 800 feet. They were common among the trees bordering the head of a large canyon in the middle of the island, where a small spring formed the center of attraction for many birds. Like their mainland relative, they frequent the tree tops, where they may be seen running in and out among the ends of the branches and fluttering about the tips of twigs in the manner of some warblers. They frequently hop from twig to twig, with their tails uptilted like gnatcatchers, but their dull garb is usually sufficient to identify them. When high up in the tops of tall trees, however, their form and habits are so warbler-like that they can not be distinguished from other small birds. A few individuals were seen on Maria Magdalena, but none on Maria Cleofa.

Corvus mexicanus Gmelin. Mexican Crow.

Two residents on Maria Madre reported that at long intervals they had seen stray crows on the island. My informants were familiar with the bird on the mainland, where it is extremely numerous about San Blas, and there is no reason to doubt the correctness of their identification.

Cissolopha beecheyi (Vigors). Beechey's Jay.

A specimen of this bird in the National Museum collection, obtained by Xantus, is labeled "Tres Marias Islands, October 15, 1859". This record, however, is doubtful.

Icterus graysoni Cassin. Grayson's Oriole.

Icterus graysoni Cassin, Proc. Acad. Nat. Sci. Phila., p. 48, 1867; Mem. Boston Soc. Nat. Hist., II, p. 280, 1874.

These beautiful birds are very common on all of the islands. Although more numerous about the settlement on Maria Madre than elsewhere, they were common in the thin, low forest all about the lower parts of the islands and were very unsuspicious During my excursions through the woods they came again and again and alighted on low branches of shrubs or trees beside the old log roads and peered at me with innocently inquiring eyes as if wondering at the strange creature newly arrived in their haunts, but evidently quite unconscious of any feeling that the newcomer might be dangerous. Such confidence made it very trying work to collect many of these birds.

They came familiarly about the houses and yards at the settlement on Maria Madre. A number of them made several visits each day to the verandas and shrubbery about the custom-house, and added greatly to the attractive surroundings by their bright colors and frank unconcern. They searched for insects among the shrubs and small trees in the patio or court, came to the veranda railing, down upon the floor, and along the walls, where plump spiders furnished many choice morsels. Several bags of corn piled against the wall on one side of the veranda were infested with weevils, which could be found creeping about on the outside of the bags. A pair of orioles was in the habit of regularly visiting the veranda and soon discovered these insects. They walked all over the bags, sometimes upside down or on one side like a nuthatch, and pried into every spot likely to contain a little beetle. They were frequently seen also clinging to the stems of the giant cactus (*Cereus*) and feeding on the juicy fruit.

As Colonel Grayson has recorded, the nests of these orioles are about a foot in length and of the usual purse shape. They are made of fibers of grass or maguey plants, lined with silk cotton and swung near the end of some slender branch overhanging a clear space, usually from 18 to 35 feet above the ground.

Grayson's oriole is evidently an offshoot from the wide-ranging *Icterus pustulatus* of the adjacent coast, but has become sufficiently distinct to rank as a species. Like so many of the island birds, it is larger than its mainland relative. The yellow is much lighter than on *I. pustulatus* and lacks most of the intense orange that is so conspicuous on many of the latter birds. Some adult males of *graysoni* have the back entirely bright yellow, while the backs of others are marked with a few narrow black shaft streaks. The females of *graysoni* are more greenish-yellow and have but faint traces of the orange shade present in typical *pustulatus*.

The following averages show the relative dimensions of the two species:

Measurements of Icterus graysoni and I. pustulatus.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Icterus graysoni	Maria Madre Island	ad. ♂	4	104	89.7	25.4	26.7
Icterus graysoni	do	ad. ♀	4	96.7	84.2	25.1	26.2
Icterus pustulatus	Western Mexico	ad. ♂	4	100.2	91	21	25.6
Icterus pustulatus	do	ad. ♀	4	91.7	81.5	20.2	24.5

Quiscalus macrourus Swainson. Great-tailed Grackle.

Two of these grackles were shot the latter part of May on a level bit of ground bordering the shore in front of the settlement on Maria Madre. They were the only ones seen and were undoubtedly stragglers from the mainland where they are abundant and resident near San Blas.

Astragalinus psaltria mexicanus (Swainson). Mexican Goldfinch.

Rather common and apparently resident, but nothing distinctive was observed in their habits. On Maria Madre they were usually found on the lower slopes and were most numerous about the settlement. Ten specimens fail to show any characters distinguishing the island birds from those of the mainland.

Cardinalis cardinalis mariæ Nelson. Tres Marias Cardinal.

Cardinalis virginianus Lawr., Proc. Boston Soc. Nat. Hist., XIV, p. 281, 1871.

Cardinalis virginianus var. *igneus* Lawr., Mem. Boston Soc. Nat. Hist., II, p. 275, 1874.

Cardinalis cardinalis mariæ Nelson, Proc. Biol. Soc. Washington, XII, p. 10, 1898.

Cardinals were very common on Maria Madre and not uncommon on the rest of the group. No one ever molests them, and they were especially abundant about the settlement, where they came into the yards and around the houses in the most familiar way. Several pairs could be found at any time during a short walk in the scrubby thickets along the lower slopes of the island. While we were hunting in the low woods it was a common occurrence for them to come very near, and after looking at the intruders with mild curiosity for a short time, to move off through the bushes in quiet pursuit of their usual occupations. At other times, while engaged in search of food among the fallen leaves they would scarcely notice one as he walked slowly by within three or four paces.

Piranga ludoviciana (Wilson). Louisiana Tanager.

During the first half of May these tanagers were not uncommon near the settlement on Maria Madre, but were not seen on the other islands. Those shot the first of the month were in fair condition, and, several pairs being seen, it was at first considered a resident species. Later, when others were secured, it was noted that they were more and more emaciated, until those killed about the middle of the month were so excessively thin, it was surprising that they had continued to live. About this time the last ones disappeared, no doubt dying from starvation. From these observations it appeared that the birds must have strayed to the island during migration, about the last of April or first of May, and were unable to find a proper food supply. At the same time they feared to start over the sea for an invisible shore and so perished. Another member of the genus, *Piranga bidentata flammea*, is resident in large numbers on the islands and found an abundant food supply, as was shown by their being among the fattest birds collected during the time that *P. ludoviciana* was dying of starvation.

Piranga bidentata flammea (Ridgway). Tres Marias Tanager.

Pyranga bidentata Lawr., Proc. Boston Soc. Nat. Hist., XIV, p. 281, 1871; Mem. Boston Soc. Nat. Hist., II, p. 274 (part), 1874.

Piranga flammea Ridgway, Man. N. Am. Birds, p. 457, 1887.

Several species of birds were very much at home about the settlement on Maria Madre, and among these the brilliant Tres Marias tanager was one of the most numerous. Like Grayson's oriole, they came daily to the veranda railing and investigated the shrubs and small trees in the court and flower garden at the custom-house. These birds were common and generally distributed in the scrubby forest on the lower parts of Maria Madre and Maria Magdalena, and probably occur on Maria Cleofa, although none were seen there. Their habits were very much like those of *Piranga bidentata* on the mainland. On the island, however, these tanagers were most numerous within a few hundred feet of sea level, while their relatives of the mainland inhabited oak forests at an altitude of 2,000 or 3,000 feet. They have a short warbling song, which is similar to, but less musical than, that of the mainland bird. They were seen hunting for food in the small tree tops of the scantier forest growths rather than in the more densely wooded areas and were very fat.

P. bidentata was described by Swainson from a specimen in the Bullock collection, taken at Temascaltepec, southwest of the Valley of Mexico, on the Pacific slope of the mountains. It was described as having the 'head, neck, and under parts golden'. This style of coloration is shown in specimens from various localities in Jalisco, Sinaloa, and the Tres Marias Islands. Judging from specimens in the National Museum and from the results of recent work, tanagers of this description are only found north of the Isthmus of Tehuantepec, on the arid western slope of Mexico, and are not common. The Tres Marias tanager is closely related to typical *P. bidentata*, and the males are so closely alike in color that it requires careful scrutiny to find distinguishing characters. In *P. flammea* the white tips of the greater and lesser wing coverts are larger and clearer white than in *P. bidentata*, thus rendering the two wing bands more conspicuous. The white spots on the outer rectrices are smaller and confined to the inner webs, except at the extreme tip; in *P. bidentata* these marks occupy most of the terminal third of the feathers. In general color of the body the two forms are indistinguishable. The bill of *P. flammea* averages longer and is decidedly more swollen, especially toward the tip; this difference is one of the most important characters of the island form. The female of *P. flammea* can be distinguished only by the larger bill and the restriction of the white spot on the outer pair of tail feathers.

The following measurements give the averages of the two forms:

Measurements of Piranga bidentata and Piranga b. flammea.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Piranga bidentata flammea.	Maria Madre Island..	ad. ♂	6	98	81	18.1	23.7
Piranga bidentata flammea.	.....do................	ad. ♀	4	95	78.7	18.4	22.5
Piranga bidentata..........	Jalisco and Sinaloa...	ad. ♂	3	98	79.3	17.3	21.1
Piranga bidentata..........	.....do................	ad. ♀	2	96	79	17	21.5

Hirundo erythrogaster Bodd. Barn Swallow.

Soon after our arrival on Maria Madre a few swallows, supposed to be this species, were seen by my assistant, but none were taken. They were undoubtedly stray migrants, for none were seen afterwards.

Vireo flavoviridis forreri (Madarasz). Forrer's Vireo.

Vireo forreri Madarász, Természetrajzi Füzetek, IX, pt. I, p. 85, 1885.

Although Forrer's vireo is one of the most abundant and widely distributed species on the islands, yet it does not appear in Grayson's list. It was very common in the small trees in the patio of the customhouse and elsewhere about the settlement on Maria Madre. Like its mainland relative, its habits are very similar to those of the red-eyed vireo. Its favorite range was in the smaller growth of forest along the lower slopes, from near the sea up to an altitude of 600 or 700 feet, but some were seen up near the summits of Maria Madre and Maria Magdalena. Next to the Tres Marias warbler, Forrer's vireo was probably the most abundant bird on Maria Madre, and its restless habits while fluttering and peering about in search of food among the small tree tops added greatly to the animation of the forest.

Vireo forreri is evidently only a geographical race of *Vireo flavoviridis.* It has the same color pattern, but the ashy crown is paler and the dusky supraorbital stripe usually obsolescent; the latter is one of the main characters upon which *forreri* was originally based, but is not constant. Some specimens from the islands have this stripe as strongly marked as dull-colored individuals of *flavoviridis* proper, although none have it so strongly marked as some of the latter. The two forms are alike on the underparts, and the greater size of *forreri* is the most constant and striking character.

Average measurements of 17 adult males of *Vireo flavoviridis forreri:* Wing, 84.3; tail, 59.3; culmen, 15.1; tarsus, 20.1. Averages of *Vireo flavoviridis* (from mainland of Mexico): Ad. ♂ (9 specimens), wing, 79.2; tail, 55.1; culmen, 14.3; tarsus, 18.7. Ad. ♀ (3 specimens), wing, 76.6; tail, 50.6; culmen, 14.1; tarsus, 18.5.

Vireo hypochryseus sordidus Nelson. Tres Marias Vireo.

Vireo hypochryseus Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 281, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 272, 1874.

Vireo hypochryseus sordidus Nelson, Proc. Biol. Soc. Washington, XII, p. 10, 1898.

A few of these vireos were seen in the thin forest on the lower slopes of Maria Madre, but were not common. They were especially numerous among the trees and tall bushes about the few springs and little streams near the summit. A few were also seen in similar places on Maria Magdalena. *Vireo f. forreri* occupies the lower slopes, while *sordidus* occurs mainly higher up, the ranges of the two birds being complementary. The Tres Marias vireo is usually found at a medium height among the foliage of thick-topped trees, rarely ascending to the extreme top. It was also often seen in the dense, tall undergrowth near water.

Compsothlypis insularis (Lawr.). Tres Marias Parula.

Parula insularis Lawr., Ann. Lyc. Nat. Hist., N. Y., X, p. 4, 1871; Grayson, Proc. Boston Soc. Nat. Hist., XIV, pp. 278, 300, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 269, 1874.

These pretty little warblers were the most abundant of the land birds on the Tres Marias. A few of them were also found on Isabel Island, and the only *Compsothlypis* taken on the mainland at San Blas belongs to this species. They frequent the thin forest of the lower slopes on the Tres Marias, and dozens of them were seen during every visit to the woods, and they were seen in smaller numbers on the higher slopes. Many also came familiarly into the small trees and shrubbery about the houses at the settlement. They were always busily at work in pursuit of insects among the branches, and searched the bark of small shrubs near the ground as well as the branches at the tops of large trees. They were rather common in the scrubby growth of stunted trees on Isabel, and were very abundant in the tree tops of the heavy forest on the mainland between San Blas and Santiago. Their song is weak and lisping and not at all musical.

There is little doubt that a good series of specimens will demonstrate that *Compsothlypis pitiayumi* of northern South America is represented in Central America and Mexico by a number of geographical races rather than by the closely related species now recognized—*C. inornata*, *C. pulchra*, *C. nigrilora*, and *C. insularis*. Even the imperfect series at hand shows signs of intergradation, but treating *C. insularis* as a species for the present, its differences from its nearest relative, *C. pulchra*, are set forth in the following notes. *C. pulchra* was the only form found on the mainland back of the low coast plain, on the tropical or subtropical slopes of the mountains. This species was described from Chihuahua, and appears to be a resident of the lower slopes of the Sierra Madre, ranging from Chihuahua to Tepic, while *C. insularis* is characteristic of the hot lowlands on the coast near San Blas and the outlying islands.

C. insularis is larger than *C. pulchra*, with a heavier shading of brown along the flanks; the yellow of the under parts is duller and more generally suffused with dull orange brown; the white spots on outer tail feathers are decidedly larger, and the bluish of the dorsal surface is grayer. In the small series examined, difference in size seems to be the most constant character. Following are average measurements of the two species:

Measurements of Compsothlypis insularis and C. pulchra.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Compsothlypis insularis	Maria Madre Island	ad. ♂	6	60	49.3	10.4	19.9
Compsothlypis insularis	do	ad. ♀	4	55.7	47.5	10	19
Compsothlypis pulchra	Jalisco and Sinaloa	ad. ♂	3	55.6	42.3	9.6	17
Compsothlypis pulchra	do	ad. ♀	1	52	41	?	17

Dendroica æstiva rubiginosa (Pallas). Alaskan Yellow Warbler.

Several of these birds were taken and others seen about the settlement on Maria Madre. They were evidently stray migrants, and most of them left before the end of May.

Dendroica æstiva morcomi Coale. Western Yellow Warbler.

Among the yellow warblers taken on Maria Madre during the first half of May were two specimens referable to *Dendroica æstiva morcomi*. Like *rubiginosa*, they were stray migrants which had wandered out of their course while en route to their more northern breeding grounds. They were found about weed patches and shrubbery in the settlement.

Dendroica auduboni (Townsend). Audubon's Warbler.

Two of these birds were seen during the first half of May about the settlement on Maria Madre, and May 30 a specimen was taken on Maria Cleofa. Like the yellow warblers, they occur merely as stray migrants and were seen only near the seashore.

Dendroica townsendii (Townsend). Townsend's Warbler.

Two or three of these warblers were seen at the settlement on Maria Madre between the 8th and 20th of May. They kept about the weed patches and yards for several days, and were stray migrants like the preceding species.

Granatellus francescæ Baird. Tres Marias Chat-Warbler.

Granatellus francescæ Baird, Rev. Am. Birds, p. 232, 1865; Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 278, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 270, 1874.

These beautiful birds were seen only on Maria Madre, but they probably occur also on Maria Magdalena, where the conditions are equally favorable. They were far from common, and inhabited the forest on the higher slopes, but two or three individuals, evidently wanderers, were encountered in the scrubby forest near the shore. They were usually seen on the ground searching for food among low underbrush and weeds. In such places they ran about among the thick stems of plants and matted undergrowth, springing up every now and then to a twig or weed stalk a foot or two from the ground, and then perhaps flitting along from stem to stem to another feeding place a few yards away. When thus passing through the undergrowth, they are very conspicuous and attractive objects, owing to their beautifully contrasted black, white, and rose-colored plumage. Their habit of carrying the tail up-tilted and more or less widely spread renders them still more conspicuous. It is doubtful if they ascend into the tops of trees, as they are even more terrestrial than their relatives the chats.

The color pattern of this species is much like that of *G. venustus*, but the black collar on the lower side of the neck in the males is nearly obsolete, being represented only by a few black feathers, the red or rose colored area on the breast and chest is paler and more restricted, the postocular white stripe larger and extending across the nape as an indistinct nuchal band, the bluish of the dorsal surface grayer, and the white on the tail more extended. The females are browner above and paler below. *G. francescæ* is larger than *G. venustus*, as shown by the following averages:

Measurements of Granatellus francescæ and G. venustus.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Granatellus francescæ	Maria Madre Island	ad. ♂	5	65.8	76.5	12.2	21
Granatellus francescæ	do	ad. ♀	2	63	74.5	12.2	21 5
Granatellus venustus	Guerrero and Oaxaca	ad. ♂	2	61.5	66.5	12	19.7
Granatellus venustus	do	ad. ♀	1	58	67	12	20.5

Wilsonia pusilla pileolata (Pall.). Pileolated Warbler.

The only one seen was taken on Maria Cleofa May 30. It was in some bushes by a little stream near the seashore and was evidently a straggling migrant.

Mimus polyglottos (Linn.). Mocking Bird.

A few mocking birds were seen on Maria Madre, where they are probably resident in small numbers. They were found only on the lower slopes near the sea. The two specimens secured appear to be identical with others from the adjacent mainland.

Thryothorus lawrencii (Ridgway). Maria Madre Wren.

Thryothorus felix Grayson, Proc. Boston Soc. Nat. Hist. XIV, p. 278, 1871 (part); Lawr., Mem. Boston Soc. Nat. Hist. II, p. 268, 1874 (part).

Thryothorus felix β lawrencii Ridgway, Bull. Nutt. Orn. Club, III, p. 10, Jan., 1878.

The song of this wren was one of the most constant and pleasing of the woodland notes heard on Maria Madre. The bird was extremely abundant everywhere in the undergrowth ranging from the shore up to the higher slopes. Like its near relatives, it is a restless little creature, constantly climbing and peering about in the thickets. The male stops every now and then to utter his song and then continues insect hunting. When in a musical mood he takes a position in some small shrub, sometimes on its summit but oftener on a branch at one side, and there pours out his song again and again at short intervals. Like many other birds on these islands, the wren was very familiar and unsuspicious, and many came every day to the fences and shrubbery around the houses at the settlement.

A series of *Thryothorus felix* from the mainland, including one specimen from the region of the type locality, and a series of *T. lawrencii* from Maria Madre, show sufficient differences to warrant giving specific rank to *lawrencii*. The latter differs very constantly in several respects from birds of the mainland, but has much the same color pattern. The series from San Blas is nearer *lawrencii* than is the specimen from near the type locality of *felix*, but there appears to be no crossing of the gap between the two.

The following measurements show the relative sizes of the two species:

Measurements of Thryothorus lawrencii and T. felix.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Thryothorus lawrencii	Maria Madre Island	ad. ♂	3	60	55.6	17.2	22
Thryothorus lawrencii	do	ad. ♀	7	57.1	54	16.8	21.4
Thryothorus felix	Santiago, Tepic to Ometepec, Guerrero.	ad. ♂	2	57.5	55.5	16	21.5
Thryothorus felix	do	ad. ♀	3	54.3	50.6	14.6	20.5

Thryothorus lawrencii magdalenæ Nelson. Magdalena Wren.

Thryothorus felix Grayson Proc. Boston Soc. Nat. Hist., XIV, p. 278, 1871 (part); Lawr., Mem. Boston Soc. Nat. Hist., II, p. 268, 1874 (part).

Thryothorus lawrencii magdalenæ Nelson, Proc. Biol. Soc. Washington, XII, p. 11, 1898.

The habits and distribution of this wren on Maria Magdalena are the same as those of *T. lawrencii* on Maria Madre. No one lives on Maria Magdalena, and the wrens are even tamer than on Maria Madre. Their confidence was shown very prettily by one encountered by Mr. Goldman in the dark bottom of a narrow rocky canyon overhung with heavy forest. He saw the little fellow busily searching for food among the fallen leaves along the base of a low cliff, and as the bird seemed very fearless he approached quietly but in full view, and succeeded in closing his hand over the tiny creature, which had continued its search without paying the slighest attention. The bird showed but little fright, and its captor, after holding it a few moments, stooped and gently opened his hand to let it escape. The wren hopped away a few feet, arranged its plumage, and then continued feeding with the utmost unconcern. Mr. Goldman watched it for a few minutes and again approached slowly. As before the bird paid no attention until he was within a yard, but when another attempt was made to pick it up, hopped away a few feet and again resumed its occupation. This was repeated three or four times with the same result, until finally the bird was left in its solitude.

Melanotis cærulescens longirostris Nelson. Tres Marias Blue Mockingbird.

Melanotis cærulescens Grayson Proc. Boston Soc. Nat. Hist., XIV, p. 275, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 266, 1874 (part).

Melanotis cærulescens longirostris Nelson, Proc. Biol. Soc. Washington, XII, p. 10 1898.

These fine songsters are very common on the Tres Marias. They keep in the thickets and low trees and bushes like a catbird and were especially numerous and familiar about the settlement on Maria Madre. In one yard, among a few fruit trees, a trough was kept full of water, where scores of blue mockingbirds came daily to drink and would almost allow themselves to be caught by hand. Their numbers and general distribution make them among the most noticeable birds on the islands, and they frequently follow one with much curiosity. Their song, although rich and varied, was not so clear and musical as that of their relatives on the mainland. The birds on Maria Madre show a marked tendency to albinism, which usually appears in the form of grayish or whitish bars on the wings and tail. In addition to the barring on the primaries and secondaries, the alula is often similarly marked and some specimens have lighter spots on the tips of the wing coverts, producing well-defined wing bands. The markings are usually symmetrical, but vary in amount and intensity with the individual. In some they are barely distinguishable and in others very conspicuous. More rarely the albinism appears on other parts of the body, occasionally in asymmetrical areas of pure white, but these spots also are sometimes regular. One specimen has the entire under surface white, except some blue feathers along the flanks, and the rump is white mixed with blue. This bird has a striking general resemblance to the Central American *Melanotis hypoleucus*. At least 2 or 3 per cent of the birds on the islands are albinistic, and the constant recurrence of the same light barring on the wings and tail seems to indicate the possible evolution of a form in which these markings will be constant.

Myadestes obscurus insularis Stejneger. Tres Marias Solitaire.

Myiadestes obscurus Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 277, 1871; Lawr., Mem. Boston Soc. Nat. Hist., II, p. 273, 1874.

Myadestes obscurus var. *insularis* Stejneger, Proc. U. S. Nat. Mus., IV, pp. 371, 373, 1882.

This is a common bird in the heavy forest about the heads of canyons on Maria Madre and Maria Magdalena. They were not found anywhere in the scrubby growth of the lower slopes, and if they occur there at all it must be only as stragglers. They are shy birds, remaining silent when approached, but when undisturbed flitting through the tree tops like wandering spirits of melody uttering their sweet strains from the mysterious depths of the forest. Their song was heard from the tops of tall trees where the birds sat amid the heavy foliage, rarely coming down to lower levels except in the morning or evening, or to drink at midday. Many were seen about a spring near the top of Maria Madre where they came to drink at noon.

Although *Myadestes obscurus insularis* is very closely related to *occidentalis*, yet it may be distinguished by several slight but constant characters, such as the greater extension and paler shade of ashy from the neck over the forward part of the back. The lower parts also are paler, especially on the throat and abdomen. The white tips to the tail feathers, mentioned by Dr. Stejneger as characteristic of this form, are equally common on specimens of *occidentalis*.

The following measurements show the relative size of the two forms:

Measurements of Myadestes obscurus insularis and Myadestes o. occidentalis.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Myadestes obscurus insularis.	Maria Madre Island ..	ad. ♂	5	102.7	102.6	12.2	22.5
Myadestes obscurus insularis.	.....do	ad. ♀	3	98.6	95.6	11.5	22
Myadestes obscurus occidentalis.	Jalisco and Sinaloa ...	ad. ♂	3	104	102.3	12.5	22.1
Myadestes obscurus occidentalis.	.....do	ad. ♀	2	100.5	92	12	21.7

Hylocichla ustulata (Nuttall). Russet-backed Thrush.

A typical specimen of this species, taken on the islands by Colonel Grayson in the winter of 1865, is in the National Museum. In his notes Colonel Grayson says: "I found this little thrush in the month of January quite abundant in the thickest of the woods of the Tres Marias. It is very timid and shy, more so than any bird I saw upon the islands; it frequently uttered a low, plaintive whistle, and seemed solitary in its habits." We saw none of them on the islands in May, and it is safe to class them as winter visitants.

Hylocichla ustulata swainsonii (Cabanis). Olive-backed Thrush.

Hylocichla ustulata almæ Oberholser, Auk, XV, p. 304, October, 1898.

Two specimens of this thrush were taken on Marie Madre, one on May 5, the other on May 19. They were found in the heavy forest back from the coast, and evidently occur only as stray migrants.

Mr. Oberholser mentions these specimens as typical examples of his subspecies, which is considered a synonym of *Hylocichla u. swainsonii* by the American Ornithologists' Union.

Merula graysoni Ridgway. Tres Marias Robin.

Turdus flavirostris Grayson, Proc. Boston Soc. Nat. Hist., XIV, p. 276, 1871 (part); Lawr., Mem. Boston Soc. Nat. Hist., II, p. 266, 1874 (part).

Merula flavirostris graysoni Ridgway, Proc. U. S. Nat. Mus., V, p. 12, 1882.

Grayson's robin is one of the most abundant and widely spread residents and takes the place of *M. flavirostris* of the mainland, which it closely resembles in habits and general appearance. Although a characteristic bird of the islands, yet occasional stragglers reach the mainland, as is shown by a perfectly typical specimen (a female in worn plumage) taken at Santiago, Territory of Tepic, June 20, 1897. On the islands it was found from the shore to the forests of the higher slopes and was also very plentiful and familiar about the settlement. It had a variety of notes, among them a rich warbling song and a characteristic clear, mellow, whistling call. While among the trees, or during their search for food upon the ground, these birds closely resemble the common robin in habits and general appearance. At the time of our visit a species of wild fig was in fruit, and the tops of the trees were swarming with these robins, tanagers, orioles, lovebirds, and trogons, all eagerly feeding upon the figs.

Merula graysoni is another of the Tres Marias birds which are evidently offshoots from species now resident on the adjacent mainland, but with differences sufficiently pronounced and constant to warrant their recognition as separate species. *Merula flavirostris*, the mainland representative of the Tres Marias robin, is much more richly colored than *graysoni*, and the differences mentioned by Mr. Ridgway are constant and well shown in the present series. The following average measurements show the relative dimensions of the two species:

Measurements of Merula graysoni and M. flavirostris.

Name.	Locality.	Sex.	Number of specimens.	Wing.	Tail.	Culmen.	Tarsus.
Merula graysoni	Maria Madre Island	ad. ♂	4	127	99.7	24.4	34.5
Merula graysoni	do	ad. ♀	5	125.6	98.8	24	34.5
Merula flavirostris	West coast Mexico	ad. ♂	4	125	99.7	21	32.6
Merula flavirostris	do	ad. ♀	5	124.4	98	23	32.4

BIRDS ERRONEOUSLY ATTRIBUTED TO THE TRES MARIAS.

Among the birds sent to the Smithsonian Institution from western Mexico by Mr. John Xantus are five species of humming birds named below which were not found on the Tres Marias either by Colonel Grayson or myself, and which are not known even from the adjacent parts of the mainland. These specimens are now in the National Museum, all labeled "Tres Marias, July, 1861." The improbability of their capture on the Tres Marias is very great, and the fact that species from such widely separated areas should be credited to these islands during a single month can be accounted for in only one way. Probably Mr. Xantus purchased these specimens from some one who misled him concerning their origin. That this could be done very easily I know from personal experience. Some years ago I purchased a small collection of birds from a San Francisco dealer, who claimed that they came from

La Paz, Lower California, but which proved to be made up of species found near Mazatlan, Sinaloa.

Thalurania luciæ Lawr.

Thalurania luciæ Lawr., Ann. Lyc. Nat. Hist., N. Y., VII, p. 2, 1867; Proc. Boston Soc. Nat. Hist., XIV, p. 284, 1871; Mem. Boston Soc. Nat. Hist., II, p. 291, 1874.

Described as new from the specimen sent in by Xantus, but proved to be *Thalurania glaucopis*, a resident of southeastern Brazil.

Florisuga mellivora (Linn.).

Lawr., Proc. Boston Soc. Nat. Hist., XIV, p. 284, 1871; Mem. Boston Soc. Nat. Hist., II, p. 291, 1874.

A well-known species of the humid tropics from southern Mexico to South America. There is no authentic record for it in western Mexico, and it is safe to say it has not been taken on the Tres Marias.

Uranomitra guatemalensis (Gould).

Lawr., Proc. Boston Soc. Nat. Hist., XIV, p. 284, 1871; Mem. Boston Soc. Nat. Hist., II, p. 292, 1874.

A species which ranges from Guatemala and British Honduras southward. There is no authentic Mexican record.

Petasophora thalassina (Swainson).

Lawr., Proc. Boston Soc. Nat. Hist., XIV, p. 284, 1871; Mem. Boston Soc. Nat. Hist., II, p. 292, 1874.

This humming bird ranges from the highlands about the Valley of Mexico southward into Central America, but there appears to be no authentic record for western Mexico.

Chlorostilbon insularis Lawr.

Chlorostilbon insularis Lawr., Ann. Lyc. Nat. Hist. N. Y., VII, p. 457, 1867; Proc. Boston Soc. Nat. Hist., XIV, p. 284, 1871; Mem. Boston Soc. Nat. Hist., II, p. 292, 1874.

This bird was described by Mr. Lawrence from a Xantus specimen, but proved to be *Chlorostilbon pucherani* of southeastern Brazil.

Merula grayi Lawr.

Merula grayi Lawr., Proc. Boston Soc. Nat. Hist., XIV, p. 276, 1871; Mem. Boston Soc. Nat. Hist., II, p. 266, 1874.

Grayson's notes on *Merula grayi* on the Tres Marias refer to pale specimens of *M. graysoni*, and his record of *M. grayi* at the city of Tepic, on the adjacent mainland, refers to *M. tristis*. *Merula tristis* is a common and widely spread species in suitable localities in western Mexico and is the only *Merula* sent in by Grayson from the city of Tepic.

Merula grayi, on the contrary, does not appear to occur anywhere in western Mexico north of the Isthmus of Tehuantepec, for no specimens were taken by Grayson nor, during our own work at many localities between the Isthmus and Mazatlan, has a single individual been noted, and there appears to be no authentic record of its occurrence there. This thrush is a species of the humid tropics, ranging along both coasts of Central America north to the Isthmus of Tehuantepec, and thence northward its range is limited to the humid region of the Gulf coast and adjacent mountain slopes of eastern Mexico.

REPTILES OF THE TRES MARIAS AND ISABEL ISLANDS.

By Leonhard Stejneger,

Curator, Division of Reptiles and Batrachians, U. S. National Museum.

The present paper is based upon the collection made on the Tres Marias and Isabel Islands in April and May, 1897, by E. W. Nelson and E. A. Goldman.

The surprising fact that the two expeditions which have collected systematically in the Tres Marias brought home the same number of species, Forrer only collecting one snake, *Diplotropis diplotropis*, which Nelson did not collect, and Nelson also collecting only one snake which Forrer did not obtain, viz, *Boa imperator*, seems to indicate that not many more species than the 16 here enumerated are to be found in these islands.

It will thus be seen that the reptile fauna is an exceedingly poor one and very disappointing in several respects. Thus most of the species are common on the opposite mainland and generally distributed over tropical Mexico and Central America. Then, again, it seems as if the species are practically identical on all the islands of the group. This would indicate a comparatively recent severance of the islands from each other as well as from the opposite mainland of Mexico.

It is worthy of note, perhaps, that there is absolutely no indication of relation to the Cape Saint Lucas fauna of Lower California. The only species occurring in both places is *Phyllodactylus tuberculosus*, a gecko of wide distribution, the presence of which is of absolutely no moment in determining zoogeographical relations.

The only species whch seems to be peculiar to the islands is *Cnemidophorus mariarum*. As will be explained more fully under the head of this species, I have never seen a specimen from the mainland, and those which have been recorded from there I regard as wrongly identified. However, the herpetology of the regions in question is too little explored in detail to incline one to be dogmatic on a point like this, but I may call attention to the fact that the swift which occurs on the little Isabel Island, about halfway between the Tres Marias and the mainland, is most certainly the same form which inhabits the latter, viz, *Cnemidophorus gularis mexicanus*, and not *C. mariarum*, to which it bears only a superficial resemblance. The species collected on Isabel Island are referred to in the following paper without any number preceding the specific names. Mr. Nelson has contributed field notes on some of the species, and these notes are given in brackets with his initials at the end of the paragraph on the species to which they refer.

TESTUDINATA.

[The tortoise-shell turtle frequents the sea about the Tres Marias, approaching the shores to mate and deposit eggs in May and June each year. At the same time the large green sea turtle abounds along these shores, where they congregate for the same purpose.—E. W. N.]

Kinosternon integrum Leconte.

I have no hesitation in endorsing Boulenger's view (Cat. Chel. Brit. Mus., p. 42) that the Tres Marias mud turtles are *K. integrum* and not *K. hirtipes*, as held by Günther (Biol. Centr.-Am., Rept., p. 15, pls. xii–xiv). They have the broader bridge and broader plastron of the former and agree with undoubted specimens from the mainland. The island specimens, of which there are four adults and one young, do not differ from those from Colima, Guanajuato, Cuernavaca (Morelos), Acaponeta (Tepic), Guadalajara (Jalisco), Presidio, and Mazatlan (Sinaloa), from all of which localities I have examined specimens. *K. hirtipes* I believe to be confined to the eastern side of Mexico.

List of specimens of Kinosternon integrum.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24606	712	Maria Madre Island	May 15, 1897
24607	713	.....do	May 15, 1897
24608	714	.....do	May 15, 1897
24609	715	.....do	May 15, 1897
24610	716	.....do	May 15, 1897

LORICATA.

Crocodylus americanus Laur.

No specimens were secured, but Mr. Nelson assures me that the crocodile occurs on Maria Magdalena Island. There can be but little doubt that it is the present species which is distributed all along the coast of Central America, Mexico, the West Indies, and southern Florida.

[The unmistakable furrow in the mud where a crocodile had hauled up on the border of a brackish lagoon on the eastern side of Maria Magdalena, the sight of a small head in the water, and the testimony of the people on Maria Madre established the fact of their occurrence. They appeared to be limited to Maria Magdalena.—E. W. N.]

SQUAMATA.

SAURI.

Phyllodactylus tuberculosus Wiegm.

This species is distributed over Mexico and Central America, and has also been collected in the Cape Saint Lucas region of Lower California, the specimens from the latter locality having been described by Cope as *Phyllodactylus xanti*.

List of specimens of Phyllodactylus tuberculosus.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24611	669	Maria Madre Island	May 21, 1897
24612	[1] 686	.....do	May 28, 1897
24613	700	Maria Cleofa Island	May 30, 1897

[1] No. 686 was taken in an old house.

Anolis nebulosus Wiegm.

All the specimens from the three islands are normally colored and alike, except No. 692, which has a wide whitish dorsal band originating on the occiput and extending down the upper surface of the tail. It is edged with dusky, and a narrow broken line of the same dusky color in the white band near the edge on each side extends from neck to rump. This specimen is small and without gular pouch; but No. 691, from the same island, which equals it in these respects, is colored like the larger specimens. Both specimens appear to be females, having no enlarged postanal scales.

This species is widely distributed over Mexico, and has been collected in the Tres Marias Islands not only by Forrer but also by Capt. William Lund, specimens from the latter being in the museum of the California Academy of Sciences in San Francisco (Van Denburgh, Proc. Phila. Acad., 1897, p. 460).

List of specimens of Anolis nebulosus.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24614	636	Maria Madre Island	May 3, 1897
24615	641	.....do	May 4, 1897
24616	[1] 683	Maria Magdalena Island	May 28, 1897
24617	[1] 684	.....do	May 28, 1897
24618	[1] 685	.....do	May 28, 1897
24619	688	.....do	May 28, 1897
24620	690	Maria Cleofa Island	May 29, 1897
24621	691	.....do	May 29, 1897
24622	692	.....do	May 29, 1897

[1] Nos. 683–685 were found living in an old house.

Ctenosaura teres (Harlan). Black Iguana.

The material at hand is very unsatisfactory inasmuch as all the full-grown specimens are of the same sex and in rather poor state of preservation, while the younger specimens afford no characters for satisfactorily separating the various forms which naturally group themselves around *Ctenosaura teres.* They are therefore left under that general name for the present, the writer hoping some day to be able to review the whole genus. The chief difficulty now lies in the lack of typical specimens of *C. teres* from Tampico and from the eastern coast of Mexico generally, and until a series of full-grown specimens of both sexes is obtained from that region it will be futile to attempt to straighten out the nomenclature of these lizards. As far as I can make out from my defective material the Tres Marias and Isabel specimens differ sufficiently from specimens from Colima and Tehuantepec to warrant their subspecific recognition, but whether identical with the Mazatlan form or not I am not able to say. There are certainly several pretty well defined races of this species; but more adult specimens and a direct comparison with the types of many of the old names in various foreign museums will be necessary before the intricate questions involved can be settled.

[The females were burrowing in the gravel in dry washes and flats on the islands the last half of May. The burrows were from 2 to 3 or 4 feet deep, and after the eggs had been deposited at the lower end, the female scraped in loose gravel until the hole was filled, and frequently raised a little mound over the entrance.—E. W. N.]

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24623	655	Maria Madre Island	May 14, 1897
24624	656	.....do	May 14, 1897
24625	659	.....do	May 15, 1897
24626	660	.....do	May 15, 1897
24627	662	.....do	May 15, 1897
24628	(bis) 662	.....do	May 17, 1897
24629	676	.....do	May 24, 1897
24630	693	Maria Cleofa Island	May 29, 1897
24631	630	Isabel Island	Apr. 23, 1897
24632	631	.....do	Apr. 23, 1897
24633	632	.....do	Apr. 23, 1897

Uta lateralis Boulenger.

Mr. Nelson remarks that this species lives on stones and driftwood near the border of the woods along the sea beaches.

Uta lateralis was based by Boulenger in 1883 upon specimens from the Tres Marias and from Presidio, near Mazatlan, collected by Forrer, and specimens from both localities are designated as 'types' in the 'Catalogue of Lizards in the British Museum.'

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24634	635	Maria Madre Island	May 3, 1897
24635	642	.....do	May 4, 1897
24636	643	.....do	May 7, 1897
24637	653	.....do	May 13, 1897
24638	670	.....do	May 21, 1897
24639	671	.....do	May 21, 1897
24640	672	.....do	May 21, 1897
24641	673	.....do	May 21, 1897
24642	674	.....do	May 21, 1897
24643	675	.....do	May 21, 1897
24644	678	.....do	May 25, 1897
24645	679	.....do	May 25, 1897

Sceloporus boulengeri Stejneger.

N. Am. Fauna No. 7, 1893, p. 180, pl. I, figs. 5*a–c*.

This species appears to be smaller than *S. clarkii*, of which it is the southern representative. A full-grown male (No. 634*e*) measures only 72^{mm} from snout to vent.

Van Denburgh's belief that *S. boulengeri* "is the same form as Cope's *S. oligoporus*" (Proc. Phila. Acad., 1897, p. 463) is not well founded. The latter is easily distinguished by having only 2 to 3 femoral pores, besides other differences. It is probably identical with *S. horridus*.

U. S. National Museum number.	Collectors' number.	Locality.	Sex.	Number of pores.	Date.
24646	634	Isabel Island	♂ ad.	8	Apr. 23, 1897
24647	634 *a*	.....do	♀ jun.	9	Apr. 23, 1897
24648	634 *b*	.....do	♂ adol.	7	Apr. 23, 1897
24649	634 *c*	.....do	♀ ad.	9	Apr. 23, 1897
24650	634 *d*	.....do	♀	9	Apr. 23, 1897
24651	634 *e*	.....do	♂ ad.	9	Apr. 23, 1897

Cnemidophorus mariarum Günther.

Cnemidophorus mariarum Günther Biol. Cent.-Am., Rept. p. 28, pl. XX, April, 1885; Boulenger, Cat. Lizards, Brit. Mus., p. 368, 1885.

The swifts from the Tres Marias are essentially alike. Those from Maria Madre are the largest and possibly also most distinctly marked; those from the small detached rock off the west side of Maria Cleofa as well as the one from the main island of that name are somewhat smaller. According to Mr. Nelson's observation those from the detached islet, which is a bare rock, the nesting place of numerous sea birds, appeared to him paler when alive than those on the other islands, but now, in alcohol, the difference, if any, is very slight.

This species, which was originally described by Günther from specimens collected by Forrer on the Tres Marias seems to be confined to this group of islands. If so, it is the only species of reptile hitherto collected which is peculiar to these islands. The species has been recorded from the mainland (by Van Denburgh, Proc. Phila. Acad., 1897, p. 463, who identifies "a large number of lizards from Mazatlan, San Blas, and Tepic" with Günther's species), but I am satisfied that these records are based upon specimens of *C. gularis mexicanus* (Peters) which superficially very much resemble the island species. The misidentification is probably due to the fact that Cope, in his monograph of the genus, overlooked the different keeling of the caudal scales which is the essential character of this species.

List of specimens of Cnemidophorus mariarum.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24652	637	Maria Madre Island	May 3, 1897
24653	638	.....do	May 3, 1897
24654	639	.....do	May 4, 1897
24655	640	.....do	May 4, 1897
24656	644	.....do	May 7, 1897
24657	645	.....do	May 7, 1897
24658	646	.....do	May 7, 1897
24659	647	.....do	May 7, 1897
24660	687	Maria Magdalena Island	May 28, 1897
24661	701	Maria Cleofa Island (outlying rock)	May 30, 1897
24662	702	.....do	May 30, 1897
24663	703	.....do	May 30, 1897
24664	704	.....do	May 30, 1897
24665	705	.....do	May 30, 1897
24666	706	Maria Cleofa Island (main island)	May 31, 1897

Cnemidophorus gularis mexicanus (Peters).

The Isabel Island swifts are identical with the mainland form, two specimens of which were brought from San Blas. They are quite distinct from the species on the Tres Marias, which is well characterized by the smaller femorals and the parallel caudals. It is strange that Cope, having had the latter character clearly pointed out by Boulenger, should have referred *C. mariarum* to *C. gularis* as a subspecies.

List of specimens of Cnemidophorus gularis mexicanus.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24667	633	Isabel Island	April 23, 1897
24668	633*a*	.....do	April 23, 1897
24669	633*b*	.....do	April 23, 1897
24670	633*c*	.....do	April 23, 1897
24671	633*d*	.....do	April 23, 1897

SERPENTES.

Boa imperator Daudin.

This is the first record of this species from the Tres Marias. The species is generally distributed through southern Mexico and Central America.

Scale rows 73.

List of specimens of Boa imperator.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24672	648	Maria Madre Island	May 12, 1897

Oxybelis acuminatus (Wied).

A common species occurring all through tropical America from Guaymas, Mexico, south.

List of specimens of Oxybelis acuminatus.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24673	677	Maria Madre Island	May 25, 1897

Diplotropis diplotropis (Günther).

This species seems to be confined to western Mexico. It was not collected by Mr. Nelson, but there are two specimens in the British Museum collected by Forrer on the Tres Marias (*Leptophis diplotropis* Boulenger, Cat. Snakes Brit. Mus., II, p. 110).

Drymobius boddaerti (Seetzen).

A common species distributed over tropical America.

In No. 681 the fourth labials on both sides are divided horizontally, so as to suggest a subpreocular. This is an adult male, and is uniformly colored above, without any markings. The adolescent specimens are uniform above, with a few scales tipped with black; the anterior part of the underside has square blackish spots. The two young ones have above brown, dark-edged, squarish spots, separated by narrow light-colored interspaces. They are marked underneath like the adolescent specimens.

No. 681, male ad.—Scale rows, 17; ventrals, 183; anal, $\frac{1}{2}$; caudals, $\frac{111}{111}$; supralabials, 9.

List of specimens of Drymobius boddaerti.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24674	652 juv.	Maria Madre Island	May 12, 1897
24675	654 ad.	.....do	May 13, 1897
24676	658 ad.	.....do	May 14, 1897
24677	661 ad.	.....do	May 15, 1897
24678	663 juv.	.....do	May 18, 1897
24679	681 ad.	Maria Magdalena Island	May 27, 1897

Bascanion lineatum Bocourt.

This species is apparently confined to western Mexico.

List of specimens of Bascanion lineatum.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24680	650	Maria Madre Island	May 12, 1897
24681	651	.....do	May 12, 1897
24682	660	.....do	May 16, 1897

Drymarchon corais melanurus (Dum. & Bibr.)

Scale rows, 19; ventrals, 205; anal, 1; caudals, $\frac{83}{83}$, supralabials, 8. Adult male with the characteristic coloring of this subspecies, which seems to be confined to Mexico and Central America.

List of specimens of Drymarchon corais melanurus.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24683	664	Maria Madre Island	May 18, 1897

Lampropeltis micropholis oligozona (Bocourt).

Scale rows, 23; ventrals, 230; anal, 1; caudals, $\frac{51}{51}$; temporals, 2 + 3. Adult male. Thirteen annuli on body, separated by wide, red interspaces, without black spots, both on back and belly; all the annuli complete, including that on neck and throat, which does not touch the parietals; snout white, with black on rostral and anterior nasal. From Boulenger's account it appears that Forrer's specimens from the Tres Marias are identical. (Cat. Snakes Brit. Mus., II, p. 204.)

Distributed over Mexico and Central America.

List of specimens of Lampropeltis micropholis oligozona.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24684	661	Maria Madre Island	May 16, 1897

Agkistrodon bilineatus (Günther).

Scale rows, 23; ventrals, 138; anal, 1; caudals, 21 + $\frac{25}{25}$. Adult male. Southern Mexico and Central America to Nicaragua.

List of specimens of Agkistrodon bilineatus.

U. S. National Museum number.	Collectors' number.	Locality.	Date.
24685	707	Maria Madre Island	May 15, 1897

Crotalus sp.?

No rattlesnake was collected on the Tres Marias by Forrer, nor by Nelson, but the latter informs me that he was told of the occurrence of a rattler on Maria Magdalena Island.

NOTES ON THE CRUSTACEA OF THE TRES MARIAS ISLANDS.

By Mary J. Rathbun,

Second Assistant Curator, Division of Marine Invertebrates, U. S. National Museum.

Of the four species of crustacea taken by E. W. Nelson and E. A. Goldman on the Tres Marias Islands in May, 1897, two are identical with forms inhabiting Lower California, one is found in all the warm countries of the world, while the fourth, a fresh-water shrimp, is distributed throughout tropical America.

Gecarcinus digueti Bouvier.

Gecarcinus digueti Bouvier, Bull. Mus. Hist. Nat., Paris, I, 8, 1895.

Maria Cleofa Island. May 30. One large male (Collectors' No. 717).

The type and only specimen hitherto collected is from Lower California, and is in the Paris Museum. This species differs from others found on the Pacific coast in its wider carapace, narrower front, longer legs, and in the form of the abdomen of the male.

Measurements.

Specimen.	Length.	Width.	Exorbital width.	Inferior width of front.	Length of merus of second ambulatory leg.	Width of same.	Length of carpus.	Width of same.	Length of propodus.	Width of same.	Length of dactylus.	Width of same.
Type, ♂, Lower California	46.3	69	25	9	33	9.7	16	8	17	7.3	24.2	3.7
♂, Maria Cleofa Island	70	104	37.5	13	46.3	13.4	22.5	11.5	21.5	10	33.5	5

The measurements of the legs are exclusive of the large spines, and the length given is that of the anterior or superior margin. The penultimate segment of the abdomen of the male is very wide. Length and distal width, 12 mm.; proximal width, 21.5.

Mr. Nelson says of these crabs:

On the Tres Marias we found them only on Maria Cleofa, where they were very numerous above high-water mark on the sandy beaches of the low eastern part of the island. They were also living very abundantly in burrows in the soft soil almost everywhere on the slopes of Isabel Island. They are nocturnal in habits, and caused some annoyance by walking over us at night while we were camped in their haunts. They began to come out of their burrows as soon as it became twilight in the evening. In both localities most of their burrows were found among the scrubby bushes. On Isabel Island they were often seen during the day sitting in the burrows a foot or so from the entrance, but scuttled back to a safe depth when I approached.

Ocypode[1] **occidentalis** Stimpson.

Ocypoda occidentalis Stimpson, Ann. Lyc. Nat. Hist. N. Y., VII, 229, 1860.

Maria Magdalena Island. May 28. One female (No. 689).
Maria Cleofa Island. May 30. One male (No. 699).

This much neglected species is distinct, it seems to me, from *O. kuhlii* de Haan, of which Miers made it a variety. According to the description of *O. kuhlii* given by de Man (Notes Leyden Mus., III, 250, 1881), who had the type before him, *O. occidentalis* differs from it in having a narrower carapace, in the outer orbital angle directed inward and not outward, in the shorter hand, the length of the upper margin of the palm being less than the width, and in having from 18 to 21 tubercles in the stridulating ridge (de Man gives 8 or 10 for *kuhlii*, while Miers figures 17). The form of the abdomen of the male furnishes excellent characters for the determination of the species of *Ocypode*. In *O. occidentalis* the penultimate segment is much wider at its middle than at its proximal end.

It is singular that this species is not mentioned in the revisions of the genus by Kingsley, 1880, or by Ortmann, 1897.

Dimensions of a type specimen, U. S. National Museum.—Male: Length, 40.5 mm.; epibranchial width, 48; exorbital width, 41; length of superior margin of palm, 22.8; entire length of propodus, 43.5; greatest width, 24.

Range.—Type locality, Cape St. Lucas. Also taken at Turtle Bay and San Jose del Cabo, Lower California, by Mr. A. W. Anthony, in 1896 and 1897.

Grapsus grapsus (Linnæus).

"This crab was very abundant on the rocks along the water's edge on the Tres Marias as well as on Isabel Island." (Nelson.)

The species is distributed throughout the tropics.

Bithynis jamaicensis (Herbst).

Maria Magdalena Island. May 27. One adult, 7 young (No. 709).
Maria Cleofa Island. May 30. One adult, 3 young (No. 710).

"These shrimps were very numerous in a small stream among the hills in the interior of Maria Magdalena, and were also numerous in streams flowing through the hilly parts of the adjacent mainland." (Nelson.)

The species is found on the Pacific slope of the continent from Lower California to Ecuador, and on the Atlantic slope from Texas to Rio de Janeiro. The following localities, not before recorded, are represented by specimens in the U. S. National Museum: On the Pacific

[1] *Ocypode*, not *Ocypoda*, Fabricius, Entom. Sys., Suppl., 312 and 347, 1798; also Entom. Sys., emend. et auct., IV, index, 115, 1796.

coast, La Paz, Lower California; Rio Presidio, Sinaloa; Rio de Alica, Tepic; Barranca Ibarra, Rio Santiago, Jalisco, and Rio Armeria, Colima, Mexico; Rio de los Platanales and Quebrada Chavarria Golfito (both tributary to the Gulf of Dulce), Costa Rica; River David, Chiriqui, United States of Colombia, 4,000 feet elevation; Guayaquil, Ecuador. On the Atlantic coast, San Antonio, Tex.; Las Moras Creek, Kinney County, Tex.; Brownsville, near mouth of Rio Grande, Tex.; Amixtlan, and Zacatlan, Puebla, Mexico; Escondido River, 50 miles from Bluefields, Nicaragua; Port Castries, St. Lucia, West Indies.

The west African form, *B. vollenhovenii* (Herklots) is no more than a subspecies of *B. jamaicensis*. It differs only in the slenderer second pair of feet, the carpal and meral joints of which are subequal. The relative lengths of the rostrum and the antennal scales and peduncles agree with those in some specimens of *jamaicensis*. The two forms are considered identical by Dr. Ortmann.

According to Dr Edward Palmer, *B. jamaicensis* is much eaten at Colima, and is offered in the market there as a choice article of food, especially on Fridays and Sundays.

PLANTS OF THE TRES MARIAS ISLANDS.

By J. N. Rose,
Assistant Curator, Division of Plants, U. S. National Museum.[1]

The Tres Marias, lying about 65 miles off the west coast of Mexico in about 22° north latitude, are among the last of the west coast islands to be studied. All the others have yielded valuable botanical results, but almost nothing has been known of the flora of these islands except in a commercial way. Several botanical expeditions had been planned to explore the islands, but heretofore none had succeeded in reaching them. They are out of the line of traffic, although some of the smaller steamers stop now and then for fuel, and small boats occasionally ply between the islands and San Blas. They are usually visited during the dry season, as it is dangerous to attempt the passage during summer and autumn.

Mr. Nelson visited the islands at the very close of the dry season, when the vegetation is at its poorest, and this accounts for the small number of species collected. His collection contains 154 numbers (Nos. 4179 to 4333) and 136 species, mostly from Maria Madre, the largest of the islands, and only a few from Maria Magdalena and Maria Cleofa. In the subjoined list the plants are from Maria Madre unless otherwise stated.

There are no cultivated plants on the islands, except one or two grasses. *Pithecolobium dulce*, perhaps introduced, is common and much prized for its delicious fruit. The exportation of Spanish cedar (*Cedrela* sp.) has long been the chief source of income for the islands, but the available supply of this timber is now nearly exhausted. The flora is purely tropical and does not differ essentially from that of the adjacent mainland. Many of the species have not been reported from the mainland opposite, but this is doubtless because the flora is not well known, since these species have been collected either farther north or south. One hundred and twelve species are named below, of which 11 are new. Many of them have a wide distribution in tropical America; all but 6, except the new species, have heretofore been reported from Mexico; 24 range northward into the United States; 64 extend into Central America; 61 into South America; 44 into the West Indies, and 21 are found in the Old World.

[1] Published by permission of the Secretary of the Smithsonian Institution.

The following report must be regarded as a preliminary one. The specimens upon which it is based are simply those in fruit or flower at the close of the dry season, a considerable number of which have not been determined specifically and a few not even generically. As will be seen from the list below, mostly trees and shrubs were collected, while the herbs, which spring up in great variety during the rainy season, are scarcely represented.

The Gamopetalæ and Apetalæ have been named by Mr. J. M. Greenman, Gramineæ by Prof. F. Lamson-Scribner, and Filices by George E. Davenport.

The following new species and varieties are based on this collection:

Ægiphila pacifica Greenman.
Beloperone nelsoni Greenman.
Buxus pubescens Greenman.
Cordia insularis Greenman.
Erythrina lanata Rose.
Euphorbia nelsoni Millspaugh.
Euphorbia subcœrulea tresmariæ Millsp.
Gilibertia insularis Rose.
Pilocarpus insularis Rose.
Ternstrœmia maltbya Rose.
Zanthoxylum insularis Rose.
Zanthoxylum nelsoni Rose.

ANNOTATED LIST OF SPECIES.

Cissampelos pareira L.

Common in Mexico and other tropical countries. May 3 to 25 (Nos. 4233 and 4262).

Argemone ochroleuca Sweet.

Widely distributed throughout Mexico. Maria Magdalena Island, May 26 to 28, 1897 (No. 4318).

Capparis cynophallophora L.

Found along the coast of Mexico, South America, and the West Indies. May 3 to 25 (No. 4302).

Capparis breynia L.

Common in Mexico, South America, and the West Indies. May 3 to 25 (No. 4219).

Cratæva tapia L.?

Perhaps this is the species which has been reported from Acapulco and Mazatlan. May 3 to 25 (No. 4274.)

Ternstrœmia maltbya Rose, sp. nov.

Tree 3 to 9 meters high; leaves obovate, entire, obtuse, glabrous, thickish, not black-punctate beneath, 5 to 10 cm. long; flowers solitary; peduncles 2.5 to 3.5 cm. long becoming curved, bracteate a short distance below the calyx; sepals 5, orbicular, 8 to 10 mm. in diameter; petals united at base, acute; stamens numerous; fruit (immature) ovate, 20 mm. long, two-celled; seeds red.

This species is in all probability Seeman's No. 2148, collected on the road from Mazatlan to Durango and enumerated in the Biologia Centrali-Americana without specific name.

Collected on Maria Madre Island, May, 1897, by T. S. Maltby (No. 105) and E. W. Nelson (No. 4242); by J. N. Rose near Colomo, Sinaloa, July, 1897 (No. 1675).

Wissadula hirsutiflora (Presl) Rose.

The type of this species came from Acapulco. It is probably common on the west coast, although its distribution and specific limits are not well known. May 3 to 25 (No. 4250).

Abutilon reventum Watson.

This species extends as far north as Arizona. May 3 to 25 (No. 4203).

Hibiscus tiliaceus L.

A common tree in most tropical countries. Maria Magdalena Island, May 26 to 28 (No. 4328a).

Melochia tomentosa L.

Common throughout tropical America. May 3 to 25 (No. 4205).

Guazuma ulmifolia Lam.

Common throughout tropical America. Maria Magdalena Island, May 26 to 28 (No. 4325).

Heteropterys floribunda H. B. K.

Common in Mexico and Central America.

Maria Magdalena Island, May 26 to 28 (No. 4323).

Guaiacum coulteri ? Gray.

Seemingly common on the west coast of Mexico. Island specimens do not correspond with the form found on the mainland and may represent an undescribed species. May 3 to 25 (No. 4180).

Zanthoxylum insularis Rose, sp. nov.

Tree 6 to 20 meters high, thornless; leaves oddly pinnate; leaflets 6 to 7 pairs, opposite, sessile, obovate to spatulate, obtuse or retuse, 2 to 3.5 cm. long, crenate, with large pellucid dots between the teeth and small scattered dots over the surface, glabrous; flowers unknown; fruit small, in a rather compact panicle; pedicels very short; stipe short and thick.

Collected by E. W. Nelson on Maria Madre Island. May 3 to 25, 1897 (No. 4278).

Zanthoxylum nelsoni Rose, sp. nov.

Tree 7.5 to 20 meters high, thornless(?); leaves oddly pinnate; leaflets about 6 pairs, distant, opposite, shortly petioled, 5 to 11 cm. long, rounded at base, long-acuminate, crenate, glabrous on both sides, thickly set with pellucid dots; inflorescence in small compact panicles; perianth complete; petals 4 (?); fruit large in dense head-like clusters, not stipitate.

A very peculiar species, unlike any Mexican one known to me. Collected by E. W. Nelson on Maria Madre Island. May 3 to 25, 1897 (No. 4279).

Pilocarpus insularis Rose, sp. nov.

Tree 3 to 6 meters high, glabrous throughout; leaflets usually in threes, some solitary or in rows, 5 to 7.5 cm. long, retuse at apex, cuneate at base, in the lateral ones more or less oblique; midvein prominent, lateral veins indistinct below, not very prominent above; racemes short and compact, 5 to 10 cm. long; fruiting pedicels horizontal, 16 mm. long; ovary deeply 4 or 5-lobed or parted, 1 to 4 lobes not maturing.

This species is near *P. longipes* of Mexico, but with somewhat different leaves, more compact inflorescence, etc. Collected by E. W. Nelson on Maria Madre Island. May 3 to 25, 1897 (No. 4307).

Amyris sp.

May 3 to 25, 1897 (No. 4237).

Picramnia sp.

A tree 4.5 to 7.5 meters high; flowers said to be greenish, but none with specimens. Much resembling the South American species *P. ciliata* Mast., but without flowers or fruit. Exact identification is doubtful. May 3 to 25 (No. 4276).

Ochna sp.

May 3 to 25 (No. 4238).

Bursera gummifera Jacq.

Common throughout tropical Mexico, Central America, the West Indies, and extending into Florida. May 3 to 25 (No. 4227).

Guarea sp.

May 3 to 25 (Nos. 4222 and 4230).

Trichilia spondioides Swartz.

Common in tropical America. May 3 to 25 (Nos. 4214 and 4309).

Ximenia americana L.

Common in most tropical countries. May 3 to 25 (No. 4224).

Schœpfia schreberi Gmel.

Seemingly rare, but has been collected in Mexico and South America. May 3 to 25, 1897 (No. 4271).

Hippocratea sp.

Maria Magdalena Island, May 26 to 28 (No. 4320). Maria Madre Island, May 3 to 25 (No. 4226).

Colubrina arborea Brandegee.

Reported from Lower California and the west coast of Mexico. May 3 to 25 (No. 4213).

Cissus sicyoides L.

A common species in tropical America. May 3 to 25 (No. 4198).

Serjania mexicana Willd.

A common species in tropical America. May 3 to 25 (No. 4231).

Paullinia sessiliflora Radl.

Heretofore only known from the type specimens collected by Dr. Edward Palmer in the State of Colima, Mexico. May 3 to 25 (No. 4210).

Urvillea ulmacea H. B. K.

Common in Mexico and northern South America. May 3 to 25 (No. 4277).

Cardiospermum corindum L.

A widely distributed species. Maria Magdalena Island, May 26 to 28 (No. 4328).

Crotalaria lupulina ? H. B. K.

Perhaps this species, which is common in Mexico, and extends into the United States. May 3 to 25 (No. 4248).

Tephrosia sp.

May 3 to 25 (No. 4193).

Desmodium sp.

May 3 to 25 (No. 4287).

Erythrina lanata Rose, sp. nov.

A small tree, 4.5 to 7.5 meters high, with a trunk 10 cm. in diameter; branches glabrous, bearing mostly single infrastipular spines; leaflets triangular, shortly acuminate, 5 to 10 cm. long, 5 to 7.5 cm. broad, glabrous or nearly so.

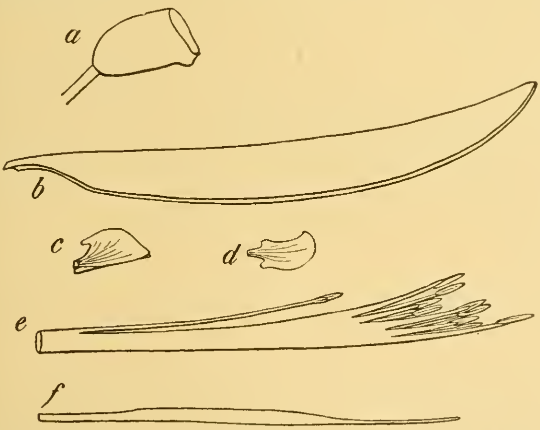

FIG. 1.—*Erythrina lanata;* *a*, calyx; *b*, banner; *c*, keel; *d*, wing; *e*, stamens; *f*, ovary.

Inflorescence unknown; calyx lanate becoming glabrate, tubular, 10 to 13 mm. long, truncate, one-toothed; banner 68 mm. long, folded, densely white-lanate, rounded at apex; wings (9 mm. long) and keel (10 mm. long) included within the calyx; ovary densely lanate; legume glabrous, 12.5 to 15 cm. long, strongly constricted between the seeds, long-stipitate, attenuate at tip; seeds small (for the genus), nearly orbicular, 6 to 8 mm. long, bright scarlet, with a dark spot at the micropyle.

The type of this species is Dr. Edward Palmer's No. 129, from Acapulco, Mexico, collected in 1894–95. To this species I would refer specimens collected by Frank Lamb near Villa Union, State of Sinaloa, January, 1893 (No. 428), and flowering specimens by W. C. Wright from the head of Mazatlan River, January, 1889 (No. 1292), and also those collected by J. N. Rose at Rosario, Sinaloa, July 10, 1897 (No. 1592), and July 22 (No. 1822). The latter two specimens are not in flower and their reference here is attended with some doubt. The seeds are larger and the pods less constricted between the seeds. Here also belongs E. W. Nelson's No. 4303 from the Tres Marias, collected May, 1897. I have tentatively referred to this species E. W. Nelson's No. 2699, taken at an altitude of 480 meters, near Santo Domingo, State of Oaxaca, June 18, 1895. It has similar pods, but is described as being but 6 to 12 cm. high and has more bluntish leaflets.

Dr. Palmer says this tree flowers in January, and is often used for hedge fences. It differs from all other Mexican species which I have seen in its white lanate banner. Its one-toothed calyx suggests *E. rosea*, but in the latter the calyx is described as obliquely truncate.

Phaseolus sp.

Maria Magdalena Island, May 26 to 28, 1897 (No. 4319).

Canavalia gladiata DC.

A species of wide distribution, perhaps throughout tropical America. May 3 to 25 (No. 4190).

Rhynchosia minima DC.

A common Mexican species extending into South America and the United States. May 3 to 25 (No. 4206).

Rhynchosia precatoria (?) (H. B. K.) DC.

This species has been reported from Acapulco and Panama. May 3 to 25 (No. 4179).

Lonchocarpus sp.

May 3 to 25 (No. 4310).

Ateleia (?) sp.

Without flowers or named specimens for comparison it is impossible to name this plant definitely. If it belongs to the genus *Ateleia* it is perhaps *A. pterocarpa*, the only species known from Mexico. A shrub or small tree 3.5 to 10.5 meters high. May 3 to 25 (No. 4186).

Cassia emarginata L.

Common in Mexico, South America, and the West Indies. May 3 to 25 (Nos. 4192 and 4297).

Cassia biflora L.

Common in tropical America. May 3 to 25 (Nos. 4194 and 4196).

Cassia atomaria L.

Common in Tropical Mexico and South America. Maria Magdalena Island, May 26 to 28 (No. 4321).

Bauhinia sp.

Apparently belonging to the genus *Bauhinia*, but very unlike any of the Mexican species with which I am familiar. A vine 6 to 9 meters long; only in fruit. May 3 to 25 (No. 4300).

Acacia sp.

This appears to be an undescribed species, of which I collected specimens on the mainland. May 3 to 25 (No. 4188).

Albizzia occidentalis Brandegee.

Probably the above species, which is found in Lower California and has been reported from western Mexico. May 3 to 25 (No. 4252).

Pithecolobium dulce Benth.

Common in tropical Mexico and South America. Often cultivated. May 3 to 25 (No. 4285).

Pithecolobium ligustrinum Klotzsch.

Common in tropical Mexico and northern South America. Maria Magdalena Island, May 26 to 28 (No. 4314).

Conocarpus erectus L.

Common throughout tropical America extending into Florida and reported from tropical Africa. May 3 to 25 (No. 4220).

Psidium sp.

Tree 6 to 9 meters high; flowers white; called 'palo prieto.' This species is not represented in the National Herbarium. May 3 to 25 (No. 4306).

Casearia corymbosa (?) H. B. K.

The Tres Marias specimens should probably be referred to this species although our herbarium material seems to represent more than one species. This form is common on the west coast of Mexico and Central America. May 3 to 25 (Nos. 4270 and 4308).

Casearia sylvestris Swartz.

Widely distributed throughout tropical Mexico, South America, and the West Indies. May 3 to 25 (No. 4241).

Casearia sp.

Maria Magdalena Island. May 26 to 28, 1897 (No. 4326).

Passiflora sp.

May 3 to 25 (No. 4249).

Opuntia sp.

May 3 to 25 (Nos. 4263 and 4286).

Gilibertia insularis Rose, sp. nov.

Tree 6 to 12 meters high; leaves 25 to 35 cm. long, including the slender petioles (7 to 18 cm. long), 9 to 20 cm. broad, entire or 3-lobed, oblong, rounded at base, rounded at apex or with a short acumination, glabrous, 3-nerved at base; fruiting inflorescence a short dense panicle;

rays 2 to 3 cm. long; pedicels 4 to 8 mm. long; fruit white, 6-lobed, 4 mm. high; styles short, connate to near the top.

Collected on Maria Madre Island May 3 to 25 (No. 4282).

Portlandia pterosperma Watson.

A species recently described by Dr. Watson, the type coming from near Guaymas, Sonora. May 3 to 25 (No. 4211).

Eupatorium sp.

May 3 to 25, 1897 (No. 4225).

Eupatorium sp.

May 3 to 25, 1897 (No. 4244).

Eupatorium collinum DC.

Common in Mexico and Central America. May 3 to 25, 1897 (No. 4199).

Mikania cordifolia Willd.

Reported from Central and South America. May 3 to 25, 1897 (No. 4299).

Conyza lyrata H. B. K.

Reported from Mexico, Central and South America. May 3 to 25 (Nos. 4290 and 4312).

Baccharis glutinosa Pers.

A common Mexican and Central American plant. May 3 to 25, 1897 (No. 4291).

Pluchea odorata Cass.

Widely distributed in Mexico and South America. May 3 to 25, 1897 (No. 4181).

Parthenium hysterophorus L.

Common in Mexico, South America, and in the southern United States. May 3 to 25, 1897 (No. 4267).

Perityle microglossa Benth.

A common Mexican plant. May 3 to 25, 1897 (No. 4266).

Porophyllum nummularium DC.

Restricted to Mexico. May 3 to 25, 1897 (No. 4292).

Trixis frutescens P. Brown.

A common Mexican and Central American plant. May 3 to 25, 1897 (Nos. 4191), and Maria Cleofa Island, May 30, 1897 (No. 4331).

Jacquinia macrocarpa Cav.

Species not represented in the National Herbarium, but reported from Mexico, and Central and South America. May 3 to 25, 1897 (No. 4208).

Gonolobus sp.

Fruit only. May 3 to 25, 1897 (No. 4313a).

Buddleia verticillata H. B. K.

A common Mexican species. May 3 to 25, 1897 (No. 4183).

Cordia sonorae Rose.

A recently described species from Sonora. May 3 to 25, 1897 (No. 4207).

Cordia insularis Greenman.

Cordia insularis Greenman, Proc. Amer. Acad. 33: 483. 1898.

The original description is as follows: "Shrub 3 to 5.5 m. high; stems and branches glabrous, reddish brown, conspicuously dotted with numerous whitish lenticels; the extreme branchlets covered with hirsute pubescence; leaves scattered, elliptic-ovate or sometimes slightly obovate, 1.5 to 3 cm. long, 1 to 1.5 cm. broad, narrowed below into a short petiole, obtuse, the upper portion more or less deeply crenate-dentate, occasionally sharply toothed, entire toward the base, hispid above, spreading hirsute-pubescent beneath, especially on the midrib and veins; inflorescence capitulate; heads small (after the corolla has fallen, about 5 mm. in diameter); peduncles, during anthesis, 1 cm. or less in length, covered with a spreading hirsute pubescence; calyx 2 mm. long, 5-dentate; teeth short, acute; corolla 3 mm. long, nearly cylindrical, with short recurved lobes, externally glabrous, pubescent inside along the line of the filaments, stamens included; style a little exserted. Collected by E. W. Nelson on Maria Madre Island of the Tres Marias group of islands. May 3 to 25, 1897 (No. 4296)."

Tournefortia candida Walp.

Not previously in herbarium. May 3 to 25, 1897 (Nos. 4217 and 4229).

Tournefortia cymosa L.

I have only seen specimens from Guatemala. May 3 to 25, 1897 (No. 4189).

Tournefortia velutina H. B. K.

Reported from the west coast of Mexico and Guatemala. May 3 to 25, 1897 (No. 4209).

Heliotropium indicum L.

Common in Mexico and most tropical countries. May 3 to 25, 1897 (No. 4253).

Heliotropium curassavicum L.

Common in Mexico and South America as well as in the Old World. Reported in the United States as far north as Oregon and Virginia. May 3 to 25, 1897 (No. 4313).

Ipomoea bona-nox L.

A common tropical plant extending into Florida. May 3 to 25, 1897 (No. 4269).

Ipomoea peduncularis Bertol.

Common in Mexico and Central America. May 3 to 25, 1897 (No. 4235).

Jacquemontia violacea Choisy.

Reported from Mexico, Central and South America, and the West Indies. May 3 to 25, 1897 (No. 4251).

Solanum nigrum L.

A widely distributed species. May 3 to 25, 1897 (No. 4200).

Solanum lanceaefolium Jacq.

A common tropical plant. May 3 to 25, 1897 (No. 4240).

Solanum callicarpaefolium Kunth & Bouché.

Common in south Mexico and northern South America. Maria Magdalena Island, May 26 to 28, 1897 (No. 4322).

Solanum torvum Swartz.

Common in Mexico and Central America. May 3 to 25, 1897 (No. 4185).

Solanum verbascifolium L.

Only reported hitherto from one station in southern Mexico. May 3 to 25, 1897 (No. 4216).

Physalis pubescens L.

A common tropical plant. May 3 to 25, 1897 (No. 4255).

Bassovia donnell-smithii Coulter.

A recently described South American and Guatemalan species. May 3 to 25, 1897 (No. 4232).

Datura discolor Bernh.

Reported from Mexico and West Indies. May 3 to 25, 1897 (No. 4197).

Nicotiana trigonophylla Dun.

Common in Mexico. May 3 to 25, 1897 (No. 4212).

Russelia sarmentosa Jacq.

A common Mexican and Central American species. (May 3 to 25, 1897 (No. 4289).

Capraria biflora L.

A widely distributed plant, extending into Florida. May 3 to 25, 1897 (No. 4195).

Bignonia aequinoctialis L. (*B. sarmentosa* Bertol.)

Recently collected at Acapulco by Dr. Edward Palmer. It is common in Central and South America. May 3 to 25, 1897 (No. 4301), and Maria Magdalena Island, May 26 to 28 (No. 4324).

Beloperone nelsoni Greenman.

Beloperone nelsoni Greenman. Proc. Amer. Acad. 33: 488. 1898.

"It is nearest *B. comosa* Nees, in DC. Prodr. 11: 416, but differs very markedly in the size of the flower and the character of the lower lip."—Greenman in litt. May 3 to 25, 1897 (No. 4246).

The original description is as follows: "Erect; stems branching, subterete, covered with a spreading or slightly reflexed grayish pubescence; leaves ovate-lanceolate or oblong-lanceolate, 5 to 10 cm. long, 2 to 4 cm. broad, obtuse at the apex, entire, narrowed below into a slender petiole, densely lineolate above, pubescent on either surface, especially on the veins, later becoming glabrous; petioles about 2 cm. in length; inflorescence terminating the stem and branches in rather close bracteate spikes; bracts oblong or obovate; bracteoles linear, nearly 1 cm. long, exceeding the calyx; calyx about 5 mm. long, deeply 5-parted; divisions nearly equal, lanceolate, acute, ciliate; corolla 2 to 2.5 cm. long; tube exceeding the limb; upper lip shortly 2-lobed, the lower more deeply 3-lobed, rather broad, somewhat plaited in the throat; capsule 10 to 12 mm. long, pubescent. Collected by E. W. Nelson on Maria Madre Island of the Tres Marias group of islands, 3–25 May, 1897 (No. 4246).

"A species closely resembling *B. comosa* Nees, but with a much shorter corolla, and broader lower lip. The leaves are also somewhat larger, longer-petioled, and much less pubescent. It may be that further material will prove this to be a variety of *B. comosa* Nees, but as the material at hand shows no sign of intergradation, it seems best for the present at least to regard Mr. Nelson's plant as a distinct species."

Lantana horrida H. B. K.

Reported from both northern and southern Mexico. May 3 to 25, 1897 (No. 4187).

Citharexylum affinis D. Don.

This is a rare Mexican species which has been "compared with the Prodromus specimen at Geneva by C. De Candolle"—J. M. G. May 3 to 25, 1897 (No. 4311).

Ægiphila pacifica Greenman.

Ægiphila pacifica Greenman, Proc. Amer. Acad. 33:485. 1898.

The original description is as follows: "Shrub 2.5 to 7 m. high; stems and branches terete, covered with a grayish brown bark and dotted here and there with lenticels, glabrous; branchlets terete, somewhat compressed at the nodes, fulvous-pubescent; leaves opposite, oblong-ovate, 5 to 15 cm. long, 3.5 to 7.5 cm. broad, more or less acuminate, entire, rounded or rather abruptly narrowed at the slightly unequal base, glabrous, or at least glabrate above, with scattered, tawny, subappressed hairs beneath, especially upon the midrib and veins; petioles less than 1 cm. in length; inflorescence terminating the stems and branches in rather close paniculate cymes; peduncles, pedicels, the subulate bracts and calyx covered by a fulvous subappressed pubescence; calyx about 4 mm. long, 4-lobed; lobes broader than long, submucronate, greenish; corolla tubular, 10 to 12 mm. long, glabrous: tube somewhat ampliated above; lobes oblong-elliptic, about 4 mm. long, obtuse; stamens equal or rarely unequal, exserted; filaments pubescent below, glabrous above; drupe yellow, obovoid, 8 to 10 mm. long, 6 to 8 mm. in diameter, one-half or more exserted from the persistent coriaceous subcrenately lobed, cup-shaped calyx.—Collected by E. W. Nelson on Maria Madre Island of the Tres Marias group of islands, 3–25 May, 1897, No. 4245 (in flower) and No. 4254 (in fruit)."

Hyptis albida H. B. K.

Several times reported from Mexico. May 3 to 25, 1897 (No. 4223).

Salvia aliena Greene.

A Mexican species. May 3 to 25, 1897 (No. 4247).

Stachys coccinea Jacq.

Common in Mexico and Central America, extending into Texas and Arizona. May 3 to 25, 1897 (No. 4265).

Iresine interrupta Benth.

Reported from western and central Mexico. May 3 to 25, 1897 (No. 4234).

Phytolacca octandra L.

May 3 to 25, 1897 (No. 4293).

Stegnosperma halimifolia Benth.

Common along the west coast of Mexico. May 3 to 25, 1897 (No. 4184).

Batis maritima L.

Extending from Florida and California to Brazil and the West Indies and also reported from the Sandwich Islands. Magdalena Island, May 26 to 28, 1897 (No. 4327).

Coccoloba leptostachya Benth.

This species has not been heretofore found in Mexico, but has been reported from Central America and South America. Maria Magdalena Island, May 26 to 28, 1897 (No. 4315).

Antigonon leptopus Hook. & Arn.

A very common vine on the west coast of Mexico. May 3 to 25, 1897 (No. 4204).

Aristolochia pardina Duch.

A little-known plant collected at Colima many years ago by Ghiesbrecht, and recently at the same place by Dr. Edward Palmer. May 3 to 25, 1897 (No. 4304).

Piper aduncum L.

Reported from Mexico, Central and South America, and the West Indies. May 3 to 25, 1897 (No. 4283).

Euphorbia sp.

May 3 to 25, 1897 (No. 4268).

Euphorbia subcaerulea tresmariae Millspaugh, var. nov.

"In the characters present in the specimens collected, this agrees well with *E. subcaerulea* Rob. and Greenm. (Pringle No. 6265, Oaxaca), except in the hairy involucre more regularly toothed involucral lobes, and in having the styles bifurcate, to the middle only, and flat-spreading with no tendency to reflexion or peltation as in the other species. The fruits may prove this to be a distinct species. May 3 to 25, 1897 (Nos. 4298 and 4202)."—Millspaugh MSS.

Euphorbia sp.

Specimens are indeterminable from lack of characters. May 3 to 25, 1897 (No. 4215).

Euphorbia nelsoni Millspaugh.

Euphorbia nelsoni Millspaugh, Bot. Gaz. 26:268. 1898.

May 3 to 25, 1897 (No. 4294, not 4284, as published).

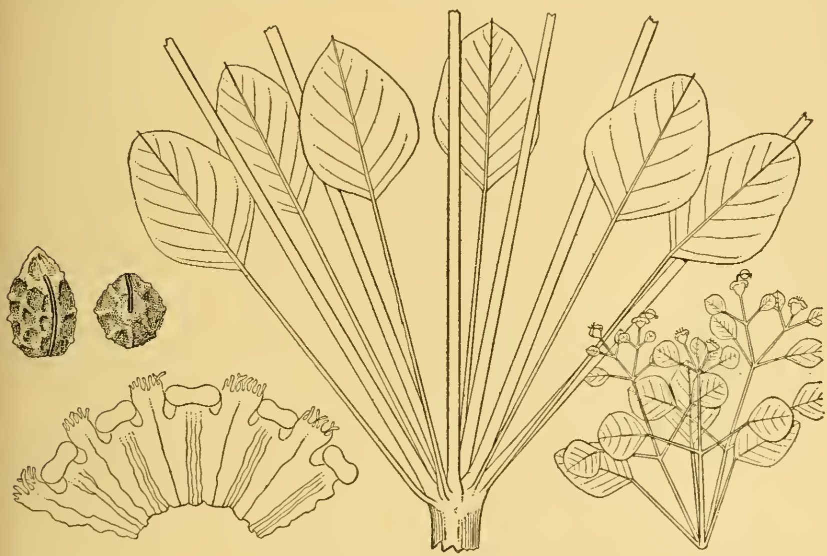

FIG. 2.—*Euphorbia nelsoni.*

The original description is as follows: "Fruticosa, glabra, longe et corymbosa ramosa, ramis teretis, internodiis longis, cortex maculatis, maculæ oblongis roseus. Foliis inferioris fasciculatis, petioliis longis filamentosis, pagina tenuis ovato-cuneatis, obtusis, apiculatis, foliis floralibus oppositis, orbiculatis petiolis limbum æquantis. Involucriis terminalibus corymbosis, pedunculatis, campanulatis glabris, lobis latis truncatis irregulariter 6–8 fimbriatis, glandulis 5, transversis oblongis integris, appendicibus minutis vel nullus. Stylis longis revoluto-circinalis. Capsulæ luridæ profunde tri-sulcatæ, semine sub-globosis pallide-fuscis, scrobiculatis, linea media nigra geminatis, rugæ anastomosantis tuberculatis 2 mm. long, 1.9 mm. lat."

Several Euphorbias were collected on the islands in too imperfect condition to determine, and it has been thought advisable to reproduce the cut[1] of the present species for the purpose of assisting future study of the flora.

[1] Through the kindness of the editors of the Botanical Gazette I am permitted to use this illustration.

The main figure shows a cluster of leaves. To the right is a flower cluster and to the left a dissected flower with end and side views of the seed.

Garcia nutans Rohr.

Found in Mexico and South America. May 3 to 25, 1897 (No. 4228).

Croton ciliato-glandulosus Ort.

May 3 to 25, 1897 (No. 4218).

Acalypha sp.

May 3 to 25, 1897 (No. 4260).

Celtis monoica Hemsley.

May 3 to 25, 1897 (No. 4236).

Buxus pubescens Greenman.

Buxus pubescens Greenman, Proc. Amer. Acad. 33:481. 1898.

The original description is as follows: "Shrub or small tree, 4.5 to 8 m. high; stems and branches covered with a grayish bark; the branchlets and younger shoots provided with a soft, spreading pubescence; leaves opposite or occasionally subalternate, sessile or nearly so, rhombic-ovate to oblong-ovate, 2 to 5 cm. long, 1.5 to nearly 3 cm. broad, 3-nerved, obtuse or acutish, mucronate, cuneate at the base, entire, ciliate, soft-pubescent beneath, more sparingly pubescent and glabrate above, showing the reticulate venation on the upper surface; inflorescence of axillary short-pedunculate much contracted subracemose pubescent clusters; staminate flowers pedicellate; pedicels 3 mm. long, about twice exceeding the ovate acute bracts; calyx deeply 4-parted; divisions ovate, acute, 2 mm. long, the inner divisions slightly broader than the outer ones; the rudimentary pistil somewhat quatrefoil or X-shaped; fertile flowers about 5 mm. long, single, sessile, terminating the inflorescence; ovary glabrous; fruit not seen.—Collected on Maria Madre Island by E. W. Nelson, 3–25 May, 1897, No. 4221.

"A species apparently endemic in the Tres Marias Islands, and most nearly related to the West Indian *B. pulchella* Baill."

Ficus radulina Watson.

A recent species of Dr. Watson's from northern Mexico. May 3 to 25, 1897 (No. 4261).

Ficus fasciculata Watson.

Only known from western Mexico. May 3 to 25, 1897 (No. 4288).

Ficus sp.

May 3 to 25, 1897 (No. 4182).

Myriocarpa longipes Liebm.

Found in Mexico and Central America. May 3 to 25, 1897 (No. 4275).

Agave sp.

Six meters high, leaves 9 to 18 dm. long; marginal teeth small, distant; end spine short, stout, pungent; capsules oblong, large, 7 cm. long.

This species belongs to the subgenus *Eugave* and the *Rigidae* group of Mr. Baker's revision. It is near *A. vivipara*, and perhaps not distinct. Mr. Nelson's plant does not seem to differ from specimens collected by me on the mainland. May 3 to 25, 1897 (No. 4264).

Cyperus ligularis L.

Reported from Mexico, Central and South America, and West Indies, as well as Africa and Australia. Maria Cleofa Island, May 30, 1897 (No. 4330).

Cyperus incompletus Link.

Reported from Mexico and Brazil. May 3 to 25, 1897 (No. 4259).

Panicum brevifolium L.

May 3 to 25 (No. 4257).

Eleusine indica Gaertn.

May 3 to 25, 1897 (No. 4305).

Dactyloctenium aegyptiacum Willd.

May 3 to 25, 1897 (Nos. 4295 and 4256); Maria Magdalena Island, May 26 to 28 (No. 4317).

Arundo donax L.

Maria Cleofa Island, May 30 (No. 4332).

Zamia loddigesii (?) Miq.

Reported from Mexico. Maria Cleofa Island, May 30, 1897 (No. 4329).

Pteris longifolia L.

Maria Madre Island, May 3 to 25, 1897 (No. 4201).

Aspidium trifoliatum Swartz.

Maria Madre Island, May 3 to 25, 1897 (No. 4280).

Aspidium patens Swartz.

A widely distributed species. Maria Magdalena Island, May 26 and 28, 1897 (No. 4316).

Adiantum concinnum H. B. K.

Maria Madre Island, May 3 to 25, 1897 (No. 4273).

Adiantum tenerum Swartz.

Maria Madre Island, May 3 to 25, 1897 (No. 4281).

Gymnogramme calomelanos Kaulf.

A widely distributed species. Maria Cleofa Island, May 30, 1897 (No. 4333).

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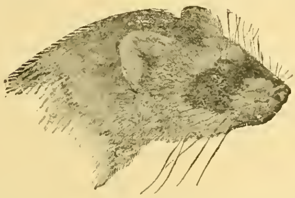

REVISION OF THE JUMPING MICE OF THE GENUS ZAPUS

BY

EDWARD A. PREBLE
ASSISTANT IN BIOLOGICAL SURVEY

Prepared under the direction of

Dr. C. HART MERRIAM
CHIEF OF DIVISION OF BIOLOGICAL SURVEY

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U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., June 15, 1899.

SIR: I have the honor to transmit herewith for publication, as No. 15 of North American Fauna, a 'Revision of the Jumping Mice of the Genus *Zapus*,' by Edward A. Preble, assistant in the Biological Survey.

Respectfully,

T. S. PALMER,
Acting Chief, Biological Survey.

HON. JAMES WILSON,
Secretary of Agriculture.

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No. 15. NORTH AMERICAN FAUNA. August, 1899.

REVISION OF THE JUMPING MICE OF THE GENUS ZAPUS.

By EDWARD A. PREBLE.

INTRODUCTION.

History and material.—The Jumping Mice of North America early attracted the attention of naturalists, but their true status and relationships long remained in obscurity. The first reference to any of the species seems to have been made by Thomas Pennant, in the latter part of the last century, who mentioned the animal under the name of the 'Long-legged Mouse of Hudson's Bay.' In 1780 Zimmermann, basing his description on that of Pennant, and supposing the animal to be congeneric with the jerboas of the Old World, named it *Dipus hudsonius*. Subsequent authors, recognizing the inapplicability of *Dipus*, referred the species successively to *Gerbillus*, *Meriones*, and *Jaculus*, until finally Dr. Elliott Coues, in 1875, after showing that all the generic names previously used were untenable, proposed *Zapus*.

Previous to 1857 a number of specific names were used for members of this genus (see pp. 10-13), but were applied mainly to specimens from the eastern United States and Canada. Suffice it to say that Baird, in 1857, and Coues, in 1877, recognized but one species, having a range nearly coincident with the present geographic distribution of the genus in North America. This resulted mainly from two causes—poor quality of existing material and the prevailing tendency of the times to lump distinct species having a superficial resemblance to one another. The material consisted mainly of poorly preserved alcoholic specimens, or skins badly made (in most cases with the skulls inside), and without satisfactory measurements. The characters distinguishing the species, therefore, were not apparent or were considered as being due merely to individual variation. In failing to examine skulls, both Baird and Coues referred specimens of the animal since described as

Zapus insignis to *Z. hudsonius*, though *insignis* has a different number of teeth and is now considered subgenerically distinct from the latter. Under the improved methods of collecting and preserving mammals now in vogue large series of well-prepared specimens have been brought together during the past few years, and several new forms have been described, mainly from the west and northwest.

The following revision of the genus *Zapus* is based on a study of more than 900 specimens, mainly in the collections of the Biological Survey of the U. S. Department of Agriculture, the U. S. National Museum, and several private individuals.[1] To the custodians and owners of these collections my thanks are cordially extended. For kind assistance and advice my thanks are also especially due to Dr. C. Hart Merriam, Dr. T. S. Palmer, and Mr. Gerrit S. Miller, jr. Through the courtesy of Mr. Miller I have had an opportunity of examining the types of *Zapus setchuanus* Pousargues, temporarily placed in his hands for comparison, and am thus able to present a complete account of the genus, including a description of this very interesting Asiatic species, the only one known from the Old World.

The National Museum collection of *Zapus*, though not extensive, contains many specimens of unusual interest from widely separated localities; that of the Biological Survey is especially rich in western specimens; and those of Miller and Bangs contain good series of eastern species. These collections, comprising many large suites of well-prepared skins, nearly all accompanied by perfect skulls and by measurements taken in the flesh, have afforded facilities for comparison never before enjoyed. Much additional material is needed, however, before certain questions concerning relationship and seasonal variation can be satisfactorily settled.

Distribution.—*Zapus* is a Boreal genus, and, with the exception of a single species, is confined to North America. The exact northern limits of its range are not well known, but are indicated by specimens from Hamilton Inlet, Labrador; Fort Churchill, on Hudson Bay; Fort Rae, on Great Slave Lake; and the Yukon River (probably Fort Yukon, just below the Arctic Circle). Southward it extends as far as Raleigh, N. C.; Wheeling, W. Va.; Jackson County, Mo.; Santa Fe, N. Mex.; and Kern River, California. Within the region thus roughly outlined there are probably no large areas where at least one member of the genus is not found. In regions where there is little or no woodland its distribution is more or less local, and is confined almost exclusively to the borders of streams. Of course, the arid deserts of the West do not offer a congenial environment.

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[1] These specimens are as follows: Biological Survey, 378; U. S. National Museum, 85; Merriam Collection, 60; Bangs Collection, 132; Miller Collection, 200; and a few from each of the following collections, American Museum of Natural History, New York; Academy of Natural Sciences, Philadelphia; Carnegie Museum, Pittsburg, Pa.; Field Columbian Museum, Chicago; and the collections of Samuel N. Rhoads and Charles F. Batchelder.

Very little is known of the geological history of *Zapus*, except that the genus dates back to the Postpliocene. In 1871 Prof. E. D. Cope recorded a mandibular ramus with incisor and second molar of a Jumping Mouse from the Port Kennedy Bone Cave in Pennsylvania.[1] On account of lack of recent specimens for direct comparison he was somewhat in doubt as to the specific identity of the remains, but referred them to *Jaculus* (= *Zapus*) *hudsonius*.[2]

External characters.—The external and cranial characters of *Zapus* have been so exhaustively treated by Baird, Coues, and others that a brief reference to them here will be sufficient. The body is considerably enlarged posteriorly, the hind legs and tail greatly developed, the forelegs rather short, and the ears somewhat longer than the surrounding fur. All the species agree closely in color and markings. A broad dorsal stripe of some shade of yellowish brown, quite thickly flecked with black-tipped hairs, is bordered by a slightly narrower lateral stripe of a lighter color and usually with less black. The fur of the entire upper parts is uniform plumbeous at base, only the tips of the hairs affecting the external appearance of the animal. Between the darker color of the sides and the white of the lower parts is a narrow stripe of clear yellowish orange, unmixed with black, and with the base of the hairs white. The lower parts are white, sometimes suffused with the color of the sides, and one species, *Z. setchuanus*, from China, has a well-defined brown ventral stripe. The tail is very long, usually about 60 per cent of the total length, and more or less distinctly bicolor, brownish above and whitish below. It is thinly covered with short hairs, which are longer on the terminal part and form a short pencil. In two of the three subgenera the tail is conspicuously tipped with white. The spring and early fall pelages differ noticeably, except in members of the subgenus *Napæozapus*, the bright color of the spring and early summer pelage becoming duller in the fall, and the dark dorsal area partially obliterated. In some species, however, the dorsal area is darker and more sharply defined in late summer and early fall than in spring and early summer.

The teats are normally 8, and arranged in pairs at regular intervals. The pectoral pair is situated just back of the forelegs, the inguinal pair far back at the base of the thighs, and the remaining pairs between. Sometimes the anterior or posterior pair remains undeveloped.

Habits.—In general but one species occurs in a given locality, but *Zapus hudsonius*, which has the widest range of all, seems to be always present throughout the range of the subgenus *Napæozapus*, the members of which are almost invariably found in deep woods near streams. All the other species delight in meadows, shrubby fields, and thickets along

[1] Preliminary report on the Vertebrata discovered in the Port Kennedy Bone Cave <Proc. Am. Philos. Soc., XII, p. 86, 1871.

Vertebrate Remains from Port Kennedy Bone Deposit <Journ. Acad. Nat. Sci. Phila., 2d ser., XI, p. 200, 1899.

[2] Spelled *hudsonianus* by Zittel, Handbuch der Palæontologie, IV, p. 527, 1893.

the edges of woods, and show a marked preference for moist locations. During the summer Jumping Mice are often seen in meadows and fields, and are more readily detected during the haying season than at other times, when they are driven from their hiding places while the grass is being cut. When disturbed they move off by a series of frog like leaps, and often remain motionless after a jump or two, especially when frightened from a nest. In leaping they are greatly assisted by their long tails, which aid in preserving their balance as in the case of other animals similarly endowed. If, by any accident, a portion of the tail is lost, the power of balancing is greatly impaired, and the animal, if startled, seems unable to pursue a direct course because of failure to land properly on its feet. Some of the earlier writers ascribe to the animal the power of leaping 4 or 5 yards. Such statements are probably exaggerated, but it is certain that *Zapus* does possess remarkable leaping powers, and when disturbed will jump 6 or 8 feet, and under some circumstances perhaps much farther. In their chosen haunts these mice do not follow beaten paths or runways like many small mammals, notably meadow mice, but seem to wander rather indiscriminately, availing themselves to some extent of natural pathways or open places.

The birth of the young (five or six in number) which occurs in a nest, ordinarily underground but sometimes placed in a hollow tree, usually takes place in May or June. Sometimes, however, it occurs as late as September; from which it seems probable that a second litter is raised, or that the breeding season continues throughout the summer. Three specimens obtained by my brother at Wilmington, Mass., September 25, 1897, which with their parents were turned up by a plow, were so young that the posterior upper molars had just appeared.

During the latter part of summer *Zapus* makes a globular nest of grass about 4 inches in diameter, with a small entrance at the side. All that I have seen were on the ground in meadows among thick grass or small bushes. One that I examined was made entirely of the straight narrow leaves of grass, and was a very beautiful little home; but though seemingly compact, it was so frail that it was impossible to preserve it. These nests are usually occupied by two individuals, presumably a pair, and seem to be used only at the close of the breeding season.

The hibernation of *Zapus* has been frequently noticed and several interesting articles have appeared mainly on this habit.[1] All the species, so far as known, hibernate during winter, though in one, at least, hibernation is not always complete—that is, individuals may awake and come out during warm intervals, after the manner of the common skunk. Dr. Merriam mentions having seen Jumping Mice abroad in northern New York on several occasions during the unusually mild winter of 1881–82. Messrs. H. H. and C. S. Brimley report that they have no positive evidence of the hibernation of *Zapus hudsonius americanus* at Raleigh, N. C., although they add that the animal is too rare to enable them to

[1] Davies, Trans. Linn. Soc. London, IV, p. 155, 1798; Barton, Trans. Am. Philos. Soc., VI, p. 143. 1804; Tenney, Am. Nat., VI, p. 330, 1872.

find out much about it. Hibernation varies with the locality, but usually begins about the time of the first heavy frosts and lasts until spring. The fall pelage is usually assumed and the animals become exceedingly fat before entering winter quarters. Although they often lay up stores of food in nests or burrows during summer, it is not known that they use this food during winter. The animals are generally found singly (sometimes in pairs) in nests in holes at a depth varying from a few inches to 2 or 3 feet below the surface. They lie rolled up like a ball with the feet close together and tail curled about them. If removed from the nest and subjected to a moderate degree of heat they revive and in the course of a few hours move about freely, but generally resume their lethargic state if again exposed to cold. The pulse and respiration are very slow.

Hibernation sometimes takes place in a nest above ground. Dr. A. K. Fisher tells me that some years ago a *Zapus* was brought to him at Lake George, New York, which some men at work in the woods had found hibernating in an elaborate nest of grass and moss, exposed by moving a log. This nest was destroyed, but when the animal was given material it constructed another, in which it resumed its interrupted sleep. It was occasionally awakened, and observations were taken on its weight, respiration, and heart beats, after which it would relapse into its state of lethargy.

NOMENCLATURE.

Five generic and 30 specific and subspecific names have been applied to various forms of Jumping Mice now included in the genus *Zapus*. In order to discuss the different species and subspecies intelligently it becomes necessary to separately consider each of these names, which may be taken up alphabetically.

GENERIC NAMES.

Dipus Zimmermann, Geog. Geschichte des Menschen u. vierfüssigen Thiere, II, p. 358. **1780**. The original description of the genus *Dipus* included six species: *D. jaculus*, *D. sagitta*, *Yerbua capensis* (=*Mus cafer*), *D. longipes*, *D. tamaricinus* and *D. hudsonius*. The name was subsequently restricted to the Old World jerboas.

Gerbillus Desmarest, Nouv. Dict. d'Hist. Nat., XXIV, p. 222. **1804**. A genus of Old World rodents allied to *Meriones*. Four nominal species of American Jumping Mice were referred to this genus by Rafinesque in 'Précis des Découv. somiologiques' (p. 14, 1814), and Am. Monthly Magazine (III, p. 446, Oct., 1818).

Meriones Illiger, Prod. Syst. Mamm. et Avium, p. 82, **1811**. The name was originally proposed by Illiger for a group including *Dipus tamaricinus* and *D. meridianus*. Cuvier apparently proposed it independently, twelve years later, for the American Jumping Mouse (Dents des Mamm., pp. 187, 256, 1823).

Jaculus Erxleben, Syst. Nat., p. 404, **1777**. A genus of Old World jerboas. The name was first used for North American species by Wagler (Nat. Syst. Amphibien, p. 23, 1830).

Zapus Coues, Bull. U. S. Geol. Surv. Terr., I, 2d ser., No. 5, p. 253, **1875**. The first tenable generic name based on a North American Jumping Mouse.

SPECIFIC AND SUBSPECIFIC NAMES.

Acadicus (Meriones) Dawson, Edinburgh New Philos. Journ., new series, III, p. 2, **1856**. Dawson, after unmistakably referring the animal since described as *Zapus insignis* to the *Meriones labradorius* of Richardson's Fauna Boreali-Americana (i. e., *Z. hudsonius*), goes on to describe *Z. hudsonius* from Nova Scotia, calling it provisionally *Meriones acadicus.*

Alascensis (Zapus) Merriam, Proc. Biol. Soc. Wash., XI, p. 223, July 15, **1897**. Dr. C. Hart Merriam has described a subspecies of *Z. hudsonius* under this name, from specimens collected at Yakutat Bay, Alaska.

Alleni (Zapus) Elliot, Field Columbian Mus., Pub. 27, Zool. Ser., I, No. 10, pp. 212–213, March, **1898**. Under this name Mr. D. G. Elliot described the form of *Zapus* inhabiting the Sierra Nevada in California.

Americanus (Dipus) Barton, Trans. Am. Philos. Soc., IV, No. XII, p. 115, **1799**. Under this name Benjamin Smith Barton described specimens from the vicinity of Philadelphia, Pa. Later (ibid, VI, 1804) he discussed the habit of hibernation and presented a figure of the animal. Mr. C. F. Batchelder has recently revived *americanus* for the form of *Z. hudsonius* inhabiting the Upper Austral zone in the Eastern States. (Proc. New Eng. Zool. Club. I, p. 6, 1899.)

Brachyurus (Gerbillus) 'Rafinesque.' A name referred to by Fischer (Syn. Mamm., p. 340, 1829) without reference, and included in the synonomy of *Zapus* by Coues (Mon. N. Am. Rodentia, p. 468, 1877). I have been unable to find the original reference, but the inapplicability of the name is self-evident.

Canadensis (Dipus) Davies, Trans. Linn. Soc. London, IV, p. 157, **1798**. Maj. Gen. Thomas Davies described specimens which he had procured in the vicinity of Quebec, Canada. He undoubtedly referred to an animal of the *hudsonius* type, and as specimens from that region do not deserve separation from the typical form, the name becomes a synonym of *hudsonius.*

Daviesii (Gerbillus) Rafinesque, 'Precis des Découv. somiologiques, p. 14, **1814**.' Rafinesque is said to have renamed *Dipus canadensis* after its describer.

Hardyi (Zapus) Batchelder, Proc. New. Eng. Zool. Club, I, p. 5, February 8, **1899**. Mr. C. F. Batchelder has recently applied this name to specimens from Mount Desert Island, Maine. From a careful study of the material at present accessible, I can find no characters of importance to separate this form from *hudsonius* as here restricted.

Hudsonius (**Dipus**) Zimmermann, Geog. Geschichte des Menschen u. vierfüssigen Thiere, II, p. 358, 1780. This is the first specific name proposed for any species of Jumping Mouse in America, and undoubtedly refers to the common eastern species which has so long borne the name. It is the only species thus far known to occur about Hudson Bay—the locality of Pennant's 'long-legged mouse,' to which Zimmermann referred.

Imperator (**Zapus**) Elliot, Field Columbian Mus., Pub. 30, Zool. Ser., I, No. 11, p. 228, February 1, 1899. Mr. D. G. Elliot has recently described a *Zapus* from the Olympic Mountains of Washington, but specimens from that region not being considered separable from typical *Z. trinotatus*, the name becomes a synonym.

Insignis (**Zapus**) Miller, Am. Naturalist, XXV, p. 472, August, 1891. Mr. Gerrit S. Miller, jr., described the species erroneously referred to *M. labradorius* (*Z. hudsonius*) by Dawson, from specimens collected on the Restigouche River, New Brunswick.

Labradorius (**Dipus**) Kerr, Animal Kingdom, p. 276, 1792. Based on the 'Labradore Jerboid Rat' of Pennant's History of Quadrupeds, 1781. Kerr says, "Inhabits Hudson's Bay and Labradore. This species was sent over from Hudson's Bay by Mr. Graham." Although Labrador is mentioned in the habitat of the species, the specimen came from Hudson Bay, and consequently the name should be restricted to the animal from that region, thus becoming a synonym of *hudsonius*.

Ladas (**Zapus**) Bangs, Proc. New Eng. Zool. Club, I, p. 10, February 28, 1899. Under this name Mr. Outram Bangs has described, as a subspecies, the form of *hudsonius* inhabiting the Labrador Peninsula.

Leonurus (**Gerbillus**) Rafinesque, Am. Monthly Mag., III, p. 446, October, 1818. From the description—"body fallow, ears very long, white inside, tail as long as body, black with a fallow tuft at end, length 6 inches, body 3"—the animal is plainly not referable to *Zapus*.

Longipes (**Mus**) Zimmermann, in Pennant's Arkt. Zool. I, p. 131, 1787.* Zimmermann erroneously identified a Jumping Mouse in spirits, sent from Hudson Bay by Mr. Graham, as *Mus longipes* of Pallas, an animal from the deserts about the Caspian Sea.

Macrourus (**Gerbillus**) 'Rafinesque,' a name referred to by Fischer (Syn. Mamm., p. 340, 1829), without reference, and included in the synonomy of *Zapus* by Dr. Coues (Mon. N. Am. Rodentia, p. 468, 1877). I have been unable to find the original reference.

Megalops (**Gerbillus**) Rafinesque, Am. Monthly Mag., III, p. 446, October, 1818. This animal he describes as follows: "Body gray, belly white." * * * "Total length 5 inches, body only 2. From the barrens of Kentucky." This can not apply to any species of Jumping Mouse.

Mellivorus (**Dipus**) Barton, Trans. Am. Philos. Soc., VI, p. 143, 1804.

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*Fide Coues, Mon. N. Am. Rodentia, p. 467, 1877. I have not seen this edition of Pennant.

This name occurs incidentally in the text, being applied to a supposed new species, with remarks on its reputed habit of passing the winter in beehives and living on the honey.

Microcephalus (Meriones) Harlan, Proc. Zool. Soc. London, p. 1, **1839.** Under this name Dr. Harlan described specimens from the vicinity of Philadelphia, Pa. The name, being antedated by *americanus* Barton, becomes a synonym.

Montanus (Zapus) Merriam, Proc. Biol. Soc. Wash., XI, p. 104, April 26, **1897.** Dr. C. Hart Merriam described the form inhabiting the Cascade Range in Oregon, under the name *Zapus trinotatus montanus*, but the characters seem to warrant its recognition as a full species.

Nemoralis (Meriones) Geoffroy St. Hilaire, Dict. Classique d'Hist. Nat., VII, p. 323, Fev., **1825.** Under this name Geoffroy published a careful description of two specimens (without locality), in the Museum d'Histoire Naturelle of Paris, which were figured by F. Cuvier and served as the basis of Cuvier's genus *Meriones*. There is nothing in the description of *nemoralis* that gives any clue to the specific identity of the animal.

Niger (Gerbillus) Rafinesque, Am. Monthly Mag., IV, p. 106, December, **1818.** A *nomen nudum* used by Rafinesque in an article entitled 'General Account of the Discoveries made in the Zoology of the Western States.'

Pacificus (Zapus) Merriam, Proc. Biol. Soc. Wash., XI, p. 104, April 26, **1897.** Under this name Dr. C. Hart Merriam described a form represented in the Biological Survey collection by specimens collected in upper Rogue River Valley, Oregon.

Princeps (Zapus) Allen, Bull. Am. Mus. Nat. Hist., V, pp. 71–73, April 28, **1893.** Dr. J. A. Allen described under this name a large species from Florida, La Plata County, Colo., which proves to be a very distinct form inhabiting the Rocky Mountain region of the United States.

Saltator (Zapus) Allen, Bull. Am. Mus. Nat. Hist., N. Y., XII, p. 3, March 4, **1899.** Dr. J. A. Allen has recently described under this name a well-marked form inhabiting northern British Columbia and the adjacent region.

Setchuanus (Zapus) Pousargues, Ann. Sci. Nat., 8e sér., I, No. 4, p. 220, Avril, **1896.** The only name based on the single Old World species of *Zapus*.

Soricinus (Gerbillus) Rafinesque, 'Précis des Découv. somiologiques p. 14, **1814.**' I have not seen the original reference.

Sylvaticus (Gerbillus) Rafinesque, Am. Monthly Mag., III, p. 354, September, **1818.** A *nomen nudum* used by Rafinesque in a letter addressed to "Samuel L. Mitchill, president, and the other members of the Lyceum of Natural History, * * * dated at Louisville, Falls of Ohio, 20 July, 1818."

Tenellus (Zapus) Merriam. Proc. Biol. Soc. Wash., XI, p. 103, April 26, **1897.** Under this name Dr. C. Hart Merriam has described a form from Kamloops, British Columbia.

Trinotatus (Zapus) Rhoads, Proc. Acad. Nat. Sci., Phila., 1849, p. 421 (January 15, **1895**). Under this name Mr. S. N. Rhoads described, from specimens taken on Lulu Island, near the mouth of Fraser River, a well marked form inhabiting the Pacific coast region from Fraser River, British Columbia, to Humboldt Bay, Calif.

Genus ZAPUS Coues.

Dipus Zimmermann, Geog. Geschichte d. Menschen u. vierfüssigen Thiere, II, p. 358, 1780.

Gerbillus Rafinesque, 'Précis des Découv. somiologiques, p. 14, 1814'. (Not *Gerbillus* Desmarest, 1804.)

Meriones F. Cuvier, Dents des Mamm., pp. 187, 256, 1823. (Not *Meriones* Illiger, 1811.)

Jaculus Wagler, Nat. Syst. Amphibien, p. 23, 1830. (Not *Jaculus* Erxleben, 1777.)

Zapus Coues, Bull. U. S. Geol. Surv. Terr., I, 2d ser., No. 5, p. 253, 1875.

Characters.—Skull not massive; brain case rather high and rounded; antorbital foramen large and oval; zygomata not widely spreading, broadly expanded anteriorly where the malar extends upward to the lachrymal. Teeth 16 or 18 (upper premolar present or wanting); enamel much folded; upper incisors compressed. much curved, deeply sulcate, and deep orange.

Body enlarged posteriorly; hind legs and tail greatly developed, the latter much exceeding length of head and body. Tail slender, uniformly tapering. Toes of hind foot five, each with separate metatarsal. Upper parts ochraceous; median dorsal band dark. Under parts white (often suffused with ochraceous); one species with brown ventral stripe.

KEY TO THE SUBGENERA OF ZAPUS.

Premolar present:
- Enamel folds closely crowded; tail not tipped with white; ears rather long; lower parts white or ochraceous .... *Zapus*
- Enamel folds not crowded; tail tipped with white; ears rather short; lower parts white with brown ventral stripe .... *Eozapus*

Premolar absent:
- Enamel folds closely crowded; tail tipped with white; ears rather long; lower parts white .... *Napæozapus*

LIST OF SPECIES AND SUBSPECIES, WITH TYPE LOCALITIES.

Subgenus *Zapus*.

Zapus alascensis.	Yakutat, Alaska.
alleni.	Pyramid Peak, Lake Tahoe, California.
americanus.	Philadelphia, Pennsylvania.
campestris nob.	Bear Lodge Mountains, Wyoming.
hudsonius.	Hudson Bay.
ladas.	Rigoulette, Hamilton Inlet, Labrador.
major nob.	Warner Mountains, Oregon.
minor nob.	Wingard, Saskatchewan.
montanus.	Crater Lake, Mount Mazama, Oregon.
nevadensis nob.	Ruby Mountains, Nevada.
orarius nob.	Point Reyes, California.
oregonus nob.	Elgin, Oregon.
pacificus.	Prospect, Rogue River Valley, Oregon.
princeps.	Florida, La Plata County, Colorado.
saltator.	Telegraph Creek, Northwest Territory.
tenellus.	Kamloops, British Columbia.
trinotatus.	Lulu Island (mouth Fraser River), British Columbia.

Subgenus *Napaeozapus.*

abietorum nob.	Peninsula Harbor, Ontario.
insignis.	Restigouche River, New Brunswick.
roanensis nob.	Magnetic City, Roan Mountain, North Carolina.

Subgenus *Eozapus.*

setchuanus.	Ta-tsien-lou, Szechuen, China.

Subgenus ZAPUS Coues.

Type Zapus hudsonius (Zimmermann), from Hudson Bay.

Subgeneric characters.—Teeth: *i.* $\frac{1-1}{1-1}$, *p.* $\frac{1-1}{0-0}$, *m.* $\frac{3-3}{3-3}=18$. Upper premolar very small, nearly cylindrical; anterior upper molar large, broadly oval; *m* 2 similar, but noticeably smaller; *m* 3 considerably smaller and nearly circular. Lower molars similar in shape and relative size (fig. 1). Enamel folds closely crowded. Interorbital constriction of medium width; frontal region moderately swollen; brain case rather high; rostrum slender and somewhat attenuated.

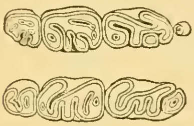

FIG. 1.—Molar teeth of *Zapus hudsonius* from Tower, Minnesota (No. 72695, U. S. Nat. Mus.) × 6.

Upper parts as in entire genus; lower parts white, sometimes suffused with color of sides; tail more or less distinctly bicolor, normally without white tip.

KEY TO SPECIES OF THE SUBGENUS ZAPUS.

Lower parts much suffused with color of sides .... *orarius.*
Lower parts not much suffused with color of sides.
  Size, large; hind foot usually more than 32 mm.
    Ears never conspicuously bordered with whitish.
      Larger; pencil of tail never normally white; lower parts often suffused with ochraceous .... *trinotatus.*
      Smaller; pencil of tail usually white; lower parts never suffused with ochraceous .... *alleni.*
    Ears usually conspicuously bordered with whitish.
      Sides light ochraceous buff .... *nevadensis.*
      Sides not light ochraceous buff.
        Skull narrow; incisive foramina very large .... *saltator.*
        Skull broad; incisive foramina not very large.
          Hind foot about 35 mm .... *major.*
          Hind foot about 32 to 34 mm.
            Incisive foramina broad posteriorly .... *oregonus.*
            Incisive foramina narrow posteriorly .... *princeps.*
  Size medium or small; hind foot usually below 32 mm.
    Size medium; hind foot 30 to 32 mm.; total length of adults more than 215 mm.
      Skull rather heavy; brain case broad; incisive foramina rather large.
        Dorsal area not very distinct .... *pacificus.*
        Dorsal area distinct.
          Rostrum considerably deflected .... *minor.*
          Rostrum not much deflected .... *montanus.*

Skull rather light: brain case narrow; incisive foramina small.
Coloration dark and dull.
Larger; basilar length of skull usually more than 18 mm. *alascensis.*
Smaller; basilar length of skull usually under 17.5 mm.. *tenellus.*
Coloration not dark and dull.
Dorsal area very much flecked with color of sides; fall pelage with dorsal area nearly black .... *campestris.*
Dorsal area not much flecked with color of sides; fall pelage with dorsal area not very dark.
Larger; hind foot about 32 mm.; tail usually more than 140 mm..... .... *ladas.*
Smaller; hind foot usually 30 or 31 mm.; tail usually below 135 mm .... *hudsonius.*
Size small; hind foot usually below 30 mm.; total length of adults usually under 215 mm... *americanus.*

ZAPUS HUDSONIUS (Zimmermann). Hudson Bay Jumping Mouse.

(Pl. I, figs. 3, 3a.)

1780. *Dipus hudsonius* Zimmermann, Geog. Geschichte d. Menschen u. vierfüssigen Thiere, II, p 358.
1792. *Dipus labradorius* Kerr, Animal Kingdom, p. 276 (based on the 'Labradore Jerboid Rat of Pennant').[1]
1798. *Dipus canadensis* Davies, Trans. Linn. Soc. London, IV, p. 157.
1822. *Gerbillus canadensis* Desmarest, Mammalogie, II, p. 321.
1825. *Gerbillus labradorius* Harlan, Fauna Am., p. 157 (in part).
1829. *Meriones labradorius* Richardson, Fauna Boreali-Americana, I. p. 144. (Not *M. labradorius* Dawson, 1856.)
1830. *Jaculus americanus* Wagler, Nat. Syst. Amphibien, p. 23.
1839. *Meriones microcephalus* Harlan, Proc. Zool. Soc. London, 1839, p. 1.
1843. *Jaculus labradorius* Wagner, Suppl. Schreber's Säugthiere, III, p. 294.
1856. *Meriones acadicus* Dawson, Edinburgh New Philos. Journ., new ser., III, p. 2.
1857. *Jaculus hudsonius* Baird, Mamm. N. Am., p. 430 (in part).
1875. *Zapus hudsonius* Coues, Bull. U. S. Geol. Surv. Terr., 2d Ser., No. 5, p. 253; Mon. N. Am. Rodentia, p. 467, 1877 (in part), and recent authors (in part).
1899. *Zapus hudsonius canadensis* Batchelder, Proc. New Eng. Zool. Club, I, p. 4.
1899. *Zapus hudsonius hardyi* Batchelder, Proc. New Eng. Zool. Club, I, p. 5. (Mount Desert Island, Maine.)

Type locality.—Hudson Bay.

Geographic distribution.—As restricted in the present paper, this species is found from the southern shores of Hudson Bay south to New Jersey, and in the mountains to North Carolina, west to Iowa and Missouri, and northwest to Alaska. It intergrades with *Z. americanus* in the upper part of the Carolinian zone in the Eastern States; with *campestris* along the edge of the Great Plains, and probably with *alascensis* somewhere in northern British America.

General characters.—Size medium, smaller than *Z. insignis*, *Z. trinotatus*, or *Z. princeps*. Skull less massive, with small molars and incisive foramina.

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[1] "Inhabits Hudson's Bay and Labradore. This species was sent over from Hudson's Bay by Mr. Graham."—Kerr.

Color.—Summer pelage: Fur of entire upper parts plumbeous at base, with tips of hairs ranging from yellowish fawn to rather dark ochraceous, rather thickly flecked with black-tipped hairs; broad dorsal stripe reaching from upper part of face to base of tail much darker than remainder of upper parts, the black-tipped hairs predominating; tail rather sharply bicolor, grayish brown above and whitish beneath; lower parts white, sometimes suffused with color of sides; feet white. *Fall pelage:* Ochraceous of sides duller and more yellowish, encroaching more on the dark dorsal area, which is sometimes almost obliterated. *Young* of the year with more ochraceous in fall pelage than the adults, and a greater tendency to fulvous wash on lower parts.

Cranial characters.—Skull rather lightly built, with rather narrow brain case, small incisive foramina, and small molars; zygomata not widely spreading; rostrum not appreciably deflected.

Measurements.—Two specimens from James Bay, Canada, measured from alcohol, average: Total length, 209; tail vertebræ, 124; hind foot, 30.5. Eleven from Tower, Minn., average: Total length, 218; tail vertebræ, 133; hind foot, 30.2. Thirty-four adults from Keene Valley, Essex County, N. Y., average:[1] Total length, 216.6; tail vertebræ, 129.25; hind foot, 31.25. *Skull:* An adult skull from James Bay measures: Basilar length, 18.5; zygomatic breadth, 11; mastoid breadth, 10; interorbital constriction, 4.2; incisor to postpalatal notch, 8.5; foramen magnum to postpalatal notch, 8; fronto-palatal depth at middle of molar series, 6.5. An adult ♀ from Ossipee, N. H., measures: Basilar length, 18.8; zygomatic breadth, 11.6; mastoid breadth, 10; interorbital constriction, 4.3; incisor to postpalatal notch, 8.6; foramen magnum to postpalatal notch, 8.2; fronto-palatal depth at middle of molar series, 6.2.

General remarks.—Zapus hudsonius, the type of the genus, was until recently the only well established species. The foregoing list of synonyms indicates that it attracted the attention of many naturalists during the early part of the century, all the names published previous to 1856 referring almost exclusively to it. *Jaculus hudsonius* of Baird (=*Zapus hudsonius* Coues) is a composite species including nearly a dozen forms now recognized as distinct. The distribution of *hudsonius*, including its four well-marked subspecies, is by far the most extensive in the genus, few North American rodents equaling it in this respect.

The only specimens of *Zapus* from Hudson Bay at present available are four alcoholic examples, in rather poor condition, from James Bay, and a part of a skin from Fort Churchill, Northwest Territory. This skin has evidently been in alcohol, and hence its color can not be depended upon. I have removed several skulls from the James Bay specimens, including one perfect adult. Since this skull agrees essentially with skulls from Tower, Minn., from which place the Biological Survey has a large series, these specimens have been assumed to be

[1] Fide Batchelder.

fairly typical and have been used for comparison in most instances. It is quite possible, however, that a series of skins from Hudson Bay would measure slightly more than the Minnesota specimens, and would perhaps differ in color. While this material, taken in connection with what is available from the type locality is sufficient for comparison with the subspecies here recognized, it will not permit the recognition of other nominal forms which may eventually prove to be well founded. A skull from Saint Catharines, Ontario, however, which may be considered a topotype of *canadensis*, is identical in appearance with one from James Bay.

Specimens examined.—Total number, 319, from the following localities:

Northwest Territory: James Bay, 4; Fort Churchill, 1; Fort Rae, 1; Fort Resolution, 1.
Ontario: Nepigon, 7; North Bay, 6; Mount Forest, 3; Michipicoten, 1; Saint Catharines, 6.
New Brunswick: Oak Bay, 30.
Nova Scotia: Halifax, 6; James River, 2; Digby, 4.
Maine: Walker Pond, 4; Mount Desert Island, 4.
New Hampshire: Ossipee, 1; Fabyans, 1.
Vermont: Brandon, 1; Mount Mansfield, 1; St. Johnsbury, 2.
Massachusetts: Wareham, 70; North Truro, 6; Middleboro, 2; Wilmington, 3; Lunenburg, 2; Belmont, 2; Ipswich, 1; Concord, 4; Lexington, 1; Dighton, 1; Wellesley, 1; Barnstable Neck, 5.
Connecticut: East Hartford, 1 (not typical); Wethersfield, 2 (not typical).
New York: Peterboro, 39; Catskills, 8; Elizabethtown, 2; Waterville, 1; Patten Mills, 1; Locust Grove, 7; Lake George, 5.
New Jersey: Lake Hopatcong, 5.
Pennsylvania: Leasuresville, 3.
Maryland: Cumberland, 1; Finzel, Garrett County (6 miles north of Frostburg), 1.
West Virginia: Wheeling, 1.
North Carolina: Roan Mountain, 1; Magnetic City, 1.
Ohio: Portland Station, 1.
Indiana: Terre Haute, 1.
Wisconsin: Racine, 1.
Michigan: Seney, 1.
Minnesota: Lac qui Parle, 1; Elk River, 25; Tower, 26.

ZAPUS HUDSONIUS LADAS Bangs. Labrador Jumping Mouse.

Zapus hudsonius ladas Bangs, Proc. New Eng. Zool. Club, I, p. 10, Feb. 28, 1899.

Type locality.—Rigoulette, Hamilton Inlet, Labrador.

Geographic distribution.—Eastern Quebec north to Hamilton Inlet, Labrador; limits of range unknown.

General characters.—Larger than typical *Zapus hudsonius* with longer tail and hind foot; coloration darker; differing also in cranial characters.

Color.—*Summer pelage:* Sides rather dark, bright ochraceous buff, moderately lined with blackish-tipped hairs; dorsal area usually less distinct than in typical *hudsonius*, much flecked with ochraceous. Lower parts white, usually more or less suffused with color of sides.

Tail quite sharply bicolored, dusky above and whitish beneath; ears usually edged with ochraceous (whitish in *hudsonius*). Feet white. *Fall pelage:* Dorsal area usually even less distinct than in summer, with the general tinge of entire upper parts yellowish instead of ochraceous.

Cranial characters.—Skull longer than that of typical *hudsonius;* zygomata considerably longer; zygomatic breadth about the same as in largest skulls of *hudsonius;* interorbital constriction slightly wider; brain case higher and averaging slightly longer; rostrum and nasals longer; bullæ considerably larger; molar series averaging slightly longer.

Measurements.—Type No. 4169 ♀ ad., collection of E. A. and O. Bangs: Total length, 238; tail vertebræ, 153; hind foot, 32. Average of five adults from Black Bay, Labrador: Total length, 228; tail vertebræ, 142; hind foot, 32. *Skull:* Average of four adults from Black Bay, Labrador: Basilar length, 18.8; zygomatic breadth, 11.4; mastoid breadth, 10.2; interorbital constriction, 4.5; incisor to postpalatal notch, 8.9; foramen magnum to postpalatal notch, 8.5; fronto-palatal depth at middle of molar series, 6.3.

General remarks.—*Zapus h. ladas* is a fairly well-marked subspecies represented by 23 specimens in the collection of E. A. and O. Bangs, and 5 in the Biological Survey collection. The best characters separating this form from typical *hudsonius*, as here restricted, are the longer tail, larger hind foot, and longer skull, with larger audital bullæ. This latter character is very evident, even in young skulls.

Specimens examined.—Total number, 28, from the following localities:

Labrador: Hamilton Inlet (type locality), 3; Black Bay, 20.
Quebec: Godbout, 5.

ZAPUS HUDSONIUS ALASCENSIS Merriam. Alaska Jumping Mouse.

Zapus hudsonius alascensis Merriam, Proc. Biol. Soc. Wash., XI, p. 223, 1897.

Type locality.—Yakutat, Alaska.

Geographic distribution.—Yakutat Bay, north to Yukon River; limits of range unknown.

General characters.—Similar to *Zapus hudsonius*, but slightly larger and darker.

Color.—Sides dull, dark ochraceous, with many black-tipped hairs; dorsal area quite distinct, but thickly flecked with brownish; beneath pure white; tail rather sharply bicolor.

Cranial characters.—Skull similar to that of typical *hudsonius*, but slightly longer and narrower; zygomata less bowed outward and slightly longer; brain case narrower; molar series longer; crown of last lower molar longer.

Measurements.—Average of four specimens from type locality: Total length, 218; tail vertebræ, 132; hind foot, 31.5. *Skull:* Average of two adults from type locality: Basilar length, 18.2; zygomatic breadth, 10.7; mastoid breadth, 10.2; interorbital constriction, 4.2; incisor to postpalatal notch, 8.5; foramen magnum to postpalatal notch, 8; fronto-palatal depth at middle of molar series, 6.2.

General remarks.—*Zapus h. alascensis* is a fairly well-marked subspecies based on four specimens collected at Yakutat Bay, Alaska. Four additional specimens in the National Museum from Alaska have been examined, but are in such poor condition as to furnish no additional characters. This form undoubtedly intergrades with true *hudsonius* somewhere in northern British America.

Specimens examined.—Total number, 8, from the following localities:

Alaska: Nushagak, 2; Yakutat Bay, 4; Yukon River, 2.

ZAPUS HUDSONIUS AMERICANUS (Barton). Carolinian Jumping Mouse.

Dipus americanus Barton, Trans. Am. Philos. Soc., IV, No. XII, p. 115, 1799.
Zapus hudsonius americanus Batchelder, Proc. New Eng. Zool. Club, I, p. 6, 1899.

Type locality.—Philadelphia, Pa.

Geographic distribution.—From vicinity of Raleigh, N. C., north through Upper Austral zone along coastal plain to southern Connecticut and lower Hudson Valley, intergrading in upper edge of its range with *Z. hudsonius.*

General characters.—Similar to *Zapus hudsonius*, but smaller; dorsal area less distinct; skull and teeth smaller.

Color.—Description of specimens in summer pelage from Raleigh, N. C.: Entire upper parts deep dull ochraceous, the dorsal area very indistinct and but slightly mixed with black-tipped hairs; sides of head much lighter than remainder of upper parts; ears very dark, nearly black; under parts whitish, suffused with ochraceous. In the fall the dorsal area is indistinct and very thickly flecked with yellowish-tipped hairs; sides dull yellowish.

Cranial characters.—Skull considerably smaller than in *Z. hudsonius*, with zygomata more arched and brain case shorter; incisive foramina shorter and relatively broader; interorbital breadth about the same; rostrum relatively deeper and shorter; molar series shorter.

Measurements.—Average of 7 adults from Raleigh, N. C.: Total length, 191.3; tail vertebræ, 115.4; hind foot, 28.3.[1] Two from Washington, D. C., average: Total length, 198.5; tail vertebræ, 117.5; hind foot, 28. *Skull*: Average of two from Raleigh, N. C.: Basilar length, 17; zygomatic breadth, 10.3; mastoid breadth, 9.2; interorbital constriction, 3.9; incisor to postpalatal notch, 8.2; foramen magnum to postpalatal notch, 7.5; fronto-palatal depth at middle of molar series, 6.

General remarks.—It is unfortunate that the name *americanus* must be adopted for this subspecies, since it was based on specimens clearly intermediate between the extremes of this form and true *hudsonius.*

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[1] Fide Batchelder.

Specimens examined.—Total number, 54, from the following localities:

New York: Long Island, 3; Montauk Point, 8; Raynor Beach, 1; Roslyn, 3; Sing Sing (not typical), 1.
New Jersey: Chatham, 1; Englewood, 1; Mount Holly, 2; 'New Jersey', 1; Phillipsburg, 1.
Pennsylvania: Chester County, 1; Culver Lake, 2; Delaware County, 2; Marple (Delaware County), 1; Schuylkill, 1; Tinicum (Delaware County), 1; Upper Darby, 1.
Maryland: Kensington, 1; Laurel, 4; Prince George County, 5; Sandy Spring, 1.
District of Columbia: Washington, 2.
Virginia: Accotink, 1; Falls Church, 1.
North Carolina: Raleigh, 7; Weaverville, 1.

ZAPUS HUDSONIUS CAMPESTRIS subsp. nov. Prairie Jumping Mouse.

Type from Bear Lodge Mountains, Wyoming, No. 65872, ♂ ad., U. S. Nat. Museum, Biological Survey Coll. Collected June 12, 1894, by B. H. Dutcher. Original No. 600.

Geographic distribution.—Great Plains from Manitoba southward to Nebraska and westward to Colorado and Wyoming.

General characters.—Similar to *Z. hudsonius*, but slightly larger and brighter in color; differing also in cranial characters.

Color.—*Summer pelage:* Sides bright ochraceous-buff, similar to brightest specimens of *hudsonius* from Eastern States, moderately lined with black-tipped hairs; dorsal area distinct, strongly suffused with color of sides; tail yellowish white below, dark grayish above. *Fall pelage:* Sides dull yellowish instead of ochraceous; dorsal area nearly black, very slightly flecked with yellowish-tipped hairs; dorsal surface of tail much darker than in summer; ears darker, conspicuously bordered with whitish.

Cranial characters.—Skull slightly larger than in *Z. hudsonius.* Skulls from the type locality, compared with those of *Z. hudsonius* from Tower, Minn., agree in interorbital breadth; brain case about as wide but higher; incisive foramina slightly larger; process on lower border of maxillary portion of zygoma more pronounced; viewed in profile, the cranium is more evenly curved.

Measurements.—Average of 4 adults from type locality: Total length, 222; tail vertebræ, 135; hind foot, 30.5. *Skull:* Average of 4 adult skulls from type locality: Basilar length, 18.7; zygomatic breadth, 11.4; mastoid breadth, 10.4; interorbital constriction, 4.2; incisor to postpalatal notch, 8.9; foramen magnum to postpalatal notch, 7.9; frontopalatal depth at middle of molar series, 6.3.

General remarks.—The present well-marked form replaces *Z. hudsonius* over the northern and more elevated portions of the plains west of Minnesota and Iowa to the base of the Rocky Mountains. The characters of this form remain remarkably constant throughout its known range. While no good intergrades have been examined, it doubtless does intergrade with true *hudsonius* in western Minnesota. The difference between summer and early fall pelage is very great, apparently greater than in any other species.

Specimens examined.—Total number, 35, from the following localities:

Manitoba: Carberry, 2; Portage la Prairie, 1; Red River settlement, 4; Selkirk settlement, 1.
North Dakota: Devils Lake, 1; Fort Sisseton, 1; Fort Wadsworth, 1; Pembina, 2.
Montana: Little Big Horn River, 1.
South Dakota: Custer, 4.
Wyoming: Bear Lodge Mountains (type locality), 6; Cheyenne, 1; Devils Tower, 1; Sherman, 1; Sundance, 1
Nebraska: Columbus, 1.
Colorado: Loveland, 5.
Missouri: Jackson County, 1.

ZAPUS TENELLUS Merriam. Kamloops Jumping Mouse.

Zapus tenellus Merriam, Proc. Biol. Soc. Wash., XI, p. 103, April 26, 1897.

Type locality.—Kamloops, British Columbia.

Geographic distribution.—Known only from vicinity of type locality.

General characters.—Size rather small; ears rather large; coloration dark.

Color.—*Early fall pelage:* Somewhat similar to *Zapus hudsonius* in corresponding pelage but much darker; sides olive yellowish, heavily intermixed with black-tipped hairs; dorsal area somewhat as in *hudsonius*, but not well defined, contrasting less with sides; tail sharply bicolor, darker above and at tip than in *hudsonius;* nose, ears, and outer sides of thigh and forearm dusky, much darker than in *hudsonius;* fore and hind feet soiled whitish.

Cranial characters.—Skull similar to that of *Zapus hudsonius*, but less swollen in frontal region; border of ascending portion of jugal straighter; cranium more arched.

Measurements.—Average of four specimens from type locality: Total length, 208; tail vertebræ, 128; hind foot, 30.5. *Skull:* Average of 3 skulls from type locality: Basilar length, 16.5; zygomatic breadth, 10.6; mastoid breadth, 9.6; interorbital constriction, 4.2; incisor to postpalatal notch, 7.6; foramen magnum to postpalatal notch, 6.9; frontopalatal depth at middle of molar series, 5.7.

General remarks.—*Zapus tenellus* is a well-marked form requiring comparison only with *Z. hudsonius* and its subspecies *alascensis*. In color it resembles *alascensis*, but in cranial characters it departs from *hudsonius* in another direction. There is a possibility that it may be found to intergrade with one of them to the northward, but until such intergradation is proved, it seems best to allow it full specific rank.

Specimens examined.—Total number, 7. from the following localities:

British Columbia: Ducks, 2; Kamloops, 5.

ZAPUS PRINCEPS Allen. Rocky Mountain Jumping Mouse.

(Pl. I, figs. 6, 6*a*.)

Zapus princeps J. A. Allen, Bull. Am. Mus. Nat. Hist., N. Y., V, p. 71, April 28, 1893.

Type locality.—Florida, La Plata County, Colo.

Geographic distribution.—Rocky Mountain region from northern New Mexico northward to Henry House, Alberta.

General characters.—Size large; skull broad and heavy, much as in *Z. hudsonius*, but much larger.

Color.—*Summer pelage:* "Above with the middle of the dorsal region pale yellowish brown, profusely mixed with blackish, so that sometimes the blackish color, sometimes the pale yellowish brown, predominates; sides of the body, forming a band on either side about equal to the dark dorsal area, yellowish brown, slightly mixed with blackish, except over a narrow lateral line, adjoining the white of lower parts, which is a clear, strong yellowish brown; lower parts white to the base of the hairs, varying in some specimens to strong ochraceous; tail indistinctly bicolor—grayish white below and pale brown above, and very thinly haired; hind feet grayish white above like the lower surface of the tail; ears narrowly edged with yellowish white."[1] In *fall pelage* adults have the dorsal area with more black and sides more yellowish than in summer; under parts pure white; immature in same pelage similar, but with dorsal area more suffused with yellowish; under parts some what suffused with color of sides.

Cranial characters.—Skull large and heavy, with rather heavy dentition. In some specimens the premolar is very small, occasionally being flattened against the adjacent tooth and scarcely functional. Immature skull short and broad, with large brain case. The incisive foramina in this and closely related species much larger than in those more nearly related to *Z. hudsonius*.

Measurements.—Average of 7 specimens from Fort Garland, Colo.: Total length, 245; tail vertebræ, 147; hind foot, 32. Average of 4 from La Barge Creek, Wyo.: Total length, 239; tail vertebræ, 150; hind foot, 32. Average of 6 from St. Mary Lake, Mont.: Total length, 232; tail vertebræ, 139; hind foot, 32. *Skull:* Average of 2 adult skulls from Fort Garland, Colo.: Basilar length, 20.7; zygomatic breadth, 12.5; mastoid breadth, 11; interorbital constriction, 4.5; incisor to postpalatal notch, 9.8; foramen magnum to postpalatal notch, 8.8; fronto-palatal depth at middle of molar series, 6.6. One from Preuss Mountains, Idaho: Basilar length, 20.5; zygomatic breadth, 13.2; mastoid breadth, 11; interorbital constriction, 4.8; incisor to postpalatal notch, 9.8; foramen magnum to postpalatal notch, 8.8; fronto-palatal depth at middle of molar series, 6.5.

General remarks.—*Zapus princeps* is one of the largest species of the genus and has the widest range of any except *Z. hudsonius*. It is mostly confined to mountains, though northward its range extends

[1] From original description in Bull. Am. Mus. Nat. Hist., N. Y., V, p. 71, 1893.

over the plains of Assiniboia and Saskatchewan, where it grades into the form here described as subspecies *minor*.

Specimens examined.—Total number, 101, from the following localities:

Alberta: Crow Nest Pass (Rocky Mountains near forty-ninth parallel), 1; Henry House, 2; 15 miles south of Henry House, 3.
British Columbia: Field, 3; Glacier, 1.
Montana: Bear Paw Mountains, 6; Big Snowy Mountains, 12; Blackfoot Agency, 2; Fort Ellis, 1; Paola, 1; Pryor Mountains, 1; St. Marys Lake, 13; Summit, 5; Upper Stillwater Lake, 2.
Idaho: Preuss Mountains, 8; Salmon River Mountains, 5.
Wyoming: Clark Fork, 1; La Barge Creek, 11; Yellowstone Lake, 1.
Colorado: Cochetope Pass, 1; Florida (type locality), 5; Fort Garland, 10; Gold Hill, 2; Rocky Mountains (39°), 1.
New Mexico: Camp Burgwyn, 2; Santa Fe, 1.

ZAPUS PRINCEPS MINOR subsp. nov., Saskatchewan Jumping Mouse.

Type from Wingard, near Carlton House, Saskatchewan, No. 73673, ♀ ad., U. S. Nat. Museum, Biological Survey Coll. Collected July 23, 1895, by J. Alden Loring. Original No. 3123.

Geographic distribution.—Plains of Saskatchewan; limits of range unknown.

General characters.—Similar to *Zapus princeps*, but smaller and differing in color and cranial characters.

Color.—*Summer pelage:* Similar to *Z. princeps*, but dorsal area darker; lower parts suffused with salmon. *Fall pelage* with dorsal area thickly flecked with yellowish and sides yellowish olive; lower parts much as in summer.

Cranial characters.—Skulls of the present form from Osler and Wingard, Saskatchewan, compared with those of *Z. princeps* from Colorado, differ as follows: Smaller; rostrum shorter and more deflected; nasals much narrower anteriorly; brain case relatively higher; interpterygoid fossa shallower.

Measurements.—Average of 10 specimens from Osler, Saskatchewan: Total length, 219; tail vertebræ, 131; hind foot, 29.9. Average of 2 from type locality: Total length, 220; tail vertebræ, 131.5; hind foot, 28. *Skull*: Average of 3 skulls from Osler, Saskatchewan: Basilar length, 18.7; zygomatic breadth, 12.2; mastoid breadth, 10.7; interorbital constriction, 4.4; incisor to postpalatal notch, 9; foramen magnum to postpalatal notch, 8.3; fronto-palatal depth at middle of molar series, 6.7.

General remarks.—*Z. minor* is a well-marked subspecies requiring comparison only with *Z. princeps*. It is evidently the northern plains representative of that species, probably intergrading with it in Assiniboia and eastern Alberta near the United States boundary and along the eastern base of the Canadian Rockies. Lack of specimens from this region makes it impossible to conclusively settle this point.

Specimens examined.—Total number, 21, from the following localities:

Saskatchewan: Osler, 15; Wingard (type locality), 3.
Assiniboia: Indian Head, 3.

ZAPUS PRINCEPS OREGONUS subsp. nov. Blue Mountains Jumping Mouse.

Type from Elgin, Blue Mountains, Oregon, No. 78156, ♂ ad., U. S. Nat. Museum, Biological Survey Coll. Collected May 29, 1896, by Edward A. Preble. Original No. 959.

Geographic distribution.—Blue Mountains of Oregon.

General characters.—Similar to *Zapus princeps*, but differing in color and in cranial characters.

Color.—*Early summer pelage:* Very similar to *Z. princeps*, but slightly lighter on sides, especially anteriorly: dorsal area and head more finely flecked with color of sides, the head especially presenting a grayish appearance; beneath pure white; whitish edging of ears very indistinct.

Cranial characters.—Compared with *Z. princeps* from Colorado, the skull of the present form differs as follows: Brain case more rounded, especially shorter and more rounded behind; zygomata shorter; incisive foramina larger and very much broader behind; audital bullæ slightly smaller.

Measurements.—Type: Total length, 250; tail vertebræ, 154; hind foot, 33. Average of 3 adults from Strawberry Butte, Oregon: Total length, 243; tail vertebræ, 146; hind foot, 32. *Skull:* Average of 3 adult skulls from type locality: Basilar length, 20.1; zygomatic breadth, 12.9; mastoid breadth, 11; interorbital constriction, 4.4; incisor to postpalatal notch, 9.7; foramen magnum to postpalatal notch, 8.5; frontopalatal depth at middle of molar series, 6.5.

General remarks.—The present form seems to replace *Z. princeps* throughout the Blue Mountains region of northeastern Oregon. Specimens from this region agree very constantly with each other and differ from typical *Z. princeps* as above indicated. It is much larger than and not at all closely related to *Z. montanus*, its relative on the west. A specimen from Mountain City, Nev., in the Brunneau Mountains, though differing in many details, is doubtfully referred to this form. Externally it differs considerably from *Z. oregonus* and agrees with *Z. nevadensis*, from the Ruby Mountains, Nev., though the skull shows that it is not closely related to that form. The skull of the Mountain City specimen also differs somewhat from that of typical *Z. oregonus*, and additional material will doubtless show it to represent a form which merits separation.

Specimens examined.—Total number, 9, from the following localities:

Oregon: Elgin, 3; Harney (10 miles north), 2; Strawberry Butte, 3.
Nevada: Mountain City (not typical), 1.

ZAPUS MAJOR sp. nov. Warner Mountain Jumping Mouse.

Type from Warner Mountains, Oregon, No. 79983, ♀ ad., U. S. Nat. Museum, Biological Survey Coll. Collected August 4, 1896, by C. Hart Merriam and Vernon Bailey. Original No. 5720.

Geographic distribution.—Known only from the type locality.

General characters.—Similar externally to *Zapus princeps*, but larger; skull closely resembling that of *Z. trinotatus*.

Color.—Type in summer pelage: Sides ochraceous-buff, moderately lined with black-tipped hairs; back slightly darker, thickly flecked with black; tail not sharply bicolored; beneath, dull white; feet soiled white.

Cranial characters.—Skull massive; brain case high and broad; zygomata rather short; palate broad and long; interpterygoid fossa broad and shallow, with bordering edge of palate much excavated. Maxillary portion of zygomata heavy and nearly perpendicular to main axis of skull; incisive foramina large and elliptical. The skull of *Z. major* differs from those of *Z. trinotatus* taken near type locality and from northern Washington, as follows: Rostrum larger and nasals broader; brain case higher; ascending portion of jugal steeper.

Measurements.—Type: Total length, 255; tail vertebræ, 155; hind foot, 35. *Skull* (type): Basilar length, 20.4; zygomatic breadth, 13; mastoid breadth, 11.2; interorbital constriction, 4.7; incisor to postpalatal notch, 10; foramen magnum to postpalatal notch, 8.6; frontopalatal depth at middle of molar series, 6.5.

General remarks.—The present form is based on a single adult specimen from the Warner Mountains, in southern Oregon. The skull bears some resemblance, especially in the form of the brain case, to those of *Z. trinotatus* and its subspecies *alleni*. It is apparently shut off by natural barriers from all of the forms surrounding it, with the possible exception of *Z. montanus*, and has no close affinities with them. From *Z. montanus* it differs to such an extent that intergradation is out of the question.

Specimens examined.—The type.

ZAPUS NEVADENSIS sp. nov. Nevada Jumping Mouse.

Type from Ruby Mountains, Nevada, No. 94185, ♀ ad., U. S. Nat. Museum, Biological Survey Coll. Collected June 21, 1898, by Vernon Bailey. Original No. 6581.

Geographic distribution.—Known only from type locality.

General characters.—Size rather large; color light; molar series long and rather narrow.

Color.—Dorsal area about as in *Z. princeps*, pale yellowish-brown, profusely mixed with black-tipped hairs; sides light ochraceous-buff, becoming almost white on cheeks, moderately lined with black-tipped hairs, the basal portion of fur cinereous, noticeably lighter in color than in *Z. princeps*, with a few white hairs intermixed; beneath, pure white.

Cranial characters.—The skull of the type and only known specimen is large, but rather lightly built. Compared with skulls of *Z. princeps* from Colorado it is smaller and flatter; brain case shorter and more rounded; incisive foramina small and elliptical; bullæ smaller; molars rather narrow, but molar series long; zygomata short and not broadly spreading. Compared with skulls of *Z. trinotatus alleni* from the Sierra Nevada, Calif., it differs as follows: Smaller, but with molar series longer; incisive foramina smaller and narrower posteriorly; zygomata shorter and less spreading; brain case flatter; rostrum shorter. Compared with the skull of the specimen from Mountain City, Nev., doubtfully referred to *Z. oregonus*, the type differs as follows: Slightly smaller and younger; zygomata shorter and zygomatic breadth slightly less; shape of brain case not strikingly different; molar series decidedly longer; incisive foramina very much smaller and narrower posteriorly; postpalatal notch indenting palate farther, nearly to middle of posterior molars; bullæ slightly smaller. Mandible slighter, but lower molar series longer.

Measurements.—Type: Total length, 242; tail vertebræ, 150; hind foot, 33. *Skull* (type): Basilar length, 19.4; zygomatic breadth, 12; mastoid breadth, 11; interorbital constriction, 4.6; incisor to postpalatal notch, 9.5; foramen magnum to postpalatal notch, 8; fronto-palatal depth at middle of molar series, 6.

General remarks.—The present form is based on a single adult specimen collected in the Ruby Mountains in east-central Nevada. It does not seem to be closely related to any of the forms whose ranges partially surround its habitat. While it is probably most nearly related to *Z. princeps*, it seems to differ enough to warrant specific separation.

Specimens examined.—The type.

ZAPUS TRINOTATUS Rhoads. Northwest Jumping Mouse.

(Pl. I, figs. 5, 5a.)

Zapus trinotatus Rhoads, Proc. Acad. Nat. Sci. Phila., 1894, p. 421, Jan. 15, 1895.
Zapus imperator Elliot, Field Columbian Mus., Pub. 30, Zool. Ser., I, No. 11, p. 228, Feb. 1, 1899; ibid, No. 13, pp. 260–261, 1 fig. in text, March, 1899. (Type from Sieg's ranch, Elwah River, Clallam County, Wash.)

Type locality.—Lulu Island, mouth of Fraser River, British Columbia.

Geographic distribution.—Coast region of southern British Columbia, Washington (including Cascades), Oregon (west of western base of Cascades), and northern California, south to Humboldt Bay.

General characters.—Size large; color bright; skull large and broad.

Color.—*Summer pelage:* Sides dark ochraceous-buff, rather heavily lined with black-tipped hairs; dorsal area very distinct, moderately flecked with color of sides; beneath white, frequently suffused or blotched with fulvous, especially in young; outer surface of forearm and legs dusky; tail quite strongly bicolored, in dried skins dusky brown above and yellowish-white below. In *early fall pelage* the sides are dull yellowish instead of ochraceous; dorsal area duller than in summer, much more thickly flecked with yellowish hairs. In immature individuals the dorsal area is especially indistinct.

Cranial characters.—Skull large and rather heavily built, about the size of that of *Z. princeps*. Brain case broader and more globular; zygomatic breadth greater; palate shorter; molars more lightly built than in that species.

Measurements.—Average of 4 adults from Neah Bay, Wash.: Total length, 248; tail vertebræ, 153; hind foot, 33.5. Four specimens from Lake Washington, Wash., average: Total length, 240; tail vertebræ, 147.5; hind foot, 34.2. Ten specimens from Lake Cushman, Wash., average: Total length, 239.5; tail vertebræ, 144.5; hind foot, 32.5. *Skull:* Six adult skulls from five localities in Washington, average: Basilar length, 20.2; zygomatic breadth, 13; mastoid breadth, 10.9; interorbital constriction, 4.3; incisor to postpalatal notch, 9.6; foramen magnum to postpalatal notch, 8.8; fronto-palatal depth at middle of molar series, 6.7.

General remarks.—*Zapus trinotatus* is one of the largest, and in early summer pelage one of the most showy species in the genus. In the absence of specimens from the exact type locality, specimens from Port Moody, British Columbia, a few miles distant on the mainland, are assumed to be typical.[1] The species is remarkably constant in characters throughout its range, examples from near the type locality not differing much from specimens from Yaquina Bay, Oregon. In the Sierra Nevada of California this species is replaced by the closely related subspecies *alleni*. In a recent paper entitled 'Preliminary descriptions of New Rodents from the Olympic Mountains,' Mr. D. G. Elliot has described the *Zapus* from that region under the name *Zapus imperator*, but in making his comparisons he ignores *Z. trinotatus*, contrasting *imperator* only with *Z. princeps*. Through the courtesy of the author I have been able to examine the type and a topotype of *imperator*. They do not differ sufficiently from *Z. trinotatus*, from the contiguous coast region and from the type locality, to admit of even subspecific separation.

Specimens examined.—Total number, 99, from the following localities:

British Columbia: Lulu Island (type locality), 2; Mount Baker Range, 4; Mount Lehman, 1; Port Moody, 3; Sumas, 3.

California: Crescent City, 1; Mad River (Carson's Camp), 1.

Oregon: Astoria, 1; Beaverton, 3; Elk Head, 1; Glendale, 1; Lincoln County, 1; Marshfield, 1; Salem, 1; Yaquina Bay, 9.

Washington: Cascade River (head), 2; Easton, 3; Granville, 1; Fort Steilacoom, 1; Kichelos Lake, 1; Lake Cushman, 15; Lake Washington, 4; Lapush, 2; Mount Rainier, 12; Mount St. Helens, 3; Neah Bay, 5; Nisqually River, 4; Olympic Mountains (head Elwah River), 2[2]; Olympic Mountains (head Soleduc River), 2; Pacific County, 5; Puget Sound, 3; 'Washington,' 1.

ZAPUS TRINOTATUS ALLENI Elliot. Allen's Jumping Mouse.

Zapus alleni Elliot, Field Columbian Mus., Pub. 27, Zool. Ser., I, No. 10, pp. 212–213, March, 1898.

Type locality.—Pyramid Peak, Lake Tahoe, California.

Geographic distribution.—Mount Shasta and southward in the Sierra Nevada to Mammoth and North Fork of Kern River, California.

[1] Since the above was written the type and a topotype have been examined and found to agree with the specimens from Port Moody.

[2] Type and topotype of *Zapus imperator*.

General characters.—Similar to *Z. trinotatus;* differing slightly in external and cranial characters.

Color.—Early summer pelage: Sides rather pale ochraceous-buff, only moderately lined with black-tipped hairs; dark dorsal area well defined, rather lighter than in *Z. trinotatus;* under parts pure white; never marked with fulvous, except that rarely young specimens are slightly suffused with this color beneath; tail in dried skins rather light grayish-brown above and yellowish-white below; tail lighter toward tip, the pencil often white. Compared with *Z. trinotatus*, adults of this species have dorsal area less flecked with color of sides and fewer black-tipped hairs on sides. Upper surface of tail, ears, head, and outer surface of thighs lighter than in *Z. trinotatus.* Immature individuals in late summer pelage have dorsal area very indistinct and much mixed with ochraceous. *Fall pelage:* An adult taken at Cassel, Calif., August 29 (very fat and doubtless about to hibernate), is in a pelage quite similar to that worn in early summer, but the sides are lighter ochraceous, especially anteriorly, and the dorsal area is more thickly flecked with color of sides. *Z. alleni* apparently does not assume the dull yellowish fall pelage of *Z. trinotatus.*

Cranial characters.—Skulls similar to those of *Z. trinotatus*, but smaller, with much smaller bullæ. From that of *Z. montanus* of the Cascade Range the skull of the present species differs so much as not to require comparison.

Measurements.—Eight adults from Emerald Bay, Lake Tahoe, average: Total length, 234.6; tail vertebræ, 143.6; hind foot, 32.5. Two adults from Mount Shasta, Calif., average: Total length, 249.5; tail vertebræ, 152.5; hind foot, 32.5. *Skull:* Eight skulls from Emerald Bay, Lake Tahoe, average: Basilar length, 19.7; zygomatic breadth, 12.6; mastoid breadth, 10.5; interorbital constriction, 4.5; incisor to postpalatal notch, 9.3; foramen magnum to postpalatal notch, 8.2; fronto-palatal depth at middle of molar series, 6.5.

General remarks.—Zapus t. alleni is a fairly well-marked subspecies occupying the Sierra Nevada of California, from Mount Shasta south to the region about the head of the North Fork of Kern River. It is a very beautiful species and differs from all others of this subgenus in often having the pencil, and occasionally more of the tail, white.

Specimens examined.—Total number, 61, from the following localities:

California: Big Trees, 1; Cassel, 1; East Fork Kaweah River, 2; Emerald Bay, Lake Tahoe, 19; Kern River (North Fork—'Kern Lakes'), 1; Lassen Peak, 14; Mammoth, 1; Mount Shasta, 20; Summit, 1; Upper Bear Creek. 1.

ZAPUS MONTANUS (Merriam). Mountain Jumping Mouse.

Zapus trinotatus montanus Merriam, Proc. Biol. Soc. Wash., XI, p. 104, April 26, 1897.

Type locality.—Crater Lake, Mount Mazama, Oregon.

Geographic distribution.—Cascade Range in Oregon.

General characters.—Smaller and duller in color than *Z. trinotatus;* also differing in cranial characters.

Color.—Summer pelage: Sides rather dark, ochraceous-buff, heavily lined with black-tipped hairs; dorsal area quite sharply defined, grizzled dusky and yellowish; outer side of legs dusky to heel; tail sharply bicolor, dark gray above and whitish beneath; fore and hind feet soiled white; immature, suffused beneath with yellowish. *Fall pelage:* Dorsal area darker than in summer, thickly flecked with light yellowish, presenting a pepper-and-salt appearance; sides yellowish-olive, heavily lined with black-tipped hairs.

Cranial characters.—Skull smaller than those of *Z. trinotatus* and *Z. princeps oregonus* and much narrower throughout; incisive foramina much narrower posteriorly; bullæ smaller.

Measurements.—Eight specimens from type locality average: Total length, 228; tail vertebræ, 135; hind foot, 31. *Skull:* Three skulls from type locality average: Basilar length, 19.5; zygomatic breadth, 12.4; mastoid breadth, 10.1; interorbital constriction, 4.5; incisor to postpalatal notch, 9; foramen magnum to postpalatal notch, 8.3; fronto-palatal depth at middle of molar series, 6.4.

General remarks.—Zapus montanus is a very well-marked form inhabiting the entire Cascade Range in Oregon. It is apparently totally distinct from all of the species whose ranges surround its habitat. The type series was taken in August, 1896, near Crater Lake at the head of a tributary of Anna Creek, on Mount Mazama, Oregon. The species was quite abundant in the meadows and the shrubbery of the wet hillsides, and nearly a dozen were taken within a few days. Several of their summer nests were found. A week or two later other specimens were taken in the same valley a few miles below. These had begun to assume the fall pelage, being slightly more olivaceous.

Two specimens taken September 9, at Fort Klamath, at the base of the mountains, had assumed the complete fall pelage. They were excessively fat, and were doubtless nearly ready to hibernate.

Specimens examined.—Total number, 16, from the following localities:

Oregon: Crater Lake (type locality), 9; Diamond Lake, 1; Fort Klamath, 2; Mount Mazama (Anna Creek), 2; Mount Hood, 2.

ZAPUS ORARIUS sp. nov. Coast Jumping Mouse.

(Pl. I, figs 4, 4a).

Type from Point Reyes, Calif., No. 250, ♂ ad., collection of E. A. and O. Bangs. Collected May 14, 1893, by Charles A. Allen. Original No. 618.

Geographic distribution.—Coast of California from Point Reyes north to Mad River, Humboldt County; limits of range unknown.

General characters.—Size, medium; dorsal area and lower parts strongly suffused with color of sides. Skull rather small and peculiar in shape.

Color.—Type in rather worn spring pelage: Sides of body and head rather dark ochraceous, moderately lined with black-tipped hairs; dorsal area not sharply defined and strongly suffused with color of sides. White of lower parts so strongly suffused with ochraceous that the white is almost obsolete, appearing only on lower parts of forelegs and between thighs; hind legs ochraceous all around; sides of throat deeper ochraceous than remainder of lower parts; feet yellowish white; tail yellowish-white below and grayish above. A specimen from Point Reyes, in the collection of Dr. C. Hart Merriam, about one-fourth grown, "has the upper parts almost uniform deep ochraceous yellow, with only the faintest trace of the dorsal area."

Cranial characters.—Skull rather small; rostrum short and considerably deflected; nasals very narrow anteriorly; greatest zygomatic breadth on plane of middle molars; zygomata rather light, the maxillary portion meeting nearly at right angles to main axis of skull; process on lower border of maxillary arm of zygoma very pronounced and nearer antorbital foramen than in any other species. Brain case high and rather globular in shape; interorbital constriction narrow; interpterygoid fossa narrow and shallow; incisive foramina rather small and evenly elliptical in shape; audital bullæ small and rather near together; upper incisors slender and more projecting than usual; mandibular symphysis short.

Measurements.—The type measures: Total length, 220; tail vertebræ, 127; hind foot (dry), 30. *Skull* (type): Basilar length, 19; zygomatic breadth, 12; mastoid breadth, 10.6; interorbital constriction, 4; incisor to postpalatal notch, 8.5; foramen magnum to postpalatal notch, 7.9; fronto-palatal depth at middle of molar series, 6.2.

General remarks.—*Zapus orarius* appears to be a very well-marked species requiring close comparison with no other known form. The type has the lower parts more intensely suffused with the color of the sides than any other specimen of the genus that I have seen. A specimen from Mad River, Humboldt County, resembles the type very closely, and another from Eureka, without a skull, undoubtedly belongs to this species. The latter is suffused beneath with ochraceous, though to a lesser extent than the type. The skull of the type bears a slight resemblance in some respects to that of *Z. pacificus*, but the differences are so great that unless the type specimen is abnormal *orarius* can not be considered closely related to *pacificus*. Much additional material is needed to clear up satisfactorily the relationships of these and other forms from this region.

Specimens examined.—Total number, 4, from the following localities:

California: Eureka, 1; Mad River (Carson's Camp), 1; Point Reyes (type locality), 2.

ZAPUS PACIFICUS Merriam. Pacific Jumping Mouse.

Zapus pacificus Merriam, Proc. Biol. Soc. Wash., XI, p. 104, April 26, 1897.

Type locality.—Prospect, Rogue River Valley, Oregon.

Geographic distribution.—Interior valleys of southwestern Oregon and northwestern California; limits of range unknown.

Color.—"Dorsal area not sharply defined, but so strongly suffused with yellowish that the yellow predominates over the black; sides buffy-yellow, moderately lined with black hairs; inner side of legs only slightly darkened; tail sharply bicolor; grayish above, white beneath; fore and hind feet soiled white."[1] A topotype, younger than the type from which the above description was taken, "has the dorsal area even less distinct, the entire upper parts being ochraceous yellow."

Cranial characters.—Compared with that of *Z. montanus* (its nearest relative geographically) the skull of *Z. pacificus* is smaller; the rostrum and nasals shorter; audital bullæ smaller; basi-occipital broader between bullæ; interpterygoid fossa shorter; upper molar series more divaricating posteriorly.

Measurements.—The type measures: Total length, 225; tail vertebræ, 141; hind foot, 31. *Skull:* Basilar length, 17.5; zygomatic breadth, 12; mastoid breadth, 10; interorbital constriction, 4.5; incisor to postpalatal notch, 8.4; foramen magnum to postpalatal notch, 7.2; fronto-palatal depth at middle of molar series, 6.

General remarks.—Owing to the small number of specimens available from the immediate region, it is impossible to discuss satisfactorily the true relationship of *Zapus pacificus* to the surrounding species. The type and a topotype taken at the same time are in a peculiar washed-out, almost albinistic, pelage, and may possibly be abnormal, especially as the locality is well within the humid, heavily forested area, where most of the animals are darker in color than their congeners to the eastward. The species, however, has fairly well marked skull characters and is undoubtedly a good form. An immature specimen from Siskiyou, Oreg., taken September 28, doubtless referable to this form, has dorsal area more distinct; sides brighter ochraceous and with more black hairs; upper surface of tail darker and fur of upper parts darker at base than specimens from the type locality. Another, from Little Shasta, Calif., taken September 20, also provisionally referred to this form, resembles the Siskiyou specimen, but has dorsal area finely flecked with yellowish instead of ochraceous.

Specimens examined.—Total number, 4, from the following localities:

Oregon: Prospect, Rogue River Valley (type locality), 2; Siskiyou, 1 (not typical).

California: Little Shasta, 1 (not typical).

ZAPUS SALTATOR Allen. Stickeen Jumping Mouse.

Zapus saltator Allen, Bull. Am. Mus. Nat. Hist., N. Y., XII, p. 3, Mar. 4, 1899.

Type locality.—Telegraph Creek, Northwest Territory, Canada.

Geographic distribution.—Telegraph Creek south to mouth of Skeena River and Tschimshian Peninsula; limits of range unknown.

General characters.—Similar in early fall pelage to *Z. trinotatus*, but smaller and differing in cranial characters.

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[1] From original description.

Color.—Fall pelage: Sides yellowish, moderately lined with black-tipped hairs; dorsal area well-defined, rather dark, and thickly flecked with yellowish; ears like back, narrowly edged with yellowish; beneath, pure white; tail dusky above and gray beneath. Compared with *Z. trinotatus* in corresponding pelage, the back is slightly darker, the tail darker above, and gray, instead of yellowish-white beneath.

Cranial characters.—Compared with *Z. trinotatus*, the skull of *Z. saltator* differs as follows: Brain case narrower; zygomatic breadth considerably less; nasals broader posteriorly. Compared with skulls of *Z. princeps* from Field and Glacier, British Columbia, and Henry House, Alberta, the skull of *Z. saltator* has the rostrum longer; palate from incisive foramina to postpalatal notch shorter; and molars, especially last upper, smaller. All of the skulls of *Z. saltator* examined agree very well among themselves, and all have the incisive foramina very large and broad posteriorly. The zygomatic expansion is small and the brain case high and narrow.

Measurements.—An adult from Port Simpson, British Columbia, measures: Total length, 245; tail vertebræ, 145; hind foot, 32. Average of five young adults from same locality: Total length, 234; tail vertebræ, 151; hind foot, 32. *Skull:* An adult skull from Port Simpson, British Columbia, measures: Basilar length, 20; zygomatic breadth, 11.8; mastoid breadth, 10.5; interorbital constriction, 4.5; incisor to postpalatal notch, 9.4; foramen magnum to postpalatal notch, 8; frontopalatal depth at middle of molar series, 6.4.

General remarks.—Zapus saltator is a well-marked form, differing considerably from its relatives to the southward. With *Z. hudsonius alascensis*, which probably meets it on the north, it requires no comparison, the immensely larger incisive foramina and larger molars of the present species distinguishing the two forms at a glance. A small series of *Z. saltator*, which forms the basis of the present description, was taken by the writer at Port Simpson, British Columbia, in August, 1897. Some of these were taken in a grassy thicket near the edge of the forest, a few feet above high-water mark, and the remainder in a garden in the village. *Z. saltator* may be found to intergrade with either *Z. trinotatus* or *Z. princeps* (it seems nearer the latter), but until its true relationship is proved it seems best to allow it full specific rank. The tail is longer and the hind foot shorter, relatively, than in *Z. trinotatus*. Through the kindness of Dr. J. A. Allen, I have been enabled to examine the type of *Z. saltator*. The skull of the type being imperfect, the cranial characters given above are taken from Port Simpson specimens.

Specimens examined.—Total number, 8, from the following localities:

Northwest Territory: Telegraph Creek, 1 (the type).
British Columbia: Inverness (mouth of Skeena River), 1; Port Simpson, 6.

NAPÆOZAPUS[1] subgenus novum.

Type Zapus insignis Miller, from Restigouche River, New Brunswick.

Subgeneric characters.—Teeth: $i. \frac{1-1}{1-1}$, $p. \frac{0-0}{0-0}$, $m. \frac{3-3}{3-3} = 16$. Skull stouter than in other subgenera; interorbital constriction greater; frontal region more swollen; middle molars equaling first in size. Enamel pattern of molars not essentially different from *Zapus*, but sulcus on inner side of upper molars deeper and persisting longer in the wearing tooth (fig. 2). General color pattern as usual in the genus, but tail tipped with white.

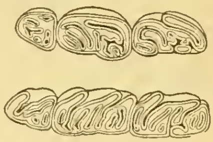

FIG. 2.—Molar teeth of *Zapus (Napæozapus) insignis* (topotype), from Restigouche River, N. B. (No. 2333, coll. E. A. and O. Bangs) × 6.

KEY TO SPECIES OF THE SUBGENUS NAPÆOZAPUS.

Hind foot less than 33 mm.; interorbital constriction usually more than 4.5 mm.
- Larger and lighter in color; hind foot usually more than 30 mm.; skull broader and stouter .... *insignis.*
- Smaller and darker; hind foot about 30 mm. or less; skull rather slender. *roanensis.*

Hind foot about 33 mm.; interorbital constriction narrow, usually less than 4.5 mm.; size large .... *abietorum.*

ZAPUS (NAPÆOZAPUS) INSIGNIS Miller. Woodland Jumping Mouse.

(Pl. I, figs 1, 1a.)

1856. *Meriones labradorius* Dawson, Edinburgh New Philos. Journ., new ser., III, p. 2.
1857. *Jaculus hudsonius* Baird, Mamm. N. Am., p. 430 (in part—specimen from Nova Scotia).
1877. *Zapus hudsonius* Coues, Mon. N. Am. Rodentia, p. 467 (in part).
1891. *Zapus insignis* Miller, Am. Naturalist, XXV, p. 472, August, 1891.

Type locality.—Restigouche River, New Brunswick.

Geographic distribution.—Canadian Zone in eastern Canada and south to western Maryland.

General characters.—Size rather large, larger than *Zapus hudsonius*, with longer ears and paler, more fulvous coloration. Tail tipped with white.

Color.—"Adult male No. $\frac{1656}{1452}$, collection of G. S. Miller, jr., Peterboro, N. Y., August 22, 1892; length, 250; tail vertebræ, 154; hind foot, 31.6; ear from notch, 18.6. Tip of tail for 23 mm., dorsum of manus and pes, and entire ventral surface pure white to base of hairs. Sides buff-yellow, tinged with clay color, except on cheeks, fore neck, and a narrow line bordering white of belly, where the yellow is noticeably purer; the fur plumbeous-gray at base and a trifle sprinkled with black, bristly hairs. These black hairs predominate on the back, where they form a sharply

[1] *Napæozapus:* ναπᾶιος, belonging to a wooded vale or dell; + *Zapus.* This name was suggested to me by Mr. Gerrit S. Miller, jr.

defined dorsal stripe slightly mixed with the color of the sides, broadest just back of the shoulders, tapering gradually to base of tail, and becoming indistinct on the head after passing between the ears. Ears externally concolor with back, internally buff-yellow; muzzle grayish-brown; whiskers mixed brownish and whitish, the longest hairs reaching beyond shoulders; tail thinly haired, so that the annulation shows distinctly, sharply bicolor, dark brown, except ventrally and at tip."[1] There is very little seasonal variation in this species, and the white of lower parts is never suffused with the color of sides.

Cranial characters.—Skull rather broad and stout; frontal region much swollen; brain case broad and rather flat; interorbital constriction broad as compared with that of all other species of the genus.

Measurements.—Nine specimens from Nova Scotia average: Total length, 238; tail vertebræ, 146.7; hind foot, 31.1. Sixteen from Peterboro, N. Y., average: Total length, 236; tail vertebræ, 147; hind foot, 30.25. One from Pocono Mountain, Pennsylvania: Total length, 224; tail vertebræ, 140; hind foot, 31. Two from Lake Hopatcong, New Jersey, average: Total length, 231; tail vertebræ, 140; hind foot, 31.5. *Skull:* Two skulls from type locality average: Basilar length, 18.7; zygomatic breadth, 12.3; mastoid breadth, 10.2; interorbital constriction, 4.9; incisor to postpalatal notch, 8.8; foramen magnum to postpalatal notch, 7.8; fronto-palatal depth at middle of molar series, 6. Four skulls from New York average: Basilar length, 19.6; zygomatic breadth, 12.9; mastoid breadth, 10.8; interorbital constriction, 5; incisor to postpalatal notch, 9; foramen magnum to postpalatal notch, 8.6; fronto-palatal depth at middle of molar series, 6.1.

General remarks.—Apparently the first published record which refers unmistakably to this species is that of Prof. J. W. Dawson, who, in 1856, in the Edinburgh New Philosophical Journal, called attention to the fact that two distinct species of Jumping Mice inhabited Nova Scotia. The present species he wrongly referred to *Meriones labradorius* (= *Zapus hudsonius*), and described true *Z. hudsonius* as a new species, calling it, provisionally, *Meriones acadicus*. In the National Museum are two specimens of *Zapus* deposited by Dawson; though mounted, they are in good condition for examination and are plainly referable respectively to *Z. insignis* and *Z. hudsonius*. Both Baird and Coues examined them, or at least similar specimens received from Dawson, but did not consider the two animals specifically distinct. *Zapus hudsonius* also occurs throughout the range of the present species, but the two prefer different situations—*Z. hudsonius*, shrubby fields and meadows, and *Z. insignis*, deep woods near streams.

This species presents remarkably little variation throughout its range. Specimens from central Pennsylvania, in the collection of Mr. S. N. Rhoads, are practically indistinguishable from examples taken near the type locality. Three specimens from Lake Hopatcong, N. J., have

[1] G. S. Miller, jr., Proc. Biol. Soc. Wash., VIII, p. 2, 1893.

slightly smaller skulls than usual, but are otherwise perfectly typical. I have also examined two specimens from western Pennsylvania, collected by Mr. W. E. Clyde Todd, and have myself collected a specimen in the mountains at Finzel, in Garrett County, Md. None of these show any approach to *Z. insignis roanensis* from Roan Mountain, North Carolina. Mr. S. N. Rhoads writes me that he has also taken the species at Summit, Cambria County, Pa.

Specimens examined.—Total number, 107, from the following localities:

New Brunswick: Restigouche River (type locality), 3.
Nova Scotia: Halifax, 3; James River, 4.
Ontario: North Bay, 6.
New Hampshire: Antrim, 1; Chocorua, 8; Dublin, 3; Fabyans, 1; Franconia, 4; Profile Lake, 10.
Vermont: Mount Mansfield, 4.
Massachusetts: Mount Greylock, 1.
New York: Cascadeville, 4; Catskills, 4; Elizabethtown, 10; Glenville, 1; Lake George, 1; Peterboro, 30.
New Jersey: Lake Hopatcong, 3.
Pennsylvania: Cherry Spring, Potter County, 1; Eaglesmere, 2; Kingston, Westmoreland County, 1; Mount Pocono, 1.
Maryland: Finzel, Garrett County (6 miles north of Frostburg), 1.

ZAPUS (NAPÆOZAPUS) INSIGNIS ROANENSIS subsp. nov. Roan Mountain Jumping Mouse.

Type from Magnetic City, foot of Roan Mountain, North Carolina, No. 66283, ♂ ad., U. S. Nat. Museum, Biological Survey Coll. Collected May 22, 1894, by A. G. Wetherby.

Geographic distribution.—Known only from Roan Mountain, North Carolina.

General characters.—Smaller and darker than typical *Z. insignis*, with smaller, narrower skull.

Color.—Sides bright tawny ochraceous; entire upper parts, including ears, considerably darker than in typical *Z. insignis*. Beneath, pure white; amount of white on tail averaging less than in *Z. insignis*.

Cranial characters.—Skull similar to that of *Z. insignis*, but smaller and more slender throughout; mandible much more slender, especially in region of molars; interorbital constriction very slightly less; frontal region much less swollen; brain case narrower; fronto-palatal depth about the same.

Measurements.—Sixteen specimens from Roan Mountain average: Total length, 220; tail vertebræ, 131; hind foot (dry), 29.5. *Skull:* Six adult skulls from Roan Mountain average: Basilar length, 18.8; zygomatic breadth, 11.7; mastoid breadth, 10.1; interorbital constriction, 4.7; incisor to postpalatal notch, 8.8; foramen magnum to postpalatal notch, 8; fronto-palatal depth at middle of molar series, 6.2.

General remarks.—The collection of the Biological Survey contains 24 specimens of this form, collected from May to September. As in typical *Z. insignis*, there is very little seasonal variation. A young individual, about one-third grown, collected at the type locality September 11, 1892, by Dr. C. Hart Merriam, resembles adults in color, except that the dorsal area is very indistinct and the nose is white. Several of the type series, including this young one, have the white on the tip of tail reduced to the merest trace. While the material examined from Maryland and Pennsylvania shows no indication of intergradation existing between typical *Z. insignis* and the present form, I have thought best to give it a trinomial name in the belief that intergradation does exist.

Specimens examined.—Total number, 24, all from Roan Mountain, North Carolina.

ZAPUS (NAPÆOZAPUS) INSIGNIS ABIETORUM subsp. nov.
Northern Woodland Jumping Mouse.

Type from Peninsula Harbor, north shore of Lake Superior, Ontario, No. 4268, ♀ ad., collection of Gerrit S. Miller, jr. Collected Sept. 27, 1896, by Gerrit S. Miller, jr.

Geographic distribution.—Probably throughout Hudsonian zone in eastern Canada; limits of range unknown.

General characters.—Larger than typical *Z. insignis*, with shorter ears and peculiar skull.

Color.—Apparently not distinguishable from *Z. insignis.*

Cranial characters.—Compared with typical *Z. insignis* the skull of the type has molar series longer and heavier; interorbital constriction narrower than in any specimen of *insignis* examined; ventral border of pterygoids nearly on plane of palate; maxillary process of zygomata shorter and zygomata much less curved than in typical *insignis;* mandible much heavier.

Measurements.—Type: Total length, 255; tail vertebræ, 160; hind foot, 33; ear from meatus, 16.6. An adult male from Godbout, Quebec, measures: Total length, 250; tail vertebræ, 160; hind foot, 32.5. *Skull* (type): Basilar length, 19.4; zygomatic breadth, 12.2; mastoid breadth, 10.5; interorbital constriction, 4.3; incisor to postpalatal notch, 9.6; foramen magnum to postpalatal notch, 8.4; fronto-palatal depth at middle of molar series, 6.

General remarks.—This form is based mainly on a single specimen, collected at Peninsula Harbor, Ontario, on the north shore of Lake Superior, in the Hudsonian zone, by Gerrit S. Miller, jr. Mr. Miller recorded this specimen[1] and described its peculiarities in some detail. A specimen in the Bangs collection, from Lake Edward, Quebec, and two from Godbout, Quebec, in Dr. Merriam's collection, while not perfectly typical, agree with the type in large size, narrow interorbital constriction, and in other peculiarities. This makes it probable that this form will be found to occur throughout the Hudsonian zone, in eastern Canada. The specimen of *Z. insignis*, recently recorded from Labrador by Mr. Outram Bangs,[2] which he thinks is not typical, may

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[1] Notes on the Mammals of Ontario <Proc. Boston Soc. Nat. Hist., XXVIII, No. 1, p. 10, April, 1897.

[2] Am. Naturalist, XXXII, No. 379, p. 493, July, 1898.

belong to this form. The type of *abietorum* is slightly larger than the largest specimens examined of the typical form, while the ear is slightly shorter than usual.

Specimens examined.—Total number, 4, from the following localities:

Ontario: Peninsula Harbor, 1 (type).
Quebec: Godbout, 2; Lake Edward, 1.

EOZAPUS[1] subgenus novum.

Type Zapus setchuanus Pousargues, from Szechuen, China.

Subgeneric characters.—Teeth: $i.\ \frac{2}{2}$, $p.\ \frac{1-1}{0-0}$, $m.\ \frac{3-3}{3-3} = 18$. Skull similar to those of the subgenera *Zapus* and *Napaeozapus*, but differing as follows: Skull relatively broader, shorter, and lower; nasals broad, distinctly forked posteriorly; antorbital foramina rather large; incisive foramina medium; posterior palatine foramina midway between incisive foramina and postpalatal notch, the latter barely reaching posterior plane of molars. Rostrum relatively shorter and broader; zygomata relatively shorter, with jugal portion almost perfectly straight, frontal region less swollen. Enamel pattern of molars somewhat similar, but enamel folds not closely crowded; last lower molar relatively larger (fig. 3). Color pattern differing from that of other subgenera in having a brown ventral stripe; tail tipped with white, as in *Napaeozapus*.

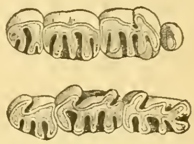


FIG. 3.—Molar teeth of *Zapus (Eozapus) setchuanus* (cotype), from Ta-tsien-lou, Szechuen, China. × 6.

ZAPUS (EOZAPUS) SETCHUANUS Pousargues. Szechuen Jumping Mouse.

(Pl. I, figs. 2, 2a.)

Zapus setchuanus Pousargues, Ann. Sci. Nat., 8e sér., I, No. 4, p. 220, Avril, 1896; Bull. Mus. d'Hist. Nat., Paris, II, p. 13, figs. 1–3, 1896.

Type locality.—Ta-tsien-lou, Szechuen, China.

Geographic distribution.—Known only from the type locality.

General characters.—Differing from all other known members of the genus in having a ventral stripe of brown.

Color.—Upper parts dark, tawny ochraceous; dorsal area sharply defined and very thickly flecked with black-tipped hairs, the sides moderately lined with same. Pattern of color above as in the American species. Beneath white, suffused with ochraceous, the white nearly obsolete on fore breast; a brownish stripe about 5 mm. wide extends the entire length of breast and belly; feet, chin, and lips white; tail strongly bicolored; brownish above and whitish beneath, with about 15 mm. of the tip pure white; ears dusky.

Cranial characters.—Compared with *Z. hudsonius* the skull of *setchuanus* differs as follows: Interorbital constriction relatively narrower;

[1] Eozapus: ἠώς, dawn, *i. e.* eastern; + *Zapus*.

frontal region less swollen; rostrum shorter and less attenuated; zygomata shorter, the maxillary portion more nearly perpendicular to main axis of skull, the jugal portion heavier and nearly straight; palate longer, the postpalatal notch not quite reaching posterior plane of molars (in American species commonly exceeding that point); nasals prolonged farther posteriorly and forking (in American species generally irregularly truncated); bullæ larger; the coronoid process of mandible not ascending so high, but longer, broader, and straighter, and the coronoid notch deeper and less rounded than in *Z. hudsonius* (fig. 4).

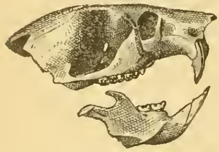


FIG. 4.—Skull of *Zapus (Eozapus) setchuanus* (cotype) from Ta-tsien-lou, Szechuen, China. × 1½.

Measurements.—The following measurements from Pousargues will serve for comparison with other species: 'Vieux,' head and body, 100; tail, 120; foot, 31; 'adulte,' head and body, 80; tail, 103; foot, 30; 'semiadulte,' head and body, 70; tail, 95; foot, 28. Skull No. 2:[1] Zygomatic breadth, 11.6; interorbital constriction, 3.6; incisor to postpalatal notch, 8.5; fronto-palatal depth at middle of molar series, 5.5. No. 3: Zygomatic breadth, 11.5; interorbital constriction, 3.8; incisor to postpalatal notch, 8.2; fronto-palatal depth at middle of molar series, 5.6.

General remarks.—This very interesting species was described from three skins in alcohol accompanied by imperfect skulls. Its describer, M. E. De Pousargues, discusses its color and other peculiarities in considerable detail, and presents a table showing the measurements of the three specimens, together with the corresponding measurements of a specimen of *Z. hudsonius*, taken from Coues. These measurements of *hudsonius* (head and body, 85; tail, 135; foot, 27), if all from one individual, must have been taken from a distorted specimen and do not give a fair idea of the proportions, the foot measurement, 27 mm., being evidently too small for an animal with the tail measuring 135. On this account the proportional differences between *setchuanus* and *hudsonius* are exaggerated. Through the courtesy of Mr. Gerrit S. Miller, jr., I have been able to examine two of these skins and the skulls, generously loaned to him by M. Pousargues. The color of these skins is apparently not much changed by the action of alcohol. The brown ventral stripe and comparatively short, hairy tail with its white tip, constitute the most striking peculiarities. The hind foot is about the same size as in *hudsonius;* the ear shorter and broader than in the American species.[2] As already stated, the skulls are all imperfect.

[1] These numbers are provisional, and owing to the imperfect condition of the skulls only these measurements could be taken.

[2] The following table will serve to show the approximate ratio of width to height of ear in *Zapus insignis, Z. hudsonius,* and *Z. setchuanus* (alcoholic specimens):

	Z. insignis. Two specimens.		*Z. hudsonius.* Two specimens.		*Z. setchuanus.* Two specimens.	
	Male.	Female.	Male.	Female.	Larger.	Smaller.
Height of ear from notch	15.5	15.5	14	14	12.5	11
Greatest width of ear	9	9	9	9	10	9

The largest is so badly crushed as to be almost worthless, and the two smaller ones lack the occipital portion of the cranium and the posterior parts of the mandibles, the shape of the angular process, therefore, being unknown. This species has the small upper premolar as in the subgenus *Zapus*, that tooth being larger than in *Z. hudsonius*. The last lower molar is also proportionately larger. All the molars differ from those of any American species in having the enamel folds not closely crowded, the resulting wide and deep sulci giving the teeth a very different appearance, though the general pattern of enamel folding is perhaps not essentially different. The incisors are lighter in color than in the American species.

Specimens examined.—Two skins and three skulls, from the type locality.

INDEX.

[New names in black-face type; synonyms in italics.]

PLATE I.

(One and one-half times natural size.)

Fig. 1. *Zapus (Napæozapus) insignis* Miller (Type). Restigouche River, New Brunswick.
(Type 387/464, Miller collection.)

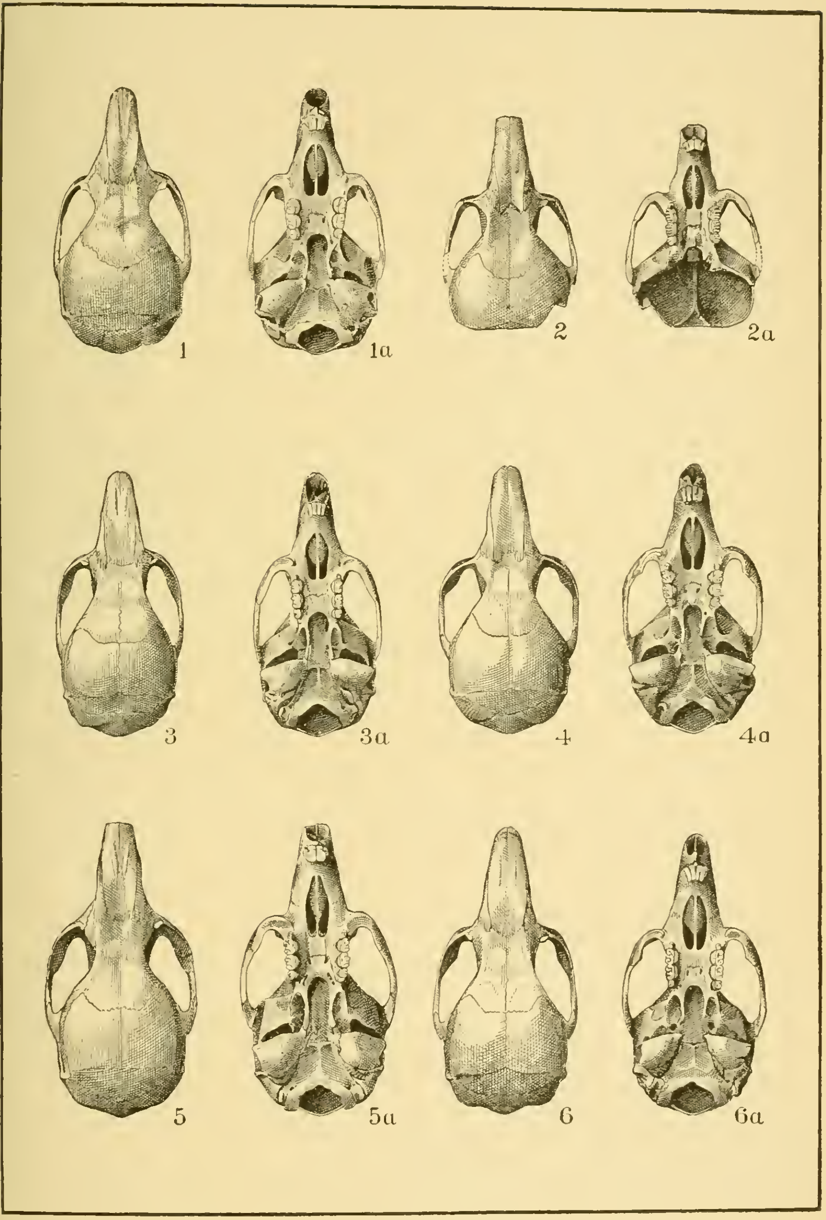
2. *Zapus (Eozapus) setchuanus* Pousargues (Cotype). Ta-tsien-lou, Szechuen, China.

3. *Zapus (Zapus) hudsonius* (Zimmermann). James Bay, Canada.
(No. 60588, U. S. Nat. Mus.)

4. *Zapus (Zapus) orarius* Preble (Type). Point Reyes, Calif.
(No. 250, Collection E. A. & O. Bangs.)

5. *Zapus (Zapus) trinotatus* Rhoads. Port Moody, British Columbia.
(No. 66928, U. S. Nat. Mus.)

6. *Zapus (Zapus) princeps* Allen (Topotype). Florida, La Plata County, Colo.
(No. 4139, Am. Mus. Nat. Hist.)



SKULLS OF ZAPUS.

1. *Zapus insignis.*
2. *Z. setchuanus.*
3. *Z. hudsonius.*
4. *Z. orarius.*
5. *Z. trinotatus.*
6. *Z. princeps.*

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DIVISION OF BIOLOGICAL SURVEY

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RESULTS OF A BIOLOGICAL SURVEY OF MOUNT SHASTA CALIFORNIA

BY

C. HART MERRIAM

CHIEF OF DIVISION OF BIOLOGICAL SURVEY

WASHINGTON

GOVERNMENT PRINTING OFFICE

1899

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF BIOLOGICAL SURVEY,
Washington, D. C., May 19, 1899.

SIR: I have the honor to transmit herewith for publication, as North American Fauna No. 16, a report on the results of a Biological Survey of Mount Shasta, California, made during the summer of 1898.

Respectfully,

C. HART MERRIAM,
Chief, Biological Survey.

Hon. JAMES WILSON,
Secretary of Agriculture.

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RESULTS OF A BIOLOGICAL SURVEY OF MOUNT SHASTA, NORTHERN CALIFORNIA.

By C. Hart Merriam.

INTRODUCTION.

At the close of the field season of 1897 the Biological Survey had nearly completed a reconnoissance of Washington and Oregon, and in previous years had carried its operations over extensive tracts in southern, middle, and northeastern California, so that with the exception of a rather large area in northern California fully two-thirds of the Pacific States had been covered. In 1898, therefore, the unworked part of northern California, reaching from the Madeline Plains on the east to the Pacific Ocean on the west, and from the Oregon boundary on the north to Lassen Butte and adjacent parts of the Sierra on the south, came to be the principal field of our investigations. In this area Mount Shasta occupies a nearly central position.

All high mountains, particularly those that stand alone, are likely to throw light on the problems of geographic distribution and are worthy of careful study. Shasta, not only because of its great altitude, but even more because of its intermediate position between the Sierra and the Cascades, promised an instructive lesson, and was therefore chosen as a base station for part of the field work of 1898.

From work previously done in the Sierra Nevada of California and the Cascade Range of Oregon it was known that many species of animals and plants are common to both ranges, and many restricted to one or the other. Shasta, lying between the two, was expected to share the common features of both, and in addition afford the northernmost limit of Sierra species, the southernmost limit of Cascade species, or an overlapping of both, so that its fauna and flora, other things being equal, should be richer than either. But Shasta proved very much drier than either the Sierra or the Cascades, and consequently many species common to the two ranges were absent, and the total number was less than was expected. Nevertheless, the mountain shares a large percentage of the common species and is, as expected, a stepping stone on which restricted Sierra and Cascade species overlap. But the representatives of the two ranges are not equally apportioned. The most evident gap is on the north, Shasta sharing many more species in common with the Sierra than with the Cascades. Indeed, the resemblance to the northern Sierra is so exceedingly close, particularly in the mammal fauna, that from the standpoint of geographic distribution Shasta could without violence be classed as part of the Sierra. This is the more surprising in view of the fact that the geographical gap between Shasta and the Cascades is only half as broad as that between Shasta and the Sierra. This subject is discussed in detail in the chapters entitled 'The Boreal fauna and flora of Shasta contrasted with corresponding faunas and floras of the Sierra and the Cascades;' 'Efficiency of Klamath Gap as a barrier to Boreal species compared with that of Pitt River and Feather River gaps collectively,' and 'Sources of the Boreal faunas of Shasta and of the Sierra and the Cascades.'

ITINERARY.

Leaving the railroad at Sisson, at the west base of Shasta, we established the first camp July 15, 1898, at a point known as Wagon Camp,

FIG. 1.—Wagon Camp.

on the south slope of the mountain, about a quarter of a mile west o Panther Creek, at an altitude of 5,700 feet (fig. 1). Wagon Camp is situ ated in a descending tongue of Shasta firs between ascending tongues of manzanita chaparral, just above the uppermost grove of ponderosa pines, on the boundary between the Canadian and Transition zones. It is abundantly supplied with water from several small springs, from which tiny streamlets run short distances before disappearing in the thirsty soil. Some of these springs unite to form a small marsh, in which flourish a number of plants not found elsewhere on the mountain. It is naturally a favorite spot for birds, and more species were seen here than elsewhere. Wagon Camp was occupied continuously by one or more members of the party from July 15 to August 1, and at brief intervals thereafter until October 3.

A few days after reaching the mountain I set out on a trip around the peak in order to become familiar with the general features of the region and lay plans for the season's work. On this trip I was accompanied by Vernon Bailey, my most experienced field assistant, and by a

Fig. 2.—Shasta from east brink of Mud Creek Canyon.

voluntary assistant, Lyman L. Merriam. We took saddle horses and a pack animal, which were of material aid, although we had much difficulty in getting them across some of the deep canyons and over the indescribably rough lava on the west side of the mountain.

Leaving Wagon Camp on the morning of July 22, we ascended Panther Creek to its source, turned easterly through 'The [South] Gate,' north of Gray and Red buttes, crossed Squaw Creek near its head, and kept on among the timberline white-bark pines to the rim of Mud Creek Canyon (pl. III), which we followed down into the Shasta firs. The first night was spent in the bottom of this canyon at an altitude of 5,600 feet—some distance below the lower fall. The second day we climbed the steep east bank of the canyon, here 1,000 feet deep (fig. 2), crossed Cold Creek and Ash Creek Canyon below timberline, and reached

Brewer Creek Canyon in the upper part of the white-bark pines. Finding absolutely no grass or other feed for the animals here, we crossed the canyon lower down (a little below the forks) and continued on over rough lava ridges in the upper edge of the forest until dark, when we camped on Inconstance Creek (fig. 3). The third day we pushed

FIG. 3.—Shasta from Inconstance Creek, near timberline on north side.

on around the north end of the mountain, keeping a little below the great glaciers, and in the main near timberline. We climbed over a number of lava ridges, availed ourselves of a natural passageway ('North Gate') at the upper end of a pair of conspicuous lava buttes, traversed a curious pumice plain covered with timberline mats of prostrate white-bark pines (fig. 22), crossed the fearful canyons of Whitney and Bolam creeks, and finally reached Shastina, where, after a very severe day, we camped on some small streams of snow water on the north side (fig. 4). The fourth morning we climbed the rough slide rock of Shastina to an altitude of 10,000 feet, in order to get around a high impassable lava ridge, and then, after encircling a great amphitheater of rough slide rock, descended by some immense masses of perpetual snow to the white-bark pines, in which we continued to the great canyon on the west side of Shastina (pl. II), which I named Diller Canyon, in honor of J. S. Diller of the U. S. Geological Survey, in recognition of his admirable researches on the geology of Shasta. After crossing Diller Canyon we kept in the upper part of the Shasta fir forest all the way to Panther Creek, which we followed down to Wagon Camp. This was the most trying day of all—sixteen miles of continual climbing, removing blocks of lava, and building trail. Our animals suffered

FIG. 4.—Shastina from north, showing great bank of snow which feeds Shastina streams.

severely, and one of them gave out entirely. However, the mountain was completely encircled after four long days, and the desired informa-

FIG. 5.—Alpine hemlocks, Squaw Creek Camp.

tion was obtained. In the main we kept near timberline, climbing over the bare rock slopes above, or descending into the dark forest below, as occasion required. And since all the canyons of Shasta radiate from the summit, all were crossed on this trip.

A base camp was next established in a grove of black alpine hemlocks near the head of the west branch of Squaw Creek, close to and just east of the upper end of Red Butte. Here one or more of the party remained continuously from August 1 till September 24. All things considered, this is probably the best camping ground on Shasta, though I am not aware that it had been used before our visit. It is close by the three upper 'meadows' on Squaw Creek and within reach of the best feed for horses found on the mountain, with the possible exception

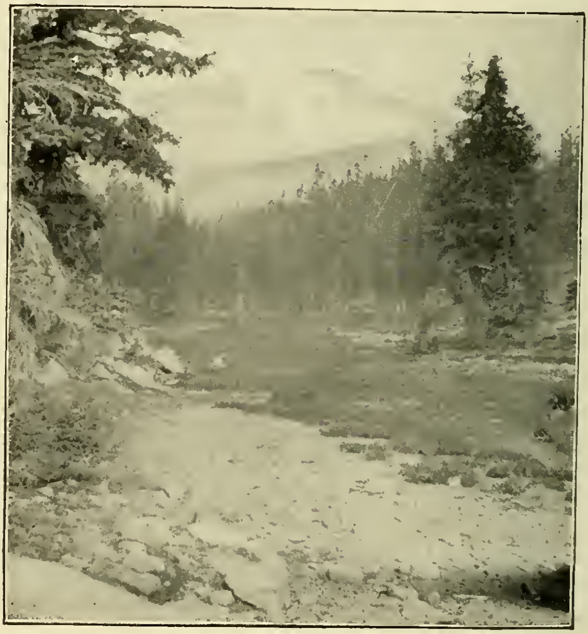

Fig. 6.—Heather meadow on Squaw Creek.

of a small area near Cold Creek, and it is by far the most convenient base from which to work the timberline region of the southern slopes.

Temporary camps were established at the head of Panther Creek, in Mud Creek Canyon at the mouth of Clear Creek, in Ash Creek Canyon a little below timberline, and high up between Mud Creek Canyon and the head of Clear Creek, from which point the main peak was twice ascended. At the base of the mountain, work was done at Sisson on the west side, in Squaw Creek and McCloud valleys on the south, and in Shasta and Little Shasta valleys on the north, and finally a trip was made completely around the mountain, mainly within the belt of yellow pines which clothes its lower slopes.

PERSONNEL.

In the field work on which the present report is based, I was aided by Vernon Bailey, chief field naturalist of the Biological Survey, and my assistants, Wilfred H. Osgood, Walter K. Fisher, and Richard T. Fisher. Vernon Bailey had charge of the work at the Shasta base camps and on a trip around the base of the mountain; Walter K. Fisher had charge of the work in Mud Creek and Ash Creek canyons and near timberline east of Mud Creek, and afterwards took a party to Fall River Lake and Lassen Butte; W. H. Osgood had charge of the work on Lassen after Walter Fisher's departure, and also visited Squaw Creek and Shasta and Little Shasta valleys; R. T. Fisher spent the season working from the various camps on Shasta and at Sisson, and accompanied Osgood on the trip to Little Shasta Valley.[1]

Our camps on Shasta were visited by Henry Gannett, chief geographer of the U. S. Geological Survey; John H. Sage, of Connecticut, secretary of the American Ornithologists' Union; and two or three others, all of whom rendered important assistance.

In addition to the work on and near Shasta covered by the present report, field work was done in various directions. Three cross sections of the Sierra Nevada, north of latitude 39°, were made by Bailey, Osgood, and myself; Bailey and Walter Fisher ran a line from Black Rock Desert, Nevada, to Shasta, by way of Madeline Plains; Bailey and I, accompanied by Henry Gannett, carried the work across the wild and little known mountains from Shasta to the ocean, which we reached at Humboldt Bay; and later in the season much work was done farther south, chiefly in the inner and outer Coast Ranges.

PREVIOUS PUBLICATIONS.

Only two publications have been found relating to the zoology and botany of the Shasta region. The first is a report by Charles H. Townsend, of the U. S. Fish Commission, who, fifteen years before our visit, was stationed at Baird, a fish hatchery on McCloud River. While there Mr. Townsend visited Berryvale (now Sisson Tavern) and accompanied Major Gilbert Thompson, who was in charge of a triangulation party of the U. S. Geological Survey, in his field work on Shasta. The results of Mr. Townsend's work are contained in an important report entitled 'Field Notes on the Mammals, Birds, and Reptiles of Northern California,' published in the fall of 1887.[2] In addition to the records in this report, Mr. Townsend has kindly placed his manuscript catalogue at my disposal, and has in several instances given me important sup-

[1] While this report was passing through the press (July, 1899), I sent Walter K. Fisher to Mount Shasta and Shasta Valley to obtain supplemental information, some of which is incorporated in the mammal, bird, and plant reports at the end.—C. H. M.

[2] Proc. U. S. National Museum, X, pp. 159-241, Nov., 1887.

plementary information respecting the exact localities at which specimens were collected, all of which is duly credited in the body of the present report.

The second publication referred to is a brief paper by Miss Alice Eastwood on 'The Alpine Flora of Mount Shasta,'[1] containing the results of a hasty trip to the summit made in August, 1893.

So far as I have been able to ascertain, this is the first and only publication relating directly to Shasta plants, although a number of species collected there during a brief visit by Prof. Wm. H. Brewer in the early sixties are mentioned in the Botany of California (by Brewer and Watson, 1876–1880).

NEW SPECIES.

In working up the collections it was found that several of the plants and mammals belonged to undescribed species. Some of the new plants have been described by Prof. E. L. Greene;[2] others remain unnamed. The new mammals are here described. The new species are:

Plants.

Agoseris monticola.
Arnica merriami.
Campanula wilkinsiana.
Phacelia frigida.
Pyrola pallida.

Mammals.

Lepus klamathensis.
Lynx fasciatus pallescens.
Neurotrichus gibbsi major.
Procyon psora pacifica.
Reithrodontomys klamathensis.
Sorex shastensis.
Thomomys monticola pinetorum.
Urocyon californicus townsendi.

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[1] Erythea, IV, No. 9, pp. 136–142, Sept., 1896.
[2] Pittonia, IV, pp. 36–40, March 17, 1899.

GENERAL FEATURES OF SHASTA.

The snowy peak of Shasta, the pride of California, is one of the highest and most accessible of the snow-clad glacier-bearing mountains of the United States. It is an old volcano, 14,450 feet in altitude, and is completely cut off from neighboring mountains—from Lassen Peak, at the north end of the Sierra proper, by the valleys of the McCloud and Pitt rivers; from the south end of the Cascade Range in Oregon by a broad lava plateau and the valley of Klamath River. The breadth of the gap on the north is diminished by a cluster of low volcanic mountains known as the Goose Nest Group.

Shasta is the best-known landmark in California. Seen from the north, south, and east it appears as a single cone pushing its lofty crown upward six or seven thousand feet above apparent timberline. Seen from the west and southwest its summit is elongated and looks more like the crest of a ridge (frontispiece). This appearance is due in part to a large secondary volcano, Shastina, which rises from the northwest shoulder of the mountain, and in part to a long ridge which pushes out to the south. This west side, the one seen by tourists in traveling over the Shasta route from San Francisco to Portland, is in many respects the least interesting. From its exposure to the direct rays of the afternoon sun it is the hottest slope, and consequently the one on which timber reaches highest and on which the ice and snow are most reduced.

Like most isolated mountains, Shasta is seen to best advantage from a distance. The most imposing view to my mind is from the northeast, the region of the Modoc lava beds, from which the peak looms up in all its icy grandeur—a single massive cone buried from top almost to bottom in continuous glaciers, below which it is encircled by a dark belt of coniferous forest. It is also very imposing as seen from the distant Trinity Mountains.

The north and east sides of the peak are completely, and the south side partly covered by glaciers, but not a glacier is to be found on the west, where the large masses of white seen from Sisson are banks of snow, more or less permanent. The only glacier visible from the railroad is Whitney Glacier, which occupies the notch between Shasta and Shastina, and may be seen from points north of Edgewood. The higher slopes, between the lower edge of the ice and snow and the upper edge of the forest, are steep and rocky. In the main they consist of radiating ridges alternating with glacial basins and precipitous canyons. As a rule the surface is light pumice and pumice sand thickly strewn with fragments of gray volcanic rock, interrupted here and there by masses and cliffs of darker lava, often reddish brown in color.

The south and east sides, except the deep canyons of Mud, Ash, and Brewer creeks, are fair traveling for mountain horses. The north side, below the great glaciers, is interrupted by exceedingly rough lava ridges and the terrible canyons of Bolam and Whitney creeks. The west side, though scored by only a single notable canyon—Diller Canyon (pl. II)—is by far the most difficult. After crossing the tremendous slopes of steep and sharp slide rock, very dangerous for horses, on the northwest side of Shastina, and surmounting the two principal lava ridges west of Shastina Creek, the way to Diller Canyon is comparatively easy. But between Diller Canyon and Cascade Gulch, a mile or so north of Horse Camp, and extending from timberline downward several thousand feet, is a chaos of lava the like of which I have never seen. It suggests the worst parts of the Snake River and Modoc lava beds turned up on end—basins, ridges, and tumultuous piles without order or direction, without beginning or ending—dry basins that empty nowhere, drier ridges that lead nowhere, until one is worn out with thirst and efforts to escape. The whole is hidden in a dark forest of Shasta firs whose hardy trunks force themselves out between the lava blocks in ways that almost surpass belief. Finally all this stops as suddenly as it began, and one emerges from the dark inferno to slake his thirst in the refreshing pools of Cascade Gulch—known only to the deer—and, with a sense of infinite relief, reenters the area of pumice sand and gray shale which stretches away to the southeast and thence onward around three-quarters of the mountain.

FIG. 7.—Pumice sand strewn with gray volcanic shale. Young hemlocks in foreground; white-bark pines in distance.

The timbered valley at the west base of Shasta falls away both to the south and to the north. On the south it drains immediately into the Sacramento River; on the north into the Shasta River, which traverses Shasta Valley and empties into Klamath River. Shasta Valley is an open plain northwest of the mountain; it is lowest at the north, and its northwestern corner ends in a pocket or basin containing the mining town of Yreka, which is doubtless the hottest part of northern California west of the axis of the Sierra-Cascade system.

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MOUNT SHASTA FROM THE NORTHWEST, SHOWING GREAT SNOWBANK IN HEAD OF DILLER CANYON.

EFFECTS OF SCANTY MOISTURE.

The flora of Shasta, contrasted with that of moister mountains immediately north and immediately south, is poor in species and individuals; and the same is true in less degree of the fauna. At least nineteen characteristic genera and numerous additional species of plants common to the Sierra and the Cascades, are unknown (p. 80); and to these must be added the distinctive species of each range which fail to reach Shasta. The luxuriant mountain meadows and flower beds that form such conspicuous features of the timberline region in the Cascades, the Olympics, the High Sierra, and the Rocky Mountains are wholly absent, and the only areas that in any way resemble them are the

FIG. 8.—Heather meadow bordering Squaw Creek. Shasta peak in distance covered with fresh snow, September 22, 1898.

insignificant patches of mountain heather and accompanying plants that carpet the moist bottoms of the glacier basins and form narrow beds along the tiny streams, where they are concentrated by the local distribution of soil moisture. The only real soil above timberline is restricted to the borders of the streamlets, where the decomposing heather has left a shallow covering. Everywhere else are pumice, broken lava, and barren cliffs.

The summer rainfall amounts to little or nothing, and when rains occur they sink and vanish in the thirsty pumice sand. The streams from melting snows are exceedingly small, averaging hardly more than a foot or two in width, and most of them disappear before reaching the base of the mountain. The turbid streams from the glaciers are larger, but they have cut for themselves deep gorges where they run their rapid courses 1,000 feet below the surface, and consequently are useless for purposes of general irrigation. They exert a local influence, it is true, since far down in the damp bottoms of the canyons and along their cool easterly lower slopes a number of moisture-loving plants occur that are not found elsewhere except about the few and widely scattered springs in the forest—serving by contrast to accentuate the general aridity. Even the black alpine hemlock, which in the Cascades forms so attractive a feature of the upper slopes, is of local occurrence on Shasta, where its distribution is interesting as furnishing an index to soil moisture. It is associated with the white-bark pine (*Pinus albicaulis*), which requires less moisture and is the dominant timberline tree. In our circuit of the peak we found the range of the white-bark pine practically continuous; that of the alpine hemlock discontinuous and greatly restricted. As a rule the hemlock is confined to narrow strips along the streams and gulches, or to tongues along the cool east sides of buttes and ridges, where the soil, sheltered from the hot afternoon sun, is able to retain more moisture than elsewhere. Below the alpine hemlocks and occupying the middle belt of the mountain is a magnificent forest of Shasta firs; but the humbler vegetation of this belt is scanty and irregular.

From what has been said it is obvious that excessive dryness prevents many of the characteristic zone species from filling their appropriate belts, restricting them to scattered spots, where, as in the desert, succulent vegetation is concentrated about springs and streams. Hence Shasta is a poor place to study the broad general facts of zone distribution, but, as shown later, an admirable place to study detailed effects of slope exposure and humidity.

GLACIAL BASINS.

As in most parts of the Sierra and many parts of the Cascades, glacial basins are conspicuous on the higher slopes of the mountain. They occupy the deep depressions between the radiating ridges, and their terminal moraines are usually clearly defined. In some of the valleys, as along the upper part of Squaw Creek, two or three such moraines may be found at intervals, marking successive stages in the retreat of the glacier. The glacial basins usually contain small streams, at least during spring and early summer, and they receive additional moisture from the melting snows, which linger long in the shadows of the ridges. This moisture permits the growth of a more abundant vegetation than occurs elsewhere on Shasta, save only along the streams. The bottoms of the basins therefore are usually carpeted with red heather (*Bryanthus* or *Phyllodoce empetriformis*) and a variety of small plants, the majority of which are inconspicuous except when in flower. Among the most noticeable of these, each contributing its mite to the general verdure of the heather beds, are the dwarf huckleberries, white alpine antennarias, silenes and ligusticums, yellow monkey flowers, violets and hieraciums, blue veronicas and asters, cream-colored feathery lutkeas and parnassias, pink epilobiums, red alpine laurels, and scarlet painted cups.[1] True grasses are scarce, but grass-like carices abound.

The mammals inhabiting the heather meadows are the rare alpine phenacomys (*Phenacomys orophilus*), the white-footed mouse (*Peromyscus gambeli*), the long-tail mountain vole (*Microtus mordax*), and the Sierra pocket gopher (*Thomomys monticola*). The gophers throw up their characteristic mounds about the edges of the heather beds but are commoner on the adjacent pumice slopes.

FIG 9.—Glacial meadow at head of Squaw Creek.

CANYONS.

All the canyons of Shasta radiate from the ice-covered summit and take remarkably straight courses down the steep sides of the mountain. Most of them are profound gorges cut by swift-flowing glacial

[1] The plants of the glacial basins in the timberline region vary somewhat with the moisture of the soil. The commonest species in moist spots and along the borders of the streamlets are: *Arnica merriami, Castilleja miniata, Epilobium clavatum, Hieracium gracile, Hypericum anagalloides, Mimulus implexus* (growing in the water), *Mimulus primuloides, Mitella pentandra, Parnassia californica, Veronica cusicki.* The commonest species in the drier parts of the heather beds are: *Antennaria media, Castilleja miniata, Hieracium gracile, Kalmia glauca microphylla, Lutkea pectinata, Ligusticum grayi, Phyllodoce empetriformis, Sibbaldia procumbens, Silene grayi, Vaccinium cæspitosum, Viola purpurea.*

streams. They average about a thousand feet in depth, and their slopes are as steep as permitted by the unstable material through which they are cut—usually pumice, gravel, and fragments of lava. Owing to the fact that all of the great glaciers are on the north, east, or southeast sides of the mountain, the canyons made by their rivers are necessarily on these sides also. The only one of any size which does not come from a glacier is Diller Canyon, on the west side of Shastina.

In most, if not all, cases the bottoms of the canyons in their upper courses are bridged for long distances by masses of ice and snow—the dumps of avalanches. Below these snow bridges are vast accumulations of loose stones, which in several instances, as in Brewer, Bolam, and Whitney canyons, are piled up in a curious manner. During periods of high water the rocks that fall in are carried down by the torrent and deposited on each side in banks several feet high, so that the traveler on reaching the bottom has to climb up over a ridge of loose stones and down again before coming to the stream. These lateral ridges form miniature canyons in the bottoms of the big ones. Most of the canyons have falls several hundred feet high in their upper courses, and some have other falls farther down. Notable falls are found high up in the canyons of Mud Creek, Ash Creek, Bolam Creek, and Whitney Creek. While difficult of access, they are well worth the effort of a visit.

Mud Creek Canyon (pl. III), the only one likely to be seen by the ordinary visitor to Shasta, is not easy to cross except near the mouth of Clear Creek, which comes into it from the east. Its east bank is a precipitous single slope about 1,000 feet in height. Its west bank, except above timberline, is broken by a forest-covered terrace or bench, and both descents are likewise steep, though less difficult than the opposite side. The canyon of Ash Creek is better timbered and a little less precipitous than that of Mud Creek. The canyons of Bolam and Whitney creeks, like that of the upper part of Mud Creek, are terrific naked chasms, very deep and so steep that in most places the loose material of their sides will not sustain the weight of a man—much less that of a horse—and when disturbed dashes in avalanches to the bottom.

Diller Canyon is peculiar (pl. II). It is a tremendous gash on the west side of the otherwise symmetrical cone of Shastina, which it cleaves from top to bottom before taking its practically straight westerly course down the rest of the mountain. It is the only canyon on Shastina, the only notable one on the west side of Shasta, and the only one anywhere on the mountain that does not emanate from a glacier. Its stream comes from enormous banks of perpetual snow.

While the upper parts of the canyons are exceedingly steep and barren, and practically devoid of vegetation, the middle and lower parts are invaded by the trees of the adjacent slopes, and in marshy and springy spots contain patches of willows, alders, and a multitude

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SOUTHEAST SLOPE OF SHASTA, SHOWING CANYONS OF MUD AND CLEAR CREEKS.
(KINDNESS OF J. S. DILLER.)

of smaller plants. These places, in Mud Creek and Ash Creek canyons, are the homes of the mountain showt'l or sewellel (*Aplodontia major*), a curious bob-tailed rodent resembling a large muskrat, which lives in a labyrinth of subterranean passages in wet ground, and cuts and drags to its burrows bundles of coarse plants on which it feeds. Weasels (*Putorius arizonensis*) are usually found in the aplodontia colonies and it is safe to assume that their presence there is the most serious factor in the life of the rightful owners of the land.

STREAMS.

The streams that come from glaciers are rapid, turbid, and muddy, and have cut deep V-shaped canyons down the steep slopes of the mountain. Those that come from melting snow are clear as crystal

FIG. 10.—Heather meadow on upper Squaw Creek, showing concentration of vegetation near stream.

and usually flow on the surface or in shallow channels hardly more than a foot or two in depth. They are smaller and less constant than those from the glaciers, and in times of high water carry so much gravel and pumice that they often block their own shallow channels and overflow, cutting new courses near the old ones. During the fluctuations incident to the irregular melting of snow they often reopen the older channels and at the same time retain the new, so that on the higher slopes it is not unusual for a mountain rivulet to occupy several beds at the same time. These are commonly separated by intervals of a few feet or a few rods, and the spaces between are often covered with patches of red heather, dotted with flowering plants of many kinds.

The banks of the more permanent streamlets are so well supplied with moisture that the heather and other plants, often mixed with alpine mosses,[1] form a sod which, growing thicker each year, gradually comes to overhang and finally bridge the swiftly running water. Even away from these sod bridges, which for long distances completely hide the water, the space between the constantly protruding banks is so narrow that only the middle part of the stream can be seen.

The icy rivulets abound in cascades, miniature waterfalls, and crystal pools, bordered by overhanging banks of moss, heather, and dwarf alpine laurel, and adorned by the waving heads of the scarlet painted

FIG. 11.—Miniature cascade on upper Squaw Creek, frequented by water shrews and ouzels.

cups and cream-colored parnassias. They are ideal homes for the water ouzel (*Cinclus mexicanus*), the large water shrew (*Neosorex navigator*), and the mountain vole (*Microtus mordax*). The latter animal is particularly abundant, and its dark burrows, almost hidden among the plants, may be found opening out on the vertical overhanging banks only a few inches above the water, so that whenever the occupants come out they may plunge in the icy stream before proceeding on their journey. Minks occur lower down along the streams, and still lower, otters.

[1] The prevailing moss on the banks of the alpine streams is *Aulacomnium androgynum*.

ROCK SLOPES.

The whole upper part of the mountain between the glaciers and snow banks above and the forest belt below consists of bare rocky slopes, broken at intervals by precipitous cliffs and small heather meadows. The slopes are largely pumice sand, strewn and mixed with fragments of gray volcanic rock, among which the individual plants are so scattered as to disappear in the general view.[1] White-footed mice (*Peromyscus gambeli*) are common on these slopes, feeding on seeds of *Polygonum newberryi* and other timberline plants. Pocket gophers (*Thomomys monticola*) occur here and there and throw up their characteristic mounds in the pumice sand between the rocks. They subsist on the tough roots

FIG. 12.—Characteristic rock slope on north side of Shastina.

of alpine plants, and were observed at intervals up to an altitude of 9,000 feet. The pika or rock cony (*Ochotona schisticeps*) inhabits steep rock slides at distant points around the peak, and lays up stores of plants for winter use. Another mammal inhabiting the rock slides

[1] The commonest plants of the bare stony pumice slopes are: *Agoseris monticola, Antennaria media, Arabis platysperma, Chænactis nevadensis, Chrysothamnus bloomeri, Cymopterus terebinthinus, Eriogonum polypodum, E. pyrolæfolium, Erigeron compositus trifidus, Hulsea larseni, H. nana, Lutkea pectinata, Lupinus 'ornatus,' L. lyalli, Pentstemon menziesi, Phlox douglasi diffusa, Polygonum newberryi, P. shastense, Saxifraga tolmiei, Senecio canus, Silene grayi, S. suksdorfi, Spraguea umbellata, Streptanthus orbiculatus,* and *Viola purpurea.* Besides these, several ferns occur very sparingly on the rock slopes. These are *Dryopteris aculeata scopulina, Cystopteris fragilis, Cheilanthes gracillima,* and *Phegopteris alpestris.*

and cliffs, but for some unaccountable reason even rarer than the cony, is the bushy-tailed wood rat or pack rat (*Neotoma cinerea*), which, if my memory serves me correctly, is less common on Shasta than on any other mountain I have visited in the West. The mountain chipmunk (*Eutamias senex*) and golden ground squirrel (*Callospermophilus chrysodeirus*) inhabit the tongues of pines on the ridges, and not infrequently live in burrows among the bare rocks. Marmots, it is safe to assert, are altogether absent. We completely encircled the peak in the neighborhood of timberline, and examined innumerable ledges and rock slides, such as on other mountains are inhabited by marmots, but without finding so much as a track or sign or even a bleached bone to indicate that any member of the genus *Arctomys* had ever inhabited Shasta. In former days the bighorn (*Ovis canadensis*) was common here, but now the occasional fragment of a skull or the scattered parts of a skeleton are all that remain. In fall the old bucks of the Columbia black-tail deer wander up on the higher ridges. Here and there, particularly in the shelter of the prostrate white-bark pines, tracks and dung of rabbits were seen, but in spite of all our efforts no member of the party succeeded in finding a rabbit on the mountain. The species is probably the Sierra rabbit (*Lepus klamathensis*), though from the large size of some of the dung pellets I was inclined to suspect the presence of *Lepus campestris.*

AVALANCHES.

During the loosening of the snow in spring, avalanches must be very common on the higher slopes, and it is probable that they exert a controlling influence in determining the timber areas above the limit of continuous forest. Nothing forces itself on the observation more firmly than the peculiar way in which the white-bark pines are restricted to the long radiating ridges where they form narrow tongues, separated by broad intervals of steep slopes and basin-shaped valleys. While it might be hazardous to assume that the absence of trees from these extensive slopes and basins is due mainly to avalanches, the fact remains that the tracts they occupy along the tops and upper slopes of the ridges are entirely out of reach of these resistless engines of destruction.

Now and then, however, an avalanche, taking an unusual course, reaches the outskirts of one of these tongues of alpine pines and snatches up and carries below all that lie within its path. This is evident from the weathered trunks and roots often found at the bottoms of slopes where trees have never grown.

The most conspicuous path of a recent avalanche observed is on Cold Creek, between the deep canyons of Mud and Ash creeks (fig. 13). Here an avalanche of unusual size must have shot down the higher slopes until it reached the upper edge of the continuous forest of Shasta firs where, instead of stopping, it cut a broad swath through the huge trees, tearing them up by the roots or snapping them off and carrying them on over an almost level tract with such resistless force that the few now left standing are deeply scarred at a height of 10 to 15 feet above the ground, showing where they were struck by other trees in passing over the deep snow. Hundreds of huge trunks 75 to 100 feet long and 3 or 4 feet in diameter are strewn in desolate confusion over the broad area that marks the place where this terrific avalanche slowed up and finally stopped. The accompanying illustration shows a part of this area, and also the gate cut by the avalanche when it struck the upper edge of the forest.

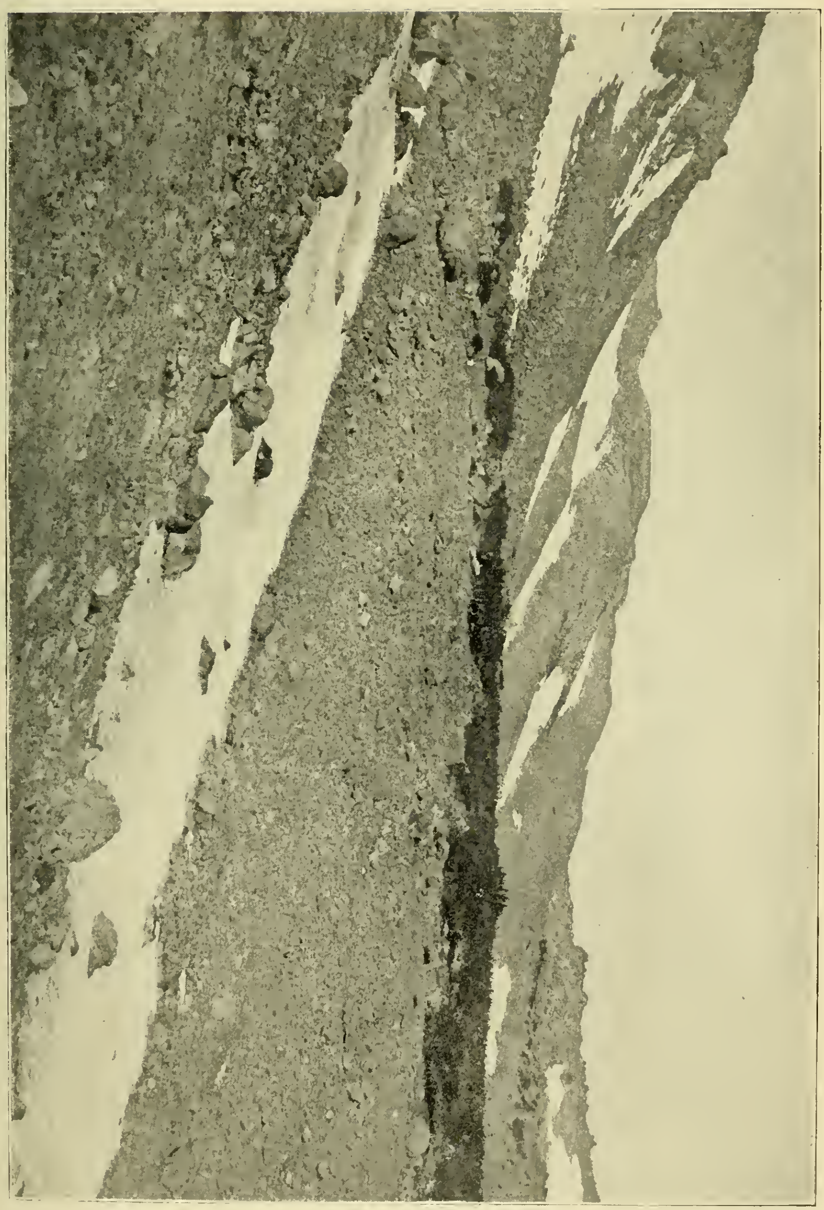
FIG. 13.—Track of avalanche invading forest of Shasta firs on Cold Creek, east side of Shasta.

TIMBERLINE.

Timberline is the upper or boreal limit of tree growth, as determined by temperature. It varies somewhat according to the particular species of tree, for even Hudsonian species differ in the degree of cold they are able to endure. Thus in the northern Cascades where the alpine hemlock and alpine fir are the dominant timberline trees, the fir pushes up to higher altitudes than the hemlock. So on Shasta, where the alpine fir is replaced by the white-bark pine, the latter is the true timberline tree and always attains higher elevations than the hemlock.

Theoretically, nothing is easier than tracing timberline on a mountain whose upper slopes are bare or dotted with alpine flowers and whose middle slopes support a continuous forest. Yet on Shasta, and on most high mountains, it is exceedingly difficult to fix the boundary of timberline or indicate its exact position on a map. Of course, it is possible to follow the uppermost trees wherever they may lead, but a map showing such a route would resemble a saw from which alternate teeth had been removed, the remaining teeth indicating the way the dwarf trees push up on the summits of ridges, the broad spaces between the teeth, the treeless gaps, usually the intervening valleys or basins. Trees always occur at some point in the bottoms of these valleys, and usually extend completely across them, but at an altitude a thousand feet or more lower than that reached on the ridges, and there is a material difference in the trees themselves. If of the same species, those in the valleys are much larger and taller; if of other species, as is frequently the case, they belong to the upper part of the belt below—the middle forest belt. On Shasta, the trees that push up highest on the ridges are always the dwarf white-bark pines, while as a rule those that bridge the intervening valleys below are full-grown alpine hemlocks or Shasta firs, the upper limit of which must not be mistaken for timberline. The difficulty lies in determining what ought to be considered true timberline, and the reason why in the absence of obvious barriers the white-bark pines do not fill more than a third or a fourth of the belt to which they properly belong. If a mountain could be found whose upper slopes form a true cone instead of a series of alternating ridges and valleys, so that successive transverse sections would be circular in outline, instead of irregularly scalloped, it is probable that timberline would form almost a true circle around the peak, rising a little on the southwest and dipping down a little on the northeast. But in the absence of such ideal conditions, actual visible timberline is usually confined to the borders of the tongues of dwarf trees that occupy the summits of the radiating ridges (pl. IV). The explanation of the absence of trees from the intervening valleys is not always easily found; still, if the valleys are studied with reference to the details of their several slope exposures and other local conditions, the position of the hypothetical timberline, in most cases, will be obvious. Let us take, for instance, one of the numerous glacial basins on the south side of Shasta, bordered on each side by lofty ridges which are capped by tongues of white-bark pines. The bottom of the valley, whenever its axial slope is steep enough to be regularly swept by avalanches, can not, of course, contain trees. The broad basin slope of the ridge on the west faces east and is in its own shadow in the afternoon; as a consequence it is too cold for trees, but is well sprinkled with alpine plants. Its summit is covered with dwarf white-bark pines, which come up from the other side and end abruptly along its eastern crest. The cold eastern slope is, in its zone position, actually above timberline, although the tongue of dwarf trees along its crest may stretch up a thousand feet above the lowest alpine plants.

On the opposite or eastern side of the basin the slope faces west or southwest, and receives the warm rays of the afternoon sun. The



TONGUE OF DWARF WHITE-BARK PINES AT EXTREME UPPER LIMIT OF TIMBERLINE.
(Kindness of J. S. Diller.)

result is that this slope, unless too steep or otherwise unsuited to tree growth, or within the track of avalanches, is commonly covered with white-bark pines. As a rule the timbered area on these westerly slopes takes the form of a broadening tongue, beginning at the highest altitude attained by trees on the crest of the ridge and increasing in width at lower altitudes until the bottom of the valley is reached and skirted, and the limit of avalanche movement passed, when the trees again strike out boldly. The pines in the basins are much larger and more erect than those on the summits of the ridges; they decrease in size with increase in elevation. The long oblique line which on the west side of each ridge marks the lower limit of tree growth commonly

FIG. 14.—High timberline ridge, showing effects of slope exposure. The dark patches on the left (west) side of the ridge are dwarf white-bark pines. (Photographed by John H. Sage.)

marks also the upper limit of the area in shadow during the late afternoon. In local spots other factors may account for the absence of trees. Thus, they are always absent from the avalanche-swept bottoms of the valleys, and from ground kept wet by springs or melting snow. Studied with these facts in view, comparatively few treeless areas will be found which can not be explained, and the position of true timberline may be fixed with some degree of certainty. This is really a very important matter inasmuch as it affects the zone position of a great many species.

It is necessary to remember that the reason trees are absent from the cold east and northeast slopes of the ridges whose summits are covered with dwarf trees is that these slopes are in their zone position truly alpine and above timberline, as already explained.

Nothing is easier than to refer to the wrong zone species found in the treeless basins between the pine-covered ridges. But when it is understood that parts of each basin, regardless of the distance below the highest tongue of timber, are unquestionably *above* timberline (and consequently *Alpine*) and that other parts, regardless of the distance above the nearest trees in the basin, are unquestionably well *below* timberline (and consequently *Hudsonian*), mistakes of this kind will be less frequent.

THE FORESTS OF SHASTA.

Shasta rises from a forested region (pl. V), and the mountain itself is continuously forest-covered up to an altitude of 7,500 or 8,000 feet. The trees of the lower slopes are those of the surrounding region, but those of the middle and upper slopes belong to such widely different species that it is necessary to divide the mountain forest into three belts, which, from their most distinctive trees, may be designated (1) the lower or yellow-pine belt; (2) the middle or Shasta fir belt, and (3) the upper or white-bark pine belt. It is interesting to observe that these forest divisions, as shown later, coincide with the three Life zones—the Transition, Canadian, and Hudsonian.

(1) The Lower Belt or Belt of Yellow or Ponderosa Pines (*Pinus ponderosa*).

The most abundant and characteristic tree of the lower slopes and surrounding region is the yellow or ponderosa pine, which forms a continuous open forest up to an altitude, on the south and west sides, of about 5,500 feet. The only material gap in the pine belt of the mountain proper is a strip about 8 miles in length on the cold northeast quadrant, which is occupied by lodge-pole pines belonging to the zone above (Canadian zone).

On the south and west the open pine forest of the basal slopes is interrupted by extensive parks, which from a distance appear to be meadows of waving grass. A nearer view shows this to be an illusion, the broad fields of green being in reality impenetrable thickets of chaparral—a chaparral of unyielding manzanita and buck brush (*Arctostaphylos patula* and *Ceanothus velutinus*, see fig. 15).

Northwest of Shasta the yellow-pine forest is interrupted by the open plain of Shasta Valley, which on the southwest ends abruptly at the town of Edgewood. North, northeast, and east of Shasta the ponderosa pine forest continues with unimportant interruptions to Devils Garden, Goose Lake, and the Madeline Plains; on the south it is practically continuous to the base of Lassen Butte, and thence along the flanks of the Sierra for 350 miles; on the southwest it follows the canyon of the Sacramento River to a little below Delta, where, in the bottom of the canyon and on its warmer slopes, the curious digger pines of the Upper Sonoran zone mix with and soon replace the ponderosa pines

PINE FOREST AT WEST BASE OF SHASTA

Showing yellow and sugar pines.

of the Transition zone. On the cooler and higher canyon slopes and adjacent foothills the ponderosa pines continue to the border of the Sacramento Valley. West of Shasta they cover all but the highest elevations of the Scott Mountains, completely surround Scott Valley, and reach up a considerable distance over the east arm of the Salmon Mountains, where, mixed as usual with Douglas firs, incense cedars, and sugar pines, they fill the Transition zone. Still farther west they occur in greater or less abundance in the valleys of Russian Creek, North and South forks of Salmon River, Trinity River, and Klamath River, and at appropriate altitudes on the west arm of Salmon Mountains, Trinity Mountains, and the mountains between Hoopa Valley and Redwood Creek. Hence the Shasta forest of ponderosa pines is

FIG. 15.—Manzanita chaparral on south slope of Shasta.

directly continuous—either broadly or by narrow and tortuous tongues—with corresponding forests of southern Oregon, northeastern California, northwestern California, and the flanks of the Sierra.

The ponderosa pines of the Shasta plateau and adjacent region are peculiar—peculiar in the extent of their variability—and deserve careful study. Not only do the cones of adjacent trees present an unusual degree of variation in size and compactness (particularly noticeable in Scott Valley), but the cones of trees subjected to apparently slight differences of temperature, moisture, and soil present certain average differences that are quite surprising. Moreover, on higher parts of the Scott Mountains, and also along their cool east base, fairly typical *Pinus jeffreyi* grows within a short distance of *ponderosa*. Whether or not the two actually intergrade, while an interesting question, is of little consequence compared with the fact that here, as in the Sierra, the two trees occupy adjoining but distinct belts—*ponderosa* the warmer and normally the lower; *jeffreyi* the colder and normally the higher. It sometimes happens, however, as in places along the cold east base of the Scott Mountains, where local conditions produce abnormal temperatures, that a strip of Jeffrey pine is sandwiched in between two areas of ponderosa pine. In this instance the low temperature comes in part from the cooling effects of cold streams, and in part from the afternoon shadows of the mountains.

The ponderosa forest is nowhere pure over any large area, but is sprinkled in varying proportion with sugar pines, incense cedars, Douglas firs, and white firs, and at lower altitudes with black oaks. The stately sugar pines are so valuable for lumber that the best have been already cut, but enough remain to show that the species was formerly common in most parts of the ponderosa forest. The incense cedars also are scattered over the whole region, but the Douglas and white firs require more moisture and consequently are less evenly distributed. They are most abundant on the borders of streams, in cool canyons, and along the well-watered east base of Mount Eddy and the Scott Mountains, where they become the dominant trees, the ponderosa pines being comparatively scarce. On drier and warmer soil, away from the cooling influence of the Scott Mountains, the ponderosa pines rapidly increase, and in the area between Black Butte, Shasta Valley, and the mountain, although sprinkled with incense cedars and black oaks, they form the purest ponderosa forest of the region.

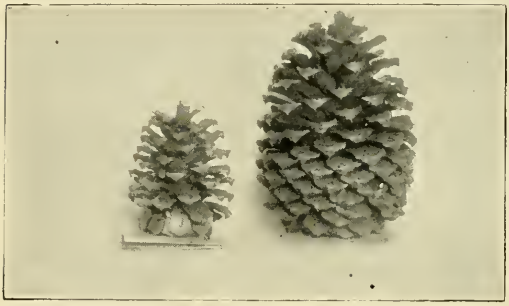


FIG. 16.—Cones of ponderosa and Jeffrey pines.

Another conifer of the yellow-pine belt is the knobcone pine (*Pinus attenuata*), a narrow interrupted tongue of which pushes up Panther Creek. The deciduous trees of this belt are the black oak (*Quercus californica*), Oregon maple (*Acer macrophyllum*), tree alder (*Alnus tenuifolia*), and Oregon dogwood (*Cornus nuttalli*). The maple and dogwood are restricted to the lowest levels and do not occur in very dry places; the alders are confined to the neighborhood of water; the oak ranges more widely over the lower half of the pine belt and thrives on dry as well as on moderately moist soils.

The conifers will be considered as individual species.

SUGAR PINE (*Pinus lambertiana*).—The sugar pine is the largest, handsomest, and noblest of our western pines, and its wood is so valuable for lumber that, except in inaccessible places, the best trees have been cut. The huge trunks, often 6 or 7 feet in diameter, rise as straight symmetrical pillars to a height of 150 or 200 feet, and are covered with fine beautiful bark. The long and graceful branches are usually confined to the upper parts of the trees, and the cones they carry are the longest known, frequently attaining a length of a foot and a half and sometimes of 2 feet. They are very light, however, and when falling are by no means so dangerous to the passer below as the shorter and more massive cones of the digger pines.


FIG. 17.—Knobcone pine on Panther Creek.

Around the base of Shasta the sugar pines reach from a point on the northwest slope about 4½ miles southeast of Edgewood, near the south end of Shasta Valley, southerly and westerly all the way around to Ash Creek, where they cease at an altitude of about 5,000 feet. They are fairly common in McCloud Valley and at Sisson, whence they extend south along the Sacramento Canyon to 'The Loop.' They are at present more abundant in the neighborhood of Black Butte than elsewhere about the mountain. In the Shasta region they are not so large as on the west slope of the Sierra in central California; still the stump of a sugar pine measured by me in McCloud Valley was 7 feet 7 inches in diameter 6 feet above the ground.

KNOBCONE PINE (*Pinus attenuata*, fig. 17).—The knobcone pine is a tree of erratic distribution. On Shasta it is confined to the lower slopes on the south side, from Panther Creek easterly to a point between the branches of Mud Creek, where it ranges irregularly from an altitude of 3,800 up to 5,600 feet. The latter limit is attained in a gully a little east of Wagon Camp, in a continuation of the Panther Creek strip. Lower down on Panther Creek, where the original forest of ponderosa and sugar pines has been removed by the combined work of lumbermen and forest fires, and the slopes are now covered by an impenetrable jungle of manzanita, this singular pine remains, commonly growing in narrow lines. The trees are rarely more than 50 feet in height, and most of them are much smaller. They bear a marvelous load of slender curved cones, which on the limbs grow close together in whorls or rows, and on the trunks are scattered or grow in circles. They remain on the trees for many years, as in the case of few other species, and their large size, extraordinary numbers, and peculiar arrangement give the tree a singular and unusual appearance.

Vernon Bailey has given me the following note on some knobcone pines examined by him on Panther Creek, September 27, 1898:

> The trees were loaded with cones, in whorls of three to seven around the branches, and down the trunks to 10 or 12 feet from the ground. Some of the cones must have been 20 or 30 years old, and perhaps much older. I cut off a lot of the old lower cones to see if the seeds were good, and put them on a bowlder and cracked them with a few hard blows of the ax. All of them were full of worm dust, with only now and then an undiscovered seed or a fat white worm. Cones of medium age (5 or 6 years back from the end of the branch) were invariably occupied by worms and worm dust, and usually contained few good seeds. Cones only 1 or 2 years old were rarely wormy. A great many of the old cones had been dug into by woodpeckers, either for seeds or, more likely, for the fat white grubs that live on the seeds. The cones are too hard to be broken or split apart by the woodpeckers, and are opened by a smooth hole drilled into the middle, or sometimes to the opposite wall. Usually the opening is long and narrow. Sometimes the whole inside of the cone has been drilled out, leaving only the shell; sometimes a small round hole has been drilled just through the outer shell.

White Fir (*Abies concolor lowiana.*)—The white fir ranges from Sisson, at the bottom of the west slope of Shasta, up to the lower edge of the Shasta fir belt, which it slightly overlaps. At Wagon Camp (fig. 1, alt. 5,700 feet) both species are common. The white fir requires more moisture than the other conifers of the lower timber belt, and consequently its distribution is discontinuous. It is most abundant along the well-watered eastern base of Mount Eddy, north of Sisson. The highest elevation at which it was observed is a warm ridge on the east side of Mud Creek Canyon, between the mouths of Mud and Clear creeks, where, with a number of other Transition zone species, it occurs at an altitude of 6,700 to 7,000 feet. This is 1,000 feet above its usual limit, and its presence here is due to the angle and steepness of the slope, as explained elsewhere (p. 49).

Abies lowiana is easily distinguished from *A. shastensis* and *A. magnifica* by the bark, which is very thick and deeply furrowed, so that it resembles that of Douglas spruce (*Pseudotsuga mucronata*) much more closely than that of the other *Abies* of the region. The cone scales are broad and rather short, and the bract is short and tricuspidate (fig. 19).

Douglas Fir or Spruce (*Pseudotsuga mucronata*).—Douglas fir is scattered irregularly through the ponderosa pine forest. Like the white fir, it prefers a moister soil than suits the ponderosa pines, and therefore thrives best in the gulches and near the streams. Thus along the cool well-watered east base of Scott Mountains the forest consists mainly of Douglas and white firs, with scattered incense cedars and sugar and ponderosa pines, while on the drier ground a little farther east the pines increase and the firs decrease or disappear. Most of the larger trees on the south and west slopes have been cut for lumber. A stump near McCloud Sawmill measures, at 6 feet above the ground, 8 feet in diameter.

INCENSE CEDAR (*Libocedrus decurrens*).—The incense cedar occurs in greater or less abundance in all parts of the ponderosa forest, on both dry and wet ground, and from the bottom of the valley at Sisson

FIG. 18.—Incense cedar on south slope below Wagon Camp.

up to the edge of the Shasta firs at Wagon Camp. But it is commonest near the cool east base of the Scott Mountains. In moist places the trees often grow in groups, but in the dry forest they are usually scattered at intervals among the pines. On Shasta the bark of the cedars is generally smooth and free from scales, except on the very youngest trees. In the more humid area between Scott Mountains and the coast the scaly bark persists for many years, so that the trunks of middle-aged trees look very different from those of corresponding size in the dry interior.

(2) **The Middle Belt or Belt of Shasta Firs** (*Abies shastensis*).

Above the forest of ponderosa pines, and therefore not connected with similar forests elsewhere, a belt of Shasta firs averaging 2 or 3 miles in breadth and 2,000 feet in vertical range completely encircles the mountain. It is the distinctive forest of Shasta—a forest of tall stately trees, dark, somber, and free from underbrush, though here and there beds of the low mountain manzanita (*Arctostaphylos nevadensis*) afford a pleasing relief from the uniform dark brown of the surface carpet—usually a shallow layer of fir needles mixed with decayed cones and wood. The massive trunks, which on the steep slopes are often swollen just above the ground to give greater strength to resist the pressure of snow, average from 4 to 6 feet in thickness and some attain a diameter of 7 or 8 feet. Above the level of winter snow their northern sides are usually covered with the handsome bushy yellow lichen, *Evernia vulpina*, which also clothes many of the branches; and in the denser parts of the forest the trees are draped with pendant masses of the long black-beard lichen, *Alectoria fremonti*. The forest almost everywhere consists of large mature trees, and is free from evidences of fire; but in one place, between Mud Creek Canyon and Cold Creek, a considerable area, evidently an old burn, is covered with young trees averaging perhaps 20 feet in height.

As a rule, the Shasta firs stop abruptly where the white-bark pines begin, and trees at their upper normal limit are of full size. But now and then on the steep and relatively warm southwesterly slopes of the ridges, dwarf Shasta firs occur. The highest point at which such were observed was at an altitude of 8,900 feet on the east rim of Mud Creek Canyon, where a few stunted trees 3 or 4 feet in height were found mixed with white-bark pines. On a similar warm slope west of Squaw Creek a scattered line of these trees was noted at an altitude of 8,100 to 8,300 feet. Here the largest were 20 feet in height. Their bark differed materially from that of trees lower down, being pale grayish instead of dark brown, and thin, smooth, and full of blisters, instead of thick and deeply furrowed. These fir trees were mistaken for another species until I had the good fortune to find a few bearing cones, which, on August 1, were two-thirds or three-fourths grown. To my surprise, they had long exserted bracts which, as in the young cones, stood straight out horizontally. Very young cones (2 to 3½ inches long) always appear to consist of bracts alone, the scales being hidden inside. On breaking open the cones the tiny scales are seen encircling the axis; they are less than half the size of the bracts and occupy the inner half of the diameter or section of the cone.

The normal bark of the Shasta fir resembles that of the alpine hemlock. It is rather regularly furrowed vertically, and the plates between the furrows are cracked horizontally, so that it suggests that of the ponderosa pine, though the plates are smaller and less red. Along the lower edge of the Shasta fir belt the bark is darker and the cracks and furrows are narrower.

The upper edge of the Shasta fir belt meets the alpine hemlocks and white-bark pines of the belt above; the lower edge the ponderosa pines, incense cedars, Douglas spruce, and white firs of the belt below. The firs are easily distinguished by bark, branches, and cones. The Shasta fir has very dark and relatively thin bark, regularly furrowed so as to form 'plates' like those of the ponderosa pines, only smaller, narrower, and transversely cracked. The branches are irregular, droop at first (from the weight of winter snow), and then curve upward, and the branchlets are small and terete, and stand out with mathematical precision; the cones are huge, and their green, tongue-like, single-pointed bracts protrude far beyond the scales, as in the noble fir of the northern Cascades. In young cones the bracts stand out straight; in old cones they are strongly deflexed. The white fir (*Abies lowiana*) has much thicker and grayer bark, deeply furrowed at base and not forming regular scales or plates; the branches are more regular and more nearly horizontal, the branchlets flatter, more spreading, and lacking the mathematical lines of the Shasta fir; the cones are more slender, and the tricuspidate bracts are short, reaching less than half-way across the scale. The cone-scale differences are shown in the accompanying diagrams. (See fig. 19.) The year 1898 was an 'off year' for cones, but plenty of old scales were found on the ground, and broken cones were discovered in holes in logs, where they had been carried by pine squirrels.

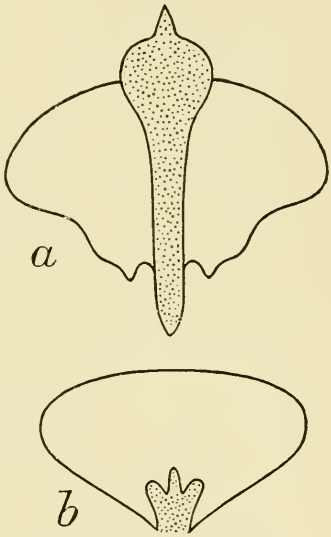


FIG. 19.—Cone scales of (*a*) *Abies shastensis* and (*b*) *Abies concolor lowiana*.

The Shasta fir forest is mainly pure, but in places, particularly on the east and northeast sides of the mountain, silver pines are scattered through it, and in one place along its lower border (between Ash and Inconstance creeks) the firs are replaced by lodge-pole pines, the only ones on the mountain.

Whether or not *Abies magnifica* occurs on Shasta is a question on which we can throw no light. I do not know how to tell *magnifica* from *shastensis* except by the cones, and the trees did not bear cones the year of our visit.[1] Still, we found great numbers of old cones tucked away by the squirrels in decayed logs, and disconnected scales under most of the trees where search was made, and among all these failed to find a single bract which was not strongly exserted. And yet Miss

[1] While this paper was passing through the press (July, 1899), Walter K. Fisher revisited Shasta. He found the firs heavily laden with cones, and although thousands of trees were examined he failed to find a single cone without the exserted bracts.

Alice Eastwood showed me, in the herbarium of the California Academy of Sciences, a cone, said to have come from Wagon Camp, in which the bracts, except a few at the base, are not exserted.

SILVER PINE OR MOUNTAIN WHITE PINE (*Pinus monticola*).—Silver pines occur here and there on Shasta, scattered among the Shasta firs. They were found in greatest abundance on a pumice slope south of Brewer Creek Canyon, where they are the dominant trees up to an altitude of 7,200 feet, and where the ground was strewn with cones of the previous year—cones in which the scales are strongly reflexed.

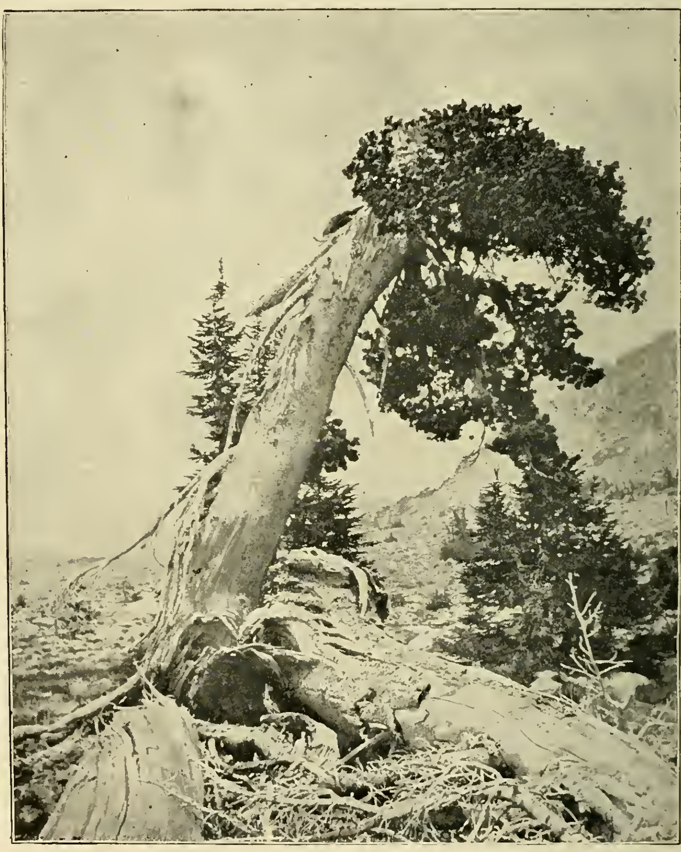


FIG. 20.—White-bark pine (*Pinus albicaulis*).

In this area, along Brewer Creek, they meet and slightly overlap the alpine hemlocks and white-bark pines of the zone above. They are common also on the steep lava ridges on the north side of Shasta, particularly in the neighborhood of Inconstance Creek and in Mud Creek Canyon, especially on the west side of the ridge between Mud and Clear creeks. A few trees occur near the top of Red Cone, east of Wagon Camp.

LODGE-POLE PINE (*Pinus murrayana*).—The lodge-pole pine was not found on Shasta except on the northeast quadrant, where Vernon Bailey, in following the wagon road around the mountain, passed through a belt of it about 8 miles in length. It begins 3 miles northeast of Ash Creek at an altitude of about 5,400 feet and reaches northerly to about 3 miles northwest of Inconstance Creek, where it ends abruptly at an altitude of 5,600 feet. Here it is the dominant tree, and in half of it the only tree. This area is covered during the latter part of the afternoon by the shadow of the mountain, and consequently is colder than places of equal altitude farther north or south. The soil is sandy and barren and the trees are of small size.

(3) The Upper Belt or Belt of White-Bark Pines (*Pinus albicaulis*).

Still above the forest of Shasta firs, braving its way upward over the bare rocky ridges into the very teeth of the domain of perpetual snow, is another timber belt—an open belt of straggling, irregular trees, whose

FIG. 21.—Dwarf white-bark pines on a high ridge.

whitened, twisted trunks with their storm-beaten heads of green are among the most weirdly picturesque objects on the mountain (fig. 20). The tree is the timberline white-bark pine, which, wherever found, pushes its way over steep and barren slopes to the extreme upper limit of tree growth.

At the lower part of its range it forms an almost continuous though narrow belt around the mountain, and often attains a height of 30 or 40 feet and a diameter of 2 feet. In the higher parts of its range it soon becomes restricted to the ridges, leaving the intervening basins and gulches bare, and as it climbs higher and higher becomes more and more reduced in size and undergoes material changes of form and position. At certain altitudes the slanting trunks, only 4 or 5 feet in height, serve as pillars to support the flattened tops which form a canopy of intertwined and matted branches (fig. 21).

These dwarf groves offer attractive shelters from wind and storm, and we usually camped among them when working the upper slopes.

The tree is one of exceptional hardihood, and as it pushes on still farther into the realm of cold the trunks become completely prostrate and the branches hug the ground, forming among the rocks dense mats which sometimes rise a foot or two above the general level, but at their upper limit usually occupy depressions, or, if growing in the lee of a bowlder, crouch behind it and continue its surface level to the adjacent slope, as if trimmed to fit. Indeed, one is amazed at the way these uppermost pines avoid exposure by flattening themselves into the hollows, as if afraid to lift a finger above the general level. Their life is a perpetual struggle—not against competing plants, but against a hostile environment. In summer they are buffeted by the winds and pelted by sand and gravel; in spring they are swept and torn by the resistless avalanches, and in winter they are deeply buried under heavy banks of snow. The prostrate trunks in young and middle-aged healthy trees are completely concealed, often half covered by stones and pumice sand, and hidden by the density of their own branches and foliage; but in very old trees, and those injured by passing avalanches or laid bare by the washing away of protecting rocks during violent storms, the trunks are partly exposed and their extraordinary features may be easily examined. As a rule they are not only naked, but the strongly twisted wood, gnarled, contorted, and, ironlike in firmness, has been eaten into by the sand blast till the knots and hardest parts stand out in prominent ridges.

A little below timberline on the north side of Shasta, between North Gate and Shastina, is an extensive gently sloping pumice plain, strewn with fragments of gray shaly lava, and thickly spotted with rather

FIG. 22.—Pumice plain north side of Shasta, showing timberline mats of white-bark pines.

large mats of pines, averaging 2 to 4 feet in height, which give a most curious aspect to the region (fig. 22). This area, which is about a mile and a half across (horizontally), must contain thousands of acres of the dwarf, flattened pines. Along its lower edge, singularly enough, trees of the same species suddenly stand upright and grow to large size, forming a rather solid forest, perhaps 30 feet in height, with an abrupt front facing the dwarf pines above. The suddenness of the transition is unusual and difficult to explain.

The forest just mentioned is probably the largest continuous area of *Pinus albicaulis* on Shasta. Situated a little below timberline, it stretches, apparently without interruption, from North Gate Buttes to Diller Canyon, a distance of fully 5 miles, thus encircling the northwest quadrant of the mountain, including Shastina.

Perhaps the most attractive grove of white-bark pines on Shasta is one that fills an open gulch or glade on the east side of North Gate Buttes. Here, in the lower part of their belt, the trees are large and uncommonly symmetrical, and the gray pumice soil is covered with silvery lupines. In ascending the gulch the pines gradually decrease in size until at 'The Gate' (alt. 8,500 feet) they are dwarfed and their tops are broadly flattened.

The normal altitudinal limits of the white-bark pines on Shasta are hard to fix. On the south and southwest sides the trees descend in places to 7,500 feet and range thence upward on the hottest ridges to an extreme limit of 9,800 feet. But this extreme altitude is attained at two points only—on the long ridge above 'The [South] Gate' (near Red Butte) and on a ridge about a quarter of a mile west of Mud Creek Canyon. On the west rim of the canyon the pines stop at 9,500 feet

FIG. 23.—A large prostrate tree of white-bark pine, a little below timberline.

and on the ridge on the east side at 8,600. Probably 9,300 to 9,500 would be a fair average for their upper limit on the warmer southerly slopes.

On the cold northeast slope, just south of Brewer Creek, they descend on a barren pumice slope to 7,000 feet, where, sparingly mixed with alpine hemlocks, they meet the upper limit of Shasta firs and silver pines.

Black Alpine Hemlock (*Tsuga mertensiana*[1]).—But the white-bark pine, although the dominant and most widely distributed tree of the upper timber belt, is not the only tree, for in places it is mixed with or replaced by the black alpine hemlock. Shasta is a very dry mountain, and yet the white-bark pine thrives on its driest slopes and grows among the bare, naked blocks of lava where tree life seems impossible. The hemlock requires more moisture, and therefore is at a decided disadvantage. It never reaches as high as *Pinus albicaulis* and attains its best development along the lower border of the Hud-

Fig. 24.—Black alpine hemlocks near Squaw Creek.

sonian zone, where it occurs in disconnected sheltered localities—usually in canyons or on the shady east or northeast sides of buttes or ridges, where there is more moisture than on the exposed slopes. Since these shady easterly slopes are always cold, the hemlocks that occupy

[1] This is the species heretofore commonly known as *Tsuga pattoni* or *Tsuga pattoniana.* It has been recently discovered that the name *Tsuga mertensiana*, commonly applied to the Pacific lowland hemlock, was first given to the present alpine species. necessitating a most unhappy change of name. Fortunately, however, the common English names of the two and their widely different zone ranges—one restricted to the low Transition belt near the coast, the other to the high Hudsonian zone on the loftiest mountains—may prevent the confusion that otherwise would result from the change of name.

them descend in tongues considerably below the usual lower limit of the belt to which they belong. The most extreme case of the kind observed is on the east side of the series of hills and ridges known on the map as 'Gray Butte,' where a gulch, sheltered from the warm afternoon sun and moistened by seepage from melting snows, carries the hemlocks to a lower altitude than they reach elsewhere. On suitable slopes they usually begin about 7,200 or 7,300 feet and range up to about 8,000 feet. The highest altitude at which they were observed is 8,700 feet, a little east of Mud Creek Canyon, where a few stunted trees were found among the white-bark pines. Their extreme upper limit is thus a thousand feet lower than that of the white-bark pines. This is

FIG. 25.—Group of alpine hemlocks near Deer Canyon.

due, in part at least, to the character of the upper slopes, where no trees can grow except on the ridges—as explained under the head of Timberline (pp. 27–30)—and here the ridges are too exposed and too dry for hemlocks.

On Shasta the alpine hemlock does not grow in such luxuriance or attain such dimensions as in the Cascade Range. The average height of mature trees seems to be 80 or 100 feet; the average diameter a little less than 3 feet. Trunks 4 and 5 feet through are by no means rare and the one shown in the accompanying photograph (fig. 26) measured 6 feet. It is a characteristic habit of hemlocks on sloping ground to grow in clusters, 3 to 7 springing from a common base. In this way, when young, they are better able to withstand the pressure of the snow.

Those that grow singly usually support themselves by having the trunks strongly curved downward just above the ground, as shown in fig. 26.

The alpine hemlock is one of the most picturesque and attractive trees of our western mountains. Its beauty is due in part to the handsome trunks and irregular drooping branches, but mainly to the dense and peculiarly tufted foliage which falls in graceful masses in such manner as to conceal the branches and upper parts of the trunks. The twigs or ultimate branchlets curve upward and the needles stand out on all sides and point outward—away from the body of the tree—producing a tufted appearance very unlike that of other conifers. This

FIG 26.—Trunk of alpine hemlock, showing thickening and curvature of base.

effect is heightened during the latter part of summer by the light green tips of the new growth.

The hemlock forest is dark, somber, and silent, and its drooping branches are draped with the dangling beards of the black-beard lichen (*Alectoria fremonti*). The only color that breaks the otherwise uniform darkness is the bright yellow lichen (*Evernia vulpina*) which covers the north or northwest sides of the trunks and upper sides of the branches—a conspicuous feature and one seemingly out of harmony with the general tone of the forest. In all these respects the hemlock forest accentuates the features of the Shasta fir forest of the belt below, with which it is directly continuous. The tree trunks and bark also resemble those of the Shasta firs. The bark is in long scales which, as the trees grow, thicken into irregular plates transversely broken at intervals of 8 to 12 inches.

In the growing tree the branches die from below upward in a curious way. First a subdivision of a low branch dies and the tips curl downward and inward, drawing together until they form a close curl or tail which can be set on fire by a single match. Dozens of these curls can be seen on most of the young trees, and also on the lowermost remaining branches of the middle-sized and some of the old ones. This process of dying and curling continues until all the lower branches are dead. Meanwhile, the curl-tails gradually drop off and litter the ground, leaving the bare dead branches hanging down at a sharp angle. These dead branches hug the trunks closer than the living ones and cling on until the bark comes off, when they form an armature of

FIG. 27.—Group of alpine hemlocks.

unsightly bleached and brittle sticks pointing downward around the trunk. These in time break off, too, so that as the tree grows into maturity the handsome trunk finally becomes clear and clean.

The alpine hemlocks are prolific bearers and the ground is always strewn with their cast-off cones, which average about $2\frac{1}{2}$ inches in length, and have a dark streak down the middle of each scale. When young the cones are conical, when old and the scales become fully reflexed they are slender, subcylindrical and only three-fourths of an inch in diameter. Year after year the cones fall to the ground in such prodigious numbers that they form a very important part in the layer of felting that covers the surface in the hemlock forests—a loose dark felting composed of disintegrating needles, twigs, and cone scales pressed firmly together by the weight of the snow in winter, and only rarely dotted by living plants. In moist spots, particularly along the borders of the tiny sparkling streams, the red heather (*Phyllodoce empetriformis*) forms little beds and the delicate feathery *Lutkea pectinata* spreads a faint veil of green over the dark soil. In the drier parts of the forest hardly a plant is seen save now and then a solitary clump of prince's pine (*Chimaphila menziesi*) or painted wintergreen (*Pyrola picta*).

Late in September the hemlocks molt and the wind brings down showers of needles that falling on the tent at night sound like rain. Their color has now changed from green to golden brown and they sprinkle the black floor of the forest so thickly as to change its appearance.

FOREST FIRES.

During the past ten years the country about Shasta, particularly on the west and south, has been repeatedly devastated by forest fires. Here, as elsewhere, lumbermen and fires have destroyed the greater part of the timber on the lower slopes and adjacent plain, which are now covered by a dense chaparral of manzanita and buckbrush, dotted with scattered pines. Fortunately, the fires have not as yet spread upward far enough to do much damage to the Shasta firs of the middle timber belt. Whether the character of these trees and the freedom of the ground beneath from combustible material will prevent the spread of fire remains to be seen. Thus far the greatest harm has been done in the forests of ponderosa and sugar pines, where lumbering operations are being carried on with painful vigor.

While we were on the mountain, from the middle of July until the end of September, one or more fires, the result of vandalism or neglect, were raging continuously on the south and west slopes, and two of them did irreparable injury. One began near some woodcutters' shanties, 3 or 4 miles below Wagon Camp, on the road to Sisson; the other and more destructive originated in the area covered by the lumbering operations from McCloud Mill and pushed swiftly up the Panther Creek slope, consuming the greater part of the only area of *Pinus attenuata* on Shasta and burning great tongues into the handsome fir forest on both sides of Wagon Camp, which it closely and almost completely surrounded.

The fire that lasted longest in the summer of 1898 did the least harm. It consumed a worthless tract of manzanita chaparral between Black Butte and the mountain, and gave off a surprisingly enormous quantity of smoke, hiding the country to the west for a full month. During its continuance the entire mountain was often enveloped in smoke and when the wind was northwest, as it was a great deal of the time, showers of burned leaves fell daily at our camps. On August 2, when we were at work on the rocky slopes above the head of Squaw Creek at an altitude of 9,500 feet, charred leaves fell so abundantly that we caught many in our hands. Great clouds of smoke rolled up between us and the sun, which became deep red like the full moon and then disappeared. At 5 o'clock the smoke began to settle back, as it always did when the chill of the evening came on, and the sun reappeared, to set as usual behind the dark outlines of the distant mountains.

Fires on the south, in the valley of the McCloud, cut off the view in that direction, and it was only at rare intervals, and usually at sunset, that we were able to see the snowy crown of Lassen Butte 60 miles away. Even Castle Crags, almost at our feet, were rarely visible. This experience is frequent in the west; and of the hundreds of persons who visit the Pacific slope every summer to see the mountains, few see more than the immediate foreground and a haze of smoke which even the strongest glass is unable to penetrate.

Along the railroad between the head of Sacramento Canyon and Shasta Valley one traverses desolate tracts which a few years ago were covered by a noble forest of ponderosa and sugar pines.

EFFECTS OF BURNS IN CHANGING ZONE POSITIONS.

A burn in the lower part of the Shasta fir forest a little above Wagon Camp affords an excellent illustration of the way fires sometimes change the zone relations of particular areas. The area in question was well within the Canadian zone before the fire, which occurred only a few years ago. Since the fire, Transition zone species have crept up the ridge, and now *Ceanothus velutinus*, *Arctostaphylos patula*, *Horkelia pseudocapitata*, *Apocynum pumilum*, *Gayophytum ramosissimum*, and others are common. The manzanita and buck-brush are young and small but are spreading, so that in a few years the ridge, which has a warm southerly slope, will be mainly Transition. But in the meantime a new growth of Shasta firs has started, and in ten or twenty years is likely to overtop and drown out the Transition zone species, enabling the Canadian zone to reclaim the burn.

Such cases of alternation of zones resulting from the clearing of forest land are not uncommon, particularly when deforestation is caused or accompanied by fire. But on steeper slopes, especially rock slopes, if the vegetable layer is burned off, the (lower) zone which creeps up to replace the (higher) one destroyed becomes permanent or nearly so.

It may be laid down as a general rule that the destruction of forests, by admitting the sun and wind, lessens the moisture in the soil and increases the temperature, thus inviting animals and plants to come in from adjacent warmer areas. Deforestation of an area therefore tends to lower its zone position.

SLOPE EXPOSURE.

By slope exposure is meant the inclination of the earth's surface at a particular point with reference to the angle at which it receives the sun's rays. The amount of heat, were it not for the retarding effect of the atmosphere, would be greatest at noon, when the sun's position with reference to the earth is most nearly vertical. But, as everyone knows, the atmosphere becomes heated slowly and does not attain its highest temperature until the middle or latter part of the afternoon, the hour varying with the locality. Hence slopes that face the sun most nearly at a right angle at the time of day when the atmosphere is hottest are naturally the hottest slopes—those that carry the zones highest; while conversely, slopes that face the opposite direction are naturally the coldest slopes—those that depress the life zones lowest. At Portland, Oregon (about 275 miles north of Shasta), the hottest part of the day in summer is a little after 4 o'clock in the afternoon, at which time the sun is nearly due west. Consequently the hottest uncomplicated slopes are those that face west or a little south of west.

The accompanying diagram shows the actual mean hourly march of atmospheric temperature at Portland, Oregon, for June, July, and August:

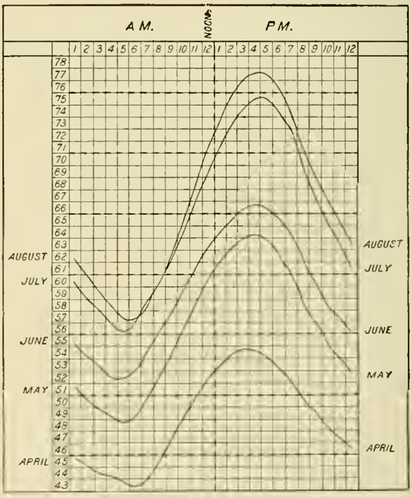


FIG. 28.—Diagram showing average hourly march of temperature.

The influence of slope exposure on the faunas and floras of mountainous regions is profound. Measured by a scale of altitudes, it amounts on ordinary slopes to nearly a thousand feet, and on steep slopes is still more marked. Thus on mountains it is usual for plants and animals of particular species to occur on warm southwesterly slopes at elevations 800 to 1,000 feet higher than on cool northeasterly slopes. Similarly on north and south ridges, the faunas and floras of the warm west slopes often belong to lower zones than those of equal elevations on the cool east slopes.

Shasta affords innumerable examples of the effects of slope exposure, both simple and complicated by canyons.

An excellent illustration of the latter is to be found in Mud Creek

Canyon, near the mouth of Clear Creek (see pl. III). The altitude of the bottom of the canyon at this point is 6,700 feet, which would naturally place it in the middle of the Canadian zone. The steep west side of the narrow ridge between the two creeks receives the afternoon sun at nearly a right angle, and is in consequence an unusually warm slope for the altitude. The result is that seeds of plants carried upward by winds and birds from the Transition zone, more than 1,000 feet below, have here found a favorable resting place and have grown into a colony of Transition zone species, among which are *Abies concolor lowiana*, *Arctostaphylos patula*, *Kunzia tridentata*, *Amelanchier alnifolia*, *Rubus parviflorus*, *Sorbus sambucifolia*, *Symphoricarpos pilosus*, *Ribes viscosissimum*, *R. amictum*, *Sambucus melanocarpa*, *Apocynum pumilum*, *Spiræa douglasi*, *Vaccinium* (*arbuscula?*), *Lupinus elmeri*, *Eriogonum marifolium*, *Gilia aggregata*, *Pteris aquilina lanuginosa*, and the large Transition zone form of *Castilleja miniata*. Just across the canyon, and in one place less than 100 feet from the lower edge of this isolated Transition colony and at a lower level, are species belonging to the Hudsonian zone—such as *Pentstemon newberryi* and *Pulsatilla occidentalis*. Thus, growing close together on opposite slopes of the same canyon, are species characteristic of zones both above and below the one to which the altitude properly belongs. This case is by no means peculiar and is a good illustration of the simpler effects of slope exposure commonly shown in mountain canyons.

Another class of cases is found on the buttes and hills. A mile and a half northeast of Wagon Camp is a conspicuous red cinder cone about 1,000 feet in height, known as Red Cone. In zone position it is well within the lower part of the Canadian belt where it is surrounded by the forest of Shasta firs, scattered trees of which push up on the basal slopes and on the south side reach the top. Just below the summit are a few silver pines belonging to the same zone. The warm southwest slope brings up from the Transition zone below thickets of manzanita, a few incense cedars, and several humbler plants. The cold northeast slope, although reaching an altitude of only about 6,800 feet, which would place it in the middle of the Canadian zone, is cold enough to bring down from the Hudsonian zone several characteristic plants, such as *Polygonum newberryi*, *Cymopterus terebinthinus*, *Cycladenia humilis*, *Eriogonum polypodum*, and *Viola purpurea*.

On the south side of Shasta an interrupted ridge or series of buttes, known collectively as 'Gray Butte,' reaches up the mountain side from Red Cone, east of Wagon Camp. northward to the gap known as 'The Gate.' In a gulch or canyon on the east side of this butte the black alpine hemlock descends more than 1,000 feet below its usual lower limit. The reason is obvious. The row of buttes cuts off the warm afternoon sun, and seepage from melting snows keeps the soil moister than in more exposed places, so that the gulch meets the two requirements of the alpine hemlock—a moist soil and a cold atmosphere. For its entire length this long tongue of hemlock is flanked by Shasta firs from the zone below, so that the usual zone relations are changed, parallel strips of Canadian and Hudsonian running up and down the mountain—instead of encircling it in the usual horizontal belts. Along Squaw Creek another tongue of alpine hemlock descends to the head of the main fall, at an altitude of about 7,250 feet, and is similarly sandwiched between ascending tongues of Shasta firs.

Between 'The [South] Gate' and the grove of alpine hemlocks on upper Squaw Creek is a prominent mass of lava 700 or 800 feet high, known as 'Red Butte.' It is about 2,000 feet below the altitude of extreme timberline and its summit is covered with trees; nevertheless its precipitous northeast side is so cold that its zone position is well above timberline, as shown by the presence there of such distinctively alpine plants as *Oxyria digyna* and *Saxifraga tolmiei*. In this case the

FIG. 29.—Dwarf pines ending abruptly along cold east side of ridge.

effect of a very cold mass of rock is added to that of the coldest slope, and the result is a lowering of alpine zone species 2,000 feet below their normal elevation on the hottest southwest slopes.

The high north and south ridges afford perhaps the simplest example of the direct influence of slope exposure. The warm west sides of these ridges usually bear trees in proportion to the availability of their slopes, while the cold east sides remain naked and alpine (see fig. 14). The way the dwarf pines stop along the east crest of the ridges is shown in the accompanying figure (fig. 29).

Finally, the glaciers of Shasta afford impressive evidence of the effects of slope exposure. My party did not take the altitudes of the glaciers, but according to the Shasta map sheet of the U. S. Geological Survey those on the cold east and northeast slopes descend below 9,000 feet, and one of them, at the head of Ash Creek, below 8,500 feet, while the only one having a south exposure (at the head of Mud Creek) stops at 11,000 feet,[1] and there are no glaciers at all on the west

[1] There is another glacier on the south side, tributary to Mud Creek, which descends lower than the one marked on the map as 'Konwakiton glacier,' but it is completely hidden by a high ridge and is not exposed to the late afternoon sun.

side. Hence if the altitudes to which glaciers descend on the various slopes be accepted as indicating the course of a sinuous line of equal temperature, it follows that the difference in temperature dependent on the angle and conditions of slope exposure, as measured by the glaciers, is equivalent to a difference of upward of 2,000 feet in altitude. But this is doubtless excessive and due in part to local influences.

EFFECTS OF STEEP SLOPES.

Steep slopes, particularly those that face the southwest and west, exaggerate the effects of slope exposure. Those that face the hot afternoon sun at nearly a right angle receive the greatest quantity of heat, but this alone is not sufficient to account for the very extraordinary degree to which the fauna and flora are sometimes affected. When it is remembered that the hottest ordinary slopes carry up the zones only 800 to 1,000 feet, one is startled to find that on some favorable steep slopes they are pushed up more than 2,000 feet above their normal limits. The explanation did not occur to me until, in discussing the matter with the geologist, G. K. Gilbert, he suggested the diurnal ascending current as the missing factor.

It is well known that in ordinary calm weather the air currents on mountain sides and in deep canyons ascend by day and descend by night. The ascending currents are warm, the descending currents cold. The night current, being in the main free from local influences that affect its temperature, must exert an essentially equal effect on all sides of a mountain; but the temperature of the ascending day current, being constantly exposed to and in fact created by the influence of the sun, must vary enormously on different slopes. The activity and effectiveness of this current increases with the steepness of the slope and the directness of its exposure to the afternoon sun. Hence the hottest normal slopes—those that face the sun at nearly a right angle during the hottest part of the day—are rendered still more potent by increased steepness, the direct exposure to the sun keeping up the supply of heat while the steepness of the slope accelerates the rate of movement of the diurnal ascending current, carrying the heated air upward a very great distance before it has time to be cooled by the general temperature of the stratum it penetrates. Thus it is that species characteristic of the Transition zone on Shasta—species which on normal southwesterly slopes attain their upper limits at an altitude of 5,500 to 5,700 feet—are in favorable places enabled to live at elevations of 7,900 and even 8,000 feet, considerably more than 2,000 feet above their normal upper limits.

The steep slopes of Diller Canyon furnish instructive illustrations of the effects of these ascending hot-air currents. Here, on the hot stony pumice slopes, such distinctive Transition zone species as *Arctostaphylos patula*, *Kunzia tridentata*, *Ceanothus velutinus*, and *Chrysothamnus-occidentalis* flourish among the Shasta firs and white-bark pines at an altitude of nearly 8,000 feet in the belt where the Canadian and Hudsonian zones overlap, and more than 2,000 feet above the extreme upper limit of their normal distribution on uncomplicated hot southwesterly slopes.

BASIN SLOPES.

Many of the glacial basins of the timberline region are broad U-shaped depressions with gently sloping bottoms, ending abruptly in terminal moraines, below which they may or may not continue on to other moraines. They were excavated by glaciers at a period when the ice cap of Shasta was much larger and more complete than at present. The upper ends of most of these valleys abut against the steep upper slopes of the peak, and are bordered on both sides by lofty ridges, so that they are walled in on three sides and thus converted into basins. Such basins, when they face the southwest, appear to promote the reflection of heat and retard the escape of hot air, so that they sometimes become hot pockets characterized by species belonging to the zone below.

LIFE ZONES OF SHASTA.

Shasta stands on a Transition zone plane, with a dilute tongue of Upper Sonoran approaching its northern base by way of Klamath and Shasta valleys. Its forested slopes rise quickly through the Boreal zones to timberline, above which its ice-clad summit towers to a height of 5,000 feet. The life zones of Shasta, therefore, beginning with the Upper Sonoran element of Shasta Valley, are—

Upper Sonoran
Transition
Canadian
Hudsonian
Arctic-Alpine.

In a generalized diagrammatic north and south section of the mountain the relations of these zones may be shown somewhat as follows:

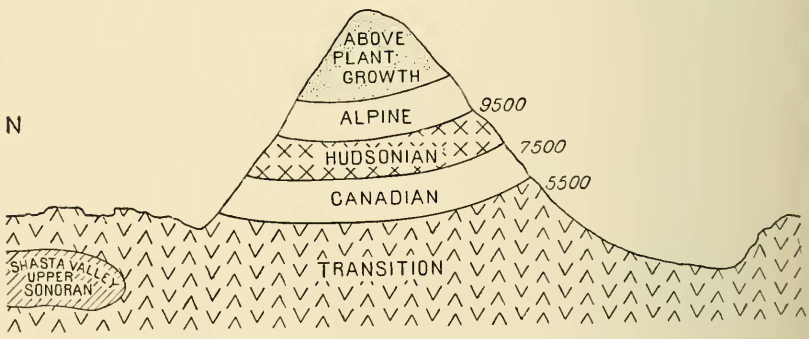


FIG. 30.—Diagram of Shasta showing relations of life zones.

The altitudes of zone boundaries here given are intended to represent their average or mean elevation on normal southerly slopes. The aridity of the mountain as a whole, with consequent scattered or 'spotty' instead of 'continuous' distribution of most of its zone species, complicated by the influences of hot and cold slopes, springs, and air currents, elsewhere discussed, which frequently carry species 1,000 feet or more above or below their normal limits, makes it almost impossible to fix with certainty the normal zone altitudes. Hence those here given must be regarded as approximate only. The average width of the belt of overlapping of adjoining zones appears to be about 800 feet; so that the normal vertical distribution of the distinctive species of each zone overreaches in both directions the altitudes given by about 400 feet.

The zone positions accorded the various species are based on personal field experience, and in the great majority of cases are believed to be correct; in a few instances, however, the evidence is inconclusive—hence the zone lists must be regarded as provisional and subject to correction. Species recently exterminated or driven away, as the mountain sheep, elk, and grizzly bear, are included in the tables.

UPPER SONORAN ZONE.

The Upper Sonoran element in the region about Shasta is dilute and is limited to Shasta Valley at the north base of the mountain, which it reaches by way of the Klamath country on the north and northeast. It has no connection whatever with the Upper Sonoran of the Sacramento Valley on the south, which ends near the point where Pitt River joins the Sacramento, about 50 miles below Shasta.

Shasta Valley is an arid plain about 25 miles in length by 10 or 12 in breadth, studded with small volcanic buttes and lava flows. It varies in altitude from a little less than 4,000 to about 2,700 feet, and is lowest at the north, where the Shasta River, by which it is traversed, flows into the Klamath River. Shasta River is in places bordered by deciduous trees, mainly *Populus trichocarpa*, *Betula occidentalis*, and *Alnus rhombifolia*. The valley is sparsely covered with rabbit brush of several species, mainly *Chrysothamnus occidentalis* and *C. viscidiflorus*, and in some places, chiefly on the east and south, by the true sagebrush (*Artemisia tridentata*). The southeastern part contains an open forest of junipers (*Juniperus occidentalis*), which meets the pine forest of the basal slopes of the mountain. The western part is an open plain very scantily dotted with rabbit brush and a few small and mainly inconspicuous plants, among which were observed: *Mentzelia lævicaulis*, *Xanthium strumarium*, *Heliotropium curassavicum*, *Verbena bracteosa*, *Datura meteloides*, *Sarcobatus vermiculatus* and *Nicotiana sp.?* Along the western border of the valley, near the Scott Mountains, several characteristic shrubs occur, among which are *Ceanothus cuneatus*, *Arctostaphylos* (*viscida?*), *Cercocarpus parvifolius*, *Eriodictyon glutinosum*, and *Garrya fremonti*.[1]

The zone position of this region is further indicated by the presence of such birds as the chat (*Icteria virens longicauda*), bush-tit (*Psaltriparus minimus californicus*), California towhee (*Pipilo fuscus crissalis*), California jay (*Aphelocoma californica*), and California valley quail (*Lophortyx californicus vallicola*). Formerly antelope were common here, but now they are rarely seen. The most abundant mammals are jack rabbits (*Lepus californicus*), sagebrush cottontails (*Lepus nut*

[1] *Garrya fremonti* is both Upper Sonoran and Transition.

talli), kangaroo rats (*Dipodomys californicus*), pocket mice (*Perognathus parvus?*), woodrats (*Neotoma fuscipes*), coyotes (*Canis ochropus*), and raccoons (*Procyon psora pacifica*).

So little work was done in Shasta Valley that the species mentioned are of course only a fraction of those present.

MAMMALS OF UPPER SONORAN ZONE (IN SHASTA VALLEY).

Restricted to Upper Sonoran.

Lepus californicus.
Lepus nuttalli.
Microtus californicus.
Perognathus (parvus?).
Peromyscus truei.
Reithrodontomys klamathensis.

Common to Upper Sonoran and Transition.

Antilocapra americana.
Canis ochropus.
Dipodomys californicus.
Mephitis occidentalis.
Myotis evotis.
Neotoma fuscipes.
Peromyscus gambeli.
Procyon psora pacifica.
Scapanus californicus.
Spermophilus douglasi.
Spilogale latifrons.
Taxidea taxus.
Vespertilio fuscus.
?Zapus pacificus.

BIRDS OF UPPER SONORAN ZONE (IN SHASTA VALLEY).

Restricted to Upper Sonoran.

Catherpes mexicanus punctulatus.
Chondestes grammacus strigatus.
Cyanocephalus cyanocephalus.[1]
Falco mexicanus.
Lanius ludovicianus excubitorides.
Otocoris alpestris merrilli.
Pipilo fuscus crissalis.
Psaltriparus minimus californicus.

Common to Upper Sonoran and Transition.

Aphelocoma californica.
Astragalinus psaltria.
Buteo swainsoni.
Calypte anna.
Carpodacus mexicanus obscurus.
Cathartes aura.
Chondestes grammacus strigatus.
Chordeiles virginianus.
Cyanospiza amœna.
Dendroica æstiva.
Geothlypis trichas occidentalis.
Icteria virens longicauda.
Lophortyx californicus vallicola.
Melanerpes formicivorus bairdi.
Phalænoptilus nuttalli.
Pipilo maculatus megalonyx.
Scolecophagus cyanocephalus.
Speotyto cunicularia hypogæa.
Spizella socialis arizonæ.
Sturnella magna neglecta.
Thryomanes bewicki spilurus.
Troglodytes aëdon parkmani.
Tyrannus verticalis.
Vireo gilvus swainsoni.
Zenaidura macroura.

TRANSITION ZONE.

Excepting Shasta Valley, the Transition zone covers the whole country about Shasta and pushes up over the basal slopes to an altitude of 5,000 or 6,000 feet. To the northeast and east it reaches and extends beyond the Klamath country and Goose Lake in Oregon, and the Madeline Plains in extreme northeastern California, interrupted only by narrow tongues of Upper Sonoran in the upper Pitt River Valley, and by small islands of Canadian on the highest mountain summits.

[1] The piñon jay visits the juniper forests in Shasta Valley in fall to feed on the juniper berries, but whether or not it breeds there is not known.

To the south the Transition zone fills the McCloud and Pitt River valleys, embraces the canyon of the Sacramento, and stretches onward along the flanks of the Sierra all the way to southern California. To the west it overspreads the wild mountain region between Shasta and the Pacific Ocean, changing gradually from Arid Transition to Humid Transition, and surrounding the Upper Sonoran bottoms of Scott and Hoopa valleys, and the Boreal summits of Salmon, Trinity, and Siskiyou mountains. It covers the lower slopes and eastern part of the Siskiyous, and passes around the southern ends of the Salmon and Trinity mountains continuously to the sea.

On the flanks of Shasta the Transition zone forms a broad continuous belt covering the basal slopes on the northwest, west, and south, but interrupted on the cold east and northeast sides by the Boreal, which here pushes down to the actual base of the mountain, crowding the Transition out to the east around a group of low volcanic hills.

On the southwest and west it pushes up on ordinary slopes to 5,500 or 6,000 feet, rising on steep pumice canyon slopes a couple of thousand feet higher, and everywhere embracing tongues of Canadian which descend along the cold streams and on the cold easterly slopes of ridges.

On Shasta the study of the Transition zone is complicated by strong local differences of soil-moisture and humidity—differences that exert a profound effect on the distribution of plants, and to a less degree on that of animals also. It has been shown elsewhere (Life Zones and Crop Zones of the United States, p. 28, September. 1898) that in some places the Arid Transition of the Rocky Mountains and Great Basin passes gradually into the Humid Transition of the Pacific coast. On Shasta similar changes occur in such small compass that they may be studied to excellent advantage. Thus, near the south end of Shasta Valley the dominant types of vegetation are *Pinus ponderosa*, *Quercus californica*, *Artemisia tridentata*, *Kunzia tridentata*, *Arctostaphylos patula*, *Chrysothamnus occidentalis*, *Rhus trilobata*, *Garrya fremonti*, and *Prunus subcordata*, all characteristic Arid Transition species. On moister soils near by, particularly in shady canyons, the dominant types are *Pseudotsuga mucronata*, *Abies concolor lowiana*, *Acer glabrum*, *Cornus nuttalli*, *Rubus parviflorus* (=*nutkanus* Auct.) *Spiræa douglasi* and other Humid Transition species.

In this connection it is important to bear in mind that the extreme bottom of the west slope of Shasta, between the Sacramento River and Shasta Valley (elevation about 3,400 feet), is decidedly cooler and more boreal than the middle part of the slope 1,000 or 2,000 feet higher. The reason is twofold: The bottom part of the west slope, from the head of the Sacramento Canyon northward, lies close to the east base of Mount Eddy and the Scott Mountains, by which it is shielded from the late afternoon sun, and consequently receives less heat than higher parts of the same slope. Furthermore, it is well watered. and the rapid evaporation caused by the dry atmosphere tends to lower the temperature still more. Higher parts of the same slope are not only very much drier, but are exposed to the direct rays of the afternoon sun, which, owing to the increasing steepness, strike the ground more nearly at a right angle than at lower elevations, the result being a material increase in the amount of heat received. It is obvious, therefore, that on the southwest and west slopes the middle part of the Transition zone is the hottest and driest, the part in which low Transition or even Upper Sonoran species are most apt to be found, while the *upper* and *lower* parts are coolest and dampest, the parts most likely to be invaded by Canadian zone species. Hence it is not surprising that Douglas and white firs, willows, alders, elder, snowberry, red spiræa, osier, and thimbleberry flourish at the top and bottom of the Transition slope, but are absent from the middle part. At the extreme foot of the slope, along the cool streams near Sisson Tavern, two normally boreal plants occur which were not found at all in the boreal belts on the mountain. These are *Linnæa borealis* and *Pachystima myrsinites*. With them is associated the mountain chinquapin (*Castanopsis sempervirens*). There is something peculiar about the distribution of *Pachystima*. It is abundant in the neighborhood of Sisson Tavern and occurs here and there, apparently on dry soil, up to an altitude of 4,700 feet, but not above. Since all three of these species are boreal, it is possible that the forms here referred to are Transition zone subspecies.

MAMMALS OF TRANSITION ZONE.

(1) *Species known to occur in the Transition zone of Shasta.*

Antilocapra americana.
Bassariscus astutus raptor.
Callospermophilus chrysodeirus.
Canis ochropus.
Castor canadensis.[1]
Cervus occidentalis.
Dipodomys californicus.
Erethizon epixanthus.
Eutamias amœnus.
Eutamias senex.
Felis oregonensis.
Lutra hudsonica.
Lutreola vison.
Lynx fasciatus pallescens.
Mephitis occidentalis.
Microtus montanus.
Microtus mordax.[1]
Myotis evotis.
Myotis lucifugus longicrus.
Neotoma cinerea.
Neotoma fuscipes.
Neurotrichus gibbsi major.
Odocoileus columbianus.
Perognathus mollipilosus.
Peromyscus boyli.
Peromyscus gambeli.
Procyon psora pacifica.
Scapanus californicus.
Sciuropterus (klamathensis?).
Sciurus albolimbatus.
Sciurus fossor.
Sorex montereyensis.
Sorex vagrans amœnus.
Spermophilus douglasi.
Spilogale latifrons.
Taxidea taxus.
Thomomys monticola pinetorum.
Urocyon californicus townsendi.
Ursus americanus.
Ursus horribilis.
Vespertilio fuscus.
Vulpes macrourus.[2]
Zapus pacificus.

[1] Restricted to cold streams which though traversing the Transition zone afford Boreal temperatures.

[2] Probably does not breed below Canadian.

MAMMALS OF TRANSITION ZONE—continued.

(2) *Restricted to Transition zone.*

Bassariscus astutus raptor.
Lynx fasciatus pallescens.
?Mephitis occidentalis.
?Microtus montanus.
Sciurus fossor.
Urocyon californicus townsendi.

(3) *Common to Transition and Upper Sonoran zones.*

[See p. 54.]

(4) *Common to Transition and Canadian zones.*

Callospermophilus chrysodeirus.
Cervus occidentalis.
Erethizon epixanthus.
Eutamias amœnus.
Eutamias senex.
Felis oregonensis.
Lutra hudsonica.
Lutreola vison energumenos.
Microtus mordax.
Myotis lucifugus longicrus.
Neotoma cinerea.
Neurotrichus gibbsi major.
Odocoileus columbianus.
Perognathus mollipilosus.
Peromyscus boyli.
Peromyscus gambeli.
Scapanus californicus.
Sciuropterus alpinus klamathensis?
Sciurus albolimbatus.
Sorex montereyensis.
Sorex vagrans amœnus.
Taxidea taxus.
Ursus americanus.
Ursus horribilis.
Vulpes macrourus.[1]

BIRDS OF TRANSITION ZONE.

(1) *Species known to occur in Transition zone of Shasta.*

Aphelocoma californica.
Aquila chrysaëtos.
Astragalinus psaltria.
Astragalinus tristis salicamans.
Bubo virginianus.
Buteo borealis calurus.
Buteo swainsoni.
Calypte anna.
Carpodacus mexicanus obscurus.
Cathartes aura.
Ceophlœus pileatus abieticola.
Certhia familiaris occidentalis.
Chætura vauxi.
Chondestes grammacus strigatus.
Chordeiles virginianus.
Circus hudsonius.
Colaptes cafer.
Contopus borealis.
Contopus richardsoni.
Cyanocitta stelleri.
Cyanospiza amœna.
Dendragapus obscurus fuliginosus.
Dendroica æstiva.
Dendroica auduboni.
Dryobates pubescens gairdneri.
Dryobates villosus hyloscopus.
Empidonax difficilis.
Empidonax hammondi.
Empidonax wrighti.
Falco sparverius.
Geothlypis tolmiei.
Geothlypis trichas occidentalis.
Glaucidium gnoma californicum.
Helminthophila celata lutescens.
Helminthophila rubricapilla gutturalis.
Hirundo erythrogastra.
Hylocichla aonalaschkæ auduboni.
Icteria virens longicauda.
Lophortyx californicus vallicola.
Melanerpes formicivorus bairdi.
Melanerpes torquatus.
Melospiza lincolni.
Melospiza melodia montana.
Merula migratoria propinqua.
Oreortyx pictus plumiferus.
Oreospiza chlorura.
Passerella iliaca megarhyncha.
Petrochelidon lunifrons.
Phalænoptilus nuttalli.
Pipilo maculatus megalonyx.
Piranga ludoviciana.
Scolecophagus cyanocephalus.

[1] Supposed to breed in Canadian and wander over Transition.

BIRDS OF TRANSITION ZONE—continued.

(1) *Species known to occur in Transition zone of Shasta*—Continued.

Selasphorus rufus.
Sialia mexicana occidentalis.
Sitta carolinensis aculeata.
Sitta pygmæa.
Speotyto cunicularia hypogæa.
Sphyrapicus ruber.
Spizella socialis arizonæ.
Stellula calliope.
Sturnella magna neglecta.
Tachycineta bicolor.
Tachycineta thalassina.
Thryomanes bewicki spilurus.
Troglodytes aëdon parkmani.
Tyrannus verticalis.
Vireo gilvus swainsoni.
Vireo solitarius cassini.
?Wilsonia pusilla pileolata.
Xenopicus albolarvatus.
Zamelodia melanocephala.
Zenaidura macroura.

(2) *Restricted to Transition zone.*

?Chætura vauxi.
Contopus richardsoni.
Dryobates pubescens gairdneri.
Glaucidium gnoma californicum.
Melanerpes torquatus.
Oreospiza chlorura.
Passerella iliaca megarhyncha.
Sialia mexicana occidentalis.[1]
Sitta pygmæa.
Sphyrapicus ruber.
Vireo solitarius cassini.
Zamelodia melanocephala.[1]

(3) *Common to Transition and Upper Sonoran zones.*

[See p. 54.]

(4) *Common to Transition and Canadian zones.*

Aquila chrysaëtos.
Bubo virginianus.
Buteo borealis calurus.
Ceophlœus pileatus abieticola.
Certhia familiaris occidentalis.
Chordeiles virginianus.
Colaptes cafer.
Contopus borealis.
Cyanocitta stelleri.
Dendragapus obscurus fuliginosus.
Dendroica auduboni.
Dryobates villosus hyloscopus.
Empidonax difficilis.
Empidonax hammondi.
Empidonax wrighti.
Falco sparverius.
Geothlypis tolmiei.
Helminthophila celata lutescens.
Helminthophila rubricapilla gutturalis.
Hylocichla aonalaschkæ auduboni.
Melospiza lincolni.
Merula migratoria propinqua.
Oreortyx pictus plumiferus.
Piranga ludoviciana.
Selasphorus rufus.
Sitta carolinensis aculeata.
Stellula calliope.
Wilsonia pusilla pileolata.
Xenopicus albolarvatus.

PLANTS OF TRANSITION ZONE.

(1) *Species known to occur in the Transition zone of Shasta.*

Abies concolor lowiana.
Acer circinatum.
Acer glabrum.
Acer macrophyllum.
Achillea lanulosa.
Alnus tenuifolia.
Amelanchier alnifolia.
Anaphalis margaritacea.
Antennaria geyeri.
Apocynum pumilum.
Aquilegia truncata.
Arctostaphylos patula.
Artemisia ludoviciana.
Artemisia tridentata.
Asarum hartwegi.
Betula occidentalis.

[1] Probably common to Transition and Upper Sonoran.

PLANTS OF TRANSITION ZONE—continued.

(1) *Species known to occur in Transition zone of Shasta*—Continued.

Carum gairdneri.
Castanopsis sempervirens.
Ceanothus cordulatus.
Ceanothus integerrimus.
Ceanothus (Cerastes) prostratus.
Ceanothus velutinus.
Cerasus demissa.
Cerasus emarginata.
Cerasus glandulosa.
Cercocarpus ledifolius.
Cercocarpus parvifolius.
Chamæsaracha nana.
Chimaphila menziesi.
Chimaphila umbellata.
Chrysamphora californica.
Chrysothamnus bloomeri angustatus.
Chrysothamnus occidentalis.
Cornus nuttalli.
Cornus pubescens.
Corylus rostrata californica.
Cratægus rivularis.
Cryptanthe geminata.
Epilobium brevistylum.
Epilobium oregonense.
Epilobium spicatum.
Eriogonum marifolium.
Eriogonum nudum.
Eupatorium occidentale.
Fragaria bracteata.
Fragaria chiloensis.
Fraxinus oregana.
Fritillaria atropurpurea.
Gayophytum ramosissimum.
Gilia aggregata.
Gilia (Collomia) grandiflora.
Hastingsia alba.
Heleniastrum rivulare.
Heracleum lanatum.
Hieracium albiflorum (large form).
Hieracium cynoglossoides nudicaule.
Hieracium greenei.
Horkelia pseudocapitata.
Juniperus occidentalis.
Kunzia tridentata.
Lappula nervosa.
Libocedrus decurrens.
Lilium washingtonianum.
Linnæa borealis.
Linum lewisi.
Lotus americanus.
Lupinus elmeri.
Lupinus minimus.
Machæranthera shastensis (large form)
Mimulus moniliformis.
Mimulus tilingi.
Osmorrhiza nuda.
Pachystima myrsinites.
Pæonia browni.
Pentstemon confertus (form not typical).
Phacelia magellanica.
Pinus attenuata.
Pinus lambertiana.
Pinus ponderosa.
Polygala cornuta.
Populus trichocarpa.
Potentilla glandulosa (large form).
Prunus subcordata.
Pseudotsuga mucronata.
Ptiloria lactucina.
Pyrola picta.
Pyrola secunda.
Quercus californica.
Rhamnus californica (or rubra).
Rhus trilobata.
Ribes amictum.
Ribes cereum.
Ribes klamathense.
Ribes viscosissimum.
Rosa californica.
Rosa gymnocarpa.
Rubus parviflorus.
Rubus vitifolius.
Salix lasiandra.
Salix nuttalli.
Salix sitchensis.
Sambucus melanocarpa.
Sisyrinchium bellum.
Smilax californica.
Solidago elongata.
Sorbus sambucifolia.
Spiræa douglasi.
Stachys ingrata.
Symphoricarpos pilosus.
Symphoricarpos racemosus.
Tritelia ixioides.
Vaccinium arbuscula.
Vagnera stellata.

PLANTS OF TRANSITION ZONE—continued.

(2) *Species restricted to Transition zone.*

Abies concolor lowiana.
Acer circinatum.
Acer glabrum.*
Acer macrophyllum.
Achillea lanulosa.
Alnus tenuifolia.
Amelanchier alnifolia.*
Anaphalis margaritacea.
Antennaria geyeri.
Apocynum pumilum.
Aquilegia truncata.
Arctostaphylos patula.
Artemisia ludoviciana (form).
Asarum hartwegi.
Ceanothus cordulatus.
Ceanothus integerrimus.
Ceanothus (Cerastes) prostratus.
Ceanothus velutinus.
Cerasus demissa.
Cerasus emarginata.
Cerasus glandulosa.
Cercocarpus ledifolius.
Chrysamphora californica.
Chrysothamnus bloomeri angustatus.
Cornus nuttalli.
Cornus pubescens.*
Corylus rostrata californica.
Cratægus rivularis.*
Cryptanthe geminata.
Fragaria bracteata.
Fragaria chiloensis.
Fritillaria atropurpurea.
Gayophytum ramosissimum.
Gilia (Collomia) grandiflora.
Hastingsia alba.
Hieracium albiflorum (large form).
Hieracium cynoglossoides nudicaule.
Hieracium greenei.
Horkelia pseudocapitata.
Lappula nervosa.
Libocedrus decurrens.
Lilium washingtonianum.
Linnæa borealis.*[1]
Linum lewisi.
Lotus americanus.
Lupinus minimus.
Osmorrhiza nuda.
Pachystima myrsinites.*
Pæonia browni.
Pinus attenuata.
Pinus lambertiana.
Pinus ponderosa.
Polygala cornuta.
Pseudotsuga mucronata.
Quercus californica.
Rhamnus californica (or rubra).
Ribes klamathense.
Ribes viscosissimum.
Rosa californica.
Rosa gymnocarpa.
Rubus parviflorus.*
Rubus vitifolius.
Salix lasiandra.
Sambucus melanocarpa.
Sisyrinchium bellum.
Smilax californica.
Solidago elongata.
Symphoricarpos pilosus.
Symphoricarpos racemosus.

In other mountains the species marked with an asterisk (*) are believed to occur in the Canadian zone as well as the Transition.

(3) *Species common to Transition and Upper Sonoran zones.*

Alnus rhombifolia.
Artemisia tridentata.
Betula occidentalis.
Cercocarpus parvifolius.
Chrysothamnus occidentalis.
Eriogonum nudum.
Fraxinus oregana.
Juniperus occidentalis.
Kunzia tridentata.
? Populus trichocarpa.
Prunus subcordata.
Rhus trilobata.

[1] *Linnæa borealis* is ordinarily a Boreal plant, but it was not found in the Boreal belt of Shasta, though common in places at Sisson. The Sisson form has been separated as var. *longiflora*, and may be worthy of recognition as a Transition zone subspecies.

PLANTS OF TRANSITION ZONE—continued.

(4) *Species common to Transition and Canadian zones.*

(Or growing on boundary between.)

Carum gairdneri.
Castanopsis sempervirens.
Castilleja miniata.
Chamæsaracha nana.
Chimaphila menziesi.
Chimaphila umbellata.
Epilobium brevistylum.
Epilobium oregonense.
Epilobium spicatum.
Eriogonum marifolium.
Eupatorium occidentale.
Gilia aggregata.
Heleniastrum rivulare.
Heracleum lanatum.
Lupinus elmeri.
Machæranthera shastensis (large form).
Mimulus moniliformis.
Mimulus tilingi.
Pentstemon confertus (form not typical).
Phacelia magellanica.
Potentilla glandulosa (large form).
Ptiloria lactucina.
Pyrola picta.
Pyrola secunda.
Ribes amictum.
Ribes cereum.
Salix nuttalli.
Salix sitchensis.
Sorbus sambucifolia.
Spiræa douglasi.
Stachys ingrata.
Tritelia ixioides.
Vaccinium arbuscula.
Vagnera stellata.

CANADIAN ZONE.

The Canadian zone on Shasta forms a broad forest belt, usually several miles in width and about 2,000 feet in vertical depth, which completely encircles the mountain. On southwesterly slopes it begins at an altitude of about 5,000 to 5,500 feet and pushes up to 7,500 to 7,800 feet.

Excepting an area of lodge-pole pines (*Pinus murrayana*) on the northeast base of the mountain, the Canadian zone is everywhere marked by a continuous forest of stately trees, consisting of Shasta firs (*Abies shastensis*), mixed in places with silver pines (*Pinus monticola*). It is a dark, somber forest, growing on a blackish soil, with very little noticeable vegetation except scattered patches of dwarf manzanita in the dry woods, and lines of more succulent plants at widely distant intervals along the borders of streams.

MAMMALS OF CANADIAN ZONE.

(1) *Species known to occur in Canadian zone on Shasta.*

Aplodontia major.
Callospermophilus chrysodeirus.
Canis lestes.
Cervus occidentalis.
Erethizon epixanthus.
Eutamias amœnus.
Eutamias senex.
Evotomys mazama.
Felis oregonensis.
Lepus klamathensis.
Lutra hudsonica.
Lutreola vison energumenos.
Microtus mordax.
Mustela caurina.
Mustela pennanti.
Myotis lucifugus longicrus.
Myotis yumanensis saturatus.
Neotoma cinerea.
Neurotrichus gibbsi major.
Odocoileus columbianus.
Perognathus mollipilosus.
Peromyscus boyli.

MAMMALS OF CANADIAN ZONE—continued.

(1) *Species known to occur in Canadian zone on Shasta*—Continued.

Peromyscus gambeli.
Putorius arizonensis.
Scapanus californicus.
Sciuropterus alpinus klamathensis?.
Sciurus albolimbatus.
Sorex montereyensis.
Sorex (Neosorex) navigator.
Sorex shastensis.
Sorex vagrans amœnus.
Taxidea taxus.
Thomomys monticola.
Ursus americanus.
Ursus horribilis.
Vulpes macrourus.
Zapus trinotatus alleni.

(2) *Species restricted to Canadian zone.*

Aplodontia major.
? Sorex (Neosorex) navigator.
Sorex shastensis.
Zapus trinotatus alleni.

(3) *Species common to Canadian and Transition zones.*

[See p. 57.]

(4) *Species common to Canadian and Hudsonian zones.*

Callospermophilus chrysodeirus.
Canis lestes.
Erethizon epixanthus.
Eutamias amœnus.
Eutamias senex.
Evotomys mazama.
Lepus klamathensis.
Microtus mordax.
Mustela caurina.
Mustela pennanti.
Myotis yumanensis saturatus.
Neotoma cinerea.
Odocoileus columbianus.
Perognathus mollipilosus.
Peromyscus gambeli.
Putorius arizonensis.
Sorex vagrans amœnus.
Thomomys monticola.
Vulpes macrourus.

BIRDS OF CANADIAN ZONE.

(1) *Species known to occur in Canadian zone on Shasta.*

Accipiter atricapillus striatulus.
Accipiter velox.
Aquila chrysaëtos.
Bubo virginianus.
Buteo borealis calurus.
Carpodacus cassini.
Ceophlœus pileatus abieticola.
Certhia familiaris occidentalis.
Chordeiles virginianus.
Cinclus mexicanus.
Coccothraustes vespertinus montanus.
Colaptes cafer.
Contopus borealis.
Cyanocitta stelleri.
Dendragapus obscurus fuliginosus.
Dendroica auduboni.
Dendroica occidentalis.
Dryobates villosus hyloscopus.
Empidonax difficilis.
Empidonax hammondi.
Empidonax wrighti.
Falco sparverius.
Geothlypis tolmiei.
Helminthophila celata lutescens.
Helminthophila rubricapilla gutturalis.
Hylocichla aonalaschkæ auduboni.
Junco hyemalis thurberi.
Loxia curvirostra bendirei.
Melospiza lincolni.
Merula migratoria propinqua.
Myadestes townsendi.
Oreortyx pictus plumiferus.
Parus gambeli.
Perisoreus obscurus.
Picoides arcticus.
Piranga ludoviciana.
Regulus calendula.
Regulus satrapa olivaceus.
Selasphorus rufus.
Sitta canadensis.
Sitta carolinensis aculeata.
Sphyrapicus thyroideus.
Spinus pinus.
Stellula calliope.
Wilsonia pusilla pileolata.
Xenopicus albolarvatus.

BIRDS OF CANADIAN ZONE—continued.

(2) *Species restricted to Canadian zone.*

Loxia curvirostra bendirei.
Melospiza lincolni.
Picoides arcticus.

(3) *Species common to Canadian and Transition zones.*

[See p. 58.]

(4) *Species common to Canadian and Hudsonian zones.*

Accipiter atricapillus striatulus.
Accipiter velox.
Aquila chrysaëtos.
Carpodacus cassini.
Cinclus mexicanus.
Coccothraustes vespertinus montanus.
Dendragapus obscurus fuliginosus.
Dendroica auduboni.
Dendroica occidentalis.
Falco sparverius.
Junco hyemalis thurberi.
?Loxia curvirostra bendirei.
Myadestes townsendi.
Parus gambeli.
Perisoreus obscurus.
Regulus calendula.
Regulus satrapa olivaceus.
Selasphorus rufus.
Sitta canadensis.
Sphyrapicus thyroideus.
Spinus pinus.
Stellula calliope.

PLANTS OF CANADIAN ZONE.

(1) *Species known to occur in Canadian zone on Shasta.*

Abies shastensis.
Aconitum columbianum.
Allium validum.
Alnus sinuata.
Arctostaphylos nevadensis.
Arnica longifolia.
Campanula wilkinsiana.
Carum gairdneri.
Castanopsis sempervirens.
Castilleja miniata.
Chamæsaracha nana.
Chimaphila menziesi.
Chimaphila umbellata.
Chrysothamnus bloomeri.
Corallorhiza bigelovi.
?Crepis intermedia.
Cymopteris terebinthinus (large form).
Delphinium sonnei.
Drosera rotundifolia.
Epilobium brevistylum.
Epilobium oregonense.
Epilobium spicatum.
Erigeron inornatus.
Eriogonum marifolium.
Eupatorium occidentale.
Gentiana simplex.
Gilia aggregata.
Habenaria leucostachys.
Habenaria unalaschensis.
Heleniastrum rivulare.
Heracleum lanatum.
Holodiscus discolor (large form).
Hypericum anagalloides.
Ligusticum grayi.
Lilium parvum.
Lupinus elmeri.
Madia bolanderi.
Machæranthera shastensis (large form).
Mimulus moniliformis.
Mimulus primuloides.
Mimulus tilingi.
Monardella odoratissima.
Pentstemon confertus (form not typical).
Pentstemon deustus.
Pentstemon gracilentus.
Phacelia magellanica.
Phlox douglasi diffusa.
Pinus monticola.
Pinus murrayana.
Potentilla glandulosa (large form).
Ptiloria lactucina.
Pyrola pallida.
Pyrola picta.
Pyrola secunda.
Ribes amictum.
Ribes cereum.
Salix nuttalli.
Salix sitchensis.
Senecio trigonophyllus.
Sorbus sambucifolia.

PLANTS OF CANADIAN ZONE—continued.

(1) *Species known to occur in Canadian zone on Shasta*—Continued.

Spiræa douglasi.
Spraguea umbellata.
Stachys ingrata.
Stellaria crispa.
Tofieldia occidentalis.
Tritelia ixioides.
Vaccinium occidentale.
Vagnera stellata.
Veratrum californicum.
Viola blanda.

(2) *Species restricted to Canadian zone.*

Abies shastensis.
Aconitum columbianum.
Allium validum.
Alnus sinuata.
Arnica longifolia.
?Corallorhiza bigelovi.
Delphinium sonnei.
Drosera rotundifolia.
Erigeron inornatus.
Gentiana simplex.
Habenaria leucostachys.
Habenaria unalaschensis.
Lilium parvum.
Madia bolanderi.
Pentstemon deustus.
Pentstemon gracilentus.
Pinus monticola.
Pinus murrayana.
Pyrola pallida.
Senecio trigonophyllus.
Tofieldia occidentalis.
Vaccinium occidentale.
Viola blanda.

(3) *Species common to Canadian and Transition zones.*

[See p. 61.]

(4) *Species common to Canadian and Hudsonian zones.*

Arctostaphylos nevadensis.
Campanula wilkinsiana.
Castanopsis sempervirens.
Castilleja miniata.
Chrysothamnus bloomeri.
Holodiscus discolor.
Hypericum anagalloides.
Ligusticum grayi.
Mimulus primuloides.
Monardella odoratissima.
Phlox douglasi diffusa.
Ribes cereum.
Spraguea umbellata.
Stellaria crispa.

HUDSONIAN ZONE.

The Hudsonian zone is the highest of the timber belts. Its sinuous upper border rises on the high ridges to inclose the narrow tongues of dwarf prostrate trees that push up on the warmest southwesterly exposures to an extreme altitude of 9,800 feet, but between the ridges it dips down a thousand feet or more, and is difficult to fix with precision. The lower border slightly overlaps the upper limit of Shasta firs. Two species of trees, and only two, grow in this zone—the black alpine hemlock (*Tsuga mertensiana*) and the white-bark pine (*Pinus albicaulis*). The hemlock is restricted to local spots, while the white-bark pine forms a practically continuous belt, as already explained (see p. 42). On warm southwesterly slopes the Hudsonian reaches from 7,500 or 7,800 up to 9,500, or in extreme cases to 9,800 feet.

MAMMALS OF HUDSONIAN ZONE.

(1) *Species known to occur in Hudsonian zone of Shasta.*

Callospermophilus chrysodeirus.
Canis lestes.
Erethizon epixanthus.
Eutamias amœnus.
Eutamias senex.
Evotomys mazama.
Lepus klamathensis.
Microtus mordax.
Mustela caurina.
Mustela pennanti.
Myotis yumanensis saturatus.
Neotoma cinerea.
Ochotona schisticeps.
Odocoileus columbianus.
Ovis canadensis.
Perognathus mollipilosus.
Peromyscus gambeli.
Phenacomys orophilus.
Putorius arizonensis.
? Sorex vagrans amœnus.[1]
? Sorex (Neosorex) navigator.[1]
Thomomys monticola.
Vulpes macrourus.
? Zapus trinotatus alleni.[1]

(2) *Species restricted to Hudsonian zone.*

Ochotona schisticeps.

(3) *Species common to Hudsonian and Canadian zones.*

[See p. 62.]

(4) *Species common to Hudsonian and Alpine zones.*

Canis lestes.[2]
Microtus mordax.
Ovis canadensis.
Peromyscus gambeli.
Phenacomys orophilus.
Thomomys monticola.
Vulpes macrourus.[2]

BIRDS OF HUDSONIAN ZONE.

(1) *Species known to occur in Hudsonian zone on Shasta.*

(Species queried are not positively known to breed in the Hudsonian, though frequently seen in this belt in July and August.)

Accipiter atricapillus striatulus.
Accipiter velox.
Aquila chrysaetos.
Carpodacus cassini.
?Certhia familiaris occidentalis.
Cinclus mexicanus.
?Coccothraustes vespertinus montanus.
Dendragapus obscurus fuliginosus.
?Dendroica auduboni.
Dendroica occidentalis.
Falco sparverius.
Junco hyemalis thurberi.
?Loxia curvirostra bendirei.
Myadestes townsendi.
Nucifraga columbiana.
Parus gambeli.
Perisoreus obscurus.
Regulus calendula.
Regulus satrapa olivaceus.
Salpinctes obsoletus.
Selasphorus rufus.
Sialia arctica.
Sitta canadensis.
?Sitta carolinensis aculeata.
Sphyrapicus thyroideus.
Spinus pinus.
Stellula calliope.
Zonotrichia leucophrys.

(2) *Species restricted to Hudsonian zone.*

Nucifraga columbiana.
Zonotrichia leucophrys.

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[1] These three species occur along the lower edge of the Hudsonian zone, but were not obtained in its upper part, and it is not certain whether or not they should be included.

[2] Does not breed above Hudsonian.

BIRDS OF HUDSONIAN ZONE—continued.

(3) *Species common to Hudsonian and Canadian zones.*

[See p. 63.]

(4) *Species common to Hudsonian and Alpine zones.*

Salpinctes obsoletus.[1]
Sialia arctica.
Stellula calliope.

PLANTS OF HUDSONIAN ZONE.

(1) *Species known to occur in Hudsonian zone on Shasta.*

Agoseris monticola.
Allium sp. —— ?
Antennaria media.
Arabis platysperma.
Arctostaphylos nevadensis.
Arnica merriami.
Arnica viscosa.
Campanula wilkinsiana.
Carex breweri.
Castanopsis sempervirens.
Castilleja affinis.
Castilleja miniata (small form).
Cheiranthus perennis.
Chrysothamnus bloomeri.
Crepis intermedia.
Cycladenia humilis.
Cymopterus terebinthinus.
Epilobium clavatum.
Epilobium obcordatum.
Epilobium pringleanum.
Erigeron armeriæfolium.
Eriogonum polypodum.
Eriogonum pyrolæfolium.
Hieracium albiflorum (alpine form).
Hieracium gracile.
Hieracium horridum.
Holodiscus discolor.
Hypericum anagalloides.
Juncus parryi.
Juniperus nana.
Kalmia glauca microphylla.
Ligusticum grayi.
Lupinus albifrons.
Lupinus 'ornatus.'
Lutkea pectinata.
Machæranthera shastensis.
Mimulus implexus.
Mimulus primuloides.
Mitella pentandra.
Monardella odoratissima.
Oreastrum alpiginum.
Oreobroma triphylla.
Orthocarpus pilosus.
Parnassia californica.
Pentstemon glaber utahensis.
Pentstemon menziesi.
Pentstemon newberryi.
Phlox douglasi diffusa.
Phyllodoce empetriformis.
Pinus albicaulis.
Polygonum newberryi.
Polygonum shastense.
Potentilla flabellifolia.
Potentilla pseudorupestris.
Pulsatilla occidentalis.
Ribes cereum.
Saxifraga bryophora.
Scutellaria nana.
Sibbaldia procumbens.
Silene grayi.
Sitanion cinereum.
Spraguea umbellata.
Stellaria crispa.
Streptanthus orbiculatus.
Tsuga mertensiana.
Vaccinium cæspitosum.
Veronica cusicki.
Viola purpurea.

(2) *Species restricted to Hudsonian zone.*

Allium sp. —— ?
Arnica merriami.
Arnica viscosa.
?Castilleja affinis.
Castilleja miniata (small form).
Cycladenia humilis.
Epilobium clavatum.
Epilobium obcordatum.

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[1] On Shasta the rock wren is restricted closely to the Alpine and Hudsonian zones, but in other places it occurs much lower down, and was recently found in Shasta Valley by W. K. Fisher.

PLANTS OF HUDSONIAN ZONE—continued.

(2) *Species restricted to Hudsonian zone*—Continued.

Epilobium pringleanum.
Holodiscus discolor (typical form).
Juniperus nana.
Kalmia glauca microphylla.
Mimulus implexus.
Mitella pentandra
Oreobroma triphylla.
Orthocarpus pilosus.
Parnassia californica.
Pentstemon glaber utahensis.
Pentstemon newberryi.
Phyllodoce empetriformis.
Pinus albicaulis.
Potentilla flabellifolia.
Potentilla pseudorupestris?
Scutellaria nana.
Tsuga mertensiana.
Vaccinium cæspitosum.

(3) *Species common to Hudsonian and Canadian zones.*

[See p. 64.]

(4) *Species common to Hudsonian and Alpine zones.*

Agoseris monticola.
Antennaria media.
Arabis platysperma.
Carex breweri.
Cheiranthus perennis.
Chrysothamnus bloomeri.
Cymopterus terebinthinus.
Erigeron armeriæfolium.
Eriogonum polypodum.
Eriogonum pyrolæfolium.
Hieracium albiflorum (alpine form).
Hieracium gracile.
Hieracium horridum.
Juncus parryi.
Ligusticum grayi.
Lupinus 'ornatus.'
Lutkea pectinata.
Macharanthera shastensis.
Oreastrum alpiginum.
Pentstemon menziesi.
Phlox douglasi diffusa.
Polygonum newberryi.
Polygonum shastense.
Pulsatilla occidentalis.
Sibbaldia procumbens.
Silene grayi.
Sitanion cinereum.
Spraguea umbellata.
Streptanthus orbiculatus.
Veronica cusicki.
Viola purpurea.

ALPINE ZONE.

The Alpine zone occupies the irregular belt of pumice and lava between timberline and the upper limit of plant growth. On the warmer southwesterly slopes its lower limit may be found at 9,500 to 9,800 feet, but on ordinary slopes it is considerably lower. The great majority of its species stop at or below an altitude of 11,000 feet, but on the relatively warm southwesterly slopes *Hulsea nana* was found at 11,300 feet, and two species, *Draba breweri* and *Polemonium pulchellum*, as high as 13,000 feet—the extreme limit of plant growth on Shasta.

MAMMALS OF ALPINE ZONE.

(1) *Species known to occur in Alpine zone on Shasta.*

Canis lestes.[1]
Microtus mordax.
Ovis canadensis.
Peromyscus gambeli.
Phenacomys orophilus.
Thomomys monticola.
Vulpes macrourus.[1]

(2) *Species restricted to Alpine zone.*

None.

[1] The coyote and fox range up into the Alpine zone, but do not breed above the Hudsonian and possibly not above the Canadian.

MAMMALS OF ALPINE ZONE—continued.

(3) *Species common to Alpine and Hudsonian zones.*

[See p. 65.]

BIRDS OF ALPINE ZONE.

(1) *Species known to occur in Alpine zone on Shasta.*

Anthus pensilvanicus.
Leucosticte tephrocotis.
Nucifraga columbiana.
Salpinctes obsoletus.
Sialia arctica.
Stellula calliope.

(2) *Species restricted to Alpine zone.*

Anthus pensilvanicus.
Leucosticte tephrocotis.

(3) *Species common to Alpine and Hudsonian zones.*

[See p. 66.]

PLANTS OF ALPINE ZONE.

(1) *Species known to occur in Alpine zone on Shasta.*

Achillea borealis.
Agoseris monticola.
Antennaria media.
Arabis platysperma.
Bikukulla uniflora.
Cardamine bellidifolia pachyphylla.
Carex breweri.
Chænactis nevadensis.
Cheiranthus perennis.
Chrysothamnus bloomeri.
Cymopterus terebinthinus.
Draba breweri.
Erigeron armeriæfolium.
Erigeron compositus trifidus.
Eriogonum polypodum.
Eriogonum pyrolæfolium.
Hieracium albiflorum (alpine form).
Hieracium gracile.
Hieracium horridum.
Hulsea larseni.
Hulsea nana.
Juncus parryi.
Ligusticum grayi.
Lupinus lyalli.
Lupinus 'ornatus.'
Lutkea pectinata.
Machæranthera shastensis.
Oreastrum alpiginum.
Oxyria digyna.
Pentstemon menziesi.
Phacelia frigida.
Phlox douglasi diffusa.
Polemonium pulchellum.
Polygonum newberryi.
Polygonum shastense.
Pulsatilla occidentalis.
Sagina saginoides.
Saxifraga tolmiei.
Senecio canus.
Sibbaldia procumbens.
Silene grayi.
Silene suksdorfi.
Sitanion cinereum.
Spraguea umbellata.
Streptanthus orbiculatus.
Veronica cusicki.
Viola purpurea.

(2) *Species restricted to Alpine zone.*

Achillea borealis.
Bikukulla uniflora.
Cardamine bellidifolia pachyphylla.
Chænactis nevadensis.
Draba breweri.
Erigeron compositus trifidus.
Hulsea larseni.
Hulsea nana.
Lupinus lyalli.
Oxyria digyna.
Phacelia frigida.
Polemonium pulchellum.
Sagina saginoides.
Saxifraga tolmiei.
Senecio canus.
Silene suksdorfi.

(3) *Species common to Alpine and Hudsonian zones.*

[See p. 67.]

THE BOREAL FAUNA AND FLORA OF SHASTA CONTRASTED WITH CORRESPONDING FAUNAS AND FLORAS OF THE SIERRA AND THE CASCADES.

In considering the relations of the boreal faunas and floras of Shasta to those of other parts of the Sierra-Cascade system it is necessary at the outset to have a clear conception not only of the extent of the range as a whole, but also of the number and magnitude of the breaks or gaps in the continuity of its boreal fauna and flora. The Cascade Range enters the State of Washington from British Columbia in latitude 49° and pushes southward completely across Washington and Oregon; its continuation, the Sierra Nevada, traverses California for a distance of 500 miles, ending a little south of Mount Whitney, in about latitude 36°. The Cascade-Sierra system, therefore, extends over 13 degrees of latitude, and has a total length of fully 1,000 miles. For the whole of this distance it rises abruptly from a low region, whose faunas and floras are in the southern part Sonoran, in the northern part Transition. The field work of the Biological Survey has shown that the narrow boreal band which occupies the higher parts of the range is not continuous, but is interrupted by four important gaps, through which Transition zone species pass freely in broad belts from one side to the other. These gaps, begining at the north, are:

(1) The *Columbia Gap*, or gorge of the Columbia River, on the boundary between Washington and Oregon, where the breadth of the Transition zone seems to be less than 50 miles.[1]

(2) The *Klamath Gap*, on the boundary between Oregon and California, extending from a little south of Mount Pitt in Oregon to Mount Shasta in California, a distance of about 50 miles. This interval is interrupted by one or two detached groups of low mountains on the California side, and by long ridges on both sides, whose summits are inhabited by boreal species, materially decreasing the actual breadth of the gap.

(3) The *Pitt River Gap*, between Mounts Shasta and Lassen in northern California. The breadth of the Transition zone here is about 60 miles.

[1]Although not bearing on the fauna of Shasta, it is interesting to note, in connection with the effects of the Columbia River Gap, that a number of species characteristic of the northern Cascades, in the State of Washington, do not occur in the southern Cascades, in Oregon. Among the mammals the most notable species of this kind are *Arctomys caligatus*, *Callospermophilus saturatus*, *Evotomys gapperi saturatus*, *Oreamnos montanus*, *Peromyscus oreas*, *Putorius washingtoni*, *Zapus trinotatus*.

(4) The *Feather River* or *Quincy Gap*, between Mount Lassen and the high ridge northwest of Honey Lake—the northern end of the Sierra proper. This gap is the shallowest, narrowest, most irregular, and least effective of all, and is the only one which has not been cut deeply and completely through the range by a large river. The Boreal zones of the two sides, at the points where they come nearest together, which is southeast of the southeastern extension of the boreal plateau on which Lassen stands, are not separated, apparently, by more than 15 miles. The distance between the Hudsonian elements appears to be several times greater. This region needs further exploration.

Fully half of the boreal species of Shasta are common to both the Sierra Nevada and the Cascade Range, and some of them extend over the entire length of the Sierra-Cascade system, inhabiting the principal boreal summits all the way from British Columbia to Mount Whitney; others are restricted to particular parts of the mountains, and each of the four gaps mentioned forms a barrier beyond which certain species do not pass. Therefore, in contrasting the boreal faunas and floras of Shasta with corresponding faunas and floras of the Sierra Nevada and Cascade Range it is necessary to fix definite limits to the terms employed. The term 'Sierra,' as used in the table headings and following discussion, is restricted to the lofty range extending from Mount Whitney northward a little beyond Honey Lake; the 'Cascades,' to the Cascades of Oregon. In other words, the term 'Sierra' is restricted so as *not* to include Shasta or Lassen;[1] the term 'Cascades' so as *not* to include the Cascades of Washington.

The paucity of animal and plant life on Shasta, contrasted with that of the Sierra and Cascades, has been already noted and is clearly shown in the following tables. The explanation, briefly stated, is that Shasta, on account of its aridity and relatively small area, is incapable of supporting so rich a fauna and flora as either of the extensive ranges between which it is situated. It is not assumed that all of the boreal species inhabiting Shasta were discovered by us, but in the case of the Canadian and Hudsonian mammals and birds, and the Hudsonian and Alpine plants it is believed that the number which escaped detection is too small to materially alter the results here given.[2]

In grouping the species for study it seems most logical to arrange the mammals, birds, and plants in two principal categories: (*a*) Boreal

[1] The flora and fauna of Lassen are not known in sufficient detail to admit of complete comparisons in either direction; hence this mountain is omitted from consideration in the accompanying tables. At the same time it should be stated that Lassen is clearly a part of the Sierra, so far as its fauna is concerned.

[2] The accompanying percentages and lists of species are provisional and subject to revision. They are based on present information and will, of course, be corrected and supplemented by future field work. They are sufficiently near the truth, however, to demonstrate certain facts and warrant certain deductions and generalizations of very great interest in connection with the origin of the boreal faunas and floras of the Sierra Nevada and Cascade Range.

species that occur on Shasta, with reference to their occurrence in the Sierra or Cascades or both; and (*b*) Boreal species that occur on the Sierra or the Cascades or both, but which, so far as known, are absent from Shasta.

BOREAL SPECIES OF SHASTA CONSIDERED WITH REFERENCE TO THEIR PRESENCE OR ABSENCE IN THE SIERRA AND THE CASCADES.

The boreal mammals, birds, and plants of Shasta have been grouped in four categories: (1) species common to Shasta and the Sierra-Cascade system as a whole; (2) species common to Shasta and the Sierra, but not known from the Cascades; (3) species common to Shasta and the Cascades but not known from the Sierra, and (4) Shasta species not known from either the Sierra or the Cascades.

Thirty-six distinctively Boreal mammals are known from Shasta, including the boreal species which range down into or through the Transition zone. Of these, 26 are common to the Sierra on the south and the Cascades on the north, 7 are common to Shasta and the Sierra but are not known from the Cascades, 1 is common to Shasta and the Cascades but is not known from the Sierra, and 2 are peculiar to Shasta.

Of the 36 distinctively Boreal mammals of Shasta, 17 are believed to be exclusively boreal. Of these, 12 are common to the Sierra and the Cascades, 4 are common to Shasta and the Sierra but are not known from the Cascades, 1 is peculiar to Shasta, but not one is common to Shasta and the Cascades which does not occur also in the Sierra.

Forty-seven distinctively Boreal birds are known from Shasta, including the boreal species which range down into or through the Transition zone. Of these, 41 are common to the Sierra and the Cascades, 4 are common to Shasta and the Sierra but are not known from the Cascades, and 2 are common to Shasta and the Cascades but are not known from the Sierra.

Of the 47 distinctively Boreal birds of Shasta, 22 are believed to be exclusively boreal. Of these, 18 are common to the Sierra and the Cascades, 2 are common to Shasta and the Sierra but are not known from the Cascades, and 2 are common to Shasta and the Cascades but are not known from the Sierra.

One hundred and twelve distinctively Boreal plants are known from Shasta, including the boreal species which range down into or through the Transition zone. Of these 55 are common to the Sierra and the Cascades; 31 are common to Shasta and the Sierra but are not known from the Cascades; 16 are common to Shasta and the Cascades but are not known from the Sierra, and 8 occur on Shasta which are not known from either the Sierra or the Cascades.

Of the 112 distinctively Boreal plants of Shasta, 101 are believed to be exclusively boreal. Of these, 47 are common to the Sierra and the Cascades; 28 are common to Shasta and the Sierra but are not known from the Cascades; 15 are common to Shasta and the Cascades but are not known from the Sierra; and 8 are restricted to Shasta.

Three mammals, 5 birds, and 68 plants are believed to be restricted to the Hudsonian and Alpine zones. Of these, 2 mammals, 3 birds, and 30 plants are common to the Sierra and the Cascades; one mammal, 1 bird, and 18 plants are common to Shasta and the Sierra but are not known from the Cascades; and no mammal, 1 bird, and 12 plants are common to Shasta and the Cascades, but are not known from the Sierra. Five Hudsonian-Alpine plants from Shasta are not known from either the Sierra or the Cascades.

These comparisons show:

(1) That of the boreal species known from Shasta, including those which range down into the Transition zone, 87 percent of the birds, 72 percent of the mammals, and only 50 percent of the plants are common to the Sierra and the Cascades.

(2) That of the exclusively boreal species known from Shasta, 85 percent of the birds, 70 percent of the mammals, and 46 percent of the plants are common to the Sierra and the Cascades.

(3) That of the exclusively Hudsonian and Alpine species known from Shasta, 60 percent of the birds, 67 percent of the mammals, and 44 percent of the plants are common to the Sierra and the Cascades.

(4) That in each instance, as would be expected, the percentage of species common to the two ranges is greater in the case of those ranging down into the Transition zone than in those restricted to the Boreal, for the obvious reason that geographically the Boreal belt is broken by broad gaps, while the Transition zone is practically continuous.

(5) That of the birds, mammals, and plants of Shasta, birds have by far the largest percentage of species common to the Sierra and the Cascades, mammals next, and plants least of all. This corresponds with the relative powers of dispersion possessed by these groups.

Arranged primarily by groups instead of zone limits, it appears that the percentages of Shasta birds common to the Sierra and the Cascades are as follows: Of boreal species, including those which range down into the Transition zone, 87 percent; of species restricted to the Boreal zones, 85 percent; of species restricted to the Hudsonian and Alpine zones, 60 percent.

The percentages of Shasta mammals common to the Sierra and the Cascades are: Of boreal species, including those which range down into the Transition zone, 72 percent; of species restricted to the Boreal zones, 70 percent; of species restricted to the Hudsonian and Alpine zones, 67 percent.[1]

The percentages of Shasta plants common to the Sierra and the Cascades are: Of boreal species, including those which range down into the Transition zone, 49 percent; of species restricted to the Boreal

[1] The number of Hudsonian-Alpine species is too small to give this percentage much value.

zones, 46 percent; of species restricted to the Hudsonian and Alpine zones, 44 percent.

For evidence of another kind—that based on the *absence* from Shasta of species which occur in the Sierra or the Cascades or both—see pages 79–82.

Following are the tables on which the foregoing generalizations are based:

(1) BOREAL SPECIES COMMON TO SHASTA AND THE SIERRA-CASCADE SYSTEM.

(Species followed by the letter T range down into or through the Transition zone.)

(*a*) MAMMALS.

Callospermophilus chrysodeirus T.
Canis lestes.
Erethizon epixanthus T.?
Eutamias amœnus T.
Eutamias senex T.
Evotomys mazama.[1]
Felis oregonensis T.
Lepus klamathensis T.?
Lutreola vison energumenos T.
Microtus mordax T.
Mustela caurina.
Mustela pennanti.
Myotis lucifugus longicrus T.
Myotis yumanensis saturatus.
Neotoma cinerea T.
Neurotrichus gibbsi major T.
Ochotona schisticeps.
Odocoileus columbianus T.
Peromyscus gambeli T.
Phenacomys orophilus.
Putorius arizonensis.
Sorex vagrans amœnus T.
Sorex (Neosorex) navigator.
Taxidea taxus T.
Ursus americanus T.
Vulpes macrourus T.

(*b*) BIRDS.

Accipiter atricapillus striatulus.
Accipiter velox.
Aquila chrysaëtos T.
Carpodacus cassini.
Ceophlœus pileatus abieticola T.
Certhia familiaris occidentalis T.
Cinclus mexicanus T.?
Coccothraustes vespertinus montanus.
Colaptes cafer T.
Contopus borealis T.
Dendragapus obscurus fuliginosus T.
Dendroica auduboni T.
Dendroica occidentalis.
Dryobates villosus hyloscopus T.
Empidonax difficilis T.
Empidonax hammondi T.
Empidonax wrighti T.
Geothlypis tolmiei T.
Helminthophila celata lutescens T.
Helminthophila rubricapilla gutturalis T.
Hylocichla aonalaschkæ auduboni T.
Melospiza lincolni T.
Merula migratoria propinqua T.
Myadestes townsendi.
Nucifraga columbiana.
Oreortyx pictus plumiferus T.
Parus gambeli.
Picoides arcticus.
Piranga ludoviciana T.
Regulus calendula.
Regulus satrapa olivaceus.
Salpinctes obsoletus T.
Selasphorus rufus T.
Sialia arctica.
Sitta canadensis.
Sitta carolinensis aculeata T.
Sphyrapicus thyroideus.
Spinus pinus.
Stellula calliope T.
Wilsonia pusilla pileolata T.?
Zonotrichia leucophrys.

[1] *Evotomys mazama*, a common Cascade species, was obtained by us on Shasta and Lassen, and doubtless occurs in the Sierra, farther south.

(c) PLANTS.

Achillea borealis.
Aconitum columbianum.
Allium validum.
Alnus sinuata.
Antennaria media.
Arabis platysperma.
Arctostaphylos nevadensis.
Bikukulla uniflora.
Cardamine bellidifolia pachyphylla.
Carex breweri.
Castanopsis sempervirens T.
Chimaphila menziesi T.
Chimaphila umbellata T.
Chrysothamnus bloomeri.
Cymopterus terebinthinus.
Drosera rotundifolia.
Epilobium obcordatum.
Epilobium pringleanum.
Eriogonum pyrolæfolium.
Gentiana simplex.
Habenaria leucostachys.
Habenaria unalaschensis.
Heracleum lanatum T.
Holodiscus discolor.
Hypericum anagalloides.
Juncus parryi.
Juniperus nana.
Kalmia glauca microphylla.
Mimulus primuloides.
Mitella pentandra.
Oreobroma triphylla.
Orthocarpus pilosus.
Oxyria digyna.
Pentstemon newberryi.
Phlox douglasi diffusa.
Pinus albicaulis.
Pinus monticola.
Pinus murrayana.
Polemonium pulchellum.
Polygonum shastense.
Potentilla flabellifolia.
Pulsatilla occidentalis.
Pyrola picta T.
Pyrola secunda T.
Ribes cereum T.
Sagina saginoides.
Salix nuttalli T.
Salix sitchensis T.
Saxifraga tolmiei.
Sibbaldia procumbens.
Sorbus sambucifolia T.
Spraguea umbellata.
Tsuga mertensiana.
Viola blanda.
Viola purpurea.

(2) BOREAL SPECIES COMMON TO SHASTA AND THE SIERRA BUT NOT KNOWN FROM THE CASCADES.

(a) MAMMALS.

Aplodontia major (represented in Cascades by A. major rainieri).
Ovis canadensis (not known or represented in Cascades).
Peromyscus boyli T. (not known or represented in Cascades).
Sciurus albolimbatus T. (represented in Cascades by S. cascadensis).
Sorex montereyensis T. (not known from any point north of Shasta).
Thomomys monticola (represented in Cascades by T. mazama).
Zapus trinotatus alleni (represented in Cascades by Z. montanus).

(b) BIRDS.

Cyanocitta stelleri frontalis T. (represented in Cascades by C. stelleri).[1]
Junco hyemalis thurberi (represented in Cascades by J. h. connectens).
Leucosticte tephrocotis[2] (represented in Cascades by L. t. littoralis).
Loxia curvirostra bendirei (represented in Cascades by L. c. minor).

[1] The Shasta jay is intermediate between *stelleri* and *frontalis*.

[2] The mention of *Leucosticte tephrocotis* in this and subsequent lists involves an assumption. *L. tephrocotis* is known to be the breeding rosy finch of the High Sierra; *L. t. littoralis* that of Mount Rainier in the Cascades of Washington. A rosy finch was found, but not secured, on Shasta. It is referred provisionally to *tephrocotis* rather than *littoralis*, because the great majority of Shasta species which are not common to both ranges are Sierra and not Cascade forms.

BOREAL SPECIES OF SHASTA AND SIERRA—Continued.

(*c*) PLANTS.

Agoseris monticola.
Arnica merriami.
Castilleja affinis.
Castilleja miniata (alpine form).
Chænactis nevadensis.
Cheiranthus perennis.
Corallorhiza bigelovi.
Crepis intermedia.
Cycladenia humilis.
Delphinium sonnei.
Draba breweri.
Erigeron armeriæfolium.
Erigeron compositus trifidus.
Erigeron inornatus.
Eriogonum polypodum.
Hieracium albiflorum (alpine form).
Hieracium horridum.
Hulsea larseni.
Madia bolanderi.
Parnassia californica.
Pentstemon gracilentus.
Ribes amictum T.
Saxifraga bryophora.
Senecio canus.
Senecio trigonophyllus.
Stellaria crispa.
Streptanthus orbiculatus.
Vaccinium cæspitosum.
Vagnera stellata T.
Veratrum californicum T.

(3) BOREAL SPECIES COMMON TO SHASTA AND THE CASCADES BUT NOT KNOWN FROM THE SIERRA.

(*a*) MAMMALS.

Cervus occidentalis T.

(*b*) BIRDS.

Anthus pensilvanicus.
Perisoreus obscurus.

(*c*) PLANTS.

Abies shastensis.
Epilobium clavatum.
Hieracium gracile.
Hulsea nana.
Ligusticum grayi.
Lupinus lyalli.
Lupinus 'ornatus.'
Lutkea pectinata.
Macharanthera shastensis.
Oreastrum alpiginum.
Pentstemon menziesi.
Phyllodoce empetriformis.
Polygonum newberryi.
Silene suksdorfi.
Tofieldia occidentalis.
Vaccinium arbuscula T.
Veronica cusicki.

(4) BOREAL SHASTA SPECIES NOT KNOWN FROM EITHER THE SIERRA OR THE CASCADES.

(*a*) MAMMALS.

Perognathus mollipilosus T.
Sorex shastensis.

(*b*) BIRDS.

[None.]

(*c*) PLANTS.

Arnica longifolia.
Arnica viscosa.[1]
Campanula wilkinsiana.[1]
Mimulus implexus.
Pentstemon glaber utahensis.
Phacelia frigida.[1]
Scutellaria nana.
Silene grayi.[1]

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[1] So far as known restricted to Shasta.

(5) EXCLUSIVELY BOREAL SPECIES OF SHASTA.

(a) MAMMALS.

Aplodontia major.
Canis lestes.
Evotomys mazama.
? Lepus klamathensis.
Microtus mordax.
Mustela caurina.
Mustela pennanti.
Myotis yumanensis saturatus.
Ochotona schisticeps.
Ovis canadensis.
Phenacomys orophilus.
Putorius arizonensis.
Sorex (Neosorex) navigator.
Sorex shastensis.
Thomomys monticola.
Vulpes macrourus.
Zapus trinotatus alleni.

(b) BIRDS.

Accipiter atricapillus striatulus.
Anthus pensilvanicus.
Carpodacus cassini.
Cinclus mexicanus.
Coccothraustes vespertinus montanus.
Dendroica occidentalis.
Junco hyemalis thurberi.
Leucosticte tephrocotis.
Loxia curvirostra bendirei.
Myadestes townsendi.
Nucifraga columbiana.
Parus gambeli.
Perisoreus obscurus.
Picoides arcticus.
Regulus calendula.
Regulus satrapa olivaceus.
Sialia arctica.
Sitta canadensis.
Sphyrapicus thyroideus.
Spinus pinus.
Wilsonia pusilla pileolata.
Zonotrichia leucophrys.

(c) PLANTS.

Abies shastensis.
Achillea borealis.
Aconitum columbianum.
Agoseris monticola.
Allium validum.
Allium sp. ——?
Alnus sinuata.
Antennaria media.
Arabis platysperma.
Arctostaphylos nevadensis.
Arnica longifolia.
Arnica merriami.
Arnica viscosa.
Bikukulla uniflora.
Campanula wilkinsiana.
Cardamine bellidifolia pachyphylla.
Carex breweri.
Castilleja miniata (alpine form).
Chænactis nevadensis.
Cheiranthus perennis.
Chrysothamnus bloomeri.
Corallorhiza bigelovi.
Crepis intermedia.
Cycladenia humilis.
Cymopterus terebinthinus.
Delphinium sonnei.
Draba breweri.
Drosera rotundifolia.
Epilobium clavatum.
Epilobium obcordatum.
Epilobium pringleanum.
Erigeron armeriæfolium.
Erigeron compositus trifidus.
Erigeron inornatus.
Eriogonum polypodum.
Eriogonum pyrolæfolium.
Gentiana simplex.
Habenaria leucostachys.
Habenaria unalaschensis.
Hieracium albiflorum (alpine form).
Hieracium gracile.
Hieracium horridum.
Holodiscus discolor.
Hulsea larseni.
Hulsea nana.
Hypericum anagalloides.
Juncus parryi.
Juniperus nana.
Kalmia glauca microphylla.
Ligusticum grayi.
Lupinus albifrons.
Lupinus lyalli.
Lupinus 'ornatus.'
Lutkea pectinata.
Machæranthera shastensis.
Madia bolanderi.
Mimulus implexus.
Mimulus primuloides.

EXCLUSIVELY BOREAL SPECIES OF SHASTA—Continued.

(c) PLANTS—continued.

Mitella pentandra.
Monardella odoratissima.
Oreastrum alpiginum.
Oreobroma triphylla.
Orthocarpus pilosus.
Oxyria digyna.
Parnassia californica.
Pentstemon deustus.
Pentstemon glaber utahensis.
Pentstemon gracilentus.
Pentstemon menziesi.
Pentstemon newberryi.
Phacelia frigida.
Phlox douglasi diffusa.
Phyllodoce empetriformis.
Pinus albicaulis.
Pinus monticola.
Pinus murrayana.
Polemonium pulchellum.
Polygonum newberryi.
Polygonum shastense.
Potentilla flabellifolia.
Potentilla pseudorupestris.
Pulsatilla occidentalis.
Sagina saginoides.
Saxifraga bryophora.
Saxifraga tolmiei.
Senecio canus.
Senecio trigonophyllus.
Sibbaldia procumbens.
Silene grayi.
Silene suksdorfi.
Sitanion cinereum.
Spraguea umbellata.
Stellaria crispa.
Streptanthus orbiculatus.
Tofieldia occidentalis.
Tsuga mertensiana.
Vaccinium cæspitosum.
Vaccinium occidentale.
Veronica cusicki.
Viola blanda.
Viola purpurea.

(6) EXCLUSIVELY HUDSONIAN-ALPINE SPECIES OF SHASTA.

MAMMALS.

Ochotona schisticeps.
Ovis canadensis.
Phenacomys orophilus.

BIRDS.

Anthus pensilvanicus.
Leucosticte tephrocotis.
Nucifraga columbiana.
Sialia arctica.
Zonotrichia leucophrys.

PLANTS.

Achillea borealis.
Agoseris monticola.
Antennaria media.
Arabis platysperma.
Arnica merriami.
Arnica viscosa.
Bikukulla uniflora.
Cardamine bellidifolia pachyphylla.
Carex breweri.
Chænactis nevadensis.
Cheiranthus perennis.
Chrysothamnus bloomeri.
Cycladenia humilis.
Cymopterus terebinthinus.
Draba breweri.
Epilobium clavatum.
Epilobium obcordatum.
Epilobium pringleanum.
Erigeron armeriæfolium.
Erigeron compositus trifidus.
Eriogonum polypodum.
Eriogonum pyrolæfolium.
Hieracium albiflorum (alpine form).
Hieracium gracile.
Hieracium horridum.
Holodiscus discolor (alpine form).
Hulsea larseni.
Hulsea nana.
Juncus parryi.
Juniperus nana.
Kalmia glauca microphylla.
Lupinus albifrons.
Lupinus lyalli.
Lupinus 'ornatus.'
Lutkea pectinata.
Machæranthera shastensis.
Mimulus implexus.
Mitella pentandra.
Oreastrum alpiginum.
Oreobroma triphylla.

EXCLUSIVELY HUDSONIAN-ALPINE SPECIES OF SHASTA—Continued.

PLANTS—continued.

Orthocarpus pilosus.
Oxyria digyna.
Parnassia californica.
Pentstemon glaber utahensis.
Pentstemon menziesi.
Pentstemon newberryi.
Phacelia frigida.
Phyllodoce empetriformis.
Pinus albicaulis.
Polemonium pulchellum.
Polygonum newberryi.
Polygonum shastense.
Potentilla flabellifolia.
Potentilla pseudorupestris.
Pulsatilla occidentalis.
Sagina saginoides.
Saxifraga bryophora.
Saxifraga tolmiei.
Senecio canus.
Sibbaldia procumbens.
Silene grayi.
Silene suksdorfi.
Sitanion cinereum.
Streptanthus orbiculatus.
Tsuga mertensiana.
Vaccinium cæspitosum.
Veronica cusicki.
Viola purpurea.

(7) EXCLUSIVELY HUDSONIAN-ALPINE SPECIES COMMON TO SHASTA AND THE SIERRA-CASCADE SYSTEM.

MAMMALS.

Ochotona schisticeps.
Phenacomys orophilus.

BIRDS.

Nucifraga columbiana.
Sialia arctica.
Zonotrichia leucophrys.

PLANTS.

Achillea borealis.
Antennaria media.
Arabis platysperma.
Bikukulla uniflora.
Cardamine bellidifolia pachyphylla.
Carex breweri.
Chrysothamnus bloomeri.
Cymopterus terebinthinus.
Epilobium obcordatum.
Epilobium pringleanum.
Eriogonum pyrolæfolium.
Holodiscus discolor (typical alpine form).
Juncus parryi.
Juniperus nana.
Kalmia glauca microphylla
Mitella pentandra.
Oreobroma triphylla.
Orthocarpus pilosus.
Oxyria digyna.
Pentstemon newberryi.
Pinus albicaulis.
Polemonium pulchellum.
Polygonum shastense.
Potentilla flabellifolia.
Pulsatilla occidentalis.
Sagina saginoides.
Saxifraga tolmiei.
Sibbaldia procumbens.
Tsuga mertensiana.
Viola purpurea.

(8) EXCLUSIVELY HUDSONIAN-ALPINE SPECIES COMMON TO SHASTA AND THE SIERRA BUT NOT KNOWN FROM THE CASCADES.

MAMMALS.

Ovis canadensis.

BIRDS.

? Leucosticte tephrocotis.

PLANTS.

Agoseris monticola.
Arnica merriami.
Chænactis nevadensis.
Cheiranthus perennis.
Cycladenia humilis.
Draba breweri.
Erigeron armeriæfolium.
Erigeron compositus trifidus.

HUDSONIAN-ALPINE SPECIES OF SHASTA AND SIERRA—Continued.

PLANTS—continued.

Eriogonum polypodum.
Hieracium albiflorum (alpine form).
Hieracium horridum.
Hulsea larseni.
Parnassia californica.
Saxifraga bryophora.
Senecio canus.
Streptanthus orbiculatus.
Vaccinium cæspitosum.

(9) EXCLUSIVELY HUDSONIAN-ALPINE SPECIES COMMON TO SHASTA AND THE CASCADES BUT NOT KNOWN FROM THE SIERRA.

MAMMALS.

None.

BIRDS.

Anthus pensilvanicus.

PLANTS.

Epilobium clavatum.
Hieracium gracile.
Hulsea nana.
Lupinus lyalli.
Lupinus 'ornatus.'
Lutkea pectinata.
Machæranthera shastensis.
Oreastrum alpiginum.
Pentstemon menziesi.
Phyllodoce empetriformis.
Polygonum newberryi.
Silene suksdorfi.
Veronica cusicki.

BOREAL SPECIES OF THE SIERRA-CASCADES NOT KNOWN FROM SHASTA.

Turning to another phase of the subject, the *absentees*, or boreal species of the Sierra and Cascades which are not known from Shasta, an equally instructive lesson may be learned.

The boreal species that occur in the Sierra or Cascades, or both, but which are not known from Shasta, have been grouped in three categories: (1) species common to the Sierra-Cascades but not known from Shasta; (2) Sierra species not known from Shasta or the Cascades; and (3) Cascade species not known from Shasta or the Sierra.[1]

(1) Boreal species common to the Sierra and the Cascades but not known from Shasta.

Only three boreal mammals are known to occur in both the Sierra and the Cascades which have not been found on Shasta. These are the Sierra marmot (*Arctomys flaviventer*), the wolverine (*Gulo luscus*), and the silver-haired bat (*Lasionycteris noctivagans*). The marmot, it may be stated with confidence, is really absent; the wolverine has been killed in the near vicinity and probably occurs on Shasta; the bat is a local species common in the mountains west of Shasta, easily overlooked and most likely to occur. Hence there is every reason to

[1] In the accompanying tables and discussion the boreal species are treated collectively, no account being taken of the important distinctions between the Alpine, Hudsonian, and Canadian species. This course has been rendered necessary by the absence of discriminative zone lists of Cascade-Sierra species.

believe that the Sierra marmot is really the only mammal common to the Sierra and the Cascades which does not occur on Shasta.

Two boreal birds believed to be common to the Sierra-Cascade system (the western winter wren, *Anorthura hiemalis pacifica*, and the Townsend warbler, *Dendroica townsendi*) have not yet been discovered on Shasta, but are liable to be found there at any time.

With plants the case is quite different, for at least 19 well-known genera, and a considerable number of species of other genera, not known from Shasta are common to the Sierra and the Cascades.

(a) MAMMALS.

Arctomys flaviventer. Gulo luscus. Lasionycteris noctivagans.

(b) BIRDS.

Anorthura hiemalis pacifica. Dendroica townsendi.

(c) PLANTS.

Genera not known from Shasta.

Arenaria.
Cassiope.
Claytonia.
Clintonia.
Erythronium.
Geum.
Heuchera.
Iris.
Ivesia.
Listera.
Mertensia.
Pedicularis.
Primula.
Raillardella.
Ranunculus.
Smelowskia.
Streptopus.
Thalictrum.
Xerophyllum.

Additional species not known from Shasta.

Arnica chamissonis.
Campanula scouleri.
Crepis nana.
Erigeron salsuginosus.
Gentiana newberryi.
Juncus orthophyllus.
Lonicera conjugalis.
Lonicera involucrata.
Polygonum bistortoides.
Populus tremuloides.
Salix barclayi.
Saxifraga nivalis.
Saxifraga punctata.

(2) Boreal Sierra species not known from Shasta or the Cascades.

Eight mammals, 1 bird, 3 coniferous trees, several shrubs, and a number of small plants are known from the High Sierra which do not occur on Shasta or the Cascades; the majority of them are restricted to the southern part of the Sierra, not reaching as far north as the mountains about Lake Tahoe, and consequently need not be considered here. Only three of the Sierra mammals (*Spermophilus beldingi*, *Eutamias speciosus frater*, and *Sorex obscurus*) which range north to the south end of Feather River Gap fail to reach Shasta, and two if not all three of these are known to cross this gap and occur on Lassen, showing that the Feather River Gap of itself is of very little significance. The details of plant distribution in these mountains are not sufficiently known to admit of safe generalizations.

BOREAL SIERRA SPECIES—Continued.

(*a*) MAMMALS.

Eutamias alpinus.[1]
Eutamias speciosus.[1]
Eutamias speciosus callipeplus.[1]
Eutamias speciosus frater.
Microtus dutcheri.[1]
Sorex obscurus.
Spermophilus beldingi.
Thomomys alpinus.[1]

(*b*) BIRDS.

Pinicola enucleator californica.

(*c*) PLANTS.

Abies magnifica.
Arenaria compacta.
Arenaria congesta.
Artemisia rothrocki.
Chrysopsis breweri.
Draba lemmoni.
Eulophus parishi.
Hulsea algida.
? Ledum glandulosum.
Leucothoe davisiæ.
Lychnis californica.
Montia fontana.
Oreobroma nevadensis.
Oreobroma pygmæa.
Phyllodoce breweri.
Pinus balfouriana.
Pinus flexilis.
Primula suffrutescens.
Quercus vacciuifolia.
Raillardella scaposa.
Ranunculus oxynotus.
Silene bernardina.
Silene californica.

(3) BOREAL CASCADE SPECIES NOT KNOWN FROM SHASTA OR THE SIERRA.

Eleven mammals, 2 birds, 3 fir trees, and a number of shrubs and other plants which inhabit the Cascade Range in Oregon are not known to occur on Shasta or in the Sierra Nevada. One of the mammals (*Eutamias townsendi*) does not reach as far south as the southern end of the Cascades, and two others (*Aplodontia major rainieri* and *Sciurus cascadensis*) are only subspecifically separable from corresponding forms in the Sierra. The remaining eight are independent specific types not represented on Shasta or in the Sierra, and all of them push south to the extreme southern end of the Cascades immediately across Klamath Gap from Shasta.

(*a*) MAMMALS.

Aplodontia major rainieri.
Eutamias townsendi.
Lynx canadensis.
Microtus (Arvicola) arvicoloides.
Microtus (Chilotus) bairdi.
Putorius cicognani streatori.
Scapanus alpinus.
Sciurus douglasi cascadensis.
Sorex (Atophyrax) bendirei.
Thomomys mazama.
Zapus montanus.

(*b*) BIRDS.

Hylocichla ustulata.
Leucosticte tephrocotis littoralis.[2]

[1] These mammals are restricted to the southern part of the Sierra and none of them come as far north as the mountains about Lake Tahoe.

[2] *Leucosticte tephrocotis littoralis* breeds in the Cascades of Washington but is not actually known from the Cascades of Oregon. It is likely to be found among the glaciers of Mount Hood and The Sisters when the birds of these mountains are studied.

(*c*) PLANTS.

Abies amabilis.
Abies lasiocarpa.
Abies nobilis.
Gaultheria myrsinites.
Menziesia ferruginea.
Rhododendron albiflorum.
Ribes erythrocarpum.
Ribes lacustre.
Rubus lasiococcus.
Silene acaulis.
Sorbus occidentalis.
Spiræa arbuscula.
Vaccinium microphyllum.
Valeriana sitchensis.

EFFICIENCY OF KLAMATH GAP AS A BARRIER TO BOREAL SPECIES COMPARED WITH THAT OF PITT RIVER AND FEATHER RIVER GAPS COLLECTIVELY.

In view of the narrowness of Klamath Gap, a break of less than 50 miles, separating the boreal fauna of Shasta from that of the Cascades, compared with the breadth of the combined Pitt River and Feather River gaps, about 100 miles, separating Shasta from the boreal fauna of the Sierra Nevada northwest of Honey Lake, one might expect Shasta to share more species with the Cascades than with the Sierra. The contrary is true. The Feather River Gap, as elsewhere explained (p. 70), is ineffective compared with the others; the branches of Feather River do not cut completely through the mountains, and the gap is merely a low part of the range, with the Honey Lake ridge and small boreal-capped peaks projecting here and there as stepping stones between the main Sierra and Mount Lassen. Pitt River Gap is deeper, cutting completely through the range between Lassen and Shasta, forming a boreal break about 60 miles in width, and there is no apparent reason why it should not be as effective a barrier as Klamath Gap, although from the standpoint of zone distribution it does not cut so low and therefore has a slightly cooler summer climate, in consequence of which it is less effective. But this difference is insufficient to explain the really great disparity in potency of the two, for in checking the extension of boreal species Klamath Gap has proved far more effective.

Passing over the species common to Shasta and the Sierra-Cascade system as a whole (see p. 73), only three of the ten distinctively Sierra mammals which reach the northern end of the Sierra fail to reach Shasta, and two if not all of these bridge the Feather River Gap and reach Mount Lassen, which is separated from Shasta by only the Pitt River Gap. On the other hand, *not one of the ten* distinctively Cascade mammals which occur at the extreme south end of the Cascade Range has been able to cross the narrow Klamath Gap to Shasta.

If the number of distinctive mammals of the Sierra-Cascade system be reduced by subtracting those which are represented in the two ranges by closely related forms[1] 8 distinctive specific types will remain

[1] Close discrimination of species and subspecies is necessary in laying off the minor subdivisions of faunas; and it is interesting from the zoological standpoint to know which and how many of the specific types common to a given area have undergone enough change in parts of that area to warrant separate recognition by name, but from the standpoint of the distribution of specific types such details are of little value.

for the southern Cascades and 7 for the northern Sierra. Of these distinctive specific types only 3 of the 7 Sierra species fail to reach Shasta, while all of the 8 Cascade species fail.

The significance of these facts appears when the Boreal faunas of the mountains north and south of Klamath Gap are studied with reference to their geographic sources of origin, as pointed out in the next chapter.

SOURCES OF THE BOREAL FAUNAS OF SHASTA AND OF THE SIERRA AND THE CASCADES.

The boreal animals and plants of the Sierra-Cascade system as a whole are not yet well enough known to admit of positive statements as to the number of species or the details of their distribution. Hence a complete study of their distribution with reference to the geographic source of origin of the various specific types is not possible. Nevertheless, enough has been learned to point to some very interesting conclusions.

It has been already shown that the boreal fauna and flora of Shasta form a part of the fauna and flora of the Sierra-Cascade system; that 70 percent of the exclusively boreal mammals of Shasta are common to both ranges; and that of the remainder, 80 percent are common to the Sierra. It is obvious therefore that, so far as mammals are concerned, Shasta may be considered a part of the Sierra (see p. 71).

Fifty-eight boreal[1] species of mammals are known from the Sierra and the Cascades. Of these, 31 (54 percent) are common to both ranges, 11 (19 percent) are restricted to the Sierra, and 16 (28 percent) to the Cascades.

Of the 58 boreal species of mammals known to inhabit the Sierra-Cascade system not a single genus or subgenus is peculiar, though the genera *Aplodontia* and *Neurotrichus* and the subgenus *Atophyrax* are restricted to the northwest coast region. With species the case is very different, for 23 of the 58 species (40 percent) are peculiar to the Sierra-Cascades; but even of these only 10 differ sufficiently from near relatives elsewhere to be considered distinct specific types. Of the 58 species whose relationships are so obvious that there can be no doubt as to their affinities and origin, 5 (9 percent) come from mountains farther north (in British Columbia, some ranging into southeastern Alaska), 8 (14 percent) are of general transcontinental boreal distribution, 16 (28 percent) are characteristic of the humid west or northwest coast region, 19 (33 percent) are identical with or closely related to species living in the Rocky Mountains, and 10 (17 percent) are distinctive superspecific types restricted to the Sierra-Cascade system.

If, instead of treating the Sierra-Cascade species collectively, we group them with reference to the particular part of the mountains they inhabit, putting the Cascade species (those north of Klamath Gap) in

[1]Our collections from the Cascades have not yet been worked up, and it is probable that several species will be added to this number.

one category, and the Sierra species (those south of Klamath Gap) in another, some additional facts are brought out which emphasize the widely different sources of origin of the distinctively Cascade species on the one hand, and the distinctively Sierra species on the other. Of the distinctively Cascade species, 25 percent are derived from mountains farther north, 12 percent are local types, 12 percent belong to transcontinental boreal types. and 25 percent to northwest-coast types. Of the distinctively Sierra species, 50 percent are specially developed local types, and 50 percent belong to types common to the Sierra and the southern Rocky Mountains.

These facts point not only to the great antiquity and effectiveness of the Klamath Gap, but also to a former east and west continuity of range of Boreal species between the Rocky Mountains of Utah and Colorado and the Sierra Nevada of California, a distance of at least 500 miles.

Sorex shastensis sp. nov. Shasta Shrew.

Type from Wagon Camp, Mount Shasta (alt. 5,700 ft. in the lower part of the Canadian zone). No. 95450, U. S. Nat. Mus., Biological Survey Coll. Collected Sept. 26, 1898, by W. H. Osgood. Orig. No. 317.

Characters.—Size small; decidedly smaller than *S. vagrans;* tail rather short; ears small, but conspicuous. Third unicuspid smaller than fourth. Skull and teeth peculiar.

Color.—Type specimen, in change from summer to winter pelage: Head and sides of neck to shoulders dull fulvous brown; rest of upper parts dark steel gray; underparts ashy brown; tail sharply bicolor, dusky above, buffy below, becoming dusky toward tip.

Cranial characters.—Skull small, decidedly smaller than in *vagrans* and as small as in *californicus;* brain case moderately high—not at all flattened as in *californicus;* rostrum rather small (about as in *californicus*); constriction swollen. Tooth row, as a whole, somewhat shorter than in *californicus;* unicuspids decidedly narrower, particularly the first and second; molariform series much as in *californicus*, but slightly smaller; large premolar very broad posteriorly.

Measurements.—Type: Total length, 90; tail vertebræ, 35; hind foot, 12.

Remarks.—This new species is based on a single specimen caught by W. H. Osgood in a trap set in a springy place among the Shasta firs, immediately above Wagon Camp. In the same trap, and in the identical spot, he caught also specimens of *Neosorex navigator* and *Neurotrichus gibbsi major.* Several specimens of *Sorex vagrans amœnus* were caught near by, but no others of this species.

Sorex shastensis is a small shrew of uncertain affinities. In several respects it resembles *S. californicus*, but differs from this species markedly in color, and still more in the form of the cranium and narrowness of the unicuspidate teeth.

Sorex vagrans amœnus Merriam. Sierra Shrew.

Twenty-two specimens of this small shrew were collected on Shasta and about its base. Two were caught among the tules at Big Spring, in Shasta Valley, on the north side of the mountain; two at Warmcastle Soda Springs, in Squaw Creek Valley, on the south side; and nineteen in the Canadian zone and lower part of the Hudsonian from Wagon Camp up to upper Squaw Creek, Mud Creek, and Ash Creek. Most of them were trapped under logs in damp places.

Sorex montereyensis Merriam. Monterey Shrew.

Six specimens of this large long-tail shrew were secured—one at the lower edge of the Hudsonian zone, near Mud Creek; four in the Canadian zone, in Mud Creek Canyon; and one in the Transition zone, in Squaw Creek Valley, near Warmcastle Soda Springs.

Sorex (Neosorex) navigator Baird. White-bellied Water-shrew.

Apparently rather scarce, as a large amount of trapping resulted in the capture of only four specimens. These were obtained at as many localities, namely, the head of Panther Creek, upper Squaw Creek, upper Ash Creek Canyon, and Wagon Camp, all in the Canadian zone.

Neurotrichus gibbsi major subsp. nov. Large Shrewmole.

Type from Carberry Ranch, Shasta County, Calif. (alt. 4,100 ft., between Mts. Shasta and Lassen). No. 65321, ♂ ad., U. S. Nat. Mus., Biological Survey Coll. Collected May 18, 1894, by C. P. Streator. Orig. No. 3789.

Characters.—Similar to *N. gibbsi*, but decidedly larger; hind feet larger; forefeet much broader and longer; tail much longer; under parts darker; skull larger and broader; fifth upper lateral tooth (the 'large premolar') decidedly *smaller* than in *N. gibbsi*, and possessing a distinct anterior cusp on the cingulum, which is absent in *gibbsi;* fifth lower lateral tooth (the 'large premolar') decidedly *larger* than in *gibbsi*.

Measurements.—Average of 3 specimens from type locality: Total length, 120; tail vertebræ, 40; hind foot, 17. Average of 4 specimens from Mount Shasta: Total length, 113; tail vertebræ, 41; hind foot, 16.2.

Remarks.—Four specimens of this new form of Gibbs shrewmole were collected by our party on Shasta—all in the Canadian zone. Three were caught in Mud Creek canyon near the mouth of Clear Creek by Walter K. Fisher and W. H. Osgood, and one was taken at Wagon Camp by Osgood. In May, 1894, my assistant, Clark P. Streator, obtained 3 specimens (the type and cotypes) at Carberry Ranch, on the south side of Pitt River, between Mounts Shasta and Lassen. Carberry Ranch is in the upper part of the Transition zone. The Canadian zone specimens from Shasta are not quite so large, but agree in other characters.

Scapanus californicus (Ayres). California Mole.

Vernon Bailey found a dead mole of this species, October 3, in the road between Wagon Camp and Sisson at an altitude of 4,500 feet. He reported mole ridges as common in places a little below Wagon Camp, and also in sandy soil in the Murray pine belt east of the mountain; W. H. Osgood saw mole ridges in Shasta Valley.

Myotis evotis (H. Allen.) Big-eared Bat.

At Sisson, September 5, R. T. Fisher obtained a specimen from a small boy, who caught it in a kitchen. The species doubtless occurs in Shasta Valley also.

Myotis lucifugus longicrus (True).

At Wagon Camp, July 17, Walter K. Fisher shot one of these bats. Small bats were abundant here, but kept so much in the forest that they were hard to shoot.

Myotis californicus (Aud. & Bach.). California Bat.

A single specimen of this species, collected on Mount Shasta by C. H. Townsend, is recorded by Miller in North American Fauna, No. 13, page 71, October, 1897.

Myotis yumanensis saturatus Miller.

Common among the alpine hemlocks at Squaw Creek Camp, where they were seen every night, darting in and out of the flickering light of the camp fire. Here I shot one the evening of August 3, and four the evening of August 9. Late in July and early in August small bats, probably the same species, were seen nearly every evening at the temporary camps on or near upper Mud Creek. The species is interesting as the only bat secured in the Hudsonian zone.

Vespertilio fuscus Beauvois. Large Brown Bat.

Common at Wagon Camp, where Vernon Bailey shot one July 17, and I shot three the evening of July 28. Many more could have been killed if desired. In 1883 C. H. Townsend obtained it at Sheep Rock. The species is one of the commonest in the foothills and valleys, and is easily recognized on the wing by its large size and its character of flight.

[**Arctomys flaviventer** (Aud. & Bach.). Mountain Marmot.

It may be asserted with confidence that no marmots of any kind live on Shasta. Our collectors were at work on the mountain from July 15 until October without seeing a single individual. Moreover, when Vernon Bailey and I made our trip completely around the peak the latter part of July we kept near timberline all the way and made a special search for marmots, but were unable to find a trace of their presence.]

Spermophilus douglasi (Richardson). Oregon Ground Squirrel.

Common at Sisson and in McCloud and Shasta valleys, whence it ranges up through the manzanita chaparral of the basal slopes nearly to Wagon Camp. At Sisson R. T. Fisher collected eight during the first half of September, and says of them: "One of the few really plentiful mammals at Sisson. Hardly an acre in the valley is free from their burrows. Under the barns and houses, in the fields, along the hot slopes east and west of the town, and even in the woods, one constantly sees them. At the time I write of, September 1–15, they seemed to be feeding chiefly on acorns and chinquapins—acorns in the valley, chinquapins on the western slopes. In behavior they were wild and sneaking; at all times difficult to approach. None appeared to have hibernated."

At Big Spring, in Shasta Valley, where they abound, W. H. Osgood saw several climb up on a beam and enter an opening in a granary.

Callospermophilus chrysodeirus Merriam. Golden-mantled Ground Squirrel.

One of the most abundant and conspicuous mammals of the mountain, where they were seen daily from the manzanita belt up to timberline, and where 52 specimens were collected. At Sisson they are rare, but 2,000 feet higher are fairly common, as they are also in Squaw Creek Valley at the south base of the mountain. In the fir forest they make their homes under logs or about the roots of trees, but in the neighborhood of timberline live in burrows under the rocks, often in slide rock, associated with small colonies of conies. At low altitudes they are usually unwary and may be easily killed with the 'auxiliary' barrel, but in the neighborhood of timberline they are so exceedingly shy it is difficult to approach within gunshot. At our camp among the alpine hemlocks on upper Squaw Creek they first kept at long range, but finding us harmless gradually overcame their fear, and finally, toward the end of the season, came to be one of the most persistent of camp robbers, stealing bread and other eatables. At the same time they never came freely and boldly as did their associates, the chipmunks, but always stole in silently and if possible kept out of sight.

This species goes into winter quarters much later than its relatives in the Rocky Mountain region. On Shasta it was seen daily near timberline until after the middle of September and a few were noticed on warm days as late as September 24, but all those secured during the latter part of the month were young of the year. Between Wagon Camp and Sisson they were seen as late as September 26.

Eutamias amœnus (Allen). Klamath Chipmunk.

Abundant in the chaparral of the lower slopes and thence up through the forest to timberline. Fifty-three specimens were obtained at various points on the mountain. At Wagon Camp they were common and were seen picking unripe serviceberries the latter part of July. At the south base of the mountain one was killed as low down as Warmcastle Soda Springs in Squaw Creek Valley. In the forest they live mostly about logs and stumps and are quite fearless, but along the upper edge of timber, where they live among the bare rocks, they are much more wary.

Eutamias senex (Allen). Allen Chipmunk.

Abundant in the Shasta fir belt and ranging down to Sisson and Warmcastle Soda Springs at the base of the mountain and up to the upper limit of continuous timber, though perhaps not to extreme timberline. Sixty-eight specimens were secured.

At Wagon Camp they were common and were usually associated with their small cousin, *E. amœnus*. They are more arboreal than the other chipmunks and we often saw them in the trees 40 or 50 feet above the ground, moving about in the branches or chasing one another around the great trunks of the hemlocks and firs. At our camp in the alpine hemlocks on Squaw Creek they were the most abundant and most fearless of the diurnal mammals. Here they were constantly associated with the less abundant golden-mantled ground squirrels (*Callospermophilus chrysodeirus*), compared with which they are bolder, more active, more graceful, and more interesting.

In camp they made frequent visits to the mess box, which they clearly regarded as public property, approaching it boldly and without suspicion and showing no concern at our presence—in marked contrast to the golden-mantled ground squirrels, which approached silently, stealthily, and by a circuitous route, in constant fear of detection. If disturbed while stuffing their cheek pouches with bits of bread, pancake, or other eatables, each chipmunk usually seized a large piece in its mouth and scampered off, returning as soon as we withdrew. In fact, they made themselves perfectly at home in camp, and evidently ranked us with other harmless inhabitants of the forest. They climbed up the sides of our tent and over towels hung to dry on branches, as if such things had always been a part of their environment. It should be added, however, that the most familiar animals were always the young of the year, which probably had no recollection of the time before our arrival.

Along the upper border of the timber, where the ground is more open and is covered with gray rocks and pumice instead of the dark felting of hemlock and fir needles and cones, the chipmunks are far more alert and wary.

After the middle of September the adults were rarely seen, and after the 20th the young came out only during the warmest part of the day.

At Sisson, R. T. Fisher found these chipmunks more abundant than any other mammal. They were common in the woods, in the chaparral, on the hillsides, and in the bottom of the valley. At the time of his visit—from the end of August to the middle of September—they were in the molt and very ragged.

Sciurus albolimbatus Allen. Sierra Pine Squirrel.

[=*S. californicus* Allen, preoccupied.]

Common in the Canadian zone forest of Shasta firs, and in the Transition forest of mixed pine and Douglas spruce. Among the Shasta firs they were seen on all sides of the mountain and came up as high as the lower edge of the alpine hemlocks. Among the pines and Douglas firs they were seen as low as Bear Butte, near Squaw Creek Valley, and were common at Sisson and thence northward along the base of the Scott Mountains. Like other pine squirrels they lay up stores of cones for winter use. At low elevations they rival the large gray tree squirrels in collecting the seeds of the huge cones of the sugar pines. At higher elevations they seem to feed largely on the much smaller seeds of the Shasta firs, the cones of which they collect in large numbers. These cones are gathered in heaps at the bases of trees, where the squirrels live, and are also stored in decayed logs, where they are stuffed into all available openings. As 1898, the year of our visit, was an 'off year' for cones, we were forced, in order to obtain specimens, to take advantage of the stores made by these squirrels the previous year. In them we found innumerable cones, more or less perfect and with the seeds still untouched, of both *Abies shastensis* and *A. lowiana*.

Sciurus fossor Peale. Oregon Gray Squirrel; Large Tree Squirrel.

Fairly common in the pine forest covering the southern and western basal slopes of Shasta. At different times during the summer these large squirrels were seen in Squaw Creek Valley and between Sisson and Edgewood. On July 13 Vernon Bailey found them common near Bear Creek, between Fall River Valley and Shasta, where the sugar pines begin. They were then cutting off the scales and eating the green seeds of the half-grown cones of sugar pines.

Sciuropterus alpinus klamathensis Merriam. Klamath Flying Squirrel.

The only flying squirrel seen by our party was observed by me in August on a cedar stub near a small stream a couple of miles below Wagon Camp, but was not secured. There is therefore some uncertainty as to the species. At Sisson I was informed that a boy had a pair alive in a cage, but he left town with them before they could be examined.

Castor canadensis Kuhl. Beaver.

Probably not now living in the immediate vicinity of Shasta, although in 1883, according to C. H. Townsend, "a number of them occupied unmolested a dam, which they had constructed in a corner of a meadow belonging to Mr. J. H. Sisson." They were formerly common in Shasta River, where Walter K. Fisher was recently told a few were seen in the winter of 1898–99.

Aplodontia major Merriam. Aplodontia; Sewellel.

In making the circuit of Shasta the latter part of July, Vernon Bailey and I discovered a colony of aplodontias in some rank vegetation covering a springy place in Ash Creek Canyon, in the upper part of the Canadian zone. A little later W. K. and R. T. Fisher were sent there and obtained two specimens. About the same time they and W. H. Osgood caught eight in Mud Creek Canyon near the mouth of Clear Creek, at an altitude of nearly 7,000 feet.

Aplodontias live in wet or damp places usually overgrown with rank vegetation, and preferably in springy, sloping ground where some of their innumerable burrows and sunken runways are kept wet by the cold trickling water. As is well known, they cut various plants, commonly rank or woody kinds, which they gather and carry in bundles to their burrows, or to places near by, where they spread them out to dry.

In Ash Creek Canyon Walter Fisher found their cuttings to consist chiefly of ferns and willows—the latter carried from a long distance. In Mud Creek Canyon the cuttings consisted chiefly, according to W. H. Osgood, of thimble-berry bushes, mountain ash, and brake ferns—the latter predominating, and in one place forming a pile as big as a bushel basket. The animals commonly live in colonies, but Osgood concluded that in Mud Creek Canyon only one individual, or at most a pair, lived in one place, "though several may be distributed among the branches of a stream."

Mus musculus Linn. House Mouse.

Abundant at Sisson, and running wild like the native species. R. T. Fisher reported them as constantly getting into his traps, particularly in the weeds and sedges in wet places along the banks of Cold Creek, where he caught a dozen or more.

Reithrodontomys klamathensis sp. nov.

Type from Big Spring ('Mayten'), Shasta Valley, Calif. No. 95414, ♂ ad., U. S. Nat. Mus., Biological Survey Coll. Collected Sept. 18, 1898, by W. H. Osgood. Orig. No. 281.

Characters.—Size medium; ears and hind feet large; tail long, only slightly shorter than in *longicauda:* color grayish or brownish gray, decidedly paler than *longicauda.*

Color.—Summer pelage: Upperparts pale grayish brown, washed with buffy on sides; underparts white, tail bicolor, dusky above, whitish below.

Cranial characters.—Skull rather large; braincase and rostrum relatively broad; audital bullæ small. The skull as a whole agrees better with that of *megalotis* than with that of *longicauda*, particularly in the length of palate and breadth of braincase; but the rostrum is broader and the audital bullæ are smaller than in either.

Measurements.—Type: Total length, 149; tail vertebræ, 71; hind foot, 19. Average of 2 adults from type locality: Total length, 144; tail vertebræ, 66; hind foot, 18.5.

Remarks.—Both in color and cranial characters *Reithrodontomys klamathensis* resembles the pale grayish *R. megalotis* of the desert region of the southern part of the Great Basin much more closely than it does the dark brownish *R. longicauda* of California west of the Sierra.

This new harvest mouse is common in wet places in Shasta and Little Shasta valleys, where four specimens were obtained by W. H. Osgood and R. T. Fisher. They were caught in little runways in wet grass near tules. The species doubtless reached Shasta Valley by way of the open Klamath country. During our explorations in eastern Oregon in 1896, numerous specimens of the same species were caught by my assistants, E. A. Preble and Cleveland Allen, in the tule marshes bordering the streams connecting Malheur and Harney lakes.

Peromyscus gambeli (Baird). Common White-footed Mouse.

Common on all, or nearly all, parts of the mountain from Sisson up to and possibly a little above extreme timberline. One hundred specimens were collected.

In choosing their homes these mice are easily suited, for they seem equally contented among the dense vegetation in damp parts of the bottoms of canyons and among the bare lava rocks and pumice soil ot the driest timberline slopes. Some were caught also in the heather meadows bordering the little streams in the Hudsonian zone. At Sisson R. T. Fisher found them rather rare except in damp woods along Cold Creek, where he caught a number under roots and stumps close to the water.

Peromyscus boyli (Baird).

Exceedingly rare, or else of such peculiar habits that it escaped observation. Only a single specimen was obtained on Shasta. It was caught at the extreme upper limit of the Canadian zone (alt. 7,800 feet) on Squaw Creek, August 9, by Walter K. Fisher. Others were secured at Fall River Lake, in the Transition zone, southeast of the base of the mountain.

Peromyscus truei (Shf.). Big-eared Mouse.

Collected in Little Shasta Valley by Walter K. Fisher, who found it living among bushes of *Ceanothus cuneatus*.

Neotoma fuscipes Baird. Round-tail Wood Rat.

Not found on Shasta, but common in some of the low valleys at its base. Their characteristic stick houses were seen in the juniper forest at the southern end of Shasta Valley, in the chaparral near Gazelle, and in several places in the Scott Mountains (Bailey). In Little Shasta Valley one was collected September 19 (Osgood).

Neotoma cinerea Ord. Bushy-tail Wood Rat.

Rather scarce. Only four specimens were obtained—two in Mud Creek Canyon near the mouth of Clear Creek, and two high up on Squaw Creek (alt. 8,800 feet). Of those caught in Mud Creek Canyon, one was trapped at the end of an old log, the other at the entrance to an aplodontia burrow. Shasta abounds in the kinds of ledges and cliffs usually inhabited by this species, but, except at rare intervals, no traces of the animals were found.

Microtus californicus (Peale). California Vole.

Not obtained by us except in Shasta Valley, where six specimens were secured in September by W. H. Osgood and R. T. Fisher. Their runways were found in very wet places in the tules at Big Spring, in Shasta Valley, and along Little Shasta Creek. Walter K. Fisher secured specimens along Shasta River, northeast of Edgewood.

Microtus montanus (Peale).

Not obtained on Shasta, but collected at Fall River Lake in August by W. K. Fisher. In August, 1883, seven specimens were collected in the grassy meadows at Sisson Tavern by C. H. Townsend.

Microtus mordax (Merriam). Mountain Vole.

Common in suitable moist places throughout the Canadian and Hudsonian zones, particularly in the heather meadows a little below timberline, where, though chiefly nocturnal, they were sometimes seen in the daytime. Their burrows abound in the heather beds, especially along the overhanging banks of streams, and are so large that some of them were at first mistaken for those of *Microtus arvicoloides*, a species which does not occur on Shasta. They were not found in the dry forest. Seventy-four specimens were collected, of which only six were obtained at Wagon Camp. Near Sisson Tavern R. T. Fisher caught fifteen along "the wet and bushy banks of a long ditch." They probably reach Sisson not from Shasta, but from Mount Eddy, in the Scott Mountains, near the foot of which Sisson Tavern is situated. Still, it is possible that the two colonies are connected along some of the few cold streams that traverse the Transition zone slopes of Shasta.

Evotomys mazama Merriam. Mountain Evotomys.

Fairly common in moist places in the Shasta fir forests of the Canadian zone, where nineteen specimens were obtained. Ten were collected in Mud Creek Canyon near the mouth of Clear Creek (altitude 6,700 feet); seven along Squaw Creek from 6,700 up to 7,700 feet; one at the head of Panther Creek at 7,700 feet, and one at Wagon Camp at 5,700 feet. They were usually caught in traps set under logs in damp or wet places.

Phenacomys orophilus Merriam. Lemming-Mouse.

Rare and local, judging from the results of our trapping. Only three specimens were obtained—all in the heather meadows along the upper part of Squaw Creek, where they were caught August 7, 10, and 12 by Walter K. Fisher.

Thomomys monticola Allen. Sierra Pocket Gopher.

Abundant throughout the boreal slopes of the mountain, from the lower part of the Canadian zone to above timberline. In the dark forests of Shasta firs their mounds were seen wherever there was enough small vegetation to furnish food, and were commonest along the streams and about the edges of marshy places, where plant life is abundant and luxuriant. Above the line of continuous timber their mounds were noticed on many of the pumice slopes between the altitudes of 8,000 and 9,000 feet. Above the head of Squaw Creek a small colony was found at an altitude of 8,300 feet, and another between 8,900 and 9,000 feet. On the east side of Mud Creek Canyon they were seen at 8,800 feet, and on the west side at 8,900 feet. On our trip around the mountain near timberline, the latter part of July, their mounds were found in almost every place where the soil was deep enough for the animals to work;

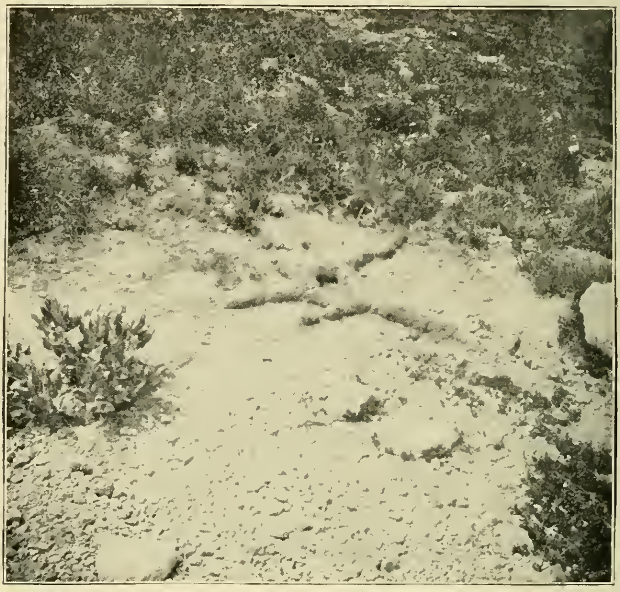

Fig. 31.—Winter earth plugs of pocket gopher.

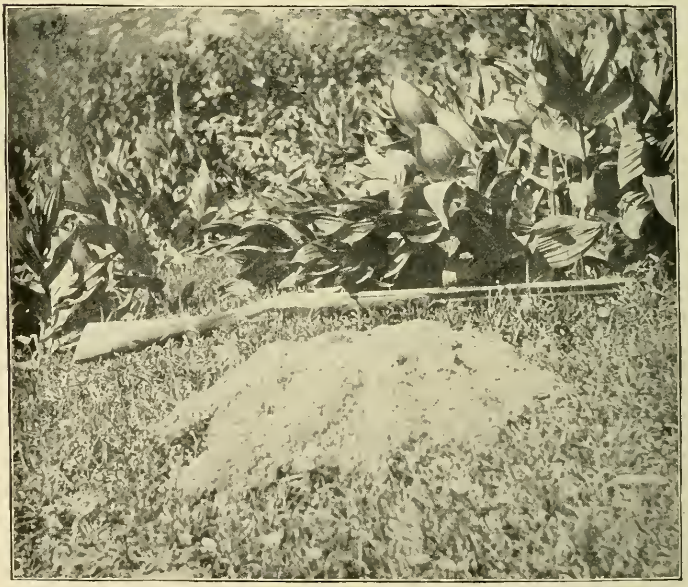

Fig. 32.—Mound made by pocket gopher. (Photographed by W. H. Osgood,)

and on the north side they were abundant nearly up to timberline, both on the main peak and on Shastina.

At Wagon Camp, and thence eastward to Panther Creek, the whole country is honeycombed with their subterranean passages. While we were at Wagon Camp they were unmitigated pests, throwing up little mounds of fresh earth in our midst every day and keeping the ground disturbed the whole time, so that it was impossible to walk in any direction outside of the marsh without stirring up a cloud of dust. I shot several in camp in the daytime, as they poked their heads out of their burrows, pushing little loads of dirt before them. They throw out the earth so rapidly that it is difficult to observe the process accurately. One *appeared* to empty it from his pouches, but I shot him in the act and found his pouches free from dirt and full of cut pieces of roots.

On the higher slopes the winter earth plugs—the cylinders of earth mixed with heather which in winter are pushed up into the snow from the underground passages—remain on the ground all summer, a striking evidence of the absence of rains, for a single hard shower would disintegrate and wash them away. They usually take the form of irregular serpentine ridges; but on Squaw Creek one was found which formed a complete oval ring with radiating cylinders. A photograph of this one, taken August 1, 1898, is here reproduced. (See fig. 31.)

Thomomys monticola pinetorum subsp. nov. Pine-woods Gopher.

Type from Sisson, Siskiyou County, Calif. No. 95152, ♂ ad., U. S. Nat. Mus., Biological Survey Coll. Collected Sept. 4, 1898, by R. T. Fisher. Orig. No. 173.

Characters.—Similar in general to *T. monticola*, but slightly smaller; skull shorter and broader; color very much paler.

Color.—Upperparts pale fulvous, almost orange fulvous (in striking contrast to the much darker colors of *monticola* and *mazama*); nose dusky; sides of head in one pelage plumbeous or slaty faintly washed with buffy; in other pelage strongly washed with ochraceous.

Cranial characters.—Skull, contrasted with that of *monticola*, short and broad, with zygomata much more widely spreading.

Measurements.—Type: Total length, 210; tail vertebræ, 76; hind foot, 28.

Remarks.—Common at Sisson and thence up to Wagon Camp, grading gradually into *T. monticola*.

Dipodomys californicus Merriam. Kangaroo Rat.

Common in the manzanita chaparral on the south side of Shasta from Squaw Creek Valley, near McCloud Mill, up along the road to Wagon Camp, as far at least as an altitude of 4,800 feet, where their unmistakable tracks abounded in the dusty soil. In Shasta Valley they are exceedingly abundant and destructive to grain, according to complaints of the ranchmen. Here W. H. Osgood found their little trails winding about through the sage brush in all directions, and saw fresh tracks in the road every morning.

Perognathus mollipilosus Coues. Mountain Pocket-Mouse.

Common in the manzanita chaparral, a little below Wagon Camp, where four were caught in July by R. T. Fisher. But the most extraordinary locality at which the species was found—and for that matter the most remarkable and abnormal place in which any species of the family has ever been found—is a subalpine pumice basin near timberline at the head of Panther Creek, where Walter K. Fisher discovered it and caught two the night of July 18. Later, six more were secured at the same place.

In Shasta Valley Vernon Bailey and W. H. Osgood found abundant signs of some species of *Perognathus*, but did not obtain specimens. The species is probably *P. parvus*, which is common in the adjacent Klamath Basin.

Erethizon epixanthus Brandt. Porcupine.

Apparently common, and yet not a specimen was obtained. Their characteristic gnawings on the trunks of small trees were seen at many points around the mountain, usually in the Hudsonian or upper part of the Canadian zone. They were common among the dwarf timberline white-bark pines on the north sides of both Shasta and Shastina; and in a small forest of young Shasta firs between Mud Creek Canyon and Cold Creek. Near timberline we several times found small trees whose tops had been gnawed in winter when they protruded above the snow. In a single instance fresh tracks were seen in the trail between Wagon Camp and Squaw Creek Camp (by Vernon Bailey). And on August 4 our favorite mule came into camp with porcupine quills in his nose. C. H. Townsend found porcupines in surprising abundance in Lassen County, south of Shasta, in 1883 and 1884, and gives an interesting account of their habits.

Zapus trinotatus alleni Elliot. Sierra Jerboa.

Fairly common in damp places on and near the mountain. Twenty specimens were collected—fifteen in the Canadian zone in Mud Creek Canyon near the mouth of Clear Creek (alt. 6,700 feet), two near the upper part of Mud Creek (alt. 7,900 feet), and three at Wagon Camp.

One of the most attractive spots near Wagon Camp is a grove of ponderosa pines in which the ground is carpeted with strawberries and scarlet painted cups, mixed with ferns and scattered clumps of serviceberries. The soil, while not wet, receives enough moisture from the little streams that sink into the ground a few rods above to enable these plants to grow in such profusion that they form a continuous meadow—'Castilleja meadow' we called it, from the abundance of painted cups. Here the jerboas abound. We saw several in the daytime, leaping about like frogs in the dense vegetation, and caught one or two in our hands.

In Mud Creek Canyon, W. H. Osgood informs me, they were also frequently seen in the daytime, in wet places under the white hellebore (*Veratrum californicum*).

Zapus pacificus Merriam. Valley Jerboa.

Only two specimens of this little-known species were secured and one of these was destroyed in the trap. They were caught in thickets on the banks of Little Shasta Creek September 20 by R. T. Fisher.

Ochotona schisticeps (Merriam). Cony; Pika.

Relatively rare and confined to small and widely separated colonies. During our circuit of the mountain, made near timberline the latter part of July, we saw what we took to be signs of conies among rocks east of Mud Creek Canyon, but finding no more believed we had been mistaken, until the evening of July 24, when we camped on some rivulets of snow water on the north side of Shastina. Here we found a small scattered colony reaching up in the slide rock from about 8,000 to nearly 10,000 feet, and a specimen was secured by Vernon Bailey. The next day we found signs in Cascade Gulch a mile or two northwest of Horse Camp. Later, when camped in the alpine hemlocks on the small west branches of Squaw Creek, we found a colony in the slide rock close by. Conies were afterwards found on both sides of Red Butte and on the east side of Gray Butte, and Osgood heard one near the head of Mud Creek Canyon. In all, 14 specimens were collected.

FIG. 33.—Rock cony (*Ochotona schisticeps*)—Photographed by F. Stephens.

This species differs in habits and voice from those of the Rocky Mountains; it is less noisy and less often heard in the middle of the day, for which reason it is more apt to escape detection, and its common note, instead of the usual 'bleat,' is a loud shrill *eh' eh,'* or *eh' eh' eh'*. It seems to be most active in the late afternoon and on moonlight evenings, and its voice is heard at all hours of the night.

On most mountains where conies live, their well known accumulations of plants of various kinds, cut and piled on the rocks to dry, are conspicuous objects. But on Shasta, where I often saw the animals carrying freshly cut plants to their dens in the slide rock, I failed to find a single 'haystack.' In one place a few fresh stems of *Polygonum newberryi*, with its large broad leaves, were seen, and in another a large accumulation of old brown leaves of the same species mixed with a larger quantity of *Phyllodoce empetriformis*—apparently left over from the previous year. But the only real 'haystack' found on the mountain by any of the party was discovered on the east side of Gray Butte September 25 by Vernon Bailey. It contained *Epilobium spicatum*, *Holodiscus discolor*, *Monardella odoratissima*, *Hieracium horridum*, *Ceanothus velutinus*, and two species of grass. The bulk of the material was *Epilobium* and *Monardella*.

On the west slope of Goose Nest Mountain, just east of Little Shasta Valley, Walter K. Fisher found conies common in an area of slide rock which extends in a practically unbroken stretch from the top to the bottom of the mountain. I have not seen the specimens.

Lepus nuttalli Bachman. Sagebrush Cottontail.

Several seen and two secured by W. H. Osgood in the sagebrush in Shasta and Little Shasta valleys, near the north base of the mountain.

Lepus klamathensis sp. nov. Klamath Rabbit.

Type from Fort Klamath, Oregon. No. 92248, ♀ ad., U. S. Nat. Mus., Biological Survey Coll. Collected Jan. 25, 1898, by B. L. Cunningham. Orig. No. 86.

Characters.—Similar to *L. columbiensis* Rhoads, but color fulvous instead of yellowish, with a distinct white stripe on hind foot; skull characters distinctive.

Color.—*Summer pelage:* Upperparts grizzled fulvous and black, the fulvous rather pale and dull, but not at all yellowish as in *columbiensis;* head, face, and pectoral collar dull fulvous; chin, throat, and belly white; a white stripe, sometimes irregular, extending along full length of upper surface of hind foot, on inner side, and usually including toes. *Winter pelage:* Either snow white all over, or like summer pelage but with black hairs much more plentiful.

Cranial characters.—Skull similar to that of *columbiensis* but somewhat smaller and narrower; interorbital breadth at anterior notch less; bullæ decidedly smaller (smallest of the *americanus-bairdi-washingtoni* group); outer face of jugal very deeply grooved anteriorly, and with upper ridge reaching anteriorly beyond end of groove.

Measurements.—Type: Total length, 432; tail vertebræ, 28; hind foot, 127. Average of 3 specimens from type locality: Total length, 410; tail vertebræ, 39; hind foot, 126.

Remarks.—*Lepus klamathensis* is a member of the *americanus-bairdi-washingtoni* group. In color it is intermediate between the yellowish *columbiensis* and the dark fulvous *washingtoni*. In cranial characters it agrees best with *columbiensis*, particularly in the great length of the postorbital processes, but in the small bullæ and peculiar form of the jugal it differs from all known members of the group.

This rabbit is common in the alder thickets in marshy places and along streams near Fort Klamath, Oregon, from which place the late Major Chas. E. Bendire sent me several specimens in the winter of 1883–84; and from which we have recently obtained additional specimens from B. L. Cunningham.

A curious feature about *Lepus klamathensis* is the fact that it sometimes does, and sometimes does not, turn white in winter. In the Biological Survey collection we have brown specimens killed late in January and white ones killed early in April.

This species was not obtained on Shasta, but rabbit dung, supposed to belong to it, was found in many places, particularly under the dwarf *Pinus albicaulis* on the timberline ridges. Rabbit signs and tracks were seen also in the manzanita chaparral, but as no specimens were secured the species is a matter of conjecture.

Lepus californicus Gray. California Jack Rabbit.

Occurs in Shasta Valley at the north base of the mountain. Several were seen and one was killed near Edgewood September 30 by W. H. Osgood.

Odocoileus columbianus (Richardson). Columbia Black-tail Deer.

Abundant on Shasta and throughout the surrounding region. Even at Wagon Camp, which probably is visited by more hunting parties than any other part of the mountain, deer were numerous, and their well-beaten trails were in constant use during our stay. At first the animals were commonest in the lower part of the Shasta fir forest, where for a long time they were not driven away even by the frequent shooting of our bird collectors. When we had been at Wagon Camp a week they were still common within an eighth of a mile. Later, however, they became less numerous in the open forest and more abundant in the dense chaparral of manzanita and buck-brush a little lower down. They were common also on Red Butte, and along all of the streams and canyons on the west, south, and southeast sides of the mountain. On the west side, where water is scarce, numbers used to visit the pools in Cascade Gulch, northwest of Horse Camp. In Mud Creek Canyon their trails were so abundant as to form almost a meshwork. When we visited this canyon first, July 22, Vernon Bailey saw eight deer; and several of us, resting on the west rim of the canyon, watched a doe and fawn on one of the trails on the opposite side. They were so plentiful in a canyon about a mile east of Squaw Creek that I named the place Deer Canyon. Several times during the season does with spotted fawns were seen in the Shasta fir forest. A yearling 'spike-buck' killed on Squaw Creek by Vernon Bailey August 7 was in the velvet, and his worn summer coat was scant and faded. Another 'spike-buck,' killed in the mountains west of Scott Valley September 15, was in the fresh gray winter coat, with only a few red hairs of the summer coat left.

In September the old bucks, which had not been observed earlier, climbed the mountain and began to appear on the higher ridges, where they travel extensively in the timberline tongues of dwarf white-bark pines. On September 18 I followed the tracks of two large bucks along the upper part of Panther Creek and found where they had bedded close together under a low Shasta fir on a steep slope, from which they could overlook the country below.

C. H. Townsend, in his notes on the mammals of northern California, gives an interesting account of this deer.

Odocoileus hemionus (Rafinesque). Mule Deer.

In the region east of Shasta, where the Columbia black-tail is the prevailing species, C. H. Townsend occasionally found the mule deer. "But in Lassen County, a hundred miles farther south, the reverse was found to be the case," and he saw nothing of the Columbia black-tail. This was in 1883 and 1884. The mule deer was not observed on Shasta by our party, although the tracks of an immense buck, seen by me early in August on the rim of Mud Creek Canyon, may have been made by it. Sherman Powell, in a recent article in Forest and Stream (April 27, 1899), states that mule deer are plentiful a little east of Shasta "on and around Glass Mountain, and also on the northeast slopes of Black Fox Mountain."

Cervus occidentalis Ham. Smith. Elk.

One of our party, R. T. Fisher, was informed by George B. Mitchell, county surveyor of Siskiyou County, that elk were shot in the neighborhood of Sisson as late as the early seventies. They were formerly abundant on and about Shasta, particularly in Squaw Creek Valley and Elk Flat, and used to range along the Scott Mountains, and thence westerly to the coast, where a few still exist.

Antilocapra americana Ord. Prong-horn Antelope.

Antelope, we were told, still inhabit the open pine forest east and northeast of Shasta. Formerly they were common in Shasta Valley and ranged west into the foothills of the Scott and Siskiyou mountains.

The following information regarding their distribution was obtained by Walter K. Fisher: In winter they ranged in the country between the Edgewood divide and the foothills of the Siskiyou mountains north of Hornbrook, extending into the low valleys west of Shasta River. They were most plentiful in the region between Little Shasta and Gazelle. Mr. Masgrave, one of the first settlers in Little Shasta Valley, is authority for the statement that formerly they frequently herded with his cattle. In Scarface Valley, west of Gazelle, he once saw a large herd which contained not less than two thousand animals.

In summer the antelope ranged extensively through Goose Nest Mountain and wooded valleys in Butte Creek region, as well as in Shasta Valley, Big Valley, Fall River Valley, and about Tule Lake, Klamath Falls, and Goose Lake. At present only a small herd remains. They stay in the remoter valleys east of the mountains and rarely come to Shasta Valley. In the summer of 1898 three were seen on the road between Little Shasta post-office and Butte Creek.

Ovis canadensis Shaw. Bighorn; Mountain Sheep.

The bighorn no longer inhabits Shasta, but its bleaching bones still remain. In early days, and as late as the seventies, many were killed here by J. H. Sisson, of Sisson Tavern. Sheep Rock, at the northeast base of the mountain, was one of their favorite and latest resorts, but probably was not used during the breeding season. In 1868 George B. Mitchell saw a band of twenty near the head of Mud Creek Canyon. In 1883 C. H. Townsend found numbers of their horns and bones scattered about everywhere on Sheep Rock, and saw the complete skeleton of a bighorn at the foot of Mud Creek glacier, high up on Shasta. An old skull was found on Red Butte by Vernon Bailey during our stay.

Canis lestes Merriam. Mountain Coyote.

Common high up on the mountain, frequenting the pumice slopes above timberline, where their tracks were often seen. Coyotes were especially common east of Mud Creek Canyon, where R. T. Fisher saw two early in August. As no specimens were secured, the species is uncertain, but since *C. lestes* is the animal inhabiting the Sierra farther south and (in a somewhat less typical form) the Klamath country farther north, it is assumed to be the mountain coyote of Shasta.

Canis ochropus Esch. Valley Coyote.

Common in Shasta valley and also at Sisson. R. T. Fisher heard them nearly every night during his stay at Sisson, from the end of August until the middle of September; and about the end of September Vernon Bailey and W. H. Osgood heard them howl at night in the south end of Shasta valley. A little farther north, in the flat valley near Montague, I saw a highly colored one at close quarters in the day time August 31. In July, 1899, Walter K. Fisher secured one in Shasta Valley.

Vulpes macrourus Baird. Mountain Red Fox.

Common on the upper slopes above timberline, where fresh tracks were seen nearly every day; but the animals were very wary and refused to enter our traps.

Urocyon californicus townsendi subsp. nov. Townsend Gray Fox.

Type from Baird, Shasta County, Calif. No. 14130, U. S. Nat. Museum. Collected November 11, 1893, by C. H. Townsend. Orig. No. 49.

Characters.—Similar to *U. californicus* Mearns, but ears decidedly smaller; fulvous tints everywhere darker and richer; rostrum broader; zygomata broader anteriorly; carnassial teeth above and below, larger and thicker. The color of the upperparts and tail is grizzled gray and black, as in *californicus*, but the fulvous of the ears, legs, and underparts is very much darker and somewhat more extensive. The sides of neck and posterior part of throat are rufous, in sharp contrast with the restricted white of the chin and anterior part of throat; the ears are dark grizzled fulvous; the white stripe on the hind foot of *californicus* has disappeared and is represented by a pale streak.

Remarks.—Gray foxes are abundant in the Transition zone about the base of Shasta, and although no specimens were secured by our party a number were obtained by C. H. Townsend in 1883 along the McCloud River.

Felis oregonensis Rafinesque. Oregon Puma; Mountain Lion.

Rather rare, but formerly common on Shasta. In July Bailey saw fresh tracks among the Shasta firs a little below Red Butte. C. H. Townsend obtained seven specimens in Shasta County in 1883 and 1884, several of which were killed near the fish hatchery on the McCloud. He states: "It is practically impossible to raise colts in the Shasta County hills on account of these pests. They destroy many hogs and young cattle also, but do not present so serious an impediment to the keeping of these animals as in the case of horses. Mr. J. B. Campbell, who trapped two panthers for me in 1883, told me that he had actually never seen more than two or three of the numerous colts born on his stock range, as they had been killed and devoured by panthers soon after birth."

Lynx fasciatus pallescens subsp. nov. Wild-cat.

Type from south base of Mount Adams, near Trout Lake, Washington. No. 76585, ♂ ad., U. S. Nat. Mus., Biological Survey Coll. Collected January 10, 1895, by D. N. Kaegi. Orig. No. 23.

Characters.—Similar to *L. fasciatus*, but slightly smaller and everywhere very much paler, particularly the head and face; basal black ear patch (in winter pelage) indistinct or absent; gray ear patch larger; general color hoary gray, contrasted with the dark rich rufous of *fasciatus*. Skull like that of *fasciatus*, but slightly smaller; carnassial teeth and second upper molar less swollen.

Remarks.—Specimens from the region about Shasta (Klamath country on the north and Pitt and McCloud rivers on the south) differ slightly from Trout Lake specimens; they show less tendency to spotting and have slightly larger carnassial teeth and audital bullæ.

This wild-cat is fairly common in the chaparral of the basal slopes of Shasta. One was seen a little below Wagon Camp, and tracks were several times noted by Vernon Bailey in the trail a little above Wagon Camp. Tracks were seen also in Shasta Valley by W. H. Osgood. In 1883–84 C. H. Townsend trapped many wild-cats along McCloud River and the lower part of Squaw Creek, where they were "apparently as numerous as [gray] foxes, and as easily secured." Most of these belong to the present species, but one belongs to the following:

Lynx californicus (Mearns). California Wild-cat.

A specimen which I provisionally refer to this species was obtained by C. H. Townsend at Baird, on McCloud River, in 1883. It is a much smaller animal than *L. fasciatus pallescens* and has conspicuously smaller teeth.

Gulo luscus (Linn.). Wolverine.

We have no positive record of the wolverine from Shasta, but it is known to occur on both the Cascades and the Sierra, and one was killed near Carberry Ranch, between Mounts Shasta and Lassen, about the year 1893 (reported by C. P. Streator).

Wolverines are notorious wanderers and it is most probable that they occur on Shasta at intervals, even if they do not permanently live there—which is by no means certain.

Taxidea taxus (Schreber). Badger.

Very rare on Shasta. In the trail between Wagon Camp and Squaw Creek Camp fresh tracks were seen August 4, by Vernon Bailey, and in Shasta Valley, at the north base of the mountain, badger holes were reported by W. H. Osgood, who also found a dead badger in the road a few miles east of McCloud Sawmill.

Mephitis occidentalis Baird. Large Skunk.

Common in the low country around Shasta. On 'Horse Trail,' leading up the mountain from Sisson, Bailey saw their tracks as high as an altitude of 6,500 feet. At Sisson they are particularly abundant in the wet meadows and thickets, where in September R. T. Fisher caught two along Cold Creek. In Shasta Valley they are also common and several were caught by W. H. Osgood and R. T. Fisher.

Spilogale latifrons Merriam. Little Spotted Skunk.

Not obtained by us, but known to occur in the general neighborhood of Shasta, both north and south of the mountain. In March, 1884, C. H. Townsend caught one on McCloud River, about midway between the mouth of this stream and Mount Shasta.

FIG. 34.—Mink. (Drawn by Ernest S. Thompson.)

Lutreola vison energumenos (Bangs). Pacific Mink.

Common along the streams at Sisson, where R. T. Fisher caught two, one on Cold Creek, the other on the upper Sacramento River.

Mustela caurina Merriam. Pacific Marten.

Common in parts of the dense forests of Shasta, particularly on the east side, where many are caught every winter by trappers. We did not succeed in obtaining a specimen, although a line of 'meat traps' was kept out fully a month. Still, fresh tracks were seen in the mud along Squaw Creek a short distance below camp by Vernon Bailey.

FIG. 35.—Marten. (Drawn by Ernest S. Thompson.)

Mustela pennanti Erxleben. Fisher.

Said to occur in the dense forest on the east side of Shasta, whence skins are brought to Sisson for sale nearly every winter. C. H. Townsend obtained two on McCloud River, about halfway between the mouth of the river and Mount Shasta, in February, 1884.

Lutra hudsonica Lacépède. Otter.

Occurs along the upper Sacramento and McCloud rivers; not noted by our party.

Putorius arizonensis Mearns. Mountain Weasel.

Apparently not common. Early in August three were caught in Mud Creek Canyon, near the mouth of Clear Creek, in traps set in *Aplodontia* runways. It is quite possible that another species, *P. xanthogenys oregonus*, inhabits the low country about the base of the mountain.

Bassariscus astutus raptor (Baird). Cacomistle; Ring-tail Cat.

Not observed by us, but doubtless occurs about the basal slopes of Shasta, as it has been captured both north and south of the mountain.

In February, 1884, C. H. Townsend caught one on McCloud River, about halfway between the mouth of the river and Mount Shasta; he also mentions a Pitt River miner who had a pair alive; and C. P. Streator reports it from old Fort Crook and Carberry Ranch. In September, 1896, one of our collectors, E. A. Preble, caught one in upper Rogue River Valley, near Prospect, Oregon.

Procyon psora pacifica subsp. nov. Pacific Raccoon.

Type from Kechelus Lake, Cascade Mountains, Washington. No. 93137, ad., U. S. Nat. Mus., Biological Survey Coll. Collected Jan. 15, 1898, by C. Hansen.

Characters.—Coloration dark; ground color dark gray instead of buffy; tail rings continuous (not interrupted along median line below); last premolar, first molar, and audital bullæ larger than in *psora*.

Color.—Upperparts dark gray everywhere profusely mixed with and obscured by black hairs; underparts sooty-plumbeous sparingly sprinkled with long buffy whitish hairs; sooty collar under throat continuous and much darker than in *psora;* black rings on tail continuous; pale rings, particularly the last one, obscured above by black hairs.

Measurements.—Type (from dry skin): Total length, 940; tail vertebræ, 310; hind foot, 115.

Remarks.—This new raccoon is most typical in the northwest coast region, particularly about Puget Sound and along the basal slopes of the northern Cascades. Specimens from Pitt River and Little Shasta Valley are much nearer *pacifica* than *psora*.

Raccoons do not occur on the higher slopes of Shasta, but are common about its base. In Little Shasta Valley W. H. Osgood and R. T. Fisher found them particularly abundant about the middle of September, and caught several in traps set under prune trees. The animals were causing much annoyance to the fruit-raisers by nightly visits to the orchards.

Ursus americanus Pallas. Black Bear.

Abundant. When we reached Shasta the middle of July, black bears were exceedingly common throughout the Shasta fir forest. On July 17, in going from Wagon Camp to timberline, we saw fresh tracks of a dozen along Panther Creek, and on the way down, three hours later, saw where four had crossed our trail after we had gone up. Their well-worn trails abounded along Panther Creek and were traversed daily until about the end of July, when, after our collectors had been shooting for nearly two weeks, the bears became alarmed and moved down into the manzanita chaparral below the Shasta firs, where they remained the rest of the season.

Ursus horribilis Ord. Grizzly or Grisly Bear.

Formerly abundant in the Shasta region; now exceedingly rare or absent. W. H. Osgood was told when in Shasta Valley that a few years ago a huge grizzly known as 'Old Clubfoot,' which had been shot at repeatedly, was killed near Goose Nest Mountain, just north of Shasta.

BIRDS OF SHASTA AND VICINITY.

(All dates except where the year is stated are for the year 1898.)

1. **Podilymbus podiceps.** Pied-billed Grebe; Hell Diver.

Several seen in the pond at Big Spring, in Shasta Valley, September 17, by W. H. Osgood. C. H. Townsend obtained it "on ponds near the base of Mount Shasta in summer" in 1883 or 1884.

2. **Anas boschas.** Mallard.

W. H. Osgood shot a mallard in Lower Squaw Creek, near Warmcastle Soda Springs, September 13, and found the species common at Big Spring, in Shasta Valley, September 17. In 1883 C. H. Townsend "found mallards August 1, at the base of Mount Shasta, in certain wet meadows where, in all probability, they had nests."

3. **Querquedula cyanoptera.** Cinnamon Teal.

The commonest duck on the small ponds and streams in Shasta Valley September 17–20 (Osgood).

4. **Spatula clypeata.** Shoveller.

Several seen in Shasta Valley September 17 by W. H. Osgood.

5. **Dafila acuta.** Pintail.

A flock of six seen in Shasta Valley September 18 by W. H. Osgood.

6. **Branta canadensis.** Canada Goose.

Three seen at Big Spring, in Shasta Valley, September 18 (Osgood).

7. **Ardea herodias.** Great Blue Heron.

Seen at Sisson July 13 by W. H. Osgood, and repeatedly observed during the first half of September by R. T. Fisher; several seen in Shasta Valley September 17–20 by W. H. Osgood; common along Shasta River (W. K. Fisher).

8. **Porzana carolina.** Sora Rail.

One seen in Shasta Valley September 18 by W. H. Osgood.

9. **Fulica americana.** Coot; Mud Hen.

One seen among the numerous ducks in the pond at Big Spring, in Shasta Valley, September 18 (Osgood).

10. **Gallinago delicata.** Wilson Snipe.

In Shasta Valley one was seen by W. H. Osgood September 18; and I saw one at Edgewood August 2, 1899. On a small tributary of McCloud River, flowing from the east base of Mount Shasta, one was shot by C. H. Townsend July 25, 1883.

11. Ereunetes occidentalis (?) Western Sandpiper.

A flock of small sandpipers supposed to be this species was seen by W. H. Osgood in Shasta Valley September 19.

12. Totanus flavipes. Yellow-legs.

A wader believed to be this species was heard in Shasta Valley September 19 by R. T. Fisher.

13. Helodromas solitarius cinnamomeus. Western Solitary Sandpiper.

Not observed by us, but in 1883 a male was seen at Sisson on August 3 by C. H. Townsend.

14. Actitis macularia. Spotted Sandpiper.

C. H. Townsend secured a spotted sandpiper at Sisson August 2, 1883. Late in July, 1899, Walter K. Fisher found it rather common on Shasta River.

15. Ægialitis vocifera. Killdeer.

Common at Sisson, where from July to early September a small flock was always crying and feeding in the meadows between the town and Sisson Tavern. Abundant and noisy in Shasta Valley September 17–20 (W. H. Osgood).

16. Oreortyx pictus plumiferus. Plumed Mountain Quail.

Fairly common, but not often seen, in the Shasta fir belt and the manzanita chaparral along its lower edge. Two or three broods were found near Wagon Camp the latter part of July, when the young were hardly a third grown. Several were seen and killed high up on Mud Creek Canyon August 8 by R. T. Fisher and W. H. Osgood, who also saw several flocks in Shasta Valley September 17–20. At Sisson, the first half of September, R. T. Fisher found many small flocks in the dry woods and chaparral west of the village.

17. Lophortyx californicus vallicola. California Valley Quail.

Not found on the mountain, but common in Little Shasta Valley, where W. H. Osgood secured a specimen September 19. In August, 1883, C. H. Townsend saw them "in considerable numbers at the base of Mount Shasta," near Sisson.

18. Dendragapus obscurus fuliginosus. Sooty Grouse.

Fairly common in the Shasta fir forest, and less so at higher altitudes. At Wagon Camp, during the last half of July, we often saw a hen grouse with half a dozen young; and in a rocky place among the alpine hemlocks near Squaw Creek, in September, we several times ran across a small flock, all full grown, feeding among patches of mountain chinquapin and the dwarf mountain manzanita (*Arctostaphylos nevadensis*). Berries of the latter formed the principal contents of the crop of one killed by Vernon Bailey August 24. Mixed with these berries were seed capsules of *Pentstemon gracilentus* and a few large ants. Usually the grouse were found singly or in bunches of two or three in the forest. When disturbed they generally flew up into the tall Shasta firs, where, instead of remaining motionless like many grouse, they walked about among the branches, stepping deliberately from limb to limb, but keeping on the opposite side from the enemy, so that it was almost impossible to see them.

The old males were sometimes found high up on the lava ridges among dwarf *Pinus albicaulis*, 1,000 feet or more above the continuous forest. When flushed they usually spread their wings and soared down the steep mountain side until lost from sight in the forest below. The 'hooting' or 'booming' of the old males, so often heard in the northern Cascades, was not heard by any of our party on Shasta.

19. **Zenaidura macroura.** Mourning Dove.

Fairly common at Sisson. In Shasta Valley W. H. Osgood found them abundant September 17–20.

[The band-tail pigeon (*Columba fasciata*) was not observed in the region by my party, but in the fall and winter of 1883 C. H. Townsend found it abundant in the foothills of the lower McCloud River, "gathering in the pine trees on the higher ridges in immense flocks."]

20. **Cathartes aura.** Turkey Vulture.

One or two seen at Wagon Camp and between Wagon Camp and Sisson in July; one seen by Walter K. Fisher at timberline, east of Mud Creek Canyon, about the end of July. At Sisson and in Shasta Valley they were more common.

21. **Circus hudsonius.** Marsh Hawk.

Seen at Sisson the middle of July (F. A. M.) and end of August (C. H. M.). Seen in Shasta Valley September 17–20 (W. H. Osgood).

22. **Accipiter velox.** Sharp-shinned Hawk.

Rather rare. One shot near Squaw Creek Camp August 10 by Vernon Bailey; one seen on Mud Creek in August, and several in Shasta Valley by W. H. Osgood September 17–20. C. H. Townsend shot one at timberline on Shasta September 7, 1883.

23. **Accipiter cooperi.** Cooper Hawk.

Rather rare. One killed above timberline (alt. 9,400 feet) above the head of Squaw Creek August 21 by R. T. Fisher. In September 1883, C. H. Townsend shot one near timberline on Shasta.

24. **Accipiter atricapillus striatulus.** Western Goshawk.

One visited our camp at Squaw Creek August 28. It was shot at but not secured. July 28, 1883, C. H. Townsend shot two young goshawks near timberline on Shasta.

25. **Buteo borealis calurus.** Western Red-tail.

Rather common. Seen from time to time at Wagon Camp in July and early August, frequently at Squaw Creek Camp in August and September, and several times above timberline. One was seen flying over the summit of Shasta July 31 by W. H. Osgood and R. T. Fisher. Common during fall migration in Shasta Valley, where Osgood saw many September 17–20, and I saw several September 29—chiefly about the narrow meadows bordering Shasta River. At Sisson Miss Florence A. Merriam saw them September 3.

FIG. 36.—Red-tail (*Buteo borealis*). Drawn by J. L. Ridgway.

26. **Buteo swainsoni.** Swainson Hawk.

Rare. July 28 I saw a nearly black Swainson hawk near an abandoned sawmill (alt. 4,800 feet) on the road from Wagon Camp to McCloud Mill. In July, 1899, Walter K. Fisher saw one in Shasta Valley.

27. **Aquila chrysaëtos.** Golden Eagle.

Rather rare, but seen from time to time flying over the mountain, usually at high altitudes. C. H. Townsend shot one near Sheep Rock, at the north base of Shasta, August 21, 1883.

28. **Haliæetus leucocephalus.** Bald Eagle.

In speaking of the bald eagle, C. H. Townsend states that when he had climbed to the extreme peak of Shasta (alt. 14,440 feet), on July 27, 1883, "an eagle came up through the fog that had gathered immediately below us and shared with us our rocky pinnacle above the clouds."

29. **Falco mexicanus.** Prairie Falcon.

Several seen and one shot in the south end of Shasta Valley, at the north base of the mountain, September 30, by W. H. Osgood, who thinks it probable that they breed on the cliffs at Sheep Rock.

30. **Falco columbarius suckleyi.** Black Merlin.

At Wagon Camp, August 8, John H. Sage and I saw a small dark falcon, supposed to be Suckley's merlin, fly into a Shasta fir, but we were unable to shoot it.

31. **Falco sparverius.** Sparrow Hawk.

Common at timberline throughout the summer. Usually seen in the heather patches and among the white-bark pines, where they were

FIG. 37.—Sparrow Hawk (*Falco sparverius*).—Drawn by J. L. Ridgway.

feeding on grasshoppers. Several were killed near timberline, east of Mud Creek Canyon, the latter part of July and early August, and one was recorded as high as 13,000 feet by Walter K. Fisher. On the west side of Mud Creek Canyon two were killed August 11 at an altitude of 10,000 feet by Vernon Bailey. Their stomachs were distended with grasshoppers. At the north base of the mountain one was seen by me on the narrow meadows bordering Shasta River in Shasta Valley September 29, and several were observed farther north in the valley September 17-20 by W. H. Osgood and R. T. Fisher. At Sisson they were seen July 15 by Miss Florence A. Merriam.

32. **Bubo virginianus.** Great Horned Owl.

Rare. Feathers were found at two or three places on the mountain, and at Sisson birds were heard hooting.

33. **Speotyto cunicularia hypogæa.** Burrowing Owl.

Not observed by us, but reported by C. H. Townsend as common "on the sage-covered districts north of Mount Shasta," about 15 miles from the mountain.

34. **Glaucidium gnoma californicum.** California Pigmy Owl.

C. H. Townsend obtained two specimens of the pigmy owl August 7, 1883, at the big spring, a mile or two north of Sisson Meadows.

35. **Megascops asio bendirei** (?). California Screech Owl.

A screech owl was heard at Wagon Camp at different times during the season, particularly the latter part of September, but as no specimen was secured there is some doubt as to the subspecies.

36. **Coccyzus americanus occidentalis.** California Cuckoo.

One shot and others seen in July, 1899, by Walter K. Fisher, among the alders and birches on Shasta River east of Edgewood.

37. **Ceryle alcyon.** Kingfisher.

A common resident in the neighborhood of Sisson, where it was seen repeatedly along Cold Creek, at the fish hatchery, and along the upper Sacramento; seen also along Shasta River north of Sisson.

38. **Dryobates villosus hyloscopus.** Cabanis Hairy Woodpecker.

Rather rare. Two or three were seen near Wagon Camp in July; two were collected where the Hudsonian and Canadian zones meet, near Squaw Creek Camp, in August (August 9 and 17); one was seen there September 1, and two were shot in the Transition zone in September (one in Squaw Creek Valley September 13, the other at Sisson September 30). At Sisson R. T. Fisher saw three or four, during the first half of September, in the big firs west of Sisson Tavern.

39. **Dryobates pubescens gairdneri.** Gairdner Woodpecker.

Obtained at Sisson by C. H. Townsend August 3, 1883.

40. **Xenopicus albolarvatus.** White-headed Woodpecker.

A common breeder in the upper part of the pine belt, and also among the Shasta and white firs near Wagon Camp, where several specimens were collected, and where a nest-containing noisy young was found the latter part of July. The nest was in a stub in a burn, with the entrance about 6 feet from the ground. At Sisson the white-headed woodpecker was seen, the middle of July, by Miss Merriam, and early in September by R. T. Fisher. In the pine woods bordering the south end of Shasta Valley I saw half a dozen September 29.

41. **Picoides arcticus.** Arctic Three-toed Woodpecker.

Rare, but evidently breeding in the Shasta fir forest of the Canadian zone, where a male was shot near Wagon Camp by John H. Sage July

Fig. 38.—Arctic Three-toed Woodpecker (*Picoides arcticus*).—Drawn by L. A. Fuertes.

20. Another was shot by Vernon Bailey July 30 in the gap between Red Cone and the lower end of Gray Butte, where a third individual was seen.

42. **Sphyrapicus ruber.** Red-breasted Sapsucker.

Fairly common at Wagon Camp, where specimens were collected in July by John H. Sage and Vernon Bailey. One was shot in Mud Creek Canyon about the end of July by R. T. Fisher, and one was seen at Sisson July 15 by Miss Merriam. September 18, one was seen in the brush along Little Shasta Creek by W. H. Osgood. In 1883 C. H. Townsend found the species "in midsummer in limited numbers on the heavily pine-timbered slopes of Mounts Shasta and Lassen."

43. **Sphyrapicus thyroideus.** Williamson Sapsucker.

A male was killed August 4 by R. T. Fisher at timberline on the east side of Mud Creek Canyon. This was the only specimen collected, though others were seen near the same place. August 25, 1883, C. H. Townsend secured one at timberline on Shasta.

44. **Ceophlœus pileatus abieticola.** Pileated Woodpecker.

Fairly common about Wagon Camp, where their loud hammering and unmistakable cries were often heard. Several times in July one visited a tree on the edge of camp, and one was heard there the day we left, September 25. September 16, W. H. Osgood and R. T. Fisher saw three between Sisson and Edgewood.

45. **Melanerpes formicivorus bairdi.** California Woodpecker.

Seen from time to time among the oaks at Sisson, where one was shot by R. T. Fisher early in September.

46. **Melanerpes torquatus.** Lewis Woodpecker.

Common at Sisson and in Squaw Creek Valley near McCloud Mill. July 25 Miss Merriam saw one at Wagon Camp; August 2 W. H. Osgood killed one and saw others high up on Mud Creek Canyon; August 3 I saw a small flock in the Shasta fir forest between Mud and Squaw creeks; August 10 Walter K. Fisher shot one near Squaw Creek; and September 17–20 W. H. Osgood saw several in Shasta Valley.

47. **Colaptes cafer.** Red shafted Flicker.

Fairly common on the mountain; seen or heard nearly every day, during the latter half of July and early August, near Wagon Camp. July 28 several were seen on the lower slope between Wagon Camp and McCloud Mill; late in July and early in August several were seen high up on Squaw and Mud creeks; August 16 one was killed by R. T. Fisher at Squaw Creek Camp; and during migration, the latter half of September, a few were seen nearly every day a little below timberline near Squaw and Panther creeks. At the time of our visits to the juniper forest in Shasta Valley, September 19 and 29, flickers were common and were probably feeding on the juniper berries. At Sisson, Florence A. Merriam found them common, the middle of July, and R. T. Fisher, the first half of September.

48. **Phalænoptilus nuttalli.** Poor-will.

The unmistakable note of the poor-will was heard in July at Wagon Camp, where the species doubtless breeds. One of the birds was seen on Lower Squaw Creek near Warmcastle Soda Springs August 13 by W. H. Osgood. Others were heard near Edgewood by Walter K. Fisher.

49. **Chordeiles virginianus.** Nighthawk.

Often seen flying at Wagon Camp, on the lower edge of the Shasta fir forest, the latter part of July. Several flocks were seen at Sisson, the first half of September, by R. T. Fisher.

50. Chætura vauxi (?). Vaux Swift.

A couple of miles below Wagon Camp a small black swift was seen by Vernon Bailey about July 24. At Sisson numbers of swifts were seen September 1 and September 10 by R. T. Fisher, and on September 3 by Florence A. Merriam, but they flew too high to be shot.

51. Aëronautes melanoleucus. White-throated Swift.

Several were seen high up on Mud Creek Canyon early in August by W. H. Osgood.

52. Calypte anna. Anna Hummingbird.

Apparently breeding at Wagon Camp, where one was shot July 22 by John H. Sage. Breeds on the lower McCloud River (Townsend).

53. Selasphorus rufus. Rufous Hummingbird.

The commonest hummingbird of Shasta, breeding, apparently, from the lower edge of the Shasta firs to timberline, though it is possible that those seen at high altitudes had moved up to feed from the painted cups in the heather meadows after the breeding season was over. At Wagon Camp, where they were abundant in July and early August, they seemed to feed chiefly from the scarlet painted cup (*Castilleja miniata*).

54. Stellula calliope. Calliope Hummingbird.

Nearly as abundant as *Selasphorus rufus*, and the commoner of the two at high altitudes. In early August both species were constantly hovering over the superb flowers of the scarlet paint brush (*Castilleja miniata*) in the heather meadows near timberline. They were seen also visiting the large yellow blossoms of *Mimulus implexus*, which singular species forms mucilaginous beds in the little streams at and below timberline. Walter K. and R. T. Fisher found them abundant in Ash Creek Canyon about the first of August, particularly among the painted cups and delphiniums.

[*Trochilus alexandri* is recorded by C. H. Townsend as breeding along the lower McCloud, but was not obtained by us. In this connection it should be remembered that we did not collect hummingbirds in the low country, either at Sisson or in Squaw Creek Valley.]

55. Tyrannus verticalis. Arkansas Kingbird.

At Gazelle, on the west side of Shasta Valley, Vernon Bailey saw three on telegraph wires October 31. C. H. Townsend records the species as breeding on the lower McCloud River. In July, 1899, Walter K. Fisher found this kingbird common in Shasta and Little Shasta valleys.

56. Sayornis saya. Say Phœbe.

One was seen about an old windmill in Shasta Valley September 19 by W. H. Osgood.

57. **Contopus borealis.** Olive-sided Flycatcher.

Common at Wagon Camp, where several pairs reared families early in the season, and where, on July 22, Miss Merriam saw a parent bird feeding young in the nest, which was in a fir tree 30 to 40 feet from the ground. In July the species was also seen at Sisson, and in Mud Creek Canyon near the mouth of Clear Creek, on the north side of the mountain.

58. **Contopus richardsoni.** Western Wood Pewee.

A fairly common breeder at Sisson, where Florence A. Merriam saw old birds feeding young in the nest (in a fir tree) July 15.

59. **Empidonax difficilis.** Western Yellow-bellied Flycatcher.

On July 29 I shot one in a thicket of cherry bushes (*Cerasus emarginata*) on the boundary between the Canadian and Transition zones, a little west of Wagon Camp, where it was doubtless breeding.

60. **Empidonax hammondi.** Hammond Flycatcher.

A common breeder near Wagon Camp, in the lower edge of the Shasta firs, where several were collected late in July. Near Squaw Creek Camp, at the upper edge of the Shasta firs, one was shot August 21, and in Mud Creek Canyon at the mouth of Clear Creek, one was shot August 7.

61. **Empidonax wrighti.** Wright Flycatcher.

One was shot at Wagon Camp July 24 by John H. Sage.

62. **Otocoris alpestris merrilli.** Dusky Horned Lark.

Common in places in Shasta Valley, particularly about Montague, where a number were secured by Walter K. Fisher. This is doubtless the form reported by C. H. Townsend, under the name *rubea*, as found "in limited numbers on the sage-covered districts north of Mount Shasta in midsummer." The locality referred to, he tells me, is in Shasta Valley, about 15 miles from the mountain.

63. **Pica pica hudsonica.** Magpie.

One was seen flying over the east side of Shasta Valley, near Sheep Rock, September 29 by Vernon Bailey and W. H. Osgood.

64. **Cyanocitta stelleri.** Steller Jay.

The form of Steller jay of the Shasta region is intermediate between true *stelleri* and the Sierra subspecies, *frontalis*.

It is one of the commonest, noisiest, and best-known birds of the region. Early in the season it was rarely seen above the lower part of the Canadian zone, and was most numerous in the Transition; but on August 2 one came all the way up to Squaw Creek Camp, in the alpine hemlocks, and a few days later a small flock was encountered, screaming, in Mud Creek Canyon at the mouth of Clear Creek. The latter half of September they were common at high altitudes and paid daily visits to our camp on upper Squaw Creek. At Sisson, apparently, they are always common.

65. **Aphelocoma californica.** California Jay.

Fairly common at Sisson, and more abundant in the lower country farther north. Seen by Vernon Bailey near Gazelle August 31, by W. H. Osgood among the junipers in Shasta Valley September 17 to 20, and by me in the undergrowth along the edge of the open pine and oak forest bordering the south end of Shasta Valley, where it was fairly common, September 29.

66. **Perisoreus obscurus.** Oregon Jay.

Unaccountably rare on Shasta during our stay. On August 6, when in a dense part of the forest east of the lower end of Gray Butte, I saw a flock of Steller jays, and with them several birds I took to be Oregon jays in the dark plumage of the young. August 20 Vernon Bailey shot one on Horse Camp Trail at an altitude of 6,600 feet, and two days later saw ten in the fir forest between Squaw Creek and Mud Creek Canyon. September 28, on his way around the mountain, he saw three above the point where the wagon road crosses Ash Creek, at an altitude of about 5,900 feet, by far the lowest point at which the species was seen. On July 29, 1899, Walter K. Fisher saw about 15 Oregon jays on Horse Camp trail.

In 1883 C. H. Townsend saw four small flocks (July 30 to September 7) in the heavily timbered forests of Mount Shasta.

67. **Corvus americanus.** Crow.

A few seen at Sisson. In July, 1889, Walter K. Fisher found them common in Shasta Valley.

68. **Nucifraga columbiana.** Clark Crow; Nutcracker.

Clark crows are among the most common, most characteristic, and most interesting birds of the higher slopes of Shasta. In summer they are closely restricted to the Hudsonian zone and adjacent rocky slopes immediately above timberline, but in fall they wander far and wide in search of food and are liable to be seen almost anywhere. Two or three, apparently young of the year, visited Wagon Camp, at the lower edge of the Shasta firs, as early as August 8; and in September it was not unusual to see small flocks or single individuals flying over the chaparral belt between Wagon Camp and Sisson.

The usual food of the Clark crow—the large nut-like seeds of *Pinus albicaulis*—having failed in 1898, the birds were feeding mainly on insects. The stomachs of specimens killed at extreme timberline contained in some cases grasshoppers only, in others chiefly beetles (Coleoptera); of those killed lower down, in the alpine hemlocks and Shasta firs, chiefly small hairless greenish caterpillars. They sometimes flew up to masses of yellow lichen, where they seemed to be picking out something to eat. On upper Squaw Creek, August 30, two were seen eating blueberries (F. A. M.). During hot afternoons the latter part of July they were often seen soaring and performing aerial antics above the forest, and also chasing insects in the air, launching out from the tree tops after them like flycatchers. As a rule, they are silent when feeding and noisy when flying about the white-bark pines. When on the ground they are very deliberate, and their broad heads and general form suggest gulls, particularly when the birds are moving away from the observer.

When searching for insects in the young hemlocks they sometimes began at the bottom and worked up, sometimes at the top and worked down. One day in early August a young-of-the-year, showing the true nutcracker spots on the breast, spent some time in camp, feeding in a small tree in our midst without showing the least annoyance at our presence. He began at the top and worked slowly downward, dropping from branch to branch and peering searchingly over the foliage and into the tufts of hemlock needles, often hanging almost bottom

FIG. 39.—Clark Crow (*Nucifraga columbiana*). Drawn by L. A. Fuertes.

side up to pick off the small green caterpillars which infested both the hemlocks and the Shasta firs. We could plainly see him grasp the little caterpillars crosswise and give a big gulp in swallowing them, as if bolting something several times as large. He went over a branch at a time, examining the whole of it carefully before moving to the one below, and sometimes went out so far toward the tip that the slender branch bent down with his weight. Another bird reversed this order of procedure, and after finally reaching the top of the tree gave a jump, aided by a slight flap of the wings, and perched on the very topmost sprig, when, gaining his balance, he opened his bill and uttered a little cry of exultation.

Clark crows were almost daily visitors to our camp among the alpine hemlocks on upper Squaw Creek until near the end of August, when they moved up to timberline to feed on the large wingless grasshoppers then abundant along the upper edge of the tongues of dwarf white-bark pines and on the lava-strewn pumice slopes at still higher elevations. Some were seen along the edge of the snow at an altitude of 11,000 feet, where dragon-flies, grasshoppers, and other insects were common.

Clark crow is a little larger than a blue jay, and his colors are put on in blocks. The body is gray; the wings and tail are black and white, in conspicuous contrast. Still, singular as it may seem, this coloration is both directive and protective. When in motion the bird is most conspicuous, the black and white patches flashing with great effect; but when quietly feeding on the ground among the gray lava rocks of the higher slopes it is not easily seen, the gray of the body resembling the gray rocks, the black markings the dark shadows. The coloration, however, is doubtless most protective at night when the bird is at roost in the trees and exposed to its worst enemies, presumably owls and martens. Contrasts of gray or white with black are among the most effective of disappearing colors at night—the black resembling patches of night shadow, the gray the interspaces.

Fig. 40.—Clark Crow (*Nucifraga columbiana*). (Photographed by Walter K. Fisher.)

The true home of the Clark crow is among the white-bark pines of the rocky wind-swept ridges not far from the region of perpetual snow. Here, from the thaws of early spring till the storms of approaching winter, not a day passes without his presence. He is a bold, powerful bird, a fit tenant for such a home, where his loud cry wakes the echoes of glacier cliffs a thousand times oftener than it reaches a human ear.

69. **Cyanocephalus cyanocephalus.** Piñon Jay.

Not an inhabitant of Shasta, but occurs in migration about its base, and may breed in the junipers in Shasta Valley.

September 28, Vernon Bailey saw six in the chaparral and yellow pines at an altitude of 4,000 feet on the wagon road between Elk Creek and Ash Creek, and the next day found a few near Sheep Rock. At Fort Crook, a little southeast of Shasta, a number were collected some years ago by Captain Feilner.

70. **Xanthocephalus xanthocephalus.** Yellow-headed Blackbird.

Not observed by us, but in 1883 C. H. Townsend often saw it "among the flocks of Brewer blackbirds that frequented the timothy meadows of Berryvale, at the western base of Mount Shasta, 3,500 feet altitude." Berryvale is the old name for the meadows near Sisson Tavern.

71. **Agelaius phœniceus.** Red-winged Blackbird.

Common in Shasta Valley September 17 to 20 (Osgood). C. H. Townsend gives it as "an abundant summer resident of the cultivated country north of Mount Shasta."

72. **Sturnella magna neglecta.** Western Meadowlark.

Common in the meadowland at Sisson and Edgewood, and in the narrow meadows bordering Shasta River, in Shasta Valley. At Wagon Camp I saw one in a grassy opening August 13, and a few days earlier Walter K. Fisher saw one in a similar place a little higher on the mountain. In the Sisson Meadows ('Strawberry Valley'), during the first half of September, R. T. Fisher found meadowlarks "gathered in flocks of as many as a hundred birds."

73. **Icterus bullocki.** Bullock Oriole.

Common along streams in Shasta and Little Shasta valleys (W. K. Fisher). Vernon Bailey tells me that at Ager, in the north end of Shasta Valley, some silver poplars in a door yard are literally full of nests of this oriole, and that when he examined them June 26, 1899, the new nests contained young orioles and the old nests young house finches (*Carpodacus m. obscurus*).

74. **Scolecophagus cyanocephalus.** Brewer Blackbird.

Fairly common at Sisson and in Shasta Valley, but not observed on the mountain except in one instance, when several were seen at extreme timberline on the east side of Mud Creek Canyon August 24 by Vernon Bailey and Florence A. Merriam.

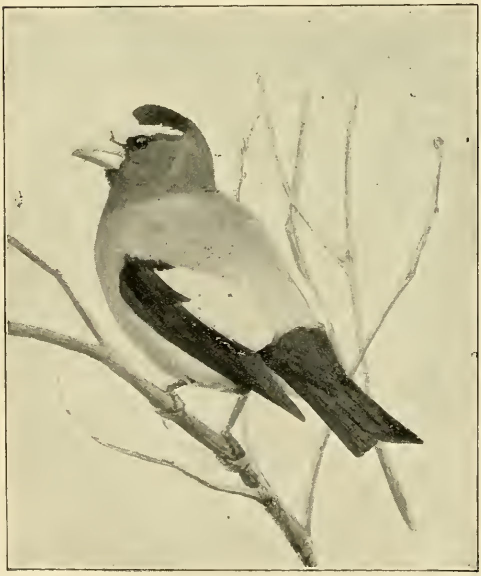

Fig. 41.—Western Evening Grosbeak (*Coccothraustes vespertinus montanus.*) Drawn by L. A. Fuertes.

75. **Coccothraustes vespertinus montanus.** Western Evening Grosbeak.

One of the commonest and most characteristic birds of the Shasta fir belt (Canadian zone), and much less common in the alpine hemlocks (Hudsonian zone). At Wagon Camp, near the lower border of the Canadian zone, small flocks were seen or heard daily whenever the camp was occupied, from the time of our arrival, the middle of July, until our departure, September 25. At Squaw Creek Camp, in the Hudsonian zone, they were much less common, but still by no means rare, and during early August their distinctive call, a short whistle, was heard every day.

In September they were rarely observed on upper Squaw Creek, but September 18 a flock was seen near the head of Panther Creek. They were common in Mud Creek Canyon about the end of July and beginning of August. On September 29 I visited the juniper forest in Shasta Valley, and was surprised to find there dozens of evening grosbeaks, and still larger numbers of Townsend solitaires, feeding on the fat berries of the junipers (*Juniperus occidentalis*). At Sisson in September R. T. Fisher found flocks flying restlessly over the valley.

When in the molt the extraordinary color combinations of the males surpass even those of the crossbills.

76. **Carpodacus cassini.** Cassin Purple Finch.

A common summer resident in the Canadian and Hudsonian zones. Specimens were collected in July and August at various points from Wagon Camp, in the lower edge of the Shasta firs, to timberline, at the upper limit of *Pinus albicaulis;* and during our circuit of the mountain near timberline July 22 to 25 the species was heard or seen every day. At our camp in the alpine hemlocks on upper Squaw Creek, it was common and tame, and in early August usually began singing about daylight. On August 5 I saw one singing in a small white-bark pine on a ridge east of Mud Creek Canyon at an altitude of 8,800 feet, far above continuous timberline. A flock, probably migrating, was observed at the head of Panther Creek September 18.

77. **Carpodacus mexicanus obscurus** (McCall). House Finch.
[= *Carpodacus m. frontalis* Auct].[1]

Common at Sisson and in Shasta Valley, but not seen on the mountain, where it is replaced by the preceding species. At Ager Vernon Bailey found it breeding abundantly in old nests of Bullock orioles.

78. **Loxia curvirostra bendirei** Ridgway. Sierra Red Crossbill.

Red crossbills are common on Shasta. Small flocks were heard nearly every day throughout the season and were frequently seen to light in the tops of the high firs, both at Wagon Camp and Squaw Creek Camp, but they never came into camp to feed, and were rarely seen near by. One was killed at Sisson September 12 by R. T. Fisher, who found the species common there at that time, feeding in the tall pines and also on the garden sunflowers. Several killed by us near timberline lodged in the dense foliage of the alpine hemlocks. C. H. Townsend obtained three specimens on Shasta. The crossbill of Shasta is intermediate between the northern subspecies *minor* and the southern subspecies *stricklandi.* It is the same as the Fort Klamath form named by Ridgway as subspecies *bendirei*; and specimens collected near Mount Whitney in the southern High Sierra by the Death Valley expedition, though published as *stricklandi*,[2] are practically indistin-

[1] For change of name see Oberholser, Auk, XVI, p. 186, April, 1899.
[2] North Am. Fauna, No. 7, p. 81, 1893.

guishable. It is customary among ornithologists to name recognizable intergrades which have definite and clearly defined breeding ranges. On this basis *bendirei* seems entitled to stand, since it occupies the isolated crest of the Sierra Nevada of California from the southern end north to Shasta, and pushes on a short distance into southern Oregon (to Fort Klamath, its type locality). At Diamond Lake, in the southern Cascades, only a few miles north of Fort Klamath, subspecies *minor* occurs. The Diamond Lake specimen[1] was shot by my assistant, E. A. Preble, August 13, 1896, and is an adult male. Owing to the late date and to the well-known erratic habits of crossbills, this bird may have been a wanderer from farther north. Hence the actual northern breeding limit of *bendirei* and the southern breeding limit of *minor* remain to be established.

It is a singular fact that two of the specimens obtained by C. H. Townsend on Lassen, between Shasta and the High Sierra, are as large and have as large bills as *stricklandi*. They were killed in summer and may have been stragglers from some of the mountains to the southeast.

79. **Leucosticte tephrocotis (?).** Gray-crowned Leucosticte.

At an altitude of 10,000 to 11,000 feet, on the south side of Shasta Peak, Vernon Bailey saw half a dozen leucostictes August 17, and again the next day. They were feeding among the rocks and on the glacier which occupies the deep cross gulch just below Konwokitan glacier. He tells me they flew down into the crevasses just as we had seen them do on Mount Rainier the previous year. Since none were collected there may be some doubt as to the species. The Sierra bird is *tephrocotis;* the Rainier form *littoralis.*

80. **Astragalinus tristis salicamans.** Willow Goldfinch.

No specimens obtained, but I am sure I saw the species at Sisson in July and August with *A. psaltria.* Walter K. Fisher reports it as common in Little Shasta Valley.

81. **Astragalinus psaltria.** Arkansas Goldfinch.

Common at Sisson and in Shasta Valley; breeds at Sisson.

82. **Spinus pinus.** Pine Siskin.

Fairly common throughout the Shasta fir forest, and ranging thence upward into the alpine hemlocks and white-bark pines. Seen or heard at frequent intervals from the time of our arrival, the middle of July, until late in September.

83. **Ammodramus sandwichensis alaudinus.** Western Savanna Sparrow.

In Shasta Valley W. H. Osgood found this species common September 17 to 20, and just below timberline on Panther Creek I saw several September 18.

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[1] This specimen, an adult male, agrees with specimens of *minor* from Wrangel, Alaska, and Neah Bay and Lapush, Washington.

84. **Chondestes grammacus strigatus.** Western Lark Sparrow.

Not observed on the mountain, but seen at Edgewood August 31, and in the bushes bordering the narrow meadows on Shasta River, in the southwestern part of Shasta Valley, September 29. Ten days earlier W. H. Osgood reported them as common a little farther north in Shasta Valley. At Sisson R. T. Fisher saw two flocks the first half of September. In August, 1883, C. H. Townsend found the species abundant "on the high-lying plains northward of Mount Shasta." In July, 1899, Walter K. Fisher reported it as the commonest bird in Shasta Valley.

85. **Zonotrichia leucophrys.** White-crowned Sparrow.

Probably breeds near timberline in the Hudsonian zone, where, near the head of Mud Creek, one was shot August 4 by W. H. Osgood. About the middle of September numbers were seen just below timberline on Panther Creek—doubtless migrants—and a little later they were common in the bushes from Wagon Camp to Sisson and along Shasta River in Shasta Valley.

Fig. 42.—White-crowned Sparrow (*Zonotrichia leucophrys*). Drawn by L. A. Fuertes.

86. **Spizella socialis arizonæ.** Western Chipping Sparrow.

As the chipping sparrow is not an inhabitant of dense forests it was not seen in the Shasta fir belt; but in the openings along the lower edge of this belt it breeds, and was feeding young at Wagon Camp in July. After the breeding season it was seen from time to time near timberline. It is a common breeder at Sisson and in Shasta Valley.

87. **Junco hyemalis thurberi.** Sierra Junco.

Common from timberline down to the lower edge of the Shasta firs. The commonest 'ground bird' of the forest. Several nests with eggs or young were found near Wagon Camp the latter part of July.

88. **Melospiza melodia montana.** Mountain Song Sparrow.

Song sparrows supposed to be this subspecies were found breeding at Wagon Camp and Sisson the middle of July. Others were seen in the tules at Big Spring, in Shasta Valley, September 17 to 20 by W. H. Osgood. One was secured at Edgewood July 19, 1899, by Walter K. Fisher, who states that it was the only one seen during his stay.

89. **Melospiza lincolni.** Lincoln Sparrow.

Breeds along the edge of the forest at Wagon Camp, where I shot one at the spring July 20. Another was obtained by R. T. Fisher on Squaw Creek (alt. about 6,700 feet) August 17. Others were seen among the alders in Mud and Ash Creek canyons about the end of July by Walter K. Fisher. At Sisson, the first half of September, R. T. Fisher found the species fairly common, and shot one among the alders bordering Cold Creek. W. H. Osgood reported it as common in Shasta Valley September 17 to 20.

90. **Passerella iliaca unalaschcensis.** Townsend Sparrow.

Common during migration (September) throughout the chaparral of the lower slopes from Sisson up to Wagon Camp. At Wagon Camp one was shot by W. H. Osgood September 22. Common also late in September in bushes in the more open parts of the forest along the east base of Scott Mountains from Sisson north to Edgewood, and in the bushes bordering Shasta River in the southern part of Shasta Valley.

Passerellas supposed to be this species were seen repeatedly at Sisson, the first half of September, by R. T. Fisher.

91. **Passerella iliaca megarhyncha.** Thick-billed Sparrow.

Breeds near Wagon Camp, apparently in the chaparral, where John H. Sage shot one July 20 and another July 22. At Sisson W. H. Osgood and Miss Merriam saw this species July 13 and 15. In the summer of 1883 C. H. Townsend found it a common breeder in the chaparral tracts of Shasta.

92. **Pipilo maculatus megalonyx.** Spurred Towhee.

Common in the undergrowth along the edges of openings in the ponderosa pine forest from Sisson to Shasta Valley. One was shot at Upton September 15 by R. T. Fisher. C. H. Townsend found it breeding commonly on the lower slopes of Shasta in 1883.

93. **Pipilo fuscus crissalis.** California Towhee.

Several seen in the chaparral near Gazelle August 31 by Vernon Bailey, and near Edgewood by Walter K. Fisher.

94. **Oreospiza chlorura.** Green-tailed Towhee.

Apparently a fairly common breeder on the lower slopes of Shasta, where in the chaparral near Wagon Camp several were seen and one was killed the latter part of July and early in August, and one was found feeding full-grown young July 28. At Sisson Miss Merriam found them the middle of July. The last one noted by me was seen in the manzanita at an altitude of 4,900 feet, on the road from Wagon Camp to Sisson, August 26.

95. **Zamelodia melanocephala.** Black-headed Grosbeak.

Seen at Sisson by W. H. Osgood July 13. At the McCloud River fish hatchery C. H. Townsend found it a common breeder in 1883.

96. **Cyanospiza amœna.** Lazuli Bunting.

Common at Sisson (where it was seen feeding young July 15 by Miss Merriam), and ranging thence up through the chaparral of the Transition zone all the way to Wagon Camp, where a nest was found and the parent secured July 17 by W. H. Osgood, who obtained another in Mud Creek Canyon August 3.

97. **Piranga ludoviciana.** Mountain Tanager.

One of the commonest, as well as handsomest, birds of the Shasta fir forest. At Wagon Camp, at the lower edge of the Canadian zone, these tanagers were seen every day from the middle of July until August 10, when that camp was temporarily abandoned. They were very tame, and spent much time in camp, drinking from our little spring and peering at us from the lower branches of the firs. On July 21 I saw several picking caterpillars from the leaves of the buck brush (*Ceanothus velutinus*) in an opening in the firs. Walter K. Fisher states that one sang continuously at his camp in Mud Creek Canyon at the mouth of Clear Creek about the end of July. At Sisson this tanager was seen July 15 by Miss Merriam.

98. **Progne subis hesperia.** Western Martin.

Not observed by us, but recorded by C. H. Townsend, who, in 1883, noticed a few "about some buildings at the west base of Mount Shasta in midsummer." One seen about 6 miles northwest of Edgewood by Walter K. Fisher.

99. **Petrochelidon lunifrons.** Cliff Swallow.

Common at Sisson, where it was noted by Miss Merriam the middle of July, and by R. T. Fisher the first half of September. Abundant in Shasta Valley (W. K. Fisher).

100. **Hirundo erythrogastra.** Barn Swallow.

Common at Sisson, and seen in Shasta Valley September 17 to 20 by W. H. Osgood. Common in Shasta Valley in July (W. K. Fisher).

101. **Tachycineta thalassina.** Violet-green Swallow.

Common at Sisson, and seen once or twice flying over the chaparral, nearly up to Wagon Camp.

102. **Tachycineta bicolor.** Tree Swallow; White-bellied Swallow.

Swallows believed to be this species were seen several times between Wagon Camp and Sisson, and C. H. Townsend records them as abundant breeders on the lower McCloud.

103. **Stelgidopteryx serripennis.** Rough-winged Swallow.

Walter K. Fisher saw some swallows at Edgewood in July, 1899, which he believed to be this species.

104. **Lanius ludovicianus excubitorides.** White-rumped Shrike.

One seen at Gazelle, on the west side of Shasta Valley, August 31, by Vernon Bailey, and one in Shasta Valley September 18 by W. H. Osgood. Rather common in Shasta Valley in July, 1899 (W. K. Fisher).

105. **Vireo solitarius cassini.** Cassin Vireo.

Fairly common along the lower border of the Shasta fir forest at Wagon Camp, where two or three were obtained the latter part of July, and where a nest containing one egg and one young was found by John H. Sage July 31. The nest was in a clump of buck-brush (*Ceanothus velutinus*) only 3 feet above the ground, in open chaparral, near the edge of the Shasta fir woods.

106. **Vireo gilvus swainsoni.** Western Warbling Vireo.

Recorded by C. H. Townsend as "found at rare intervals in midsummer about the base of Shasta." A vireo heard by us several times at Sisson was probably this species. Walter K. Fisher found it at Edgewood, among the bushes along Shasta River, where he secured a specimen July 19, 1899.

107. **Helminthophila rubricapilla gutturalis.** Calaveras Warbler.

Common in the chaparral at Wagon Camp, where several specimens were collected the last half of July. Later the species was seen with other warblers in the trees higher up on the mountain.

108. **Helminthophila celata lutescens.** Lutescent Warbler.

Fairly common and apparently breeding at Wagon Camp, in the lower edge of the Shasta firs, where two were collected July 20. One was shot in the alpine hemlocks on Squaw Creek August 6 by Vernon Bailey.

109. **Dendroica æstiva.** Yellow Warbler.

Seen at Sisson, the middle of July, by Miss Merriam. The only one seen on the mountain was shot in the chaparral near the edge of the fir forest at Wagon Camp July 29 by John H. Sage. Common in bushes along Shasta River in Shasta Valley (W. K. Fisher).

110. **Dendroica auduboni.** Audubon Warbler.

Abundant throughout the forest region of Shasta, from timberline down to the lower edge of the Canadian zone. At Wagon Camp Miss Merriam saw them feeding fullgrown young July 18 and August 1. In August and September they were seen daily at our camp in the alpine hemlocks, often in mixed flocks of chickadees and other birds. When we left Wagon Camp, September 25, they were still common there.

August 9 and 10, spotted young were collected, one with the brown sides coming in and one with the yellow just beginning to show. At

FIG. 43.—Audubon Warbler (*Dendroica auduboni*). Drawn by L. A. Fuertes.

Sisson, Miss Merriam saw them the middle of July, and R. T. Fisher found them common the first half of September.

111. **Dendroica occidentalis.** Hermit Warbler.

Fairly common in the Hudsonian and upper part of the Canadian forest during August (collected at Squaw Creek Camp at intervals from August 3 to August 28); not seen in July.

112. **Geothlypis tolmiei.** Macgillivray Warbler.

Seen at Sisson and Wagon Camp about the middle of July, and again at the latter locality August 1 and August 3. One was shot in Mud Creek Canyon at an altitude of 6,700 feet by W. H. Osgood August 7. In July and August, 1883, C. H. Townsend found it not uncommon on the mountain.

113. **Geothlypis trichas occidentalis.** Western Yellow-throat.

At Big Spring, in Shasta Valley, W. H. Osgood found this warbler common in the tules September 17 to 20; and August 6, 1883, C. H. Townsend secured an immature specimen at the base of Mount Shasta.

114. **Icteria virens longicauda.** Long-tailed Chat.

Fairly common at Sisson, and common in the lower country farther north—at Gazelle and on toward Yreka. Common along Shasta River in Shasta Valley (W. K. Fisher).

115. **Wilsonia pusilla pileolata.** Pileolated Warbler.

Common in Mud Creek Canyon the latter part of July and early August; seen at Sisson July 13 by W. H. Osgood, and at Wagon Camp August 3 by Miss Merriam; several seen at Squaw Creek in flocks of chickadees and warblers during August and September; seen in wild cherry bushes at Wagon Camp September 25. In the summer of 1883 C. H. Townsend found it rather common on Shasta.

116. **Anthus pensilvanicus.** Pipit; Titlark.

In a barren rocky basin above timberline, near the head of Panther Creek, on July 17 I heard titlarks and saw Arctic bluebirds. At the same place two months later (September 18) titlarks were common. In Shasta Valley September 17 to 20 W. H. Osgood saw flocks along the road.

117. **Cinclus mexicanus.** Dipper; Water Ouzel.

Common on the upper part of Squaw Creek as far as the timber extends, and sometimes seen above timberline. Seen also on Panther Creek, near its head, and on Mud and Ash creeks. On Squaw Creek we often watched the ouzels feeding among the cascades and clear cold pools between the upper heather meadow and the main fall. One afternoon just before dark (6 o'clock) I was surprised to see an ouzel fly up into the dead top of a tree, light on a branch, and climb up several feet on the trunk with his short tail hanging straight down, after the manner of a woodpecker.

118. **Salpinctes obsoletus.** Rock Wren.

Rather rare on Shasta and confined apparently to the bare rocky slopes near and above timberline. August 2, at an altitude of 8,600 feet, on one of the ridges above the head of Squaw Creek, I found a pair—the first noted on the mountain. August 11, on the west rim of Mud Creek Canyon, I first heard them at 9,000 feet, and Vernon Bailey followed them up and shot one at 9,800 feet. A week later he saw one at an altitude of 10,400 feet. August 27, Miss Merriam saw one in 'The Gate,' between the heads of Panther Creek and Squaw Creek. In 1883 C. H. Townsend found them common above timberline on Shasta, and observed them also on Sheep Rock. In July, 1899, Walter K. Fisher found them among lava ledges in Shasta Valley.

119. **Catherpes mexicanus punctulatus.** Canyon Wren.

Not observed by us, but recorded by Townsend, who in 1883 saw one—doubtless a straggler—above timberline on Shasta, and others at Sheep Rock, at the northeast base of the mountain, where he heard the bird's wonderful song and was deeply impressed by it.

120. **Thryomanes bewicki spilurus.** Vigors Wren.

Seen at Sisson, but not on the mountain. Recorded by C. H. Townsend from "the base of Shasta."

121. **Troglodytes aëdon parkmani.** Parkman Wren.

Rare on the mountain. One collected near Squaw Creek Camp (alt. 6,750 feet) August 18 by R. T. Fisher, and one in Mud Creek Canyon (alt. 6,780 feet) August 9 by W. H. Osgood. More common at Sisson, where it was observed by Miss Merriam the middle of July. C. H. Townsend records it as abundant in midsummer "among the piled-up logs of a certain clearing in the forest at the base of Mount Shasta." The bird seems to be intermediate between *parkmani* and *aztecus*.

122. **Cistothorus palustris paludicola.** Tule Wren.

At Big Spring, in Shasta Valley, W. H. Osgood found these wrens common September 17 to 20.

[The western winter wren (*Anorthura hiemalis pacifica*) was not observed by us, but was found by C. H. Townsend in the mossy canyons of the lower McCloud. It doubtless occurs in the upper canyon of the Sacramento near Sisson, and quite possibly in other suitable places about the mountain.]

123. **Certhia familiaris occidentalis.** Western Brown Creeper.

Not common, but seen now and then in the alpine hemlocks on Squaw Creek and in the Shasta firs, lower down. The earliest record is July 24 (J. H. S.); the latest, September 15 (C. H. M.). At Wagon Camp John H. Sage shot one and saw another July 27; and Miss Merriam saw one in the same place August 1, one at Squaw Creek August 30, and two at Sisson September 3.

124. **Sitta carolinensis aculeata.** Slender-billed Nuthatch.

Not common on the mountain, and only moderately so at Sisson. A few were seen at Squaw Creek Camp from time to time in August, once or twice in the mixed flocks of chickadees and warblers.

125. **Sitta canadensis.** Red-breasted Nuthatch.

Common from the lower edge of the Shasta fir belt up to timberline; and from the time of our arrival, the middle of July, until our departure, the latter part of September. In September it was often seen in mixed flocks with mountain chickadees and Audubon warblers.

126. **Sitta pygmæa.** Pigmy Nuthatch.

In the ponderosa pines near Sisson, W. H. Osgood saw pigmy nuthatches July 13, and I saw a small flock September 30. At the southwest end of Shasta Valley, not far from Edgewood, Osgood saw several in the pines September 20.

127. **Parus gambeli.** Mountain Chickadee.

Common and widely distributed. In the firs at Wagon Camp they were among the commonest birds, and at higher altitudes were seen or heard nearly every day. Early on the morning of July 24, after camping for the night in the shelter of a narrow fringe of dwarf white-bark pines at timberline, on one of the desolate torrent-swept beds of Inconstance Creek, high up on the north side of Shasta, we were saluted by a small flock of these cheerful little birds. In September they helped form the mixed flocks, along with Audubon and other warblers, Canada nuthatches, and other small fry so often seen among the Shasta firs and alpine hemlocks. At Sisson Miss Merriam saw them about the middle of July; they were common there in September, and were noted in Shasta Valley by W. H. Osgood September 17 to 20.

128. **Parus rufescens.** Chestnut-backed Chickadee.

Not observed by us, but recorded by C. H. Townsend, who "obtained a single individual at the western base of Mount Shasta on July 14, 1883."

129. **Psaltriparus minimus californicus.** California Bush-Tit.

Common along Little Shasta Creek September 18 (W. H. Osgood). Seen in the chaparral west of Gazelle, on the west side of Shasta Valley, August 31 (Vernon Bailey). Townsend found it a common breeder near the fish hatchery on the Lower McCloud River.

130. **Regulus satrapa olivaceus.** Western Golden-crowned Kinglet.

Both kinglets are common on Shasta and doubtless breed in the Shasta firs of the Canadian zone. The golden-crown was often seen and heard at Wagon Camp, where it was collected July 18. It was also common just within the lower edge of the fir forest in Mud Creek Canyon July 23, and a couple of miles higher up about the end of the month. C. H. Townsend obtained specimens at timberline in July, 1883.

131. **Regulus calendula.** Ruby-crowned Kinglet.

The ruby-crown was frequently heard by various members of the expedition, and at different altitudes, from Wagon Camp in the lower edge of the Shasta firs, to timberline, where one was collected by W. H. Osgood August 4. In 1883 C. H. Townsend obtained two specimens, one at timberline August 15, the other at an elevation of about 6,000 feet September 2.

132. **Myadestes townsendi.** Townsend Solitaire.

Not an uncommon breeder on the higher slopes of Shasta, where I saw six during our stay. The lowest of these was at Wagon Camp, in the lower edge of the Shasta firs, where one drank at our spring July 31. The others were in the Hudsonian zone, and most of them in the alpine hemlocks at or near our camp on Squaw Creek, just below timberline.

They were usually seen in early evening when they came to drink from the little streams in the forest, and were always silent and rather shy. Late in July and early in August they were seen with arctic bluebirds by Walter K. Fisher at and below timberline near Mud Creek Canyon. They probably winter in the junipers in Shasta Valley, where W. H. Osgood saw them September 17 to 20, and where I saw dozens feeding on the juniper berries and singing freely September 29. Late in July, 1883, C. H. Townsend found one of these birds "frozen in the snow and ice which filled the crater of the extinct volcano of Shasta."

133. **Hylocichla aonalaschkæ auduboni.** Dwarf Hermit Thrush.

Evidently breeds in the dark Shasta fir forest of the mountain and in the damp forest of white and Douglas firs near Sisson Tavern, where Miss Merriam heard them in full song the middle of July. At Wagon Camp W. H. Osgood shot one July 17; and near Squaw Creek Camp I shot another September 20. C. H. Townsend records it from the southern slope of Shasta under date of July 25.

134. **Merula migratoria propinqua.** Western Robin.

Robins were fairly common at Wagon Camp, where we heard their evening song the day of our arrival, July 15, and where they were seen carrying food to young July 26 (F. A. M.). Higher up they were seen from time to time, but were not common. Along the upper part of Mud Creek Canyon Walter K. Fisher found them "fairly common but erratic" the latter part of July and first few days of August. At Squaw Creek Camp, in the alpine hemlocks, we saw a flock on the morning of August 12, and others September 15. Just below timberline on Panther Creek a few were seen migrating September 18. In Shasta Valley they were common among the junipers September 29. At Sisson they are common breeders, and a few were seen whenever any of our party were there, from July 14 until the end of September. A nest containing three eggs was found July 13 by W. H. Osgood.

135. **Sialia mexicana occidentalis.** Western Bluebird.

A common breeder at Sisson, where families, including lately fledged young, haunted the fences the first half of September (R. T. Fisher). In Shasta Valley W. H. Osgood found them common September 17 to 20, and a few small flocks were seen by me among the junipers September 29. At Sisson the species was common the latter part of September. In 1883 a nest containing nearly grown young was found by C. H. Townsend in a post hole in the ground at Sisson Tavern late in July.

136. **Sialia arctica.** Mountain Bluebird; Arctic Bluebird.

A common breeder on the higher slopes of Shasta, where they were constantly seen in July and early August, but rarely afterwards. On our first visit to timberline, July 17, they were very abundant on the bare rocks above timberline near the head of Panther Creek, and a week later were seen on the rim of Mud Creek Canyon. On the rocky slopes at and above timberline on the east side of Mud Creek Canyon early in August they were the most characteristic birds (W. K. Fisher); and they were seen near the same place August 18 (V. Bailey). September 20 a small flock visited our camp on upper Squaw Creek.

In July, 1883, C. H. Townsend found the species abundant at timberline, where full fledged young accompanied their parents.

NOTES ON THE DISTRIBUTION OF SHASTA PLANTS.

The study of the geographic distribution of animals and plants in the Sierra-Cascades can not be completed until authentic lists of species are brought together from several important localities from which at present no data are available. The need of such lists, with detailed altitudes and zone positions, is particularly urgent in the case of detached mountains, as Shasta and Lassen, which are separated from each other and from the continuous ranges on either side by gaps low enough to be broadly filled by Transition zone species. The Boreal species of these mountains, being thus completely cut off from the nearest corresponding colonies, form islands in the long Boreal chain that stretches southward from British Columbia to southern California.

The present imperfect list of the plants of Mount Shasta is offered as an humble contribution toward the needed material. It is based almost wholly on my own personal observations and is known to be far from complete. More pressing work along other lines made it impracticable to give much time to plants, and the date of arrival at the mountain (the middle of July) was so late that many of the early flowering species had disappeared. The Boreal species, owing to their greater importance, have received most attention; the Transition zone species least. In the case of Alpine and Hudsonian species it is believed that few remain to be added.

I am indebted to Miss Lewanna Wilkins for collecting and pressing most of the plants preserved during the first six weeks of our stay on the mountain; and to John H. Sage for the use of a collection made by him during the same period. The plants obtained subsequent to August 8 were collected by Vernon Bailey and myself

Although two seasons' field work in the Cascade Range had given me a certain acquaintance with the more conspicuous plants common to these mountains and Mount Shasta, I was still much handicapped in the determination of the species, and not being a botanist myself was obliged to appeal to professional botanists for assistance. I am indebted most of all to Miss Alice Eastwood, curator of the herbarium of the California Academy of Sciences, whose courtesy and promptness in identifying plants, sent her from time to time while I was still in the field, were of the utmost assistance. I am also particularly indebted to Prof. E. L. Greene, of the Catholic University at Washington, who has taken the trouble to examine a large number of species, and to describe several which proved to be new. Other botanists who kindly determined special species or special genera are Mrs. N. L. Britton, Mr. Frederick V. Coville, Prof. W. R. Dudley, Mr. M. L. Fernald, Mr. John B. Leiberg, Mr. C. L. Pollard, Dr. B. L. Robinson, Dr. J. N. Rose, Prof. P. A. Rydberg, Mr. J. K. Small, and Prof. William Trelease. In order to properly place the credit for this assistance, the botanist responsible for the identification is in each instance mentioned. Where no one is named I am personally responsible.

A few mosses and ferns were found in the timberline region of Shasta. The mosses, kindly determined by Mrs. Britton, are *Harpidium* (*? exannulatum* Gumb.), *Aulacomnium androgynum* Sch., and a species of *Philonotis*. They are confined rather closely to the borders of the alpine streams, where the *Aulacomnium* forms compact mats of a yellowish color.

The ferns have been determined by Mr. William R. Maxon through the courtesy of Mr. Frederick V. Coville, curator of the National Herbarium. The species which grow sparingly in the heather meadows and under the edges of rocks near timberline are: *Dryopteris aculeata scopulina* (Eaton), *Cystopteris fragilis* (L.) Bernh., *Cheilanthes gracillima* D. C. Eaton, *Cryptogramme acrostichoides* R. Br., and *Phegopteris alpestris* (Hoppe) Mett. Much lower down, along the boundary between the Canadian and Transition zones, *Pteris aquilina lanuginosa* (Bory) Hooker, and *Asplenium filixfœmina* (L.) Bernh. occur. The brake (*Pteris*) is very abundant on the pumice sand at Wagon Camp and Sisson and wherever there is sufficient moisture in the soil in spring and early summer. The black-beard lichen (*Alectoria fremonti*) and the handsome yellow tree lichen (*Evernia vulpina*) abound in the dark forest of Shasta firs.

In the chapter on 'Life Zones' the more distinctive species have been grouped according to their vertical distribution (see pp. 52–68), but for convenience in finding the notes relating to particular species, they are here arranged in systematic order. In the case of certain plants found by us only on the borderland between adjacent zones, the zone position is in doubt and must be determined by future study.

The most important kinds of plants from the standpoint of geographic distribution are naturally those that remain longest in a particular spot. Hence, as pointed out by Coville,[1] trees, shrubs, and perennials are the kinds most useful in determining zone boundaries. For this reason little attention is here given to annuals.

Pinus monticola Douglas. Silver Pine; Mountain White Pine.

Common in places, chiefly in the upper half of the Canadian zone, but local and by no means generally distributed. Wherever it occurs it is mixed with Shasta firs, and in places it reaches up high enough to overlap the lower edge of the black alpine hemlocks and white-bark timberline pines. (See p. 38.)

[1] Botany of Death Valley Expedition, pp. 17–18, 1893.

Pinus lambertiana Douglas. Sugar Pine.

Fairly common in most parts of the Transition zone forest of ponderosa pines, and occurring here and there in the immense areas of chaparral that cover the lower slopes on the south and west sides of the mountain. (See pp. 32–33.)

Pinus albicaulis Engelmann. White-bark Pine.

The timberline tree of Shasta, which it encircles at altitudes ranging, according to slope, from about 7,000 up to 8,000 feet, and pushing up on the warmest ridges to an extreme elevation of 9,800 feet. In its distribution therefore it fills the Hudsonian zone except in places unsuited to tree growth. The only tree competing with it on Shasta is the black alpine hemlock, which, requiring more moisture, is at a disadvantage and is confined to special localities, as explained in full under that species. (See pp. 39–42.)

Pinus ponderosa Laws. Ponderosa or Yellow Pine.

The most abundant and characteristic tree of the lower slopes and basal plane of Shasta, where, filling the Transition zone, it forms a continuous open forest of wide extent. (See pp. 30–32.)

Pinus murrayana Balfour. Lodge-pole Pine.

Confined to the northeast quadrant of Shasta, where it occupies the lower part of the Canadian zone. (See pp. 38–39.)

Pinus attenuata Lemmon. Knobcone Pine.

Common in a limited area in the Transition zone on the south side of Shasta, where it is confined to the lower slopes (from about 4,000 to 5,600 feet altitude) from Panther Creek easterly to between the branches of Mud Creek. (See pp. 33–34.)

Tsuga mertensiana (Bong.) Carr.[1] Black Alpine Hemlock.

A characteristic tree of the Hudsonian zone, where, however, it is not generally distributed for the reason that the upper slopes of Shasta are in most places too dry for it. It occurs in the same belt with *Pinus albicaulis*, but does not reach so high, and, requiring more moisture, is confined to disconnected localities, usually in canyons and gulches or along the shady sides of buttes or ridges. (See pp. 42–46.)

Pseudotsuga mucronata (Raf.). Sudw. Douglas Fir or Spruce.

Common, scattered through the less arid parts of the forest of ponderosa pines which clothes the lower Transition zone slopes of Shasta and extends away in all directions (see p. 32). A subspecies *pendula* (Engelm.) Sudworth, with "branches, at least the lower ones, very slender and long-pendent," has been described from Sisson (Bot. Calif., II, 483, 1880; Sudworth, Check List Forest Trees of U. S., 24, 1898), and is common thence westerly to the coast. (See pp. 34–35).

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[1] For change of name from *Tsuga pattoni* to *T. mertensiana,* see footnote p. 42.

Abies shastensis Lemmon. Shasta Fir.

The dominant tree of the Canadian zone, covering the middle slopes and completely encircling the mountain in a solid belt about 2,000 feet in vertical breadth. Its upper border overlaps the lower edge of the Hudsonian; its lower border, the upper edge of the Transition. Along Panther and Squaw creeks, on the south slope, it ranges from about 5,500 up to 7,500 feet, and on steep southwesterly slopes considerably higher. (See pp. 36–38.)

Abies concolor lowiana (Murray) Lemmon. White Fir.

The common and only true fir of the basal slopes of Shasta, where it occurs in moist places from the altitude of Wagon Camp (5,700 feet) down to the very bottom of Sisson Valley at the base of Mount Eddy (alt. 3,400 feet). It thus fills the Transition zone, except in places that are too dry for it. (See p. 34.)

Libocedrus decurrens Torrey. Incense Cedar.

Common throughout the Transition zone forest of ponderosa pines, except in the dryest places. (See p. 35.)

Chamæcyparis lawsoniana (Murray) Parlat. Lawson Cypress.

Attributed to "the Shasta Mountains" (Bot. Calif., II, p. 115, 1880), but not found by us.[1]

Juniperus nana Willd. Dwarf Alpine Juniper.

Fairly common in places close to timberline, usually associated with *Pinus albicaulis* in the upper part of the Hudsonian zone. On Shasta it usually grows in small patches less than a foot high and, as a rule, only a few feet in diameter; in the Olympics, on Mount Rainier, and on numerous other mountains it forms much larger patches. Between Mud Creek Canyon and the high ridges above Squaw Creek, it pushes up to extreme timberline at 9,800 feet, along with *Pinus albicaulis*. On the north side of Shasta and Shastina it was found in crevices among the sharp lava rocks at altitudes varying from 8,300 to 9,000 feet, and was common on the curious *albicaulis* plain stretching westerly from 'North Gate' to Bolam Creek.

Juniperus occidentalis Hooker. Western Juniper.

Abundant in the south end of Shasta Valley, where it forms a forest many miles in extent. Scattered trees begin 4 or 4½ miles easterly from Edgewood, and become more and more plentiful to the north until, at a distance of about 5 miles south from Big Spring, they suddenly become abundant and cover the whole country east of the main mass of lava buttes, forming a continuous juniper forest which fills the southern part of Shasta Valley and reaches northward, I am told, into Little

[1] Another cypress attributed to Shasta but not seen by us is *Cupressus macnabiana* Murr., "originally reported by Jeffrey from Mount Shasta at 5,000 feet altitude" (Bot. Calif., II, p. 114, 1880). In both instances, probably, the term 'Shasta' was used in a rather loose sense, as covering adjacent mountains not then named.

Shasta Valley. When visited about the end of September, the trees were full of their large berries, and many birds, including evening grosbeaks and Townsend solitaires, were there in numbers feeding on them. The zone position of this tree, which appears to be the type form, is high Upper Sonoran and low Transition. The boreal form common in the Sierra, but not found on Shasta, should be different.

Sitanion cinereum J. G. Smith. Alpine Grass.

The common grass of the glacial meadows, but nowhere sufficiently abundant to form anything like a sod. It is closely related to *S. elymoides* Raf., from which it has been recently separated by Mr. Jared G. Smith.

Carex breweri Boott. Alpine Carex.

Common in the glacial meadows and scattered sparingly over the moist slopes. (Identified by F. V. Coville.)

Juncus parryi Engelm. Parry Juncus.

Common in the heather patches and other moist places from slightly below timberline up through the Alpine zone. Noted by Vernon Bailey as high as 11,300 feet. (Identified by F. V. Coville.)

Allium validum Watson. Large Wild Onion.

Abundant in the Canadian zone along the streams of the Shasta fir belt, and often growing in the lower heather beds along the lower border of the Hudsonian zone. (Identified by Professor Greene.)

Allium sp. —?

A very small species is common in the glacial meadows at the head of Squaw Creek, but matures so early that we were unable to obtain anything but the bulbs.

Calochortus nudus Watson.

Fairly common along the lower edge of the Canadian zone near Wagon Camp, flowering late in July. (Identified by Miss Eastwood and Professor Greene.)

Calochortus maweanus Leichtlin.

Not rare at Wagon Camp, but not seen elsewhere. An elegant little species with white hairy flowers. (Identified by Professor Greene.)

Fritillaria atropurpurea Nutt.

Common in the chaparral of the Transition zone basal slopes from Sisson up to Wagon Camp. (Identified by Miss Eastwood.)

Hastingsia alba (Durand) Wats.

Common near Wagon Camp, where its long and slender cylindrical spikes were in flower the latter part of July. (Identified by Miss Eastwood and Professor Greene.)

Lilium parvum Kellogg. Tiger Lily.

Common in marshy places in the lower part of the Shasta fir belt, particularly at Wagon Camp, where it was flowering abundantly about the middle of July, and was still in fruit as late as the end of September. (Identified by Miss Eastwood.)

Lilium washingtonianum Kellogg. Washington Lily.

This superb lily, with large white and very fragrant flowers, is common in the manzanita in the upper part of the Transition zone, and occurs sparingly at lower altitudes. At Sisson it was in fruit the end of September. The flowers had passed their prime by the middle of July, but occasional plants were found in blossom as late as the end of the month.

Tofieldia occidentalis Watson.

Common near the bottom of the Canadian zone at Wagon Camp. (Identified by Professor Greene.)

Tritelia ixioides (Ait.) Greene (=*Brodiæa*).

Common at Wagon Camp on the border between the Canadian and Transition zones, where its yellow star flowers were in bloom the latter half of July. (Identified by Professor Greene.)

Vagnera stellata (Linn.) Morong.

Common at Wagon Camp, particularly in open grassy places along the edges of the fir forest, where it was flowering abundantly when we reached the mountain, the middle of July. Plants still holding their fruit were observed when we left Wagon Camp, September 25.

Fig. 44.—White Hellebore (*Veratrum californicum*). Photographed by W. K. Fisher.

Veratrum californicum Durand. White Hellebore.

Abundant at numerous localities along the streams and in marshy spots in the Canadian and upper part of the Transition zones. Particularly common at Wagon Camp, and also on Squaw Creek just above the middle meadow.

Smilax californica Gray. California Smilax.

Occurs in places in the lower part of the Transition zone along Shasta River between Edgewood and Sisson, but nearer Sisson. Not observed elsewhere.

Sisyrinchium bellum Watson. Blue-eyed Grass.

Fairly common in the Transition zone near Wagon Camp.

Corallorhiza bigelovi Watson.

Not uncommon in the woods near Wagon Camp. (Identified by Professor Greene.)

Habenaria leucostachys (Lindl.) Watson.

Common in the marsh at Wagon Camp. (Identified by Professor Greene.)

Habenaria unalaschensis Watson.

A boreal species, fairly common in the marsh near Wagon Camp, growing with the last. (Identified by Professor Greene.)

Populus trichocarpa T. & G. Western Balsam Poplar.

Common in the upper Sacramento Canyon near Sisson, and less so along Shasta River at the south end of Shasta Valley.

Salix lasiandra Bentham. Black Willow.

Abundant in cool moist places about Sisson. (Identified by Miss Eastwood.)

Salix nuttalli Sargent. Nuttall Willow.

Common in moist places in canyons of the Canadian zone and near Wagon Camp. (Identified by F. V. Coville.)

Salix sitchensis Sanson. Sitka Willow.

Common in canyons in the Canadian zone. Found in Mud Creek Canyon near the mouth of Clear Creek. (Identified by F. V. Coville.)

Alnus rhombifolia Nutt. White Tree Alder.

Observed only on Shasta River in the southern part of Shasta Valley, where its zone position appears to be Upper Sonoran. Shasta Valley is one belt lower than the rest of the region about Shasta and contains a dilute tongue of Upper Sonoran species that come in from the north by way of Klamath River Valley.

Alnus sinuata (Regel) Rydb. Alder.

Common in moist places in the canyons of the Canadian zone. In Mud Creek Canyon noted as high as 6,700 feet. Found also near Wagon Camp. (Identified by F. V. Coville.)

Alnus tenuifolia Nutt. Paperleaf Alder.

[=*A. incana var. virescens* Wats].

A Transition zone species common along streams in the neighborhood of Sisson Tavern and along the east base of Scott Mountains. (Identified by F. V. Coville.)

Betula occidentalis Hooker. Birch.

Fairly common along Shasta River at the south end of Shasta Valley. Not observed elsewhere.

Corylus rostrata californica A. DC.

Fairly common in the Transition zone in Squaw Creek Valley near McCloud Mill, and probably elsewhere at the base of the mountain.

Castanopsis sempervirens (Kellogg) Dudley. Sierra Chinquapin.

The distribution of the mountain chinquapin on Shasta is discontinuous. It is possible that two forms exist, one apparently restricted to the manzanita chaparral of the Transition zone from Sisson up to the lower edge of the Shasta fir belt; the other to the scattered stretches of *Pinus albicaulis* of the Hudsonian zone, where it reaches timberline on the rocky slopes and ridges.

Prof. William R. Dudley, of Stanford University, California, has, at my request, kindly looked up the proper name for the boreal Sierra chinquapin, which he finds to be *sempervirens* of Kellogg.[1] The type locality of *sempervirens* is the west slope of the Sierra near Mariposa. I have found the species abundant on a ridge near a stage station called Chinquapin, between Mariposa and the Yosemite, where it occurs with *Pinus jeffreyi*, *P. lambertiana*, *Abies magnifica*, *Pseudotsuga mucronata*, and *Prunus emarginata* at and above an altitude of 6,200 feet. The locality, therefore, is along the overlapping borderland between the Transition and Canadian zones.

Professor Dudley tells me that the 'var. *minor*' Bentham is the small southern coast range form of the true coast chinquapin, *Castanopsis chrysophylla*, and that the type locality is the Santa Cruz Mountains. *C. chrysophylla* is a handsome tree 75 to 125 feet in height, with large leaves, ending in long, slender attenuate points; *C. sempervirens* is a bush with small and relatively bluntly rounded leaves. I found both species common on the Trinity Mountains: *C. chrysophylla* on the sunny lower slopes in the Transition zone; *C. sempervirens* on the cold summit in the lower edge of the Canadian zone, where it is associated with *Arctostaphylos nevadensis*, *Cerasus emarginata*, *Ceanothus velutinus*, the dwarf mountain form of *Quercus chrysolepis*, and the very distinct *Q. vaccinifolia*.[2]

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[1] Proc. Calif. Acad. Sci., I, p. 75, 1855 (reprint).

[2] *Quercus vaccinifolia* Kellogg is another excellent species, usually confounded with the dwarf mountain form of *Q. chrysolepis*, with which it has nothing to do. Their zone relations are much the same as those of the two species of *Castanopsis*, for *Q. vaccinifolia* occurs along the lower edge of the Boreal, and ranges up through the Canadian zone, always in rocky places, while *Q. chrysolepis* belongs to the Transition zone. Their ranges join where these zones meet, and I have found both growing side by side on the Trinity Mountains, and also on the Sierra. *Quercus chrysolepis* is a Transition zone tree which at the upper limit of its range is always dwarfed and often reduced to a shrub; but irrespective of size it always retains its characteristic leaves and acorn cups. *Quercus vacciuifolia* is always a small bush—rarely much over a meter in height—and, whether in fruit or not, is distinguishable at a glance by the character of its leaves and cups. The leaves are smaller, narrower, thinner, and blunter (commonly narrowly oval with an obtuse point instead of sharply lanceolate) and lack the yellow tomentum underneath; furthermore, their margins, although somewhat thickened, are not distinctly revolute. The acorn cups are smaller and thinner, and lack the beautiful yellow 'turban' so characteristic of *chrysolepis*; the acorns average shorter and thicker and the basal scar is smaller. The branchlets are much more slender, and glabrous or nearly so, instead of tomentose.

It is remarkable that a shrub of such wide distribution, and one differing so conspicuously from the tree chinquapin (*Castanopsis chrysophylla*), should so long escape recognition as a distinct species.

Quercus californica (Torr.) Cooper. Black Oak.

[= *Q. kelloggi* Newb.]

The only oak of Shasta, where it is confined to the basal slopes of the Transition zone, reaching up on the south and west sides to an altitude of 4,500 feet. It is fairly common in McCloud Valley, more common at Sisson, and increases in abundance to the northward. Between Black Butte and Edgewood it is mixed with ponderosa pines and is one of the most conspicuous trees. It does not attain such large size in this region as nearer the coast and farther south in the Sierra.

[*Quercus garryana* was not found immediately about Shasta, and *Quercus wislizeni*, which pushes up the canyon of the Sacramento a long distance, does not fairly enter the region.]

Asarum hartwegi Watson. Wild Ginger.

Occurs here and there throughout the Transition zone, but is commonest in damp places on the lower slopes. It does not reach quite up to Wagon Camp, but in a warm lava basin on the west side of the mountain was found at an altitude a little higher than Wagon Camp.

Eriogonum marifolium T. & G. Yellow Eriogonum.

Common at Wagon Camp and other points along the lower edge of the Canadian zone and in the upper part of the Transition. The species seems to belong to the Transition rather than the Canadian zone, and Shasta is its type locality. (Identified by J. K. Small.)

Eriogonum polypodum Small. Small-leaf Alpine Eriogonum.

The commonest and most widely distributed *Eriogonum* of the higher slopes, where it ranges from the lower edge of the Hudsonian zone up to and far above timberline. The highest altitude at which it was obtained is 10,000 feet. Its leaves are small and densely covered with a white woolly or hairy material, and its tortuous prostrate branches are so intertwined as to form little mats several inches in diameter on the stony pumice slopes; these whitish mats are vastly more compact and dense above timberline than below. The roots are strong but rather slender, and, like those of many other plants that live on the barren, wind-swept pumice slopes, are of extreme length. The main root usually slopes obliquely for 80 or 90 millimeters, and then divides into four or five slender rootlets 900 to 1,000 millimeters in length. The whitish tomentose leaves rarely rise more than 25 or 30 millimeters above the ground; the fruit stems 100 to 150 millimeters.

This plant and *Polygonum shastense* are probably the most abundant, conspicuous, and widespread plants of the Hudsonian and Alpine zones. They thrive in very dry soils and therefore are not confined to the moist basins and strips bordering the streams, as are *Phyllodoce*, *Lutkea*, and many others. (Identified by J. K. Small.)

Eriogonum pyrolæfolium Hooker. Large-leaf Alpine Eriogonum.

Abundant on the pumice slopes of the Hudsonian and Arctic-Alpine zones, where it is associated with the foregoing species and with *Polygonum shastense*, *P. newberryi*, *Pentstemon davidsoni*, and others. It is easily recognized by its large roundish deep-green leaves, in striking contrast to the much smaller whitish-tomentose leaves of its congener and associate, *Erigonum polypodum*. Both species are common all the way around the mountain. The present species (*pyrolæfolium*) is rarely found above an altitude of 9,500 feet, but on a warm slope east of Mud Creek Canyon Vernon Bailey found it as high as 10,000 feet. It flowered the second time above the head of Squaw Creek the latter part of September and was then in flower and fruit simultaneously. Its root is large, thick, tapering, and moderately strong; it subdivides into about half a dozen rootlets which penetrate so deeply into the soil that it is difficult to obtain specimens without breaking them. The longest root measured was 750 millimeters to the broken end. The leaves reach about 30 millimeters above the ground; the fruit stems 70 millimeters. The old imbricating leaf stems remain attached for several years and form a series of scales around the upper part of the perennial rootstalk.

Eriogonum nudum Dougl. Naked-stem Eriogonum.

Common in the lower part of the Transition zone, particularly about Sisson, where it was flowering plentifully as late as the end of September. It is easily recognized by its tall, green naked stems, which rise from a bunch of large tomentose leaves.

Oxyria digyna (Linn.) Alpine Sorrel.

One of the characteristic alpine species, growing in cold spots among the rocks at high altitudes on all sides of the mountain; found by Vernon Bailey as high as 11,200 feet. On the north side of Shastina we collected it at 8,900 feet, and on the northeast side of Red Butte as low as 7,600 feet. This is the lowest station at which it was found, and since *Pinus albicaulis* occurs above Red Butte the locality might be mistaken to be below timberline, but the sorrel grows only among the rocks on the cold northeast slopes, where there are no trees and where the temperature is truly alpine.

Polygonum shastense Brewer. Shasta Polygonum.

One of the commonest and most characteristic plants of the stony pumice slopes of the Hudsonian and Alpine zones. A singular and attractive plant, particularly in September, when it is heavily laden with white and red flowers and fruit. As a rule the flowers are whitish, turning red as the fruit begins to develop. No two plants could well be more different in general appearance than this species and its congener and associate *Polygonum newberryi*, and few species bear a closer resemblance than *P. shastense* and its geographically remote relative *P. paronychia*. The resemblance is not only most striking, but is exceedingly interesting from the standpoint of geographic distribution. *Polygonum shastense* lives at high altitudes in the High Sierra and Cascade Range, while *P. paronychia* inhabits the outer sea beach in northern California and Oregon, where it is bathed in the chilly fogs of the Pacific Ocean. The root of *Polygonum shastense* is of moderate size and slopes very obliquely into the soil. It divides into half a dozen long slender rootlets, which penetrate to a depth of 550 millimeters or more. One specimen examined divided into three main roots of rather large size, which tapered very gradually and reached a length of 750 millimeters. The branches are prostrate and usually form loosely intertwined mats 300 to 500 millimeters in diameter, rising in some cases 40 to 50 millimeters above the surface, but usually flattened on the ground.

Polygonum newberryi Small. Broad-leaf Polygonum.

Abundant from the lower edge of the Hudsonian zone up to a little above timberline, where its big green leaves are very conspicuous on the pale pumice soil and among the broken fragments of gray lava rock. About the middle of September the leaves turn red—often a deep handsome red—and begin to fall, so that by the end of the month the plant has practically disappeared. Its buckwheat-like fruit is a favorite food of the mice inhabiting the higher slopes.

Oreobroma triphylla (Wats.) Howell. Dwarf Alpine Spring Beauty.

This tiny inconspicuous plant was found near timberline north and northwest of Red Butte. (Identified by Professor Greene.)

Spraguea umbellata Torr. Pussy-paws.

Abundant on the pumice slopes of the Hudsonian zone, beyond which it pushes both upward and downward on suitable soils. The highest altitude at which it was noted is 9,400 feet on the east side of Mud Creek Canyon, but it was rarely seen above 9,000 feet. On the other hand, a form of it descends in suitable spots to the lower edge of the Canadian zone near Wagon Camp (altitude 5,600 feet), and to the same altitude in the lower part of Mud Creek Canyon.

Stellaria crispa C. & S.

Collected by Vernon Bailey and Miss Wilkins in Mud Creek Canyon near the junction of Clear Creek. (Identified by Professor Greene.)

Sagina saginoides (L.) Brit.

Occurs above timberline; collected by Miss Wilkins.

Silene grayi Watson. Hudsonian Catchfly.

Common in stony places and along streams below timberline in the Hudsonian zone. Found both in the stony pumice soil and in the heather beds. (Identified by Miss Eastwood and Dr. B. L. Robinson.)

Silene suksdorfi Robinson.[1] Alpine Catchfly.

An alpine species common in scattered tufts, which form small compact mats under the edges of rocks, well above timberline. Often mixed with *Erigeron compositus*. (Identified by Dr. B. L. Robinson.)

Aconitum columbianum Nutt. Monkshood.

Common in a marshy place in the Shasta fir forest at Wagon Camp, where its tall wands of handsome blue flowers were conspicuous in July and its fruit in September.

Aquilegia truncata Fisch. & Mey. Red Columbine.

Common near Wagon Camp, in the upper part of the Transition zone. (Identified by Professor Greene.)

Delphinium sonnei Greene. Larkspur.

Common in moist spots in the Shasta fir forest near Wagon Camp, and also in the canyon of Ash Creek. (Identified by Professor Greene.)

Pæonia browni Dougl. Wild Paeony.

Occurs sparingly in the upper part of the ponderosa pine forest (Transition zone), particularly in the neighborhood of Wagon Camp.

Pulsatilla occidentalis Watson.

Common in places on the higher slopes (Hudsonian zone), particularly where the snow lies late. It blooms as the snow recedes, leaving a handsome globular head of feathery plumes which waves in the breeze long after the season of flowering.

Bikukulla uniflora (Kellogg) Howell.

Reported by Miss Eastwood from above timberline on Horse Camp Trail; not found by us.

Arabis platysperma Gray. Flat-pod Arabis.

The commonest and most widely distributed crucifer of the higher slopes of Shasta, where it occurs on stony slopes and along the edges of the heather beds from the lower edge of the Hudsonian zone upward on warm slopes to 10,200 feet. Its extreme vertical range appears to be about 3,000 feet. (Identified by Miss Eastwood.)

Cardamine bellidifolia pachyphylla Coville.

This small alpine crucifer, with white flowers and rather broad dark green leaves, is nowhere abundant, but was observed here and there above timberline, both on the main peak of Shasta and on Shastina. (Identified by F. V. Coville.)

Cheiranthus perennis (Coville) Greene. [=*Erysimum asperum perenne* Coville.]

Vernon Bailey and I found this coarse yellow-flowered crucifer at timberline on the north slope of Shastina July 24, but did not observe it elsewhere. (Identified by Professor Greene.)

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[1] Botanical Gazette, vol. 16, p. 44, pl. 6, 1891.

Draba breweri Wats. Sierra Alpine Draba.

Collected east of Mud Creek Canyon at an altitude of 13,000 feet by Miss Wilkins; not observed elsewhere. This *Draba* and *Polemonium pulchellum* are the only plants found at so great an elevation. (Identified by F. V. Coville.)

Streptanthus orbiculatus Greene.

A Hudsonian species common on pumice soil in stony places at and below timberline all the way around the mountain. The plant is easily recognized by its long curved slender pods and its rather large domed leaves. The length of the large tapering root only slightly exceeds the height of the plant. (Identified by Professor Greene.)

Chrysamphora californica (Torr.) Greene. California Pitcher Plant. (= *Darlingtonia* Auct.)

This interesting pitcher plant is exceedingly local in distribution. Mr. Elmer Applegate tells me that it is common in the upper part of the Sacramento Canyon, a short distance from Sisson Tavern. It has been reported as occurring in the 'marshes' of Shasta, but we did not find it on the mountain, nor did we find any marshy areas more than a few rods in extent.

Drosera rotundifolia Linn. Sundew.

Collected by Miss Wilkins in the springy bog just above Wagon Camp in the Canadian zone. Not observed elsewhere.

Mitella pentandra Hook.

Common in the heather patches along the overhanging banks of streams in the Hudsonian zone. Abundant at Squaw Creek Camp. (Identified by Professor Greene.)

Parnassia californica (Gray) Greene. Grass-of-Parnassus.

This elegant flower is common along the water courses of the Hudsonian zone, usually growing along the overhanging banks of the tiny rivulets. It blossoms late, and a few plants were still in flower when snow fell, the last week in September.

Saxifraga bryophora Gray.

Reported by Miss Eastwood from the timberline region on Horse Camp Trail; not found by us.

Saxifraga tolmiei[1] T. & G. Alpine Rock Saxifrage.

Common above timberline, where it usually forms small dense mats in moist places among rocks. On Inconstance Creek, on the north side of Shasta, it was found as low as 7,600 feet. On the south slope it ranges up to 11,000 feet, or possibly higher. On the cold northeast side of Red Butte it occurs among the rocks with *Oxyria digyna*. (See p. 50.)

[1] The spelling *tolmæi* should be regarded as an obvious typographical error.

Peltiphyllum peltatum (Torr.) Engler. Giant Water Saxifrage.

One of the most conspicuous plants in the bottom of the Sacramento Canyon, where its clusters of huge incised roundish leaves along the water's edge suggest the devil's club. It ranges along the Sacramento River from just below Sisson nearly to the Sacramento Valley.

Ribes amictum Greene.

Occurs at Wagon Camp, along Squaw Creek, and in the bottom of Mud Creek Canyon at an altitude of 6,700 feet. (Identified by Professor Greene.)

Ribes cereum Dougl.

Found near timberline near the head of Panther Creek, and also much lower down.

Ribes viscosissimum Pursh.

Common near Wagon Camp and observed at other points within the Transition zone, particularly along Squaw Creek.

Ribes klamathense Coville.

Occurs in cool moist places in the Transition zone at Sisson. (Identified by F. V. Coville.)

Cercocarpus ledifolius Nutt. Mountain Mahogany.

Common on Sheep Rock and thence to the southeastern corner of Shasta Valley (V. Bailey), and on warm, dry slopes of the Scott Mountains, where *C. parvifolius* also occurs.

Fragaria bracteata Heller. Small Strawberry.

Common on the lower slopes. Just below Wagon Camp strawberries and painted cups are so abundant as to form an almost continuous carpet under the uppermost grove of ponderosa pines. (Identified provisionally by P. A. Rydberg.)

Fragaria chilensis Duchesne. Large Strawberry.

Occurs with the last a little below Wagon Camp, but is much commoner lower down, particularly near Sisson. Sisson Tavern was formerly called 'Berryvale' and is located in 'Strawberry' Valley. Both names were derived from the abundance of this wild fruit there in early days. (Identified provisionally by P. A. Rydberg.)

Holodiscus discolor (Pursh) Maxim. Alpine Spiræa.

Common on rocks at and a little below timberline, usually associated with *Pinus albicaulis*. It is a small, fragrant bush, usually less than a foot in height, and always grows among rocks at high altitudes. In the Hudsonian zone it was found all the way around the mountain, and was in blossom from about July 20 until September. A larger form, which the botanists do not appear to have named, occurs lower down, in the Canadian zone. It has larger, broader, and thinner leaves and should be separated.

Spiræa douglasi Hook. Red Spiræa.

Common in moist places in the Canadian and Transition zones, but most abundant in the latter. It is common at Sisson, at the west base of the mountain, and in Squaw Creek Valley on the south side, and thence upward, in suitable moist spots, to Wagon Camp at 5,700 feet, along Squaw Creek at 6,000 feet, and in Mud Creek Canyon as high as 6,700 feet.

Horkelia pseudocapitata Rydberg.

Abundant in the Transition zone near Wagon Camp, particularly about the upper limit of *Pinus ponderosa*. (Identified by P. A. Rydberg.)

Kunzia tridentata (Pursh.) Spreng.

Irregularly distributed in the Transition zone; commonest in the manzanita chaparral of the lower slopes. On the north side of the mountain it is exceedingly abundant, and in the open pine forest bordering the south end of Shasta Valley attains unusually large size. On the west side, north of Sisson, it occurs sparingly on most of the warmer and drier knolls, and more plentifully between Black Butte and Shasta Valley. It is almost always associated with *Arctostaphylos patula*, with which it ascends some of the warmer slopes to points far above the upper limit of its usual distribution. Thus it was found on a southwest slope in Mud Creek Canyon between the altitudes of 6,700 and 7,400 feet; on similar slopes near Horse Trail and in Diller Canyon as high as 7,800 to 7,900 feet, and on a warm pumice ridge north of Shastina at 7,500 feet.[1] In Squaw Creek Valley, near McCloud Mill, a form occurs which has exceedingly narrow leaves.

Lutkea pectinata (Hook.) Kuntze.

Abundant in the Hudsonian zone, chiefly in the neighborhood of timberline, where it is common along the little streams in the upper edge of the forest, and in the glacial basins which are wet from melting snows in the early part of the season, but may be dry at the time the plant blossoms. In damp spots, particularly along the borders of cool springs, the individual plants often stand so near together as to form extensive beds.

Potentilla flabellifolia Hook.

Occurs here and there, a little below timberline, in the Hudsonian zone. (Identified by Miss Eastwood and P. A. Rydberg.)

Potentilla pseudorupestris Rydberg. Dwarf Alpine Potentilla.

A dwarf Alpine or high Hudsonian *Potentilla* of the *glandulosa* type, collected on the north side of Shastina at an altitude of about 8,800 feet, is provisionally referred to this species by Mr. Rydberg.

[1] For an explanation of this seemingly abnormal range, see p. 49.

Potentilla glandulosa Lindl. Large Yellow Potentilla.

A large *Potentilla* from the Transition zone, near Wagon Camp, is identified by Mr. Rydberg as *P. glandulosa.*

Rosa californica C. & S. California Rose.

Abundant in moist places in the Transition zone near Sisson Tavern and along the east base of Mount Eddy.

Rosa gymnocarpa Nutt. Wild Rose.

Common in places in the Transition zone, particularly a little below Wagon Camp.

Rubus parviflorus Nutt. [=*R. nutkanus* Auct.] Western Thimbleberry.

Common in cool moist places in McCloud Valley and at Sisson, and thence up through the Transition zone to an altitude of 5,200 feet on the road to Wagon Camp, and 6,000 feet along Squaw Creek and in Mud Creek Canyon. Most of the Transition slopes of Shasta are too dry for the thimbleberry.

Rubus vitifolius C. & S. Blackberry.

Common in cool moist places in the Transition zone near Sisson and along the east base of the Scott Mountains.

Sibbaldia procumbens Linn. Alpine Sibbaldia.

Common in the Hudsonian zone near timberline, particularly in springy places and in the heather beds. Usually occurs in small patches below extreme timberline.

Amelanchier alnifolia Nutt. Serviceberry.

Abundant in moderately moist parts of the Transition zone. On the west and southwest sides of the mountain it reaches from Sisson to Wagon Camp. On a warm southwest slope on the steep ridge between Mud Creek Canyon and Clear Creek it occurs, with several other Transition zone species, at the unusual altitude of about 7,000 feet. (See p. 49.)

Cratægus rivularis Nutt. Black Haw.

Common in the Transition zone about the west base of Shasta, particularly along streams at the east base of Mount Eddy, from the head of the Sacramento northward, usually in cool moist soil. Common near Sisson Tavern.

Sorbus sambucifolia (C. & S.). Mountain Ash.

Rather scarce and confined chiefly to the relatively moist Transition zone slopes of the canyons. In Mud Creek Canyon it was found along the bottom from 5,600 feet to 6,700 feet. Along Squaw Creek it was found at about 5,500 feet.

Cerasus demissa (Nutt.). Western Chokecherry.

Common in places in the lower part of the Transition zone. Observed on the south slope above McCloud Mill, mainly in the gulches; also in the neighborhood of Sisson, and near the south end of Shasta Valley.

Cerasus emarginata Dougl. Bush Cherry; Bitter Red Cherry.

Abundant in places in the chaparral of the Transition zone. In Sacramento Canyon, south of Shasta. it begins at 'The Loop,'[1] and ranges up to the lower edge of the Canadian zone. It is profusely abundant at Wagon Camp, where it is a straggling bush a little higher than a man's head, and usually grows in thickets. It ascends Mud Creek Canyon to an altitude of 5,600 or 5,700 feet.

Cerasus glandulosa Kellogg.

A sapling or small tree having large broad leaves; collected by me a short distance south of Sisson Tavern. (Identified by Professor Greene.)

Prunus subcordata Benth. Wild Plum.

Common in places along the southern and western borders of Shasta Valley, usually in the edge of the open *Pinus ponderosa* forest and often growing with *Rhus* and *Kunzia.* We found it also near Etna, on the west side of Scott Valley.

Cercis occidentalis Torr. Red-bud.

Reported from Mount Shasta in the Botany of California, but not found by us except in the Sacramento Canyon, where it is common.

Lotus americanus (Nutt.) Bisch. [= *Hosackia americana.*]

Common in the Transition zone at Wagon Camp, and thence along the road to Sisson, growing chiefly in open places in the chaparral.

Lupinus elmeri Greene [= *L. albicaulis sylvestris* Auct.]

Common in places throughout the upper part of the Transition zone, and ranging into the Canadian. Common at Wagon Camp and a little above. Found also in Mud Creek Canyon at mouth of Clear Creek. (Identified by J. B. Leiberg.)

Lupinus 'ornatus' Auct. [not of Douglas.] Silvery Lupine.

This beautiful species is common in spots near and a little below timberline, sometimes covering extensive areas, but not uniformly distributed. Where it occurs it is usually sufficiently abundant to give the mountain side the effect of a distinct silvery covering. It always grows on stony or pumice slopes and usually among or near white bark pines, although in a few instances it was found outside of the pine areas. It is common near the head of Squaw Creek and on both sides of Mud Creek Canyon. On the east side of this canyon it is particularly abundant just above the trees, and stops abruptly at an altitude of 8,200 to 8,400 feet, to be replaced by the dwarf Alpine *L. lyalli.* On the north side of Shasta it is common in an open forest of white-bark

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[1] In this and subsequent references to 'The Loop' the statement means that in going north along the railroad track we first saw the plant at 'The Loop.' The species may occur farther south in the canyon on suitable slopes above the level of the railroad.

pines in a shallow gulch at the east base of the lava buttes just below 'North Gate.' The upper limit of the silvery lupine usually coincides with the lower limit of the dwarf lupine (*L. lyalli*), which species generally pushes from this point upward through the Alpine zone.

The root of the silvery lupine is slender and tough, and soon divides into two or three very long wire-like rootlets which run a rather shallow course in the sand. Some of them measure 750 millimeters. The plant at timberline averages about 60 millimeters in height.

Mr. Leiberg tells me that this species, although commonly referred to '*ornatus*', is not *ornatus* of Douglas. It has also been called *L. argenteus decumbens* Watson.

Lupinus albifrons Benth.

Collected near Horse Camp August 20 by Vernon Bailey and Miss Wilkins. (Identified by J. B. Leiberg.)

Lupinus lyalli Gray. Dwarf Alpine Lupine.

Abundant and widely distributed over the higher rocky pumice slopes from timberline or a little above up to an altitude of slightly more than 10,000 feet. (Identified by J. B. Leiberg.)

Lupinus minimus Dougl. Dwarf Lowland Lupine.

Common in the Transition zone at Sisson. (Identified by J. B. Leiberg.)

Vicia americana Muhl.

Rather common at and below Wagon Camp, and still in flower when we left, September 25.

Linum lewisi Pursh. Wild Hemp.

Abundant at Wagon Camp, where its delicate blue flowers were conspicuous in July, and its large subglobular seed capsules in September.

Polygala cornuta Kellogg.

Occurs plentifully in the dry pine woods of the Transition zone near Sisson Tavern, but was not observed on the mountain proper. (Identified by Miss Eastwood.)

Rhus trilobata Nutt.

In going north from Sisson we first observed this species a mile or two south of Edgewood, to the north and east of which it became more and more common. Its zone position here is along the borderland between the Transition and Upper Sonoran zones.

Pachystima myrsinites Raf. Oregon Boxwood.

Common in the Transition zone at the west base of Shasta, from Sisson up to an altitude of about 4,700 feet, usually in manzanita chaparral. Its absence from the higher slopes within the proper zone limits of the species is probably due to heat and dryness, as explained elsewhere (p. 56), but it is possible that the Sisson plant is a Transition zone subspecies of the true Boreal *P. myrsinites*.

Acer macrophyllum Pursh. Oregon Maple; Big-leaf Maple.

The tree maple is rare in the region about Shasta, where it was observed only in moist places in the lower part of the Transition zone near Sisson and in the upper part of the Sacramento Canyon.

Acer glabrum Torr. Bush Maple.

Fairly common in McCloud Valley and in moist places along streams and canyons in the Transition zone. In Mud Creek Canyon it was found up to an altitude a little above 5,600 feet, and along Squaw Creek to nearly 6,000 feet.

Acer circinatum Pursh. Vine Maple.

This characteristic west-coast species, with nearly circular 7-point leaves, occurs sparingly in moist places near Sisson Tavern, but is not common. It is one of the most distinctive plants of the humid Pacific coast division of the Transition zone.

Ceanothus cordulatus Kellogg. Snow Bush.

Common in the lower part of the Transition zone on the southern and western basal slopes of Shasta. In the upper part of Sacramento Canyon it first occurs at 'The Loop,' whence it is abundant northerly to within a mile or two of Edgewood. At Sisson and in Squaw Creek and McCloud valleys it is very abundant, but for some reason not apparent it does not reach on Shasta its usual upper limit, and was not observed anywhere above 4,900 feet. Possibly it is choked out by the other chaparral, which is made up mainly of manzanita (*Arctostaphylos patula*) and buck-brush (*Ceanothus velutinus*).

Ceanothus cuneatus Nutt. Wedge-leaf Ceanothus.

This is one of the most characteristic shrubs of the Upper Sonoran zone in California, where it is generally associated with the curious digger pines. The region about Shasta is too high for it. It occurs, however, in the lower valleys, both north and south of Sisson. On the north it reaches from Yreka to a little beyond Edgewood, appearing a mile or two south of the latter point on the road to Sisson, and about 4 miles southwest of it on a road farther west. Skipping the broad Transition belt between Edgewood and the Sacramento, it occurs next at Delta, in the Sacramento Canyon, and ranges thence southerly. Its upper border meets the lower border of another species, *C. cordulatus*, which is common at Sisson, as well as on the southern and western basal slopes of Shasta.

Ceanothus velutinus Dougl. Buck-brush.

Profusely abundant on all the manzanita-covered slopes of Shasta, from the lower part of the Canadian zone down nearly to the lower edge of the Transition. Mixed with *Arctostaphylos patula* in nearly equal proportion it forms the dominant chaparral of the mountain.

Tongues of it push up on warm southerly slopes to about 6,600 feet[1] altitude, and it descends on the west slope to about 4,200 feet (half a mile east of Sisson), and on the south slope to 3,600 feet (near McCloud Mill). Along the east base of Mount Eddy, where it is sheltered from the afternoon sun, it appears about 2 miles north of Sisson (altitude 3,700 feet), and continues northerly for many miles.

Ceanothus integerrimus H. & A. California Lilac.

Common in parts of the Transition zone, notably in Squaw Creek Valley near McCloud Mill, and in the upper Sacramento Valley a little below Sisson, but very scarce or absent on the slopes of Shasta proper. Like *C. cordulatus* it seems to be kept out by some unknown cause, possibly choked out by other species. Perhaps the soil is too dry for it.

Ceanothus (Cerastes) prostratus Benth. Squaw Carpet.

In following the Sacramento Canyon northward, Squaw Carpet was first seen at the 'The Loop,' a few miles south of Sisson, whence it occurs in greater or less abundance throughout the ponderosa pine forest and manzanita chaparral to the lower slopes of Shasta, where on the southwest side it reaches up to 5,200 feet.

Rhamnus californica Esch. (This form may be *R. rubra* Greene.)

Scarce and confined to low altitudes in the Transition zone. Found by Vernon Bailey in Squaw Creek Valley below 4,000 feet. Specimen lost.

Hypericum anagalloides C. & S. Dwarf Hypericum.

Common in spots in wet places in the Hudsonian and Canadian zones. It was most common in the second meadow on Squaw Creek, and by no means rare near Wagon Camp, and was in flower in late July and throughout August.

Viola blanda Willd. White Violet.

Collected by Miss Wilkins in the middle meadow on Squaw Creek, at an altitude of 7,500 feet. Not observed elsewhere.

Viola purpurea Kellogg. Alpine Yellow Violet.

Common on dry rocky slopes on pumice soil from some distance below timberline upward, on warm southerly exposures, to 9,300 feet. When we reached the mountain, the middle of July, its yellow flowers were conspicuous, although even at that time the species had nearly passed flowering. Its fruit and dark green leaves remained as late as the latter part of September, sharply outlined against the whitish stones and pumice of the bleak and barren upper slopes, where a violet seemed singularly out of place. (Identified by Miss Eastwood and Professor Greene.)

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[1] For its extreme upper limit, on hot canyon slopes, see remarks under *Arctostaphylos patula*, p. 158.

Mentzelia lævicaulis (Dougl.) T. & G.

Rather common in Shasta Valley, but not found elsewhere about the mountain. This species seems to belong to the Upper Sonoran zone, and therefore has no place in the flora of Mount Shasta.

Epilobium spicatum Lamarck. Willow Herb; Fire-weed.

Abundant in places, chiefly on old burns in the Canadian and Transition zones. At Wagon Camp it did not begin to flower until near the middle of August; at Sisson it was still in flower in places as late as the middle of September.

Epilobium brevistylum Barbey.

Collected at Wagon Camp, where it is tolerably common in moist places; the largest species next to *spicatum*. (Identified by Professor Trelease.)

Epilobium oregonense Hausskn.

Common at Wagon Camp. A large form occurring also at Wagon Camp Professor Trelease considers as probably *E. glaberrimum* Barbey.

? Epilobium hornemanni Reichenb.

Some poor specimens, with exceedingly long seed capsules, collected by me a little below timberline about the end of the season, are doubtfully referred to this species by Professor Trelease.

Epilobium clavatum Trelease.

Abundant in the heather meadows and along the edges of the cool streams of the Hudsonian zone at and a little below timberline. (Identified by Professor Trelease.)

Epilobium pringleanum Hausskn.

A tiny alpine species, rarely as tall as one's thumb, occurring here and there on the borders of the highest streamlets above timberline. (Identified by Professor Trelease.)

Epilobium obcordatum Gray. Rose Epilobium.

Local—common near timberline on the steep west side (east slope) of Mud Creek Canyon. A remarkable plant, strikingly unlike the others of its genus. It has a woody base and is really a dwarf bush. Its large red flowers are showy and very handsome. (Identified by Miss Eastwood and Professor Trelease.)

Gayophytum ramosissimum T. & G.

Abundant throughout the Transition zone, where it was equally common at Sisson and at Wagon Camp and was in flower as late as the end of September. (Identified by Miss Eastwood.)

Carum gairdneri (Hook. & Arn.) Gray.

Rather common in damp soil at Wagon Camp where the Canadian and Transition zones meet. (Identified by Dr. J. N. Rose.)

Cymopterus terebinthinus T. & G.

Common in the neighborhood of timberline, usually in stony places on dry pumice slopes; found also on top of Red Cone, a little east of Wagon Camp. This species has a large and woody root and a remarkably rank and lasting odor. Its zone position is Hudsonian; a larger unrecognized form occurs in the Canadian zone. (Identified by Miss Eastwood and Dr. Rose.)

Ligusticum grayi Coulter & Rose.

Common throughout the Hudsonian zone, particularly a little below timberline, where it occurs most abundantly in the beds of heather along the little streams. In places it pushes down into the Canadian zone. (Identified by Miss Eastwood and Dr. Rose.)

Heracleum lanatum Michx. Cow Parsnip.

Occurs in damp places in the Canadian zone. In Mud Creek Canyon near the mouth of Clear Creek it was found as high as 6,700 feet. (Identified by Dr. Rose.)

Osmorrhiza nuda Torr.

Found sparingly at Wagon Camp and at Sisson.

Cornus nuttalli Audubon. Oregon Dogwood.

Rather common in moist places in the lower half of the Transition zone. It occurs in Squaw Creek Valley near McCloud Mill, and is common along the streams near Sisson Tavern; on the road from Wagon Camp to Sisson it was seen up to an altitude of 4,500 feet.

Cornus pubescens Nutt.

Common in cool damp soil near Sisson and along the upper Sacramento.

Chimaphila umbellata (L.) Nutt.

Occurs here and there throughout the drier parts of the forest, but is less common than *Chimaphila menziesi*.

Chimaphila menziesi Spreng.

Fairly common throughout the Shasta fir forest, and also in the mixed forest of pines and firs from the upper Sacramento Canyon northward (Canadian and Transition).

Pyrola picta Smith.

Occurs here and there throughout the forest of Shasta firs, where its ornamental light-marbled leaves are pleasingly conspicuous against the dark soil.

Pyrola pallida Greene.[1]

Found sparingly on the dry summit of Red Cone, about a mile east of Wagon Camp. (Identified by Professor Greene.)

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[1] Pittonia, IV, p. 39, March 17, 1899.

Pyrola secunda Linn.

Decidedly less common than *P. picta*, but like it found in the Shasta fir forest.

Pterospora andromedæ Nutt. Pinedrops

Found in the dry woods along the border between the Canadian and Transition zones. (Identified by Professor Greene.)

Pleuricospora fimbriolata Gray.

Collected at Wagon Camp by Miss Wilkins. (Identified by F. V. Coville.)

Sarcodes sanguinea Torr. Snow Plant.

This handsome plant is reported as common on the forested slopes of Shasta at the time of melting snow in spring. It probably occurs in both the Canadian and Transition zones.

Arctostaphylos nevadensis Gray. Dwarf Mountain Manzanita.

Common in the Canadian and Hudsonian zones, growing in extensive beds a foot or less in height. On the high ridges, among the timber-line *Pinus albicaulis*, these beds of green cover the pale gray lava rocks, and in the dark forests of Shasta fir they form the only conspicuous surface vegetation.

Arctostaphylos patula Greene. Green Manzanita.

The most abundant and troublesome chaparral of Shasta. It is a characteristic Transition zone species and covers the lower slopes all the way around the mountain except a belt about 10 miles wide on the

FIG. 45.—Manzanita chaparral.

northeast base, reaching from Ash Creek to about 3 miles northwest of Inconstance Creek, which is too cold for it and is occupied by Canadian zone species. On the north, west, and south it covers practically the whole of a broad belt several miles in width, reaching from base level to the lower edge of the Canadian zone and formerly occupied in the main by a forest of ponderosa pines, some of which still remain scattered over it. Except at its extreme lower limit, it is usually mixed with buck-brush (*Ceanothus velutinus*).

Seen from a distance, the extensive areas of manzanita on the lower slopes of Shasta are very deceptive. They look like meadows of green grass, but to cross them is in most cases impossible, owing to the density of the growth and rigidity of the branches. For this reason they form secure retreats for black bears, deer, wild-cats and other animals.

At two places on the west side of the mountain *Arctostaphylos patula* reaches the extraordinary altitude of 7,800 to 7,900 feet. One of these is on the north side of Diller Canyon, the other on the north side of Horse Camp Trail. Both stations are on long and steep southwest pumice slopes which receive the hot rays of the afternoon sun almost at a right angle, carrying up numerous Transition zone species nearly 2,000 feet above their normal limit. (See p. 51.) From the southwest base of Shasta the green manzanita reaches down the canyon of the Sacramento River to 'The Loop.'

Phyllodoce empetriformis (Gray). Red Heather.

[=*Bryanthus empetriformis* Auct.]

Abundant along the cold streams of the Hudsonian zone and in the bottoms of the glacial basins that are kept moist by melting snows; commonest between the altitudes of 7,500 and 8,500 feet, and not seen above 9,100 feet. This is the only 'heather' found on Shasta. It usually forms extensive beds or carpets in which numerous other plants find a congenial home. These beds are practically the only flower gardens on the mountain, and the only areas where small plants are plentiful enough to give the effect of continuous green; hence they are commonly spoken of as 'heather meadows.'

Kalmia glauca microphylla Hook. Alpine Laurel.

Abundant in most of the heather meadows just below timberline, particularly along Squaw Creek. In general size and aspect the alpine laurel resembles the red heather so closely that at a little distance it is difficult to tell them apart.

Vaccinium cæspitosum Mich. Dwarf Alpine Blueberry.

Abundant on the higher slopes within the Hudsonian zone, reaching a little above timberline. Common here and there in the stony pumice flats and basins, but commonest near the streams, where it is scattered through the heather and forms beds of its own along the outer edges of the heather beds. Its leaves turn dark red or garnet during the latter half of September, contrasting handsomely with the dark green of the heather. In the neighborhood of timberline the dwarf blueberry is rarely more than three or four inches in height. It was in full bloom the middle of July.

The form here referred to is the dwarf High Sierra one, given under *cæspitosum* by Coville, in his 'Botany of the Death Valley Expedition' (p. 145, 1893).

Vaccinium arbuscula (Gray) [= *Vaccinium cæspitosum* var. *arbuscula* Gray].

Common in moist places in the Transition zone from Wagon Camp down to Warmcastle Soda Springs at the south base of the mountain. This species seems to be distinct from the dwarf boreal *V. cæspitosum*. It averages about 2 feet (60 centimeters) in height and has red branches and decidedly larger and thicker leaves than the alpine *cæspitosum*. Whether or not the latter is the typical form is another question. The zone position of *V. arbuscula* is probably Canadian and Transition.

Vaccinium occidentale Gray. Blueberry.

Common in the Canadian zone in some of the canyons, and in the marsh at Wagon Camp, where it fruited early.

Fraxinus oregana Nutt. Oregon Ash.

Occurs sparingly in the upper Sacramento Canyon, but was not observed about the actual base of the mountain.

Gentiana simplex Gray. Blue Gentian.

Common in the Canadian zone swamp at Wagon Camp the first half of August. (Identified by Professor Greene.)

Apocynum pumilum (Gray) Greene.

Common in suitable places throughout the Transition zone, from which it pushes up a short distance into the lower edge of the Canadian. With other Transition zone species it was found on a warm slope in Mud Creek Canyon at 6,700 feet. (Identified by Professor Greene.)

Cycladenia humilis Benth.

Common in places in the Hudsonian zone, but very local. It occurs plentifully on the top of Red Cone, a short distance northeast of Wagon Camp, at an elevation of about 6,600 feet; on a red lapilli hill which forms a part of Red Butte, just east of 'The [South] Gate,' and on both sides of Mud Creek Canyon a little below true timberline. The highest altitude at which it was observed was 8,700 feet on a southwesterly slope on the west side of Mud Creek Canyon. *Cycladenia humilis* is a curious and rather striking plant. It usually has four large entire leaves, suggesting those of *Polygonum newberryi*, and bears a pair of conspicuous red tubular flowers followed by two curious seed pods, which are very long and lie side by side, one above the other, like the barrels of a Winchester rifle. (Identified by Miss Eastwood.)

Gilia aggregata (Pursh) Spreng.

Common throughout the ponderosa pine forests of the Transition zone and sometimes seen in the lower part of the Shasta fir forest, where its handsome scarlet flowers are very attractive. On warm southwest slopes near Panther Creek it was found as high as 6,600 feet, and between Mud and Clear creeks as high as 6,700 feet, but these are abnormal altitudes due to unusually warm exposures and soil.

Collomia grandiflora Dougl.

Common in the upper part of the Transition zone a little below Wagon Camp, where it was flowering abundantly the last half of July.

Phlox douglasi diffusa (Benth.) Gray. Alpine Phlox.

A common, widely distributed, and conspicuous plant of the higher slopes within the Hudsonian zone, sometimes straggling down into the Canadian zone. It occurs in scattered tufts on the dry rocky slopes and ridges, usually on pumice soil, and is commonest in the neighborhood of timberline. It blossoms early, and flowers were rarely seen as late as the latter part of July. After flowering the whole plant withers and is disintegrated by the wind, so that little more than the woody base remains.

Polemonium pulchellum Bunge.

A characteristic but not abundant Alpine species, occurring here and there among rocks far above timberline. On the north side of Shastina it was in full bloom July 24 at an altitude of 8,900 feet. On the south side of Shasta, above Squaw Creek, and on both sides of Mud Creek Canyon, it was not found below 9,500 feet, whence it ranges up to 13,000 feet. This species and *Draba breweri* were both observed at 13,000 feet, and are the highest plants found on Shasta. (Identified by Professor Greene.)

Phacelia frigida Greene.[1] Dwarf Alpine Phacelia.

This new species, which Professor Greene has kindly described at my request from specimens collected by us above the head of Squaw Creek, is common and widely distributed on the higher and more barren rocky slopes, beginning above timberline and reaching, on southerly slopes, as high at least as 10,200 feet. The lowest altitude at which it was found is 8,700 feet, on a cold slope.

Phacelia magellanica (Lam.) Coville.

A plant which, in the present unsatisfactory state of the group, it seems necessary to refer here, is abundant on the lower slopes, particularly in the Transition zone, where it was in flower throughout the summer and as late as the end of September.

Cryptanthe geminata Greene.

Rather common in the Transition zone below Wagon Camp. (Identified by Professor Greene.)

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[1] Pittonia, IV, pp. 39–40, March 17, 1899.

Lappula nervosa (Kellogg) Greene.

Abundant in the openings near and a little below Wagon Camp, where it is the most troublesome 'stick-tight' of the region, filling the forelocks and manes of the horses and binding them together in a dense mat.

Monardella odoratissima Benth.

Abundant in the Canadian zone and much less common in the Hudsonian. Abundant in the chaparral at Wagon Camp and found in several places on warm sunny slopes as high as 7,800 or 7,900 feet, and in one place near the head of Squaw Creek at 8,300 feet. In the latter locality only a few bunches occur among the rocks and no others were observed for a long distance below.

Scutellaria nana Gray. Dwarf Skullcap.

This interesting little yellow-flowered skullcap was found at one place only—the north slope of Shastina, at an altitude of 8,800 feet, where it was flowering July 24. If this alpine plant is the same as the type of *S. nana*, which came from the hot desert region near Pyramid Lake, Nevada, its occurrence at timberline on Shasta must be accidental. (Identified by F. V. Coville.)

Stachys ingrata Greene.

Abundant in moist soil at Wagon Camp, on the border between the Canadian and Transition zones. (Identified by Professor Greene.)

Chamæsaracha nana Gray.

This solanaceous plant, which has la ge white flowers and looks like a dwarf potato, is common in an old burn near Wagon Camp, where the Canadian and Transition zones overlap. (Identified by Miss Eastwood.)

Castilleja miniata Dougl. Scarlet Painted Cup.

Common and conspicuous. A large form, probably the type form—since the type came from the Blue Mountains of Oregon—is common in moist places in the lower part of the Canadian zone and upper part of the Transition. It was flowering abundantly in the uppermost grove of ponderosa pines at Wagon Camp the latter half of July. A smaller form, apparently unnamed, abounds in the heather beds of the Hudsonian zone near and a little below timberline, where it was flowering profusely the first half of August.

The scarlet painted cup is one of the handsomest flowers of the mountain. Where the plants are abundant on the dark heather the effect of the bright green corolla tubes protruding in slender spindles from the vivid scarlet mass of bracts and calyx is superb. Early in August the calliope hummingbirds were constantly hovering over these flowers. (Identified by M. L. Fernald.)

Castilleja affinis Hook. & Arn.

A plant collected in the Hudsonian zone near timberline just north of Red Butte by Vernon Bailey has been identified as this species by M. L. Fernald. Since the type locality of *affinis* is the low coast strip near San Francisco or Monterey, the typical form would hardly be expected to occur in the high timberline region of Shasta.

Orthocarpus pilosus Watson.

Common in places near timberline, particularly near 'The [South] Gate,' between the heads of Panther Creek and Squaw Creek. (Identified by M. L. Fernald.)

Mimulus implexus Greene.

Abundant in wet places throughout the Hudsonian zone, reaching its greatest perfection in the neighborhood of timberline. In the shallow rapids of some of the mountain rivulets it grows in such profusion that its leaves form extensive mucilaginous patches, which completely fill the beds of the streams. Its large and showy yellow flowers were in blossom from the latter part of July until the end of September. (Identified by Professor Greene.)

Mimulus moniliformis Greene.

Two forms of large yellow *Mimulus* grow in the marsh at Wagon Camp, in the lower edge of the Canadian zone. (Identified by Professor Greene.)

Mimulus tilingi (Regel.) Greene.

Common in the marsh at Wagon Camp. (Identified by Professor Greene.)

Mimulus primuloides Benth.

Common in patches in marshy places and along streams in the Canadian and Hudsonian zones, but much more common in the Canadian than in the Hudsonian. It was abundant at Wagon Camp and also in some of the heather meadows along Squaw Creek and other streams. (Identified by Miss Eastwood and Professor Greene.)

Pentstemon menziesi Hook.

One of the most characteristic and widely distributed plants of the higher slopes, where it is common among the bare rocks all the way around the mountain. It is common in the Hudsonian zone in the neighborhood of timberline, but much more abundant in the Alpine, and was found by Vernon Bailey as high as 10,200 feet. This species is easily distinguished from the other Alpine species of the region by its smooth entire leaves and relatively small bluish or violet blue flowers, which become pink or reddish with age. (Identified by Professor Greene.) The plant is by no means typical, but seems to be intermediate between *menziesi* and *davidsoni*. It may be a distinct species.

Pentstemon newberryi Gray.

Common in places in the Hudsonian zone and possibly in the upper part of the Canadian; much less generally distributed than *P. menziesi* and usually occurring at lower altitudes. On the north side of Shastina it was flowering, the latter part of July, at an elevation of 7,600 feet, and at the same time on the cold east slope of Mud Creek Canyon as low down as 5,600 feet. Its flowers are much larger than those of *P. menziesi* and red instead of bluish; its leaves are longer, and are serrate instead of entire.

Pentstemon glaber utahensis Watson.

Abundant just below timberline on the curious *Pinus albicaulis* plain between North Gate and Bolam Creek, on the north side of Shasta, where it was flowering plentifully July 24. It was not seen elsewhere on the mountain. Its blue-purple flowers are even larger than those of *P. newberryi* and are very showy and handsome. (Identified by Professor Greene.)

Pentstemon deustus (Dougl.). Yellow Pentstemon.

Common in the rough black lava beds in the Shasta fir forest north of Cascade Gulch, on the west side of the mountain, at an altitude of about 7,500 feet, but not seen elsewhere. This species is a dwarf bush 5 or 6 inches high, with yellow flowers and strongly serrate leaves. (Identified by Professor Greene.)

Pentstemon gracilentus Gray.

Abundant in places in the Shasta fir forest, particularly between the canyons of Mud and Ash creeks, in the Canadian zone. (Identified by Miss Eastwood and Professor Greene.)

Pentstemon confertus Dougl. (Not typical.)

Common near Wagon Camp. (Identified by Miss Eastwood and Professor Greene.)

Veronica cusicki Gray.

Common just below timberline, particularly along the little streams where it grows in the grass and heather on the overhanging banks. It was flowering abundantly from the time of our arrival, the middle of July, until about the middle of August. (Identified by Miss Eastwood and Professor Greene.)

Boschniakia strobilacea Gray.

Collected at Wagon Camp by Miss Wilkins. (Identified by Professor Greene.)

Linnæa borealis Linn. Twin Bell-flower.

Fairly common along one of the streams half a mile north of Sisson Tavern, but not noticed elsewhere. This form was described by Torrey as variety *longiflora*.

Sambucus melanocarpa Gray. Blackberry Elder.

Common in moist parts of the Transition zone, particularly in the canyons. (Identified by Professor Greene.)

Symphoricarpos racemosus Mich. Snowberry.

Common about Sisson Tavern and in cool moist places along the base of Mount Eddy.

Symphoricarpos pilosus Greene. Mountain Snowberry.

Abundant in the upper part of the Transition zone, particularly at Wagon Camp and along Squaw Creek. (Identified by Professor Greene.)

Campanula wilkinsiana Greene.[1] Shasta Bluebell.

This new bluebell, recently described by Professor Greene from specimens collected by us on the upper part of Squaw Creek, is common in the lower heather meadows, and less so in the marshy place at Wagon Camp. It is singular that the only *Campanula* found on Shasta should be new, the usual Sierra and Cascade species being absent. The present species, which is named after Miss Lewanna Wilkins, averages 4 to 5 inches in height and has a rather small flower. Its zone position is Hudsonian and Canadian.

Achillea lanulosa Nutt.

Common in the Transition zone at and below Wagon Camp. (Identified by C. L. Pollard.)

Achillea borealis Bong. Dwarf Alpine Yarrow.

Occurs in places on the stony pumice slopes above timberline. Between the heads of Mud and Squaw creeks Vernon Bailey found it at an altitude of 9,600 feet. (Identified by C. L. Pollard.)

Anaphalis margaritacea (L.) B. & H.

Common in dry open places in the chaparral from Sisson to Wagon Camp. (Identified by Professor Greene.)

Antennaria geyeri Gray. Geyer Everlasting.

A large specimen of this handsome everlasting was collected by Vernon Bailey in the Transition zone just below Wagon Camp September 25. The species was not noted elsewhere. (Identified by Miss Eastwood and Professor Greene.)

Antennaria media Greene [=*A. alpina* Auct.]. Alpine Everlasting.

Common in open parts of the Hudsonian zone in the neighborhood of timberline on most parts of Shasta and on Shastina. On ordinary slopes it ranges from an altitude below 8,000 feet up to about 9,000. (Identified by Professor Greene.)

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[1] Pittonia, IV, pp. 38–39, March 17, 1899.

Arnica merriami Greene.[1]

Common in the heather meadows and along the edges of streams in most parts of the Hudsonian zone. This new species has just been described by Professor Greene from specimens collected by us on the moist banks of the small west arm of Upper Squaw Creek, under the alpine hemlocks, where it is very common.

Arnica longifolia D. C. Eaton.

Common in moist places in the Canadian zone, chiefly on the banks of streams. (Identified by Professor Greene.)

Arnica viscosa Gray.

This singular species, which differs strikingly in appearance and habit from most members of its genus, grows in dense patches, usually 2 or 3 feet in diameter, among the bare lava rocks on steep slopes near timberline. On the south side of Shasta it was fairly common and flowering abundantly in August. (Identified by Miss Eastwood.)

Artemisia tridentata Nutt. True Sagebrush.

Sagebrush is unknown in the region about Shasta except in Shasta Valley, which it invades and overspreads from the Klamath country on the north. It reaches the extreme south end of Shasta Valley and penetrates a short distance into the bordering forest of ponderosa pines, where it mixes with *Kunzia tridentata*. Pushing southeasterly over Shasta Valley it reaches the gap at Sheep Rock. Its zone position is Upper Sonoran and Transition.

Artemisia ludoviciana Nutt.

A form of *Artemisia ludoviciana* is common in places just below Wagon Camp, along the upper edge of the Transition zone. When the species and subspecies now lumped under the above name are properly defined, several useful zone plants may be added to their appropriate lists.

Machæranthera shastensis Gray. Shasta Alpine Aster.
[=*Aster shastensis* Auct.].

A dwarf alpine species abounding on the bare rocky pumice slopes in the neighborhood of timberline, and common also on the borders of the heather beds in the glacial meadows. This is the type form. A related but unnamed form, usually a foot and a half or more in height, is common and widely distributed on the lower slopes, chiefly in the upper part of the Transition and lower part of the Canadian zones.

Oreastrum alpiginum (Gray) Greene.

Common in the neighborhood of timberline, particularly in moist places. (Identified by Professor Greene.)

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[1] Pittonia, IV, p. 36, March 17, 1899.

Chænactis nevadensis (Kellogg) Gray. Alpine Chænactis.

This curious composite, with whitish tubular flowers, much divided sticky leaves, and a smell like that of alcoholic specimens, occurs here and there in the pumice sand and among the broken lava shale above timberline. It was first seen in flower on the north side of Shastina July 24 (alt. 9,000 feet), and early in August was flowering plentifully on the south slope of Shasta above the head of Squaw Creek (alt. 9,300 feet). (Identified by Professor Greene.)

Chrysothamnus bloomeri (Gray) Greene.

One of the commonest and most widely distributed plants of the higher slopes, where it occupies pumice soils from the bottom of the Hudsonian zone up to several hundred feet above timberline. It was rarely found above an altitude of 9,000 feet.

This plant is very long lived, and although the part above ground is relatively small it springs from a large woody base resembling that of the true sagebrush. The root is enormous. The main taproot (sometimes double) usually sinks so deeply into the soil that I was unable to dig one up without breaking off the terminal point. In mature plants the main root measures about 200 millimeters in circumference where it enters the ground, and is 500 to 600 millimeters in length. It gives off numerous small and slender rootlets some of which exceed 600 millimeters in length. The height of the plant above ground rarely exceeds 150 millimeters.

Chrysothamnus bloomeri angustatus (Gray) Greene.

Common at Wagon Camp and in various parts of the Transition zone, usually scattered through the manzanita chaparral. Vernon Bailey collected it at Sheep Rock. (Identified by Professor Greene.)

Chrysothamnus occidentalis Greene. Rabbit Brush.

Fairly common in open spots on the lower slopes throughout the Transition zone, where it is mixed with *Kunzia tridentata*, *Arctostaphylos patula*, and *Ceanothus velutinus*. This large white-stemmed species occurs sparingly in dry soil at Sisson, and thence to Edgewood and Shasta Valley, in the upper edge of the Upper Sonoran zone, where it is common among the sagebrush. It was obtained at Sheep Rock by Vernon Bailey. (Identified by Professor Greene.)

Chrysothamnus viscidiflorus Nutt.

Common in the upper part of the Upper Sonoran zone in Shasta Valley. (Identified by Professor Greene.)

Erigeron armeriæfolium Turcz.

Rather common near timberline. Specimens were collected above Squaw Creek, near the head of Mud Creek Canyon, and on the north slope of Shastina. (Identified by Professor Greene.)

Erigeron compositus trifidus Hook.

Common on the slopes of broken shale and pumice above timberline, where it often grows in mats of *Silene suksdorfi* close under the edges of rocks. On the south side of Shasta it was not observed lower than 9,200 feet, but on the cold north slope of Shastina it was found as low as 8,900 feet. Its yellow flowers are rather conspicuous, and were noted from the latter part of July until late in August. (Identified by Professor Greene.)

Erigeron inornatus Gray.

This tall and much-branched *Erigeron* was found in Mud Creek Canyon and along Squaw Creek, a little below the fall, at an altitude of 6,800 feet. (Identified by Professor Greene.)

Eupatorium occidentale Hook.

Collected by Vernon Bailey and Miss Wilkins on Horse Camp Trail on the boundary between the Transition and Canadian zones. (Identified by Professor Greene.)

Heleniastrum rivulare Greene.

Common on damp ground at Wagon Camp, on the boundary between the Canadian and Transition zones. (Identified by Miss Eastwood.)

Hulsea nana Gray.

A common and characteristic plant of the barren alpine slopes above timberline, where its showy yellow heads are conspicuous among the bare rocks. Its leaves are sticky, crinkled, and relatively smooth. It was found on most of the high ridges above timberline all the way around the mountain, and was obtained on the north side of Shastina at an altitude of 9,000 feet. Its highest limit on the southwest side, as observed by Vernon Bailey, is 11,300 feet. (Identified by Miss Eastwood and Professor Greene.)

Hulsea larseni Gray.

Common on the pumice slopes above timberline, growing with *H. nana*, from which it may be easily distinguished by the leaves, which are covered with a dense whitish pubescence. (Identified by Professor Greene.)

Madia bolanderi Gray.

Very common in the marsh at Wagon Camp, where it was in blossom all summer. Common also along some of the streams in the upper part of the Transition zone, where the low temperature resulting from the water carries narrow tongues of Canadian zone species down to altitudes below their normal limits. (Identified by Miss Eastwood.)

Senecio trigonophyllus Greene.

Common along Panther Creek in the Shasta fir belt. (Identified by Miss Eastwood and Professor Greene.)

Senecio canus Hook.

Common on the rock-strewn pumice slopes above timberline. (Identified by Miss Eastwood and Professor Greene.)

Solidago elongata Nutt.

Abundant in open grassy places at Wagon Camp, where it was in flower in August and September. (Identified by Professor Greene.)

Agoseris monticola Greene.[1] Alpine Dandelion.

Abundant in the neighborhood of timberline on the stony slopes and basins, where its yellow dandelion-like flowers were conspicuous from the end of July until the middle of September. On warm southerly slopes it was observed as high as 9,750 feet. Its wavy leaves are sometimes entire, sometimes indented or cut. This species has just been described by Professor Greene from specimens collected by us at timberline on Shasta.

Crepis intermedia Gray.

Collected by Miss Wilkins in Mud Creek Canyon near the mouth of Clear Creek, where its zone position is either Hudsonian or Canadian. (Identified by F. V. Coville.)

Hieracium albiflorum Hook.

Common in places along the upper part of the Transition zone. Collected at Wagon Camp, on Squaw Creek, and on a warm slope in Mud Creek Canyon near the mouth of Clear Creek. (Identified by Miss Eastwood and Professor Greene.) A dwarf alpine form, apparently not yet named, occurs above timberline and is fairly common above the head of Squaw Creek, growing with *H. horridum*.

Hieracium cynoglossoides nudicaule Gray.

Very common in the Transition zone just below Wagon Camp. (Identified by Professor Greene.)

Hieracium horridum Fries.

Common in places on the higher slopes at and above timberline, forming small and densely hairy tufts among the rocks. The plant, particularly when young, is completely covered by a very dense growth of stiff silky white hairs which give it a woolly appearance.

Hieracium gracile Hook.

Common in the heather beds just below timberline, where its conspicuous yellow flowers were in blossom the early part of August. (Identified by Miss Eastwood and Professor Greene.)

Hieracium greenei Gray.

Fairly common just below Wagon Camp in the Transition zone. The type locality of this species is in the Scott Mountains a little west of Shasta. (Identified by Professor Greene.)

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[1] Pittonia, IV, p. 37, March 17, 1899.

Ptiloria lactucina (Gray) Greene. (=*Stephanomeria lactucina* Auct.)

This curious composite, with milky juice and conspicuous pinkish flowers, suddenly appeared on burns near Wagon Camp the latter part of August. It was not observed elsewhere. (Identified by Miss Eastwood and Professor Greene.)

FIG. 46.—Monument on summit of Shasta. (Photographed by W. H. Osgood.)

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[Names of new species in black-face type. For zone position of species, see alphabetical lists, pages 54—79.]