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CONTENTS OF VOLUME XI

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Volume XI, No. 1, pp. 1-40, plates 1-2, map

THE GOPHER SNAKES OF BAJA CALIFORNIA, WITH DESCRIPTIONS OF NEW SUBSPECIES OF PITUOPHIS CATENIFER

BY

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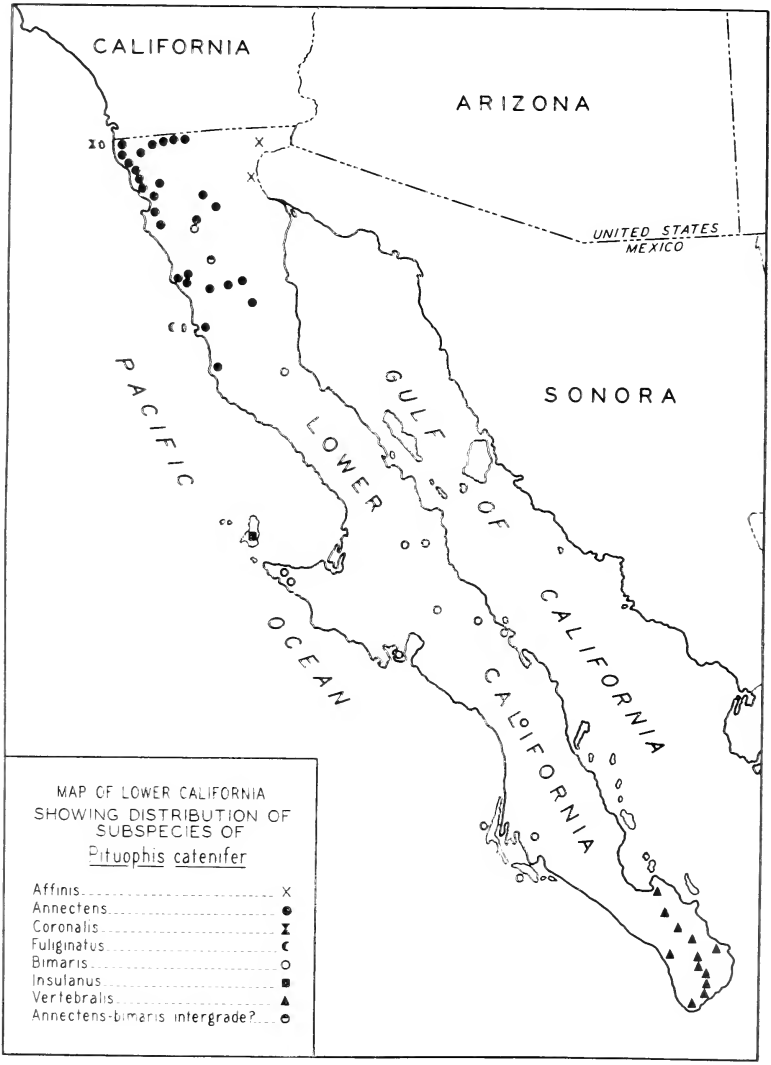
TABLE OF CONTENTS


CALIFORNIA
ARIZONA
UNITED STATES
MEXICO
SONORA
PACIFIC
OCEAN
LOWER CALIFORNIA
GULF OF CALIFORNIA
MAP OF LOWER CALIFORNIA
SHOWING DISTRIBUTION OF
SUBSPECIES OF
Pituophis catenifer
Affinis ×
Annectens ●
Coronalis ⧗
Fuliginatus ☾
Bimaris ○
Insulanus ■
Vertebralis ▲
Annectens-bimaris intergrade? ⊖

THE GOPHER SNAKES OF BAJA CALIFORNIA, WITH DESCRIPTIONS OF NEW SUBSPECIES OF PITUOPHIS CATENIFER

BY

LAURENCE M. KLAUBER

Curator of Reptiles and Amphibians, San Diego Society of Natural History

INTRODUCTION

There have been lately added to the collection of the San Diego Society of Natural History, and to my own, specimens of gopher snakes of the genus *Pituophis* from various localities in Baja California, Mexico. Some of these are from areas of importance in determining relationships, and it therefore has seemed desirable to resurvey the snakes of the peninsula. Through the courtesy of a number of institutions I have had the privilege of examining their collections from Baja California. As a result, I find four new subspecies to be distinguishable, one mainland and three island. These I shall describe, following which the previously known forms, as newly delimited, will be summarized. These determinations have been facilitated by recently acquired material from the southwestern United States not available to those who have previously made revisions of the genus (Van Denburgh and Slevin, 1919; Van Denburgh, 1920; Miss Stull, 1932, 1940). I expect to discuss the classification of some of the forms not occurring in Baja California in a subsequent paper.

SUMMARY OF RELATIONSHIPS

Before undertaking the descriptions of the new forms, it is necessary to summarize my reasons for considering all of them, and in fact all the gopher or bull snakes of the region west of the Mississippi River (except *ruthveni*), to be subspecies of a single form, *Pituophis catenifer*. I find an unbroken chain of intergradation connecting them all, either evident or strongly indicated.

First, the subspecies *catenifer catenifer* intergrades with *annectens* north of Santa Barbara, California. These two subspecies are not sharply differentiated and therefore the zone of intergradation is broad.

Catenifer intergrades with *deserticola* in the western Mojave Desert at the foot of the Tehachapi Mountains, and in the Lassen and the Klamath areas. Similarly, *annectens* intergrades with *deserticola* where the San Gabriel and San Bernardino ranges descend into the Mojave Desert.

Deserticola, in turn, intergrades with *affinis* along the northern border of Riverside County, California, and across the Grand and Marble canyons, and to the south of Kayenta, in northern Arizona. *Affinis* and *sayi* intergrade along a broad contact from central New Mexico south across western Texas into Chihuahua and Coahuila. *Deserticola* may intergrade directly with *sayi* at the headwaters of the Green River in western Wyoming, but I have no final proof of this.

Annectens and *affinis* may contact or overlap in eastern San Diego County, California; there is no evidence here of intergradation, although fairly good series of both forms are available from closely contiguous points, which, in this area, involve a steep ecological gradient. Two peculiar specimens from the Sierra Juárez in Baja California suggest the possibility of *annectens-affinis* intergradation in the mountain passes there. In any case, the *annectens-affinis* interconnection is complete through *deserticola*.

Summarizing, in the United States we have the unbroken chain, *annectens-catenifer-deserticola-affinis-sayi*, together with the short circuit, *annectens-deserticola*, and possibly *deserticola-sayi*. In Baja California the connection *annectens-affinis* is suggested but not proven.

The weakest strand in the web is that connecting *vertebralis* with the rest. *Vertebralis*, through the new mid-peninsular subspecies *bimaris*, with which it undoubtedly intergrades, overlaps *annectens*, based on USNM 37536, a specimen of *bimaris* from Alamo (Lat. 31°30′ N.) on the coastal side of the Sierra Juárez. This specimen was collected by Nelson and Goldman and thus there is every reason to accept the accuracy of the locality data. Should further collecting in this vicinity substantiate this *bimaris-annectens* overlap, it will be a pertinent argument against considering *vertebralis* a subspecies of *catenifer*. However, there is another route by way of which there may be intergradation. Along the desert side of the mountains in northeastern Baja California, there is no specimen of *Pituophis* available from between El Mármol (Lat. 30° N.), where *bimaris* occurs, and the vicinity of El Mayor (Lat. 32° N.), where *affinis* has been collected. All of the intervening country is undoubtedly inhabited by *Pituophis*, but much of it is quite inaccessible, so that no specimens are available yet. *Bimaris* resembles *deserticola*—particularly specimens from the western Mojave Desert—in many ways. It appears to me that an intrusion of *affinis* into the Salton or Cahuilla Basin has broken a contact between them; but just as *deserticola* intergrades with *affinis* in Riverside County, so I think it probable that *bimaris* and *affinis* will be found to intergrade in the Gulf-coast desert between El Mármol and El Mayor, no doubt somewhere in the vicinity of San Felipe (Lat. 31° N.). Hence, partly because of this expected intergradation, and also by reason of the obvious resemblance between *deserticola* and *bimaris* (although territorially separated by the intrusion of *affinis*), I have considered *vertebralis* to be a subspecies of *catenifer*. If future collecting along the northeastern desert coast of Baja California should eventually show an overlap between *bimaris* and *affinis*, then the Cape form must be known as *vertebralis vertebralis*, with *bimaris* and *insulanus* as its subspecies.

As to the island forms *insulanus*, *fuliginatus*, and *coronalis*, so obvious are the relationships of the first to *bimaris*, and of the two latter to *annectens*, together with some overlapping in the distinguishing characters, that I think subspecific rather than specific segregation is to be preferred. This carries with it no suggestion of weakness with respect to the validity of the new forms.

Since I am considering all of the forms discussed to be subspecies of *Pituophis catenifer* (Blainville), 1835, I shall simplify the discussions by usually employing only the subspecific names, without repeating the generic and specific names or initials.

DESCRIPTIONS OF NEW FORMS

The first new form to be described is one which occupies the middle section of the peninsula. The snakes of this area have hitherto been considered to belong to the species *Pituophis vertebralis* (Blainville), whose revised status I shall touch on later.

Pituophis catenifer bimaris subsp. nov.

BAJA CALIFORNIA GOPHER SNAKE

1899. *Coluber catenifer*, var. *vertebralis* Mocquard, Nouv. Arch. Mus. Nat. Hist., ser. 4, vol 1, p. 320.
1900. *Pityophis vertebralis* (part) Cope, Rept. U. S. Nat. Mus. for 1898, p. 879.
1917. *Pituophis vertebralis* (part) Stejneger and Barbour, Checklist of N. A. Amph. and Rept., ed. 1, p. 86.

Type.—No. 32621 in the collection of LMK. Collected at Santa Gertrudis, near El Arco (Lat. 28° N.), Baja California, Mexico, by Robert S. Hoard, August 1939.

Diagnosis.—A subspecies closely allied to *vertebralis*, from which it differs in having black (sometimes blackish-brown) anterior body blotches, whereas in the Cape form the anterior dark blotches are red or red-brown. From *deserticola*, of the Great Basin and the Mojave Desert, *bimaris* may be segregated by its fewer body blotches. It more often has a dark subcaudal stripe than *deserticola*, and less often shows dark streaks in the anterior dorsal light areas or interspaces, these streaks being characteristic of most *deserticola*. *Affinis* has brown anterior blotches as compared to the black of *bimaris*. The narrow and raised rostral in *sayi* is quite distinct from the broader and flatter scale in the Baja California form. *Bimaris* has fewer blotches than *insulanus*, *annectens*, *catenifer*, *coronalis*, or *fuliginatus*.

Description of the Type.—An adult male with a length over-all of 1728 mm., and tail length of 231 mm., ratio .134. The body is of normal *Pituophis* form, the head wedge-shaped when viewed from above, and moderately distinct from the neck. The scale rows are 31–31–22, the ventrals number 243, and the subcaudals 65, all divided. The anal is entire. The central dorsal scale rows are strongly keeled; the ridges become fainter on the sides and the 5 lower lateral rows are smooth. The two lowest are considerably enlarged. There are paired apical scale pits.

The rostral is triangular and is somewhat wider than high. It is slightly raised above the surrounding scales, and, viewed from above, is moderately convex. It contacts the first supralabials, prenasals, and internasals, indenting the latter for about half their depths. There are four prefrontals, the inner long and slim; they are widest anteriorly. The outer prefrontals curve down over the canthus to contact the loreals. The frontal is widest anteriorly. The parietals are fused into a single wrinkled and irregular scale.

The nasals are subequal. The loreal is small, longer than high, and pointed posteriorly. There are two preoculars, the upper much the larger. There are three postoculars, the middle somewhat larger than the other two. The temporals are not in regular rows and are of uneven size; they are 3+3, 3+3. The supralabials number 8–8, the next to the last being the largest, and the fourth touching the eye. The infralabials number 13–12, the seventh being much the largest. The mental is small and triangular; it is followed by the first infralabials, which are in contact medianly. There are two long anterior genials, followed by a shorter, somewhat divergent pair separated by two rows of gulars.

The head is brown above, almost without marks. Below it is immaculate cream-color.

The dorsum is marked with 40 dark blotches, and the tail with 10. The anterior blotches are jet-black. Beginning at the eighth the blotches turn brownish until at mid-body they are reddish-brown, the posterior tips of the scales being darker. Then again the blotches turn darker; about thirteen anterior to the vent they are jet-black and remain so to the tip of the tail.

Anteriorly, the blotches are highly irregular and confluent. They are somewhat longer than wide. On each side there is an alternating series of long, thin black blotches which form lateral boundaries of the interspaces, and almost surround them. Below are two other series, the lower and smaller engaging the edges of the ventrals, which are otherwise clear. The anterior light interspaces are not streaked with dark.

Posteriorly, the main dorsal blotches become somewhat shorter and more regular. On the tail they are oval in shape, and are about equal to the interspaces. Here there is a single row of secondary blotches on either side. Midventrally on the tail there is a longitudinal dark streak with serrated edges.

The body surface between blotches is cream-colored to white, as is also the ventrum. However, it is probable that there was once considerable orange-color dorsally and anteriorly between blotches.

Paratypes.—Sixteen paratypes are available, the localities being listed from south to north as follows: LMK 2934-5 El Refugio (northeast of Magdalena Bay); USNM 15157 Ballenas Bay: LMK 32523 18 miles north of Punta

Prieta (Lat. 27° N.); LMK 3813, SDSNH 11553, MVZ 10673-4, MZUM 76462 San Ignacio; LMK 31032 Thurtoe Bay (1 mile south of Turtle Bay, on the west coast); SDSNH 17562-3 Rancho Las Flores (12 miles east of El Arco); LMK 1129, LMK 1181, CAS 62957 El Mármol (= Onyx Mine, Lat. 30° N.); USNM 37536 Alamo (= El Alamo, Lat. 31½° N.). In addition, two island specimens are at hand, USNM 37537 from Santa Margarita, and CAS 59390 from Magdalena, which are tentatively assigned to this subspecies; however, they are not included in the statistics which follow, although the type is.

The scale rows at mid-body vary from 31 to 35, being 33 in half the specimens, and less often 35 in the remainder than 31. The ventrals in the males (13) range from 238 to 249, mean 243.5; and in the females (4) from 253 to 257, mean 255.5.* The subcaudals in the males range from 63 to 72, mean 67.0, and in the females from 56 to 63, mean 58.8. The supralabials are usually 9, sometimes 8, and rarely 10; they average slightly under *vertebralis*, which has a mean of 9, the highest in the genus. The infralabials in *bimaris* range from 11 to 14, being most often 13. The preoculars always number 2; and the postoculars usually 3, but occasionally 4 and in one case 5. One labial contacts the eye in every specimen. The first temporals vary from 3 to 6 and the second from 3 to 5; they are highly irregular in arrangement. The scales on top of the head are rather constant for *Pituophis*. An azygos, which I should define as a central scale at the junction of the frontal and prefrontals, is not present in any specimen. There are four prefrontals in all specimens but one, in which each outer scute is fused to an inner.

Although the longest specimen I have seen measured about 1800 mm., I am told that this snake grows to a larger size, especially in the vicinity of San Ignacio. The ratio of the tail length to length over-all averages about .140 in adult males, and .127 in adult females.

The body blotches vary from 34 to 46, mean 40.8; and the tail spots from 8 to 13, mean 11.3. These numbers are lower than in almost any other subspecies.

The pattern of *bimaris* is characterized by the presence of jet-black blotches both anteriorly and posteriorly. Between, the northerly specimens may be black throughout, but more often the blotches at mid-body are brown, streaked wtih dark-brown or even with black. Toward the south, as the range of *vertebralis* is approached, the number of the anterior black blotches decreases, there being a greater expanse of brown, or even red blotches, in the mid-section.

The secondary side-blotches are usually confluent with the main series anteriorly, thus isolating the first few interspaces into light spots within a solid black band, in a manner characteristic of *deserticola;* however, these light spots are not streaked with dark, as is so marked in most *deserticola*, although sometimes lacking in specimens from the western Mojave. In general, the streaking, both dorsally and laterally, is less evident in *bimaris* than *deserticola*.

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* In comparing these figures with those given by Miss Stull for *vertebralis* (1940, Table 9, p. 92), it should be noted that all specimens in her table are of the sex opposite to that listed.

Ventrally *bimaris* is unmarked cream-color or white, except that the outer edges of the scutes are frequently blotched by the lowest row of lateral dark spots. All but four specimens have a dark caudal mid-ventral line, particularly evident posteriorly, but this is not so uniform as in *vertebralis.*

The ground color is cream or white, and is clearer and brighter than in any other subspecies except *vertebralis* and the most southwesterly *deserticola.* The dorsal interspaces and the head in *bimaris* are usually orange or red, particularly in the southerly specimens, but this color virtually disappears in preservation.

Except for a dark subocular vertical line, the head of *bimaris* is usually unmarked. Sometimes the dark labial sutures so characteristic of most *Pituophis* are present; a few inconspicuous marks are occasionally seen on the frontal and parietals, but they are not strongly evident as in *insulanus.*

The two specimens from Santa Margarita and Magdalena islands do not seem to be peculiar in any way, except that the one from Santa Margarita has an unusually high ventral scale count; it is a female with 263 scutes compared with a record of 257 among the mainland specimens.

Range.—Bimaris occurs in the peninsula of Baja California from about Lat. 24° 20′ N. to Lat. 30° N., and from coast to coast. One record is known north of the latter line, this being Alamo, Lat. 31½° N. It is likewise found on Santa Margarita and Magdalena islands.

In addition to the localities given in listing the types and paratypes, the following have been cited in the literature: Arroyo de Santa Agueda, San Bartolomé Bay, and Comondú.

Remarks.—Bimaris certainly intergrades with *vertebralis* to the south, and the area of intergradation is probably fairly broad. Nevertheless, the geographical segregation is remarkably consistent for snakes as variable in pattern as these gopher snakes. If we take, as an arbitrary division, a line drawn across the south end of the peninsula at its narrowest point, where indented by the Bay of La Paz (about Lat. 24° 20′ N.), we have the following segregation:

	North of Bay of La Paz	*South of Bay of La Paz*
Anterior dark blotches black or dark-brown	21	2
Anterior dark blotches red or red-brown	1	33

In this table I have included the three specimens mentioned by Mocquard, 1899: without them none north of the line would have failed to key correctly. As it is, allowing for an intergrading area which may be more accurately delineated when additional material has been obtained, probably 90 per cent or more of the specimens will key out correctly.

The absence of specimens from critical areas renders the northerly contacts of *bimaris* much less certain. I think it likely that it will eventually be shown to intergrade with *affinis* somewhere along the desert (Gulf of California) coast northward between El Mármol and the delta of the Colorado River, where *affinis* is known to occur. The intervening territory is well suited to either of these desert subspecies. The single specimen from Alamo remains somewhat of an anomaly.

Intergradation with the coastal-mountain *annectens* seems very doubtful, not only because of the presence of the undiluted Alamo specimen in *annectens* territory, but because of the lack of *bimaris* tendencies in the most southerly *annectens*. The distance separating this *annectens* (collected at the mouth of the Rosario River) from the nearest *bimaris* at El Mármol is some sixty miles. El Mármol is almost due east of Rosario and lies on the opposite side of the rolling hills at the south end of the Sierra San Miguel. If intergradation occurs, the modification must be quite abrupt.

That *insulanus* of Cedros Island is an off-shoot of *bimaris* is suggested by a number of characteristic features of pattern. Nevertheless the differences, which will be discussed in connection with the description of the island subspecies, have now become consistent enough to warrant a subspecific segregation. There is no overlap in number of body blotches, although a slight overlap may be found when larger series of both forms become available.

Pituophis catenifer insulanus subsp. nov.

CEDROS ISLAND GOPHER SNAKE

Plate 1, fig. 1.

1926. *Pituophis catenifer annectens* (part) Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 15, no. 3, p. 206.

1932. *Pituophis vertebralis* (part) Stull, Occ. Papers Mus. Zoöl., Univ. Mich., no. 250, p. 3.

Type.—No. 56353 in the collection of the California Academy of Sciences. Collected on Cedros (Cerros) Island off the west coast of Baja California, Mexico, by J. R. Slevin, August 7, 1922.

Diagnosis.—A subspecies nearest to *P. c. bimaris*, from which it differs in having more than 50 body blotches while *bimaris* has less than this number. From *vertebralis* and *affinis* it may be segregated by its black anterior blotches, while they have brown or red. *Insulanus* has a shorter tail and fewer dorsal blotches than *annectens*; is darker than *catenifer*, and has more ventral scales; lacks the subocular scales of *coronalis;* and is without the paired subcaudal dark stripes of *fuliginatus*. It differs from *deserticola* in pattern, and from *sayi* in having a flatter and less protruding rostral.

Description of the Type.—A female with a length over-all of 1210 mm., and tail length of 151 mm., ratio .125. The body is of normal *Pituophis* shape, the head wedge-shaped when viewed from above, and moderately distinct from the neck. The snout is neither as sharp as in *affinis* nor as blunt as in *annectens*. The scale rows are 32–33–23, the ventrals number 247, and the subcaudals 58, all divided. The anal is entire. The central dorsal scale rows are keeled, but the 9 lower lateral rows are smooth. The lowest row is somewhat enlarged. Paired apical scale pits are present and in some scale rows are accentuated by dark dots.

The rostral is triangular and is wider than high. It contacts the first supralabials, prenasals, and internasals. It indents the latter for about half their depths. There are four prefrontals, the inner long and slim; they are widest anteriorly. The outer curve down over the canthus to contact the loreals. The frontal is widest anteriorly. The parietals are wrinkled and irregular, and are separated by a crooked suture. Each supraocular is partly sutured posteriorly, this being characteristic of this subspecies.

The nasals are subequal. The loreal is pointed posteriorly; there is a small subloreal on the right. There are two preoculars, the upper much the larger. There are three postoculars, the middle somewhat larger than the other two. The temporals are not in regular rows; they are 3+5, 5+5. The supralabials number 8–9, the next to the last being the largest; the fourth touches the eye on the right and the fifth on the left. The infralabials number 13–13, the seventh being the largest. The mental is small and triangular; it is followed by the first infralabials which are in contact medianly. There are two long pregenials, followed by a shorter pair, separated by two rows of gulars.

The head is tan above (it was red in life), heavily mottled with black from the frontal posteriorly. There is a faint vertical dark mark below the eye and a few spots remain of a postocular dark stripe. The chin is immaculate cream.

The dorsum is marked with 57 dark blotches, and the tail with 12. The anterior blotches are jet-black; they are confluent laterally, thus accentuating the interspaces as small buff spots on a black background. At the third or fourth dark blotch back of the head a few lighter streaks become evident at the scale centers. These gradually increase in size and number until, at mid-body practically all the scales in the dark blotches are gray, only a few scale edges remaining black. The interspaces, however, remain cream and virtually clear, except that some of the scales toward the sides have dark central streaks. Then posteriorly there is again an increase in dark pigment; the grayish scales are increasingly edged with black until, some 10 blotches anterior to the vent, they are solid-black and continue so to the tip of the tail. On the sides there are subsidiary alternating blotches. These begin as black streaks on the neck, but at mid-body become an irregular mixture of scales with black central streaks and others punctated with gray. These side marks are confluent with the main dorsal series so that throughout there is more regularity in the light dorsal interspaces, which are essentially a series of light blotches, than in the dark blotches. Posteriorly the lateral auxiliary blotches become more regular; they are black and it can be seen that there are four series on each side, the lowest engaging the outer edges of the ventral scutes. These ventral marks, on an otherwise clear cream background, are darkest posteriorly. The underside of the tail is much mottled, with a mid-ventral dark line posteriorly.

Paratypes.—Six paratypes, all from Cedros Island, are available: USNM 14088 and 54764; MCZ 19732-4; and CAS 59568.

The following statistics will serve to summarize the subspecies. The type has been included in these data. There are three of each sex available and one, a skin, which is indeterminate.

The scale rows at mid-body are usually 33, occasionally 31. The ventrals in the males are all 240, and in the females 247 or 248. The subcaudals in the males range from 58 to 65, mean 62.3; and in the females from 57 to 59, mean 58. The supralabials are usually 9, occasionally 8, and rarely 10. The infralabials are generally 12 or 13, but sometimes 14. The rostral is wider than high, with the upper lateral edges somewhat concave. The snout is blunt and the rostral is not raised above the adjacent scales. The indentation of the internasals is usually to about half their depths, but may be less. The loreal is wider than high and pointed posteriorly; in half the counts there is a second smaller loreal in the upper angle between two supralabials (the second and third, or third and fourth) in a manner characteristic of many specimens of *deserticola*. There are usually 2 preoculars, but sometimes 1 or 3. The postoculars are most often 3 but may number 4 or 5. The temporals are 3 to 5 in the first row, and 4 or 5 in the second; they are too irregular in size and arrangement to be of any interest diagnostically. An upper labial (the fourth or fifth) contacts the eye in every specimen. The scales on top of the head are rather constant. Every specimen has 4 prefrontals; none has an azygos. The greatest irregularities are in the supraoculars, which are likely to have partial or complete posterior diagonal sutures, although this is not true of every specimen. The parietals are wrinkled and uneven, with no well-defined sutures separating them from the succeeding head scales.

This snake grows to a length of at least 1400 millimeters. The adult tail proportionalities (to length over-all) are about .143 in the males and .129 in the females.

The body blotches vary from 52 to 64, mean 55.3; and the dorsal tail spots from 11 to 17, mean 13.6.

The pattern of *insulanus* comprises a series of irregular dorsal blotches which are black anteriorly and posteriorly, but gray (rarely brown) at mid-body. The change from black to the lighter color is produced by the gradual lightening of scale centers. At mid-body the posterior ends of the scales tend to be darker. On the sides there are auxiliary alternating blotches which are often confluent with the dorsal series and with each other; they are highly irregular and there is extensive dark streaking within and between them, thus producing a much more mottled appearance than is evident in *bimaris* or the more southerly *deserticola*. Anteriorly the first side-blotches are joined to the main series so that the light interspaces are themselves isolated into a series of light blotches in the manner characteristic of *bimaris* and *deserticola*. The edges of these blotches are rather irregular in *insulanus*, and they are less marked by dark streaks on the scale keels than is usual in *deserticola*. Toward the tail the dorsal blotches are more regular and well-defined.

Judging from the type, which I saw alive through the courtesy of Mr.

J. R. Slevin, these snakes are brilliantly marked with red anteriorly, between the black blotches, but this color is lost in preservation, becoming yellow or cream. The outer edges of the ventrals are blotched with black or gray by the lowest series of lateral body spots. The tail is much mottled with black on the underside, and posteriorly there is sometimes a black line like that which characterizes *bimaris* and *vertebralis*.

The head, which is probably red in life, is spotted above with a large number of conspicuous round or oval black spots, which are especially evident on the frontal, supraoculars, and parietals. These marks are characteristic of this subspecies and are present in all well-preserved specimens. The postocular dark dash and the dark lines which mark the labial sutures in most forms of *Pituophis* are absent or only faintly evident in *insulanus;* their absence is in peculiar contrast to the unusual and accentuated spotting on top of the head. Below, the head is unicolor cream.

Range.—Insulanus is found only on Cedros Island, off the Pacific Coast of Baja California, Mexico.

Remarks.—Insulanus is most closely related to the nearest mainland form, *bimaris*, through which, in turn, it is allied to *vertebralis* and to *deserticola*, rather than to either *annectens* or *affinis*. This is evident from the tail proportionality and various characteristics of pattern, yet it is more mottled than either. In almost all cases the black spots in the frontal area serve as a key character that will readily segregate *insulanus*. There is no overlapping in number of body blotches between *insulanus* and *bimaris*, for the former has from 52 to 64 with an average of 55.3, while the latter ranges from 34 to 46 with an average of 40.8. Even when much larger series have become available, it may be expected that only rarely will a specimen of one form fall within the limits of the other. *Insulanus* does overlap *deserticola* in blotch counts, yet it is readily distinguishable by the lack of regularity of its anterior blotches, the lack of dark streaks in the interspaces (which may, however, be absent in some Mojave specimens of *deserticola*), and the absence of postocular and subocular dark vertical lines or streaks.

Pituophis catenifer fuliginatus subsp. nov.

SAN MARTÍN ISLAND GOPHER SNAKE

1877. *Pityophis sayi bellona* Streets, Bull. U. S. Nat. Mus., no. 7, p. 40.

1895. *Pituophis catenifer deserticola* Van Denburgh, Proc. Cal. Acad. Sci., ser. 2, vol. 5, p. 149.

1905. *Pituophis catenifer* (part) Van Denburgh, Proc. Cal. Acad. Sci., ser. 3, vol. 4, no. 1, p. 21.

1919. *Pituophis catenifer annectens* (part) Van Denburgh and Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 9, no. 6, p. 216.

Type.—No. 17449 in the collection of the San Diego Society of Natural History. Collected on San Martín Island, off the west coast of Baja California, Mexico, by Lewis W. Walker, July 11, 1939.

Diagnosis.—A subspecies closely allied to *P. c. annectens* of the adjacent mainland, from which it differs in having a darker pattern, much black spotting on the head, a lower average number of body blotches, usually single instead of two preoculars, a high frequency of aberrant prefrontals, and in the possession of paired, dark, longitudinal streaks on the ventral surface of the tail, the latter being rarely and less perfectly present in *annectens*, wherein these streaks, if present, comprise series of separate, dark triangles. The same differences of blotch counts, pattern, and tail length which segregate *annectens* from the other subspecies of the genus will apply as well to *fuliginatus*, except that the latter is nearer *catenifer* in blotch counts.

Description of the Type—A young adult female. Length over-all 960 mm.; length of tail 153 mm.; ratio of tail to length over-all .159. The body is of normal *Pituophis* proportions. The head is moderately distinct from the neck, and is wedge-shaped, but blunt anteriorly, when viewed from above. The scale rows are 31-35-25. The dorsal rows are much smaller than the lateral and are strongly keeled; about 8 lateral rows on either side are smooth. There are paired apical scale pits, which are moderately evident posteriorly.

There are 245 ventrals, and 72 paired subcaudals. The anal is entire.

The rostral is large, recurved, deeply indented below, and contacts the first supralabials, the prenasals, and the internasals. It is wider than high and is not raised above the adjacent scales. The internasals are narrowly in contact on the median line and diverge posteriorly. There are four prefrontals, with an azygos at the point where they contact the frontal. The outer prefrontals diverge anteriorly and curve downward over the canthus, where they touch the loreals, postnasals, and, narrowly, the internasals. The frontal is widest anteriorly and only slightly indents the parietals. The supraoculars are narrow anteriorly and touch the outer prefrontals at a point. The parietals are short and posteriorly irregular.

The nasals are subequal and are narrowest at the nasal suture. The loreals are longer than high and are pointed posteriorly where they abut the preoculars. There is a small extra loreal below on the right. There are two preoculars on either side (not characteristic of this subspecies), the upper large, the lower very small. There are four subequal postoculars on either side. The temporals are highly irregular in size and arrangement; they are 4+4, 4+5. There are 8 supralabials on the right and 9 on the left, the next to the last being the largest, followed by the next anterior. The fourth touches the eye on the right and the fifth on the left. The lower labials are 13-13, the seventh being the largest. The mental is small and triangular. It is followed by the first infralabials, which are in contact medianly; then a pair of long genials medianly in contact, and a second shorter pair separated by two rows of gulars.

The head is brown above. heavily mottled with black, especially posterior to the central prefrontals. On the sides it is buff, with a wide black streak from the eye to the angle of the mouth, a wide vertical line below the eye, and narrower black lines following the sutures between the lower labials. The ground color of the sides of the head is buff to gray. The lower surface is cream-color. All of these colors refer to the specimen as preserved in alcohol.

The dorsum is marked by a series of square black blotches about 7 scale-rows wide and 3½ scales long (end to end). The interspaces are buff and about ½ scale wide anteriorly, becoming brown and one scale wide posteriorly. There are about 70 blotches in the central series. Alternating with the main series there is a somewhat smaller series on either side, and these in turn are followed by two others, each smaller than that above, and therefore with wider interspaces. In general effect the light elements of the pattern form a net. Laterally the scales in the interspaces are centrally streaked or punctated with gray. The lateral blotches and interspaces are rather irregular. The ventral scales are yellowish-buff, and are blotched and stippled with dark gray, especially posteriorly. On the tail there are 19 squarish blotches above, with an alternating secondary series on either side. The interspaces are buff above and stippled-gray on the sides. The lower surface of the tail has a pair of dark-brown (almost black) streaks with an even, light stripe between. The outer edges of the dark streaks are serrated, since each subcaudal is marked with a spot which is widest posteriorly. Each spot contacts its posterior fellow, hence the dark streaks are continuous, although somewhat irregular posteriorly.

Paratypes.—Fourteen paratypes, all from San Martín Island, are available: SDSNH 17463-4; USNM 8565 and 24395; MVZ 9703-6; LA 633; and CAS 8678, 43588-9, and 59678-9.

The following summary is based on the type and paratypes: The scale rows at mid-body, while most often 33, may be 31 or 35. The ventrals in the males (10) vary from 224 to 234 with an average of 229.7; and in the females (5) from 236 to 245, average 242.2. This is a greater sexual difference than is to be expected when more specimens become available so that the probable population means may be more accurately known. The subcaudals in the males vary from 73 to 82, with an average of 76.5; in the females 67 to 72, average 70.3. The supralabials are 8 or 9, with the latter slightly predominating. Every specimen has at least one supralabial (the fourth or fifth) in contact with the eye, thus differing from *coronalis*; in 7 cases out of 30 two labials contact the eye, showing a resemblance in this character to *deppei* and *lineaticollis* of southern Mexico and Central America. The infralabials are most often 13, but may be 12, or, less frequently, 14. The rostral is pentagonal in shape and is wider than high. It usually indents the internasals for about half their depths, but may completely separate them. The loreal is longer than high, with a posterior point indenting the upper preocular. In several specimens subloreals are present, and in one the main loreal is divided vertically. *Fuliginatus* usually has a single preocular (23 out of 30 counts), a condition reversing that found in the peninsula specimens of *annectens*, in which a single preocular was noted in only 26 counts out of 102, the majority having 2. This difference in proportions is, of course, significant. The postoculars generally number 4, but sometimes 3 or 5. Azygos scales are present in 6 specimens out of 15, a higher proportion than in any other western *Pituophis;* and, in general, this subspecies is notable for the irregularity of the plates in the prefrontal area. Only 3 specimens out of 15 have the arrangement which is characteristic of most mainland snakes—that is, 4 regular prefrontals. In these island snakes there seems to be no standard, each individual differing in some degree from its fellows. Thus there are central prefrontals fused to each other, or to either or both outer prefrontals, in a variety of ways. Several specimens have a diamond-shaped central prefrontal, surrounded by internasals and outer prefrontals. These anomalies occasionally include the frontal. The parietals are also highly irregular but this is not so unusual in *Pituophis.* The supraoculars are not sutured as in *insulanus.*

This snake grows to a length of at least 1400 mm. The smallest specimen measured 327 mm. The adult tail proportions, in relation to length over-all, average .175 in the males and .157 in the females, thus showing an affinity to *annectens* rather than *bimaris.*

The body blotches vary from 55 to 70, mean 62.6, and the tail spots from 14 to 22, mean 19.1. The blotches are significantly fewer than in mainland *annectens* but there is too much overlap to afford a useful key character.

The dorsal pattern of *fuliginatus* comprises a series of central blotches which are black anteriorly and at the tail, and may be either black, brown, or red-brown at mid-body. Anteriorly the main dorsal series is not regular in form, or well separated from the first lateral series on either side; the interspaces are narrow, much streaked with dark pigment, and comprise an irregular, light net-work. Posteriorly the blotches tend to become better separated and more uniform. The interspaces are cream anteriorly, and buff or brown toward the tail. There are about 6 auxiliary series of blotches on either side, the lowest engaging the ventrals. Anteriorly some of the light areas between these series tend to form light longitudinal lines, but these are not always present. Posteriorly the sides, between blotches, are suffused with gray or brown. The ventral surface is yellowish, much mottled or blotched with black or gray. On the underside of the tail is the most characteristic feature of the pattern of this snake—a mid-ventral, even-edged light stripe, bordered on either side by a black or dark-brown stripe. While interruptions in these stripes are not rare, they are quite regular in 12 specimens out of 15. One of the others has lost its tail so that no determination can be made; in a second the stripes are highly irregular, and in the last quite imperfect.

It is to be understood that paired dark stripes are occasionally met with in *annectens, deserticola,* and in *catenifer* as well, but when present they usually comprise rows of dark triangles, the upper points of which barely touch their fellows on the next scale. In *fuliginatus* the dark mark on each scale contacts its neighbor rather broadly, although the mark usually widens posteriorly, thus causing the outer edges of the dark streaks to be serrated. Occasionally specimens of *catenifer* or *deserticola* will be found, particularly in central Washington, Oregon, and northeastern California, in which the subcaudal tail stripes are as perfect as in *fuliginatus.* While this complicates the preparation of a key, it does not invalidate *fuliginatus*, which differs from the northwestern snakes in other characteristics of scale counts and tail proportionality.

The excess of black pigment in *fuliginatus*, which results in the body being darker than in most *annectens*, also affects the head marks. The usual dark marks in western *Pituophis*—a line across the prefrontals, a stripe from the eye to the angle of the mouth, a vertical subocular streak or triangle, and dark marks in both the upper and lower labial sutures, are all present. In addition the frontal, supraoculars, and parietals are much mottled with black. In *annectens* such marks in the fronto-parietal area, if present, are generally brown. The ground color of the head of *fuliginatus* is brown above and buff below. The lower jaw is unmarked except for the dark lines between infralabials.

Range.—Fuliginatus occurs only on San Martín Island, off the Pacific Coast of Baja California, at Lat. 30°29′ N.

Remarks.—San Martín is a small volcanic island only a mile in diameter, and but 2½ miles from the coast. The nearest point on the mainland is the cape along the west side of San Quintín Bay.

Notwithstanding the proximity of the island to the mainland, the animal population must have been long isolated. All of the four reptiles thus far collected there show differences from the forms of the adjacent mainland. First there is *Uta martinensis*, which belongs to the *stansburiana* group and has been considered a valid species for forty years. Then there is an alligator lizard, *Gerrhonotus multicarinatus*, which Van Denburgh described as a new subspecies, *ignavus*, in 1905. Although this is not currently recognized, Fitch (1938, p. 399) states that its validity may well be demonstrated by additional material. One specimen of a ring-necked snake, *Diadophis amabilis similis*, has been collected on the island. Blanchard (1942, p. 46) has pointed out that this differs in certain particulars from the mainland form, and more specimens may justify segregation. Thus it might be expected that the gopher snakes also, of which an adequate series is available, would show differences warranting nomenclatorial distinction.

As would be anticipated, *fuliginatus* most closely resembles *annectens* of the adjacent mainland. It is not greatly different in pattern, although more completely pigmented with black, and generally darker, conditions probably not unrelated to the color of the lava on which it lives. It has somewhat fewer blotches on body and tail.

The tail-length proportionality in *fuliginatus* further verifies its close relationship with *annectens*; in fact, it may have the greater ratio of the two, although it would take more material to prove this. In any case, it differs, in this important character, from the shorter-tailed forms, *deserticola*, *affinis*, *bimaris*, *insulanus*, and *vertebralis*.

As to scalation, *fuliginatus* has 9 (instead of 8) supralabials somewhat oftener than *annectens*, has a higher percentage of single preoculars, and more often has fused and otherwise irregular prefrontals with azygos scales present.

With respect to the frequency of having 2 labials in contact with the eye, the proportion in *fuliginatus* was 7 out of 30 counts, or 23.6 per cent. In 94 counts on specimens of *annectens* from northwestern Baja California, there were 5, or 5.3 per cent with 2 labials in contact, and, in 174 counts on San Diego County specimens, 2.9 per cent.

Because of overlapping, none of these characters is as useful in a key as the parallel dark strikes under the tail. As these stripes are occasionally imperfect in *fuliginatus*, and sometimes appear (although seldom as continuous lines) in *annectens*, *catenifer*, and *deserticola*, I deem only a subspecific distinction to be warranted for the newly described form.

Laurence M. Huey tells me that the gopher snakes are quite common on the island, although they are not easy to catch, since they readily escape into the lava crevices. No doubt they feed on the two mammals found there, an endemic wood rat, *Neotoma martinensis*, and a white-footed mouse, *Peromyscus maniculatus exiguus*. J. R. Slevin found one eating a young bird.

Pituophis catenifer coronalis subsp. nov.

CORONADO ISLAND GOPHER SNAKE

1914. *Pituophis catenifer* Van Denburgh and Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 4, no. 5, p. 141.

1919. *Pituophis catenifer annectens* (part) Van Denburgh and Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 9, no. 6, p. 216.

Type.—No. 20229 in the collection of LMK. Collected on South Coronado Island, Mexico, by Philip M. Klauber, June 11, 1933.

Diagnosis.—A subspecies closely allied to the mainland *P. c. annectens*, from which it differs in usually having suboculars interposed between the supralabials and the eye, and in the frequent abnormalities of the head scales. There are some differences in pattern; among others the island form has fewer blotches, but the overlap would prevent this being employed as a key character. The presence of suboculars will distinguish *coronalis* from other *catenifer* subspecies. In some areas suboculars occur with considerable frequency in *deserticola*, but this subspecies has fewer subcaudals and body blotches than *coronalis*, and differs in other ways.

Description of the Type.—A female with a length over-all of 1150 mm., and tail length of 171 mm., ratio .149. The body is of normal *Pituophis* shape, the head rather blunt when viewed from above, and moderately distinct from the neck. The scale rows are 33–33–23, the ventrals number 232, and the subcaudals 71, all divided. The anal is entire. The central dorsal scale rows are keeled, but the 10 lower lateral rows on each side are smooth. The three lowest are considerably enlarged. Apical scale pits seem to be virtually absent, although a few pairs may be discerned.

The rostral is triangular and is wider than high. Viewed from above it is slightly convex; it is not raised above the other scales. It contacts the first supralabials, prenasals, and internasals, and deeply indents the latter. There are four prefrontals, the inner triangular, and the outer small, with their anterior halves split off to form an extra outer prefrontal on either side. The frontal is widest anteriorly, the supraoculars posteriorly. The parietals are wrinkled and irregular.

The nasals are subequal. The loreal is small and pointed posteriorly. There are two preoculars, the upper much the larger. There are four postoculars, of which the two lower are the smaller. The two lower are really to be considered suboculars, since they completely prevent any contact between the upper labials and the eye, a condition rare in *Pituophis*. The temporals are not in regular rows; they are 4+4, 4+4. The supralabials number 10–9, the next to the last being the largest. The infralabials number 13–14, the seventh being much the largest. The mental is small and triangular; it is followed by the first infralabials which are in contact medianly. There are two long anterior genials, followed by a shorter pair which are separated by two or three rows of gulars.

The head is light-brown above, with an irregular dark spot on the parietals. There is a dark streak in the suture below each eye, and the penultimate supralabial is marked posteriorly. Some of the sutures between the lower labials are darkened, otherwise the lower surface of the head is immaculate cream.

The dorsum is marked with about 64 dark blotches, and the tail with 20. They are highly irregular and often confluent anteriorly, so that opinions might differ as to the number. The anterior blotches are black; at mid-body they are brown, speckled with dark-brown. Posteriorly they are darkened, again becoming black on the tail. In the posterior part of the body they are square, well separated, and are about equal to the interspaces. The ground color is grayish-buff, laterally suffused wtih brown, but becoming lighter posteriorly.

The ventrum is buff, the posterior edge of each scute being somewhat darkened. There is no distinctive pattern on the underside of the tail.

Paratypes.—There are three paratypes, SDSNH 11365 and CAS 13588-9. The latter are from South Coronado Island as is the type, but the locality of No. 11365 is given merely as "Coronado Islands." I have no record of gopher snakes having been taken on any of this group but South Island; however, there may be some significance in the fact that this is the only specimen of the four in which the labials contact the eyes.

The following statistics summarize this rather inadequate series, in which I have included the type. There are three females and one male.

The scale rows at mid-body vary from 31 to 35. The male has 222 ventrals, the females 229 to 233. The subcaudals number 82 in the male, 69 to 71 in the females. The supralabials vary from 7 to 10, and the infralabials from 11 to 14. Both series of labials are characterized by occasional fusions of adjacent members into scales of abnormal length. The rostral is wider than high and is not raised. The loreal is longer than high and is single in all cases. There are usually 2 but, in one case, 3 preoculars; the postoculars number 3 to 5. As the labials contact the eye in only one specimen out of four, and then narrowly, the lower of these postoculars are, in fact, suboculars. The temporals vary from 3+4 to 4+5. The prefrontals are quite irregular; in no specimen are there 4 in what is the normal arrangement for *annectens.* Usually the posterior ends of what would ordinarily be the outer prefrontals are fused to the inner, while the outer ends, separated by sutures, might be considered supraloreals. In the single specimen wherein the labials contact the eye, the contact is quite narrow, just the opposite of the condition in the other *annectens* island relative, *fuliginatus,* in which it is particularly wide. No specimen has an azygos.

The longest available specimen is the type, 1150 mm., the shortest is 353 mm. We have too few specimens, only one an adult, to determine the tail proportionality; it is apparently similar to that of *annectens.*

The body blotches vary from 64 to 70 and the tail spots from 20 to 24. These are lower than average figures for *annectens.*

In pattern *coronalis* is much like *annectens,* except that the body blotches are narrower, more circular, and more widely separated, especially toward the tail; there is also less streaking between blotches and on the sides. The anterior and posterior blotches are black, those between brown; in this there is no difference from most *annectens.* The ground color is buff or yellowish, suffused with gray or brown punctations laterally. The ventrum is buff with scattered suffusions or blotches of gray or black. The tail of one specimen has an imperfect double row of triangles on the underside; the others are virtually unmarked.

The head is not conspicuously marked—less so than in most *annectens.* A subocular dark line is always present.

Range.—Coronalis is found only on South Coronado Island, off the northwest coast of Baja California, Mexico. One specimen is labeled only "Coronado Islands", and may have come from one of the others of the group. These Coronado Islands* are not to be confused with those in the Gulf of California, or with Coronado, a city on the broad section of the peninsula which forms the southwesterly outer boundary of San Diego Bay.

Remarks.—Coronalis is obviously derived from *annectens,* from which it has been isolated long enough to have acquired differences in pattern and head scales. The former, while useful when comparative material is available, will not serve as a key character, although it may be noted that the four specimens of *coronalis* available have an average of 67.3 body blotches, while *annectens* in northwestern Baja California has 75.5, and in San Diego County 76.8. More important are the irregularly fused head plates in the island form; and, above all, the lack of contact between labials and eye in three out of four specimens.

Out of 47 specimens of *annectens* from northwestern Baja California only two (both from San José) have suboculars preventing a contact of a labial with the eye, and in these this condition is found only on one side of the head. Thus the proportions are 6 out of 8 (75 per cent) on the island compared with 2 out of 94 (2.1 per cent) on the mainland. In 115 *annectens*

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* More properly Coronados Islands.

selected at random from a San Diego County series, 7 counts out of 230 (3.0 per cent) proved positive. Only two specimens out of the 115 had suboculars on both sides. In some areas a considerable proportion of *deserticola* specimens have suboculars. This does not invalidate *coronalis*, since they differ in other characters, but it does complicate the preparation of a key.

A juvenile specimen of *coronalis* had eaten two fledgling birds.

REDESCRIPTIONS OF OLD FORMS

Pituophis catenifer vertebralis (Blainville)

SAN LUCAN GOPHER SNAKE

Plate 1, fig. 2.

1835. *Coluber vertebralis* Blainville, Nouv. Ann. Mus. Hist. Nat., vol. 4, p. 293. Type locality "Californie", which included Baja California; type specimen in Paris Museum.

1854. *Pituophis vertebralis* Duméril and Bibron, Erp. Gen., vol. 7, p. 238.

1860. *Pityophis haematois* Cope, Proc. Acad. Nat. Sci. Phila., vol. 12, p. 342. Type locality Cape San Lucas; type specimens USNM 4682 (2).

1861. *Pityophis vertebralis* Cope, Proc. Acad. Nat. Sci. Phila., vol. 13, p. 300.

1884. *Pityophis catenifer vertebralis* Garman, Bull. Essex Inst., vol. 16, p. 27.

Diagnosis.—A subspecies characterized by a short tail, high ventral scale counts, anterior red or red-brown blotches changing to black posteriorly, and a black mid-ventral band under the tail. Its nearest relatives are *bimaris, insulanus*, and *deserticola* in that order. The first two may be segregated from *vertebralis* by their black anterior blotches; the third is also black anteriorly, although occasionally specimens from the western Mojave Desert have reddish or brown blotches in front. But these usually have dark streaks on the keels of the light scales in the anterior interspaces, as well as dark frontal and postocular streaks; also, they rarely have the dark subcaudal stripe characteristic of *vertebralis*.

Applicability of Name.—Blainville's original description (1835, p. 293), and his figures (pl. 27), would lead one to question seriously whether the type really represented the snakes from the Cape region of Baja California that have so long been designated by the name *vertebralis*. However, the redescriptions by Duméril and Bibron (1854, p. 238) and Bocourt (1888, p. 672), as well as the figure in Jan's Iconographie (1867, liv. 22, pl. 1), leave little doubt as to the applicability of the name, stressing as they do, such recognizable characters as the chainlike anterior pattern of light blotches, the black posterior blotches, and the subcaudal dark streak.

Material.—Of *vertebralis*, as now restricted by the segregation of *bimaris*, I have had available for study 33 specimens, as follows: LMK 3814, 20509-10, 20555, 20879, 20945, 21500, 21513, 23128, and ANSP 3791 Cape San Lucas; SDSNH 17660 10 mi. s. of Miraflores; USNM 12631 (2), 12644 La Paz, 37538 Cape San Lucas, 37539 San José del Cabo, 37540 Santa Anita, 64583 Miraflores; AMNH 5588-90 Miraflores; CAS 45874 San Pedro, 45875 San Antonio, 45876-7 San Bartolo, 45878 Agua Caliente; Stanford 4113 San José del Cabo; MVZ 11839-42 Todos Santos, 11843 Santa Anita, and 11844 Eureka. Counts are available on two other specimens, USNM 4682 (2) Cape San Lucas (the types of Cope's *haematois*). Of these specimens 21 are males, 14 females.

Description.—The following summary is based on the above material. The scale rows at mid-body usually number 33, sometimes 35 and rarely 31. Paired apical scale pits are evident. The ventrals in the males range from 238 to 251, mean 243.5; and in the females 246 to 257, mean 250.4. The anal is entire. The subcaudals vary in the males from 60 to 69, mean 65.0; and in the females from 57 to 63, mean 59.2. A few of the anterior scales are sometimes undivided. The supralabials are usually 9 but are occasionally 8 or 10; the average is almost exactly 9, the highest in the genus. The next to the last is the largest; the fifth touches the eye. The infralabials are most often 13, sometimes 12 or 14, rarely 11 or 15. Usually the seventh is the largest.

The rostral is wider than high, is only moderately convex when viewed from above, and is not raised above the surrounding scales. The apex of the rostral is rounded and indents the internasals to about half their depths. The loreal is wider than high and is posteriorly pointed, where it abuts the upper preocular. Rarely a small extra loreal may be noted above or below. The preoculars are 2, or rarely 1 or 3. The postoculars usually number 3, occasionally 4, and in one instance 5. The temporals are highly irregular in size and arrangement; they vary from 2+4 and 3+3 to 6+6. The scales on the top of the head are quite regular for *Pituophis*. No specimen has a true azygos (at the junction of the prefrontals and frontal), although in one specimen there is an extra scale between the internasals and the central prefrontals. Another has one outer prefrontal divided transversely. With these exceptions all specimens have 4 prefrontals. The supraoculars usually contact the outer prefrontals. The parietals are somewhat irregular, especially posteriorly; on the sides they are usually indented by a small scale back of each upper postocular.

The longest specimen I have seen measured about 1700 mm. The ratio of the tail to length over-all averages about .135 in the adult males and .123 in the females. Thus the tail is slightly shorter than in *bimaris* and closely approaches *affinis*; *vertebralis* is a much shorter-tailed snake than *annectens* or *catenifer*.

Vertebralis is the handsomest of the gopher or bull snakes, with the possible exception of *insulanus*. Preserved specimens give little idea of the brilliant anterior red color in life, as this fades to brown or may almost disappear. This is not the case with the black posterior blotches, which have remained unchanged in museum specimens collected nearly 100 years ago.

The pattern comprises a series of blotches which are red and saddle-shaped (that is, with narrow centers and wide lateral wings) anteriorly, gradually changing through red-brown and brown to jet-black somewhat anterior to the tail. On the neck the wings of the dorsal blotches tend to merge, as in *deserticola*, completely enclosing diamond-shaped light areas (the true interspaces) which are pink or sometimes orange. Posteriorly the blotches become square and well separated. The dorsal interspaces may continue pink to the tail, or they may become orange or yellowish posteriorly. The auxiliary lateral blotches are usually elongated anteriorly, and are rather indefinite in outline. Often the anterior lateral streaks may be darker than the main dorsal blotches; sometimes they are dark-brown or black. There are 2 or 3 rows of auxiliary lateral blotches on the neck. Posteriorly, as these blotches darken, they also become more evenly outlined: usually there are 3 or 4 alternating series at mid-body, the lowest engaging the edges of the abdominal scutes. The ground color, both laterally and ventrally, is yellow, cream, or buff. Below, the ventrum is usually clear anteriorly, but marked with gray or spots of black punctations caudad.

On the tail there is a series of dorsal black spots which may be square, round, or elliptical, with a single secondary series on each side anteriorly. On the underside of the tail there is usually a dark streak, often somewhat irregular and always with serrated edges. This stripe is quite characteristic of this subspecies (it is somewhat less frequent and perfect in *bimaris*); and, in the series available to me, is evident in all but 3 out of 33 specimens, although in some cases only on the posterior part of the tail.

The head is mottled or suffused with red above and is unmarked below.

This color description has been based largely on specimens from Cape San Lucas and San José del Cabo. Some of those from further north have darker scales, or scales with dark posterior tips, scattered within the anterior dorsal red blotches, or in the lateral series. CAS 45875 from San Antonio is quite dark anteriorly, although not as black as typical *bimaris*. Another dark specimen is MVZ 11842; this is black anteriorly and is much more like *bimaris* than *vertebralis*, although four other specimens from the same vicinity (Todos Santos) are typical *vertebralis*, except for more than the usual amount of dark streaking forward. These are the two specimens to which attention has been called in the table on page 10. Mainly, in distinguishing *vertebralis* from *bimaris*, one must look for a considerable contrast in color between the anterior and posterior dorsal body blotches in the former, while there is little or none in the latter.

The body blotches vary from 38 to 57, although all but 4 specimens fall between 39 and 49. The mean is 44.0. The tail spots vary between 8 and 15, with a mean of 11.3.

Range.—*Vertebralis*, as newly defined, occurs only in the Cape region of Baja California, south of the isthmus formed by La Paz Bay (Lat. 24°20′ N.). Here it has been collected at La Paz, San Pedro, San Antonio, San Bartolo, Eureka, Todos Santos, Agua Caliente, Miraflores (also 10. mi. s.), Santa Anita, San José del Cabo, and Cape San Lucas. It seems to be quite plentiful and well-distributed throughout this area.

Remarks.—*Vertebralis* intergrades with *bimaris*, the next subspecies to the north, which in turn relates it to *insulanus*, and, more distantly, to *deserticola*. The fact that *vertebralis* has light anterior blotches, as opposed to the dark *bimaris*, together with its slightly shorter tail, suggests a possible influence of *affinis*, across the Gulf of California in Sonora. Such relationships are found in other genera such as *Crotalus*, *Lichanura*, and *Coleonyx*.

Pituophis catenifer annectens Baird and Girard

SAN DIEGAN GOPHER SNAKE

Plate 2, fig. 1.

1853. *Pituophis annectens* Baird and Girard, Cat. N. Amer. Rept., part 1, p. 72. Type specimen USNM 1839; type locality San Diego, California.

1859. *Pityophis annectens* Baird, Reptiles, in Explor. and Surv. for Railroad Route etc., vol. 10, part 3, p. 15.

1919. *Pituophis catenifer annectens* (part) Van Denburgh and Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 9, no. 6, p. 216.

Diagnosis.—A subspecies differing from all others except *catenifer*, *fuliginatus*, and *coronalis* in the high number of body blotches and the high tail-length ratio. On the average it has more body blotches and ventral scutes than *catenifer*, and is more often black and with confluent blotches anteriorly. It lacks the well-defined and continuous subcaudal stripes of *fuliginatus* and also the conspicuous black mottling on the head of the latter. From *coronalis* it differs in usually having a labial in contact with the eye.

Material.—Good series of this common snake are available for study, 52 from Baja California, over 300 from San Diego County, and 150 from elsewhere in southern California.

Description.—The following summary is based entirely on the Baja California specimens. The scale rows at mid-body are usually 31 or 33, occasionally 35 and rarely 37. The central dorsal rows are sharply keeled; these ridges are less accentuated laterally and the lowest 6 or 7 rows are smooth. The lowest 3 or 4 rows are larger than the rest. Paired apical scale pits are in evidence, often emphasized by tiny dark spots. The ventrals in the males (27) vary from 223 to 242, mean 232.6; and in the females (21) from 230 to 253, mean 240.6. The anal is entire. The subcaudals number from 75 to 89 in the males, mean 81.1. One specimen has 68 but it is impossible to tell whether the tail is complete. The females range from 73 to 82, mean 76.5. The supralabials most often number 8, sometimes 9, and rarely 10. The next to the last is the largest. Usually the fourth enters the eye, although if there are 9 it may be the fifth. In 2 counts out of 94 there is a complete row of suboculars so that no labial touches the orbit. In 5 counts there were two labials touching the eye. The infralabials are usually 12 or 13, but are occasionally 14, or less often 11 or 15. The seventh is the largest; the first pair meet on the median line. Behind there is a pair of large chin shields, followed by a smaller, divergent pair, the latter separated by 2 or 3 rows of gulars.

The rostral is as wide as high, or, more often, slightly wider. It is not raised above the surrounding scales. Viewed vertically the front edge is almost flat, giving the snout a blunt appearance. The rostral parts the internasals for about half their depths; they are posteriorly divergent. There are usually 4 prefrontals, but sometimes they are fused into 3 scales, and, in six specimens, into 2. Six specimens out of 50 have an azygos, a central small scale posterior to the inner prefrontals. The supraoculars are widest posteriorly and the frontal anteriorly. The supraoculars contact the outer prefrontals. The parietals are wrinkled, and with uneven borders. The nasals are subequal, with the nostril at the upper end of the suture. The loreal is longer than high with a lower posterior point. Occasionally there is an extra loreal in the angle between the nearest supralabial sutures. One quarter of the specimens have a single preocular, the remainder two; when there are two the lower is much the smaller. The postoculars are most often 3, but there may be 4 or, less often, 5. The temporals. which are irregular in size and arrangement, number from 2+4 and 3+3, to 6+6.

The longest specimen I have seen from Lower California measures 1700 mm. This is the longest-tailed of all the gopher snakes (with the possible exception of two of the new island subspecies); adult males have a tail to length over-all ratio of about .170 and the females .155.

As to pattern, *annectens* is rather drab, lacking the bright and contrasting colors evident in the other subspecies. The dorsal blotches are usually black anteriorly and posteriorly; they may be black throughout, but more often are brown or red-brown at mid-body. Occasionally (6 cases out of 54) the anterior blotches are brown, although in such instances the blotches are bordered with black; or each scale may have a brown center with a black edge. Brown anterior blotches are more apt to be found in juveniles. Non-black blotches posteriorly occur more often. Sometimes the last blotches have gray or brown scales with black edges.

Anteriorly the dorsal blotches are quite irregular and indefinite; they are often confluent with each other and with the first lateral series. They are usually longer than wide. The interspaces comprise rows or streaks of yellow scales. Posteriorly the blotches become wider and rounder; the interspaces are buff or gray, streaked with brown, and the contrast remains imperfect. Finally, toward the tail the blotches become more distinct, the interspaces being lighter. There are usually 4 rows of alternating spots on each side anteriorly. The sides between blotches are so suffused with gray or brown punctations, or streaks on individual scales, that it is difficult to assign a color to the background. The lower surfaces are buff or yellow, spotted with black or punctated with gray. The outer edges of the ventrals are often marked by the lowest lateral series of blotches. The underside of the tail is usually stippled with gray. Occasionally there are blotches subcaudally, and sometimes double rows of brown or black triangles, the analogues of the twin dark stripes in *fuliginatus*.

The head is brown above, sometimes mottled in the parietal area with darker-brown or black. There is generally a sharp contrast between the most advanced black body-blotch and the brown of the head. Usually there is a slightly darker-brown streak across the anterior ends of the supraoculars and the frontal. A postocular dark streak, ending at the angle of the mouth, is sometimes faintly in evidence. The dark streaks in the labial sutures, so characteristic of many *Pituophis*, are generally present, particularly the one immediately below the eye. The head is buff on the sides, and, except for the darkened labial sutures, is immaculate below.

Young specimens are usually brighter, with clearer spots and more color contrast.

The body blotches in these Baja California *annectens* vary in number from 57 to 90, mean 75.5; and the tail spots from 17 to 29, mean 23.0.

Range.—The subspecies *annectens* ranges from Santa Barbara County, California, south to the southern end of the San Pedro Mártir Mountains in Baja California (Lat. 30° N.). In this area it is found from the coast, through the interior valleys and mesas, to the crests of the mountains, and well down the desert slopes, but not on the desert itself.

Baja California localities are as follows: Tijuana, Rosarita Beach, Redondo (S. D. and A. E. Ry.), Lindero (S. D. and A. E. Ry.), half way between Tijuana and Tecate, Tecate, Zacatosa, Descanso Point (also 1 m. n.), Mesquite Point, San Miguel Mission, 6 m. s. of Jatay, El Tigre grade, Ensenada (also 3, 8, 10, 12, 15, and 23 mi. n., and 7 mi. s.), Guadalupe Valley, Laguna Hanson, Sierra Juárez, 8 mi. n. of Alamo, Santo Tomás, San Antonio del Mar (= Johnson Ranch, also 10 mi. n.), Johnson Canyon (n. of San Antonio del Mar), Trinidad (intergrade), San José (= Rancho San José, Lat. 31° N.), Socorro Mine, La Encantada, San Pedro (Mártir) Mt., San Quintín, and mouth of Rosario River (Lat. 30° N.).

Remarks.—*Annectens*, as it occurs in northwestern Baja California, does not differ in any notable way from the snakes found in the vicinity of the type locality, San Diego, California. The Baja California specimens have slightly higher ventral and subcaudal scale counts, and fewer blotches. As might be expected in an area extending from a foggy coast, through dry, interior valleys to mountains exceeding 10,000 feet in altitude, there is a considerable local variation in scale counts and pattern. Some of the mountain specimens, from such localities as Laguna Hanson and La Encantada, have fewer body blotches, but this is not a uniform tendency.

There are two aberrant specimens from *annectens* territory, not including USNM 37536 from Alamo, which I have discussed elsewhere. The first is SDSNH 16863 from 8 miles north of Alamo. This has an *annectens* tail ratio and is, in fact, *annectens* in all particulars except that it is red or red-brown throughout, without any black, and the blotch count is low. Tentatively, I consider it an aberrant *annectens* with the black element of the coloring absent. It could hardly be considered an *annectens-affinis* intergrade in view of the tail length.

The other queer specimen is CNHM 1394 from Trinidad (Valle de la Trinidad). This is black both anteriorly and posteriorly, with a coloration and pattern reminiscent of both *bimaris* and *annectens*. It has a *bimaris* or *affinis* tail ratio; the blotch count (56) is too high for the former. I presume it is an intergrade, possibly *bimaris-annectens*. This can only be decided when much more material is available from this area.

The relationships of *annectens* to the island forms *fuliginatus* and *coronalis* have been discussed under those subspecies.

Of the mainland subspecies, *annectens* intergrades in northern Santa Barbara County with *catenifer*, from which it is not sharply differentiated. It intergrades with *deserticola* at the foot of the San Gabriel and San Bernardino ranges, where they merge into the Mojave Desert in Los Angeles and San Bernardino counties. Direct intergradation with *affinis* or *bimaris* is as yet uncertain.

Pituophis catenifer affinis Hallowell

SONORAN GOPHER SNAKE

Plate 2, fig. 2.

1852. *Pituophis affinis* Hallowell, Proc. Acad. Nat. Sci. Phila., vol. 6, p. 181. No type specimen mentioned; type locality New Mexico, later (1854, p. 146) stated to be the Zuni River, New Mexico (which included Arizona).

1920. *Pituophis catenifer rutilus* Van Denburgh, Proc. Cal. Acad. Sci., ser. 4, vol. 10, no. 1, p. 24. Type specimen CAS 33869; type locality Tucson, Pima County, Arizona.

1932. *Pituophis sayi affinis* Stull, Occ. Papers Mus. Zoöl., Univ. Mich., no. 250, p. 4.

1943. *Pituophis catenifer affinis* Smith and Mittleman, Trans. Kans. Acad. Sci., vol. 46. p. 248.

Diagnosis.—A subspecies which can be distinguished from *catenifer*, *annectens*, *fuliginatus*, and *coronalis* by its proportionately shorter tail and fewer body blotches. It can be segregated from *deserticola*, *bimaris*, and *insulanus* by its brown anterior blotches, compared with black on the others. It may be separated from *vertebralis* since it lacks the black subcaudal stripe which characterizes the latter; also, *vertebralis* has black blotches at the base of the tail, while those of *affinis* are brown or dark-brown. *Affinis* has a rostral which is relatively wider and not so prominently raised above the surrounding scales as in *sayi*; when the rostral is viewed from above the anterior curve is flatter in *affinis* than in *sayi*.

Material.—Only two specimens of this subspecies from Baja California are available to me. These are USNM 22035 from Gardners Laguna, Salton

River (Mearns, 1907, p. 130), and MVZ 9562 from 23 miles north of El Mayor. Fortunately, adequate material is at hand from nearby Imperial County on the United States side of the international boundary, where the ecological conditions, involving both primitive desert and irrigated fields, are quite the same. In the days before irrigation these lowlands were occasionally watered by the overflow from the Colorado River, which periodically filled a number of shallow lakes. Similarly, the conditions in the Borego Valley of San Diego County match those at the foot of the Sierra Juárez and Sierra Cocopah below the line. Therefore, I have based the description of the subspecies *affinis*, which follows, on the two Baja California specimens, together with 12 from San Diego County and 73 from Imperial County. Of these specimens, 38 are males, 39 are females, and the rest are heads only. The Arizona material has been omitted because of territorial variations.

Description.—The scale rows at mid-body are most often 33 but may vary from 29 to 35. They are strongly keeled dorsally, but less so on the sides; from 5 to 7 of the lowest lateral rows are generally smooth. Paired apical scale pits are evident, particularly at the posterior end of the body, some being accentuated by dark spots. The ventrals in the males vary from 232 to 251; most of them fall between 234 and 244; the mean is 239.6. In the females the variation is from 234 to 257, with the major portion falling between 241 and 252; the mean is 246.0. The anal is undivided. The subcaudals vary from 61 to 70 in the males, with an average of 65.1; and in the females from 50 to 63, with an average of 57.7. The supralabials usually number 8, but are occasionally 9, and, rarely, 7 or 10. Usually the fourth touches the orbit, and the next to the last is the largest. The infralabials generally number 13, but are not infrequently 12 or 14, and rarely 11, 15, or even 16. The seventh is the largest. The first pair meet on the median line; they are followed, first by a pair of large genials in contact, and then by a pair of smaller divergent genials which are separated by two or three rows of gulars.

The rostral may be a little higher than wide or the dimensions may be equal. Viewed from above it is convex, the snout being slightly sharper than in *annectens*. Occasionally it is slightly raised above the surrounding scales. It indents the internasals for about half their depths. Most specimens have four prefrontals, although in some specimens an outer and an inner may be fused. Occasionally the outer end of a prefrontal is cut off to form what might be considered an upper loreal. The supraoculars are narrowest anteriorly; they usually contact the outer prefrontals. The parietals are triangular and have irregular outer edges, particularly because of the invasion of a scale behind the upper postoculars. The anterior nasal is slightly larger than the posterior. The loreals, of which there is usually only one on each side, are longer than high. The preoculars are ordinarily 2–2 with the lower quite small compared to the upper; in 14 per cent of the counts there is a single preocular. The postoculars are subequal; they are most often 3–3 but there may be 4 or even 5 on a side. The temporals are highly irregular in shape; they vary from 2 to 6 in the first row, and 3 to 6 in the second.

The longest specimen I have from Imperial County measures 1708 mm., and the shortest 415 mm. This snake grows to a large size in some sections of Arizona, probably well exceeding 2000 mm. The ratio of the length of the tail to the length over-all in the adults is about .136 in the males and .125 in the females. It is a short-tailed snake compared with *deserticola*, or especially with *annectens*. I have discussed tail-length equations and comparisons elsewhere (Klauber, 1943; see particularly p. 41 and table 13, but note that the series referred to as *P. c. deserticola* I, Imperial County, should be called *P. c. affinis*).

Affinis is primarily a brown-blotched snake with much dark streaking of individual scales in the interspaces. The main dorsal series is usually light-brown anteriorly, becoming darker toward the tail until, at the end, the blotches may be almost black. The anterior blotches are often outlined with dark-brown and sometimes even with black. The anterior blotches are not saddle-shaped, but the interspaces frequently are. The interspaces are usually buff, but within them there are many scales which are conspicuously darkened by brown streaks on their keels; this is particularly evident laterally, the dorsal interspaces being often clear. There are about four series of auxiliary and alternating blotches on the side. Both the main series and the auxiliaries tend to become more widely separated, and more even and clearly outlined posteriorly. The color below is cream or yellow, with some spotting on the outer edges of the ventrals. The subcaudal surface is usually spotted; rarely these spots may form longitudinal lines.

The head is light-brown or buff above, and lighter on the sides. There is usually a wide dark-brown line across the fronts of the supraoculars and the frontal. Back of this line there are dark-brown spots scattered in the frontal and parietal areas. There is generally a dark line from the eye toward the angle of the mouth, with a vertical termination between the last two supralabials. There are the usual *Pituophis* streaks which follow the labial sutures, the one under the eye being widened and accentuated. The head is unspotted below.

The body blotches in these Californian specimens range from 41 to 62; with 4 exceptions out of 78 they fall between 43 and 58. The mean is 49.1. The tail spots vary from 10 to 19 with a mean of 14.1.

Range.—Since only two specimens are available from Baja California, collected at Gardners Laguna and near El Mayor, the range in the peninsula is imperfectly known. Reasoning from the situation in San Diego and Imperial counties, it may be expected to occur from the desert foothills of the Sierra Juárez eastward, and along the Gulf of California coast southward until it meets and intergrades with, or overlaps, *bimaris*, probably in the vicinity of San Felipe.

The general range of *affinis* is from central New Mexico, western Texas, Chihuahua, and southern Coahuila, westward through Arizona (excluding the section north of the Colorado River and extreme northern Navajo and Apache counties inhabited by *deserticola*) to central Riverside, Imperial, and northeastern San Diego counties in California; Sonora; extreme northern Sinaloa; and northeastern Baja California.

Remarks.—My reasons for assigning the gopher snakes of northeastern Baja California to the subspecies *P. c. affinis* rather than to *P. c. deserticola*, and the relationship between these two subspecies will be discussed in a subsequent paper on the gopher snakes of the Pacific Coast and Great Basin.

KEY TO SUBSPECIES OF *Pituophis catenifer* IN BAJA CALIFORNIA

1a	Supralabials usually not in contact with the eye South Coronado Island	*P. c. coronalis*
1b	At least one supralabial usually touching the eye	2
2a	Two parallel dark stripes formed of contiguous scale blotches on the underside of the tail San Martín Island	*P. c. fuliginatus*
2b	No parallel continuous dark stripes on underside of tail, although there may be rows of adjacent triangles	3
3a	Dark blotches on the body (exclusive of the tail) usually exceed 63; posterior lateral ground color suffused with gray Northwestern coastal, foothill, and mountain area from the U. S. Border south to Lat. 30° N.	*P. c annectens*
3b	Dark blotches on the body (exclusive of the tail) usually 63 or less; posterior lateral ground color not suffused with gray	4
4a	Anterior body blotches black	5
4b	Anterior body blotches red or brown	6
5a	Body blotches 50 or more Cedros Island	*P. c. insulanus*
5b	Body blotches less than 50 Central area of the peninsula, from coast to coast, from Lat. 24°21′ N. to Lat. 30° N. with an occasional specimen as far north as Lat. 31°30′ N. Also Santa Margarita and Magdalena islands.	*P. c. bimaris*

6a Posterior body blotches (at base of tail) brown; no subcaudal dark stripe — *P. c. affinis*
Delta of the Colorado River and the northeastern desert area.

6b Posterior body blotches (at base of tail) black; a dark subcaudal stripe usually present — *P. c. vertebralis*
Cape region south of Lat. 24°20′ N.

Note: It has been possible to simplify the key considerably by excluding subspecies which do not occur in Baja California. The gopher snakes are so variable that an infallible key cannot be devised. Successful determinations must be premised on the use of locality data as well, for the complete differentiation of subspecies is based on the summation of more characters than can be included in a key.

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The following abbreviations have been used in the designation of museum specimens:

AMNH	American Museum of Natural History
ANSP	Academy of Natural Sciences of Philadelphia
CAS	California Academy of Sciences
CNHM	Chicago Natural History Museum
LA	Los Angeles County Museum of History, Science and Art
LMK	Collection of L. M. Klauber
MCZ	Museum of Comparative Zoölogy, Harvard University

MVZ	Museum of Vertebrate Zoölogy, University of California
MZUM	Museum of Zoölogy, University of Michigan
SDSNH	San Diego Society of Natural History
SU	Natural History Museum, Stanford University
USNM	United States National Museum

SUMMARY

This paper comprises a resurvey of the gopher snakes of the genus *Pituophis*, found in Baja California, Mexico, based on additional material which has recently become available. All the gopher snakes of the area are deemed to be subspecies of *Pituophis catenifer* (Blainville), 1835.

Four new subspecies are described: *P. c. bimaris* from the central area of the peninsula; *P. c. insulanus* from Cedros Island; *P. c. fuliginatus* from San Martín Island; and *P. c. coronalis* from South Coronado Island. The first two are nearest to *P. c. vertebralis* of the Cape region, the others to *P. c. annectens* of the San Diegan faunal area. The only other form found in the peninsula is *P. c. affinis* of the northeastern desert and Colorado River delta.

The previously known forms, as newly circumscribed, are summarized. Relationships are discussed.

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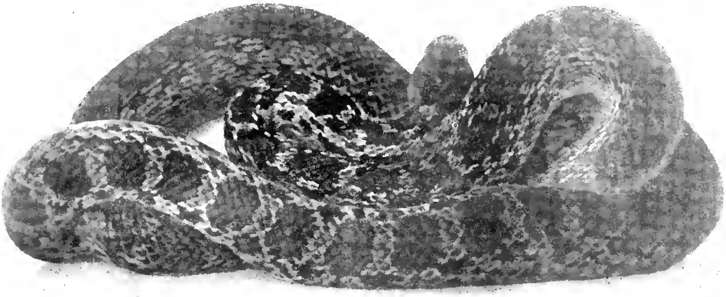

Fig. 1. *Pituophis catenifer insulanus*

Adult female (type specimen) from Cedros Island. Collected and photographed by J. R. Slevin, California Academy of Sciences.

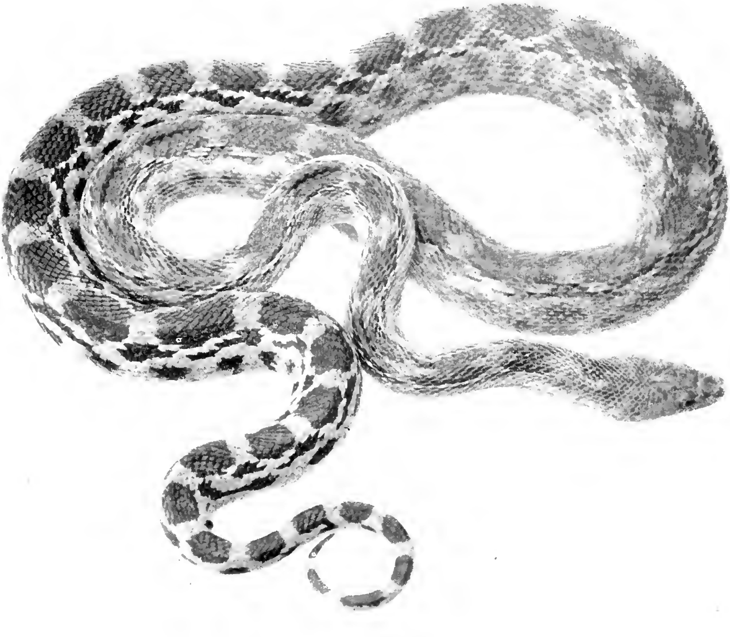

Fig. 2. *Pituophis catenifer vertebralis*

Specimen from Cape San Lucas, Baja California. Collected by Fred Lewis. Photograph by L. C. Kobler.

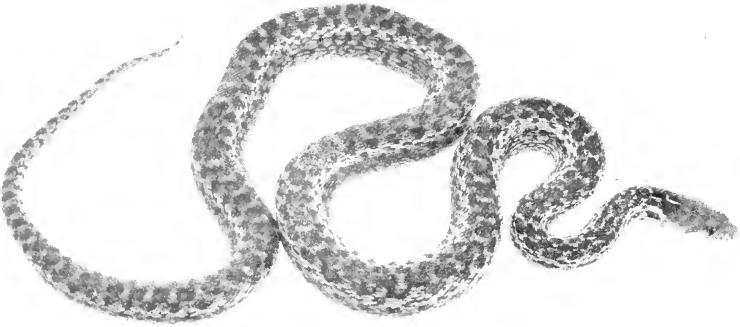

Fig. 1. *Pituophis catenifer annectens*

Adult female from Mesquite Point, Baja California. Collected by Dr. C. L. Hubbs. Photograph by L. C. Kobler.

Fig. 2. *Pituophis catenifer affinis*

Adult male from 10 miles west of Benson, Cochise County, Arizona. Collected by Robert Hoard. Photograph by L. C. Kobler.

TRANSACTIONS
OF THE
SAN DIEGO SOCIETY OF NATURAL HISTORY

VOLUME XI, No. 2, pp. 41-48, plate 3. AUGUST 26, 1946

A NEW GOPHER SNAKE (PITUOPHIS) FROM SANTA CRUZ ISLAND, CALIFORNIA

BY

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In a recent study of the gopher snakes of the genus *Pituophis* in Baja California,* it was found that three island populations differed sufficiently from those of the mainland to warrant recognition as new subspecies. This naturally led to an investigation of the snakes found on the islands off the coast of the State of California, *Pituophis* being definitely known to occur on two, Santa Cruz and Santa Catalina, and rumored on a third, San Clemente. I have been unable to find any important differences between the Santa Catalina specimens and *Pituophis catenifer annectens* of the nearby mainland; but the Santa Cruz Island snakes, while overlapping, in some degree, both *P. catenifer catenifer* and *P. c. annectens*, possess average differences which warrant nomenclatorial segregation.

Pituophis catenifer pumilus subsp. nov.

SANTA CRUZ ISLAND GOPHER SNAKE

Plate 3, fig. 1.

1914. *Pituophis catenifer* Van Denburgh and Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 4, no. 5, p. 136.

1919. *Pituophis catenifer catenifer* (part) Van Denburgh and Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 9, no. 6, p. 211.

Type.—No. 17238 in the collection of the San Diego Society of Natural History. Collected on Santa Cruz Island, Santa Barbara County, California, by Norman Bilderback, May 5, 1938.

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* The Gopher Snakes of Baja California, with Descriptions of New Subspecies of *Pituophis catenifer*. Trans. San Diego Soc. Nat. Hist., Vol. 11, No. 1, pp. 1-40, 1946.

Diagnosis. A subspecies most closely resembling *P. c. catenifer* and *P. c. annectens* of the mainland, and differing in tail length and pattern from all other mainland species and subspecies of the genus, as do these two. It most nearly resembles *annectens* in pattern, including color and blotch counts, but is nearer *catenifer* in the number of ventral and subcaudal scales. It differs from both in having fewer scale rows—although with some overlapping—and in being stunted in size. In comparison with other island forms, *pumilus* has more blotches and a proportionately longer tail than *insulanus*, lacks the parallel darks subcaudal stripes and extensive dark head blotches of *fuliginatus*, and is without the subocular scales of *coronalis*.

Description of the Type.—A male, probably a young adult. Length over-all 646 mm.; length of tail 111 mm.; ratio of tail to length over-all .172. The body is relatively slim for *Pituophis*. The head is moderately distinct from the neck, and is wedge-shaped, with a rounded snout. The scale rows are 25–29–19. There are 29 scales only at one or two places forward of mid-body, where there are short runs of extra scales; elsewhere 27 rows are the maximum. The dorsal rows are conspicuously keeled, and are smaller than the lateral. About 8 of the lowest rows on either side are smooth. The lateral row next to the ventrals is considerably larger than those above.

There are 217 ventrals, and 72 subcaudals, most of which are paired, although the third to fifth after the anal are undivided.

The rostral is the same in height and width, and is not conspicuously raised above the contiguous scales. It is recurved over the top of the snout and almost completely separates the internasals. The internasals are triangular and posteriorly divergent. There are four prefrontals, the inner long and triangular, the outer curved over the canthus to contact the loreals. The frontal is quadrangular and is widest in front; it indents the parietals for less than ¼ of their length. The supraoculars are narrow in front and do not touch the prefrontals. The parietals are relatively short and even-edged; they are not conspicuously indented by the uppermost temporals, as in many western *Pituophis*.

The nasals are subequal, with large nares at the upper end of the suture which separates them. There is a small oval loreal on either side, with a tiny subloreal on the left. The eye is large. The preoculars are 2–2, the upper much the larger; the postoculars are 3–3 and are subequal. The temporals are 3+3, 3+3; they are more regular than in many *Pituophis*. The lowest in the first row on the right is very small.

The supralabials are 8–8; the seventh is the largest but does not greatly exceed the sixth; the fourth touches the eye. The infralabials are 12–12, the first pair meeting on the median line; the seventh is the largest, with the sixth next in order of size. The mental is small and triangular. The anterior genials are long and narrow; they are medianly in contact; the posterior are still slimmer and are separated by 2 to 4 rows of gulars.

The head is light-brown. The posterior edges of the prefrontals are slightly darkened, and the parietals are spotted with black. On the sides the usual *Pituophis* postocular stripe is irregularly in evidence. There is a heavy black mark under each eye in the suture between the fourth and fifth supralabials, and the two sutures anterior to these are marked with thin black lines. A few of the infralabial sutures are also lined with black, otherwise the ventral surface of the head is unmarked cream-color.

There is a series of 78 median blotches on the body, and 25 spots on the tail. Anteriorly there are four alternating secondary series on either side. The main series is highly irregular and somewhat indefinite, for although many of the included scales are black, particularly in front, others are centrally streaked with brown or gray, and the light scales in the interspaces are punctated with darker. Thus there is a general effect of mottling which interrupts the regularity of the pattern. The first lateral series on either side is more or less confluent with the dorsal blotches anteriorly. The interspaces, where evident, are buff; but the sides are much suffused with gray or brown, upon which the black secondary series of spots are scattered. There are black blotches on the outer edges of the ventrals, with another paired series of brown spots midventrally. The ground color of the under surface is buff. Posteriorly the main dorsal series is more solidly black, with the interspaces clearer, so that they are also more definite. On the whole the snake gives the impression of being grayer than *annectens*, especially on the sides, where there is sufficient gray to suggest longitudinal stripes.

Paratypes.—Eight paratypes are available: CAS 36120-1, 45131; Stanford 8389; MCZ 12679; and MVZ 11131-3. The last three are from Johnson's or Johnson's Landing, near Gull Rock; the localities of the others are given merely as Santa Cruz Island.

The scale rows vary from 23-27-19 to 27-29-21. Together with the type, whose counts are included in the following statistics, 2 specimens have 27 rows at mid-body, one has 28, and 6 have 29. This is a lower average than in any other subspecies.

The ventrals vary from 209 to 226 in the males (7 counts), mean 215.0; in the females from 212 to 221 (2 counts), mean 216.5. The subcaudals in the males range from 69 to 73 with a mean of 70.9; and in the females from 55 to 61, mean 58.0. These averages are somewhat below those of mainland *P. c. catenifer*. Several specimens have a block of 3 to 5 undivided subcaudals beginning 2 or 3 scales back of the anal plate, but this is not universal.

The snout is blunt compared to mainland *Pituophis*. The supralabials are usually 8 but may be 9 or rarely 10. Only one supralabial touches the eye; this is the fourth where the total is 8, or the fifth if there are 9 or 10. The infralabials are generally 12 but range from 10 to 13. The loreals are usually single but there is a small subloreal in 3 counts out of 18. The preoculars are single in 9 counts out of 18, and paired in the others; the second preocular, if present, is always small and is the lower of the two. The postoculars number 3 in 12 out of 18 counts, 4 in the others. They are subequal in size. The temporals vary from 2—3 to 3—4 or 4—3. They average fewer and are more regular than in the mainland snakes. There are 4 prefrontals in all specimens. They are not laterally divided or irregular in any other way, nor has any specimen an azygos. The supraoculars touch the prefrontals in some specimens but not in others. The parietals are regular and are triangular in shape.

The ratio of the tail length to length over-all averages about .173 in the males and .156 in the females. The longest specimen, a male, measures 788 mm.; the shortest 228 mm.

The body blotches vary from 58 to 85 (mean 75.6), and the tail spots from 17 to 26 (mean 22.2).

The pattern comprises a series of dorsal spots or blotches which are usually black from head to tail, although they may be brownish, or the scales comprising them may have brown centers, at mid-body. Anteriorly the blotches are generally longer than wide, being about 5 scale rows wide and 3 scales (end to end) long. They are quite irregular, and often confluent with each other, or with the first subsidiary series on either side, especially on the neck. Posteriorly they are round or oval. and are better separated and more distinct. There are generally 4 or 5 lateral series of blotches, the lowest of which marks the outer edges of the ventrals. The tail also is somewhat spotted below; in some specimens there are a few triangular spots in parallel rows.

The ground color is brown, or gray, middorsally and laterally, with a gray streak between, which is rather characteristic of this subspecies. The ventrum has a cream or buff ground color.

On the head a brown transverse bar between the prefrontals and supraoculars is sometimes present, but in other specimens is obsolete; the same may be said of a postocular dark streak which seems to be lost with age. There are generally a few black or brown spots on the frontal and parietals. There is always a vertical dark bar, or triangle, in the supralabial suture below the eye; and other labial sutures are often touched with dark. The head has a brown ground color above, and cream or buff below.

Range.—*Pumilus* is found only on Santa Cruz Island, one of the Santa Barbara group, off the coast of California.

Remarks.—*Pumilus* most nearly resembles the mainland snakes in the vicinity of Santa Barbara, which are *annectens*, with tendencies toward *catenifer*. From these it does not differ greatly in pattern, although slightly more streaked anteriorly, and often (but not always) with narrower anterior dorsal blotches. With respect to scutellation, in comparison with these mainland snakes *pumilus* has fewer ventrals and subcaudals on the average, and more often has single preoculars.

Pumilus more frequently has 2 temporals in the first row than is the case in the mainland specimens. While the difference is significant, there is overlapping. The temporals do not usually constitute a satisfactory character for identification in *Pituophis* because of the irregularity of their arrangement.

The most consistent difference from the mainland *Pituophis* is in scale rows. Snakes with only 29 rows are rather unusual on the mainland of California, while on Santa Cruz Island all available specimens have 29 or less.

Comparing our nine specimens of *pumilus* with a series of eight *annectens*, kindly sent me from Santa Barbara by Mr. Waldo G. Abbott, we have the following comparative distribution:

Scale Rows	*Santa Cruz Island*	*Santa Barbara*
27	2	
28	1	
29	6	
30		
31		3
32		2
33		2
34		1
	9	8

Or we may make the following comparison with all available scale-row data on *catenifer catenifer* and *c. annectens* from the mainland:

Scale Rows	*P. c. pumilus*	*P. c. catenifer*	*P. c. annectens*
27	2		
28	1		
29	6	20	9
30		3	10
31		172	139
32		7	40
33		128	242
34		3	25
35		18	59
36			3
37		1	5
38			1
	9	352	533

It will be observed that only about 5.7 per cent of *catenifer catenifer* and 1.7 per cent of *c. annectens* have 29 scale rows, whereas all *c. pumilus* have 29 or less. Although 9 is a relatively small sample from which to estimate the actual population composition of *pumilus*, there is no doubt as to the significance of this difference. Twenty-nine scale rows occur most frequently in *catenifer catenifer* in snakes from the Sacramento Valley. Specimens of *deserticola* with 29 scale rows are quite prevalent in some areas, but this subspecies differs from *pumilus* in other characters of lepidosis, pattern, and proportionate tail length.

Another important difference in *pumilus* is its size. We have reason to believe it to be a stunted form, although this is difficult to prove. The dispersion curve of sizes in a population of snakes does not lend itself to mathematical analysis, so we are unable to make estimates of the degree to which size limits will be increased as more specimens become available, although we know there will be such an increase. We have the following evidence concerning the relative sizes of *pumilus* and other subspecies:

1. Comparisons with other island forms, of which relatively small samples are available:

Subspecies	*Number of Specimens*	*Size Range mm.*
P. c. pumilus	9	228 – 788
P. c. insulanus	7	460 – 1213
P. c. fuliginatus	15	327 – 1390
P. c. coronalis	4	353 – 1150
P. c. annectens (Santa Catalina)	3	489 – 1051

2. A similar comparison may be made with the Abbott series of mainland snakes from Santa Barbara:

Locality	*Number of Specimens*	*Size Range mm.*
Santa Cruz Island	9	228 – 788
Santa Barbara	8	361 – 1478

3. Out of over 300 *catenifer catenifer* the shortest normal specimen is 310 mm. There is one specimen, MVZ 2314, which is only 202 mm., but this is clearly abnormal. It has a peculiar navel which divides some ten of the adjacent ventrals, although it was found on a lawn, and therefore it is not an unhatched embryo. One may doubt whether it would have survived. The shortest *pumilus* (228 mm.) is not a freak . It was collected in April, and therefore must have been more than six months old. The next to the shortest specimen, CAS 36121, also collected in April (but by a different collector, in a different year) measures 272 mm., considerably smaller than any *catenifer catenifer*.

4. The smallest *annectens*, out of some 416 specimens collected in the wild, measures 350 mm.; the next smallest 359. Out of 73 young *annectens* hatched by Mr. C. B. Perkins at the San Diego Zoo, the two shortest measured 322 mm. each. This was in a brood of 10, all notable for their small size (range 322 to 346 mm., mean 333); the smallest in any other brood measured 355 mm.

Summing up, I think the evidence rather strong that *pumilus* is a stunted subspecies, distinctly smaller than the mainland subspecies *catenifer* and *annectens*. Neither of the latter, by the way, is particularly large among *Pituophis*; they are considerably exceeded in size by *affinis*, *bimaris*, and *sayi*.

The only contrary evidence is a comment by Mr. E. Z. Rett, of the Santa Barbara Museum of Natural History, to the effect that he saw only one snake on the island in many visits. This was a gopher snake which he tried to capture but failed. It appeared to him to be 4 or 5 feet in length.

In view of the overlapping in scale rows, I consider only a subspecific designation warranted, even though actual intergradation is not possible.

One *pumilus* contained the remains of a small mammal.

Acknowledgments.—I am greatly indebted to Mr. J. R. Slevin, California Academy of Sciences; Mr. Thomas L. Rodgers, Museum of Vertebrate Zoölogy, University of California; Miss Margaret Storey, Natural History Museum, Stanford University; and Mr. Arthur Loveridge, Museum of Comparative Zoölogy, Harvard University, for the loan of specimens in the collections of which they have charge. Mr. Waldo G. Abbott kindly furnished specimens from Santa Barbara, which have been useful for comparison. To Mr. C. B. Perkins I wish to express my thanks for critical suggestions.

Summary.—*Pituophis catenifer pumilus* is described as a new subspecies from Santa Cruz Island off the coast of southern California. It differs from its nearest relatives of the mainland, *P. c. catenifer* and *P. c. annectens*, in having fewer scale rows, on the average, and in probably being a stunted form.

Fig. 1. *Pituophis catenifer pumilus*

Santa Cruz Island, California. Photograph by J. R. Slevin, California Academy of Sciences.

TRANSACTIONS
OF THE
SAN DIEGO SOCIETY OF NATURAL HISTORY

VOLUME XI, No. 3, pp. 49-52 FEBRUARY 25, 1947

AN UNDESCRIBED RACE OF THE MANGROVE WARBLER FROM BAJA CALIFORNIA, MEXICO

BY

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In April, 1927, Laurence M. Huey collected a series of nine breeding Mangrove Warblers at San Ignacio and Pond lagoons on the west coast of central Baja California. The locality (Lat. 27° N) is the northernmost point at which mangroves (*Rhizophora*) occur on the Pacific coast and is the only one known north of the extensive "manglares" at Magdalena Bay where this ecologically restricted warbler is to be found. A description of these isolated lagoons has been written by Huey (Condor, 29, 1927: 239-243) and they need not be further discussed here.

Although the specimens referred to have been recorded by the collector and later cited by Grinnell (Univ. Calif. Pub. Zool., 32, 1928: 199), their taxononic status had never been determined until I recently had the opportunity to do so when investigating the Baja California collections at the Natural History Museum. They are quite distinct from *Dendroica erithachorides castaneiceps* of the southern and eastern portions of the peninsula and are described below. In the bestowal of a formal name I am mindful not only of a long and friendly association but also of Mr. Huey's generosity in communicating to me much of his extensive knowledge of the distribution of birds in Baja California.

Dendroica erithachorides hueyi new subspecies

SAN IGNACIO MANGROVE WARBLER

Type.—Breeding male adult, number 11471, San Diego Society of Natural History; San Ignacio Lagoon, Pacific coast of Baja California, April 18, 1927; collected by Laurence M. Huey.

Subspecific characters.—Most nearly similar to *Dendroica erithachorides castaneiceps* Ridgway of southern Baja California and resembling that race in relatively large size, restriction of yellow on inner webs of rectrices, and obscure or obsolescent ventral streaking of adult males. It differs from *castaneiceps*, however, in decidedly darker and more olive (less yellowish) green coloration of the upper parts, and still further restriction of yellow on inner webs of rectrices.

Range.—San Ignacio and Pond lagoons on the Pacific coast of central Baja California.

Remarks.—The specific name *erithachorides* is used only after some consideration. I am well aware that current concept favors the consolidation of the three closely related groups, the Yellow Warblers (*aestiva*), the Golden Warblers (*petechia*), and the Mangrove Warblers (*erithachorides*) under the single specific name of *petechia*. But it seems to me that what is perhaps only fortuitous overlap of *some* characters has been overemphasized and, conversely, that more basic differences including rigidly restricted environment (during the breeding season at least) have correspondingly been minimized.

Whether or not the Mangrove Warblers which breed northerly in Sonora and Baja California are migratory is a moot question. The weight of evidence at this time is that such is the case. There is the comment by Frazar (Brewster, Birds of the Cape Region, 1902, p. 182), of a slight seasonal fluctuation in numbers at La Paz. More definite is the observation by Bancroft (Condor, 32, 1930: 42), of the "appearance, in migration, in early May" at San Lucas (27° 14′), the most northerly point of occurrence on the Gulf side of the peninsula. Finally, there is my own field experience which has failed to find the species at all during the winter months of December to mid-March in Sonora, and the detection of but a single individual at Concepción Bay on the Gulf coast of Baja California in January, 1932. I believe from this evidence, which is perhaps indicative rather than conclusive, that it is reasonable to suppose a withdrawal from the most northerly areas in winter.

Among the 78 specimens examined from the range of *castaneiceps* there is one individual, a female (13533 Dickey Coll.), taken at La Paz on October 2, 1923, which has the characters of *hueyi* in such positive degree that it cannot be included in the known range of variability (which is considerable) of female *castaneiceps*. On this basis I tentatively include La Paz as within the dispersal range of *hueyi*. Further evidence would be desirable, but in view of the limited breeding range and consequent numerical rarity of *hueyi* its detection in localities where *castaneiceps* is common is pretty much a matter of chance. To make sure that the type of *castaneiceps* might not be such a specimen I submitted two of the San Ignacio males to Dr. Alexander Wetmore. He informs me that the type (89940 U. S. Nat. Mus.), an adult male collected at La Paz, December 16, 1882, by Lyman Belding, is representative of the population resident at La Paz.

The breeding ranges of the three races of the Mangrove Warbler which occur in the Gulf area are summarized here. Distribution is not continuous but is restricted to estuaries, bays, and shores where an adequate growth of mangroves occurs.

Dendroica erithachorides rhizophorae van Rossem
SONORA MANGROVE WARBLER

DENDROICA ERITHACHORIDES RHIZOPHORAE van Rossem, Trans. San Diego Soc. Nat. Hist., 8, No. 10: 67-68, August 24, 1935. (Tóbari Bay, Sonora, México). Coasts of Nayarít (*fide* Wetmore), Sinaloa, and Sonora, north to Tepopa Bay at lat. 29° 18′ N.

Dendroica erithachorides castaneiceps Ridgway
LA PAZ MANGROVE WARBLER

DENDROICA BRYANTI CASTANEICEPS Ridgway, Proc. U. S. Nat. Mus., 8, No. 22: 350, Sept. 2 [Sept. 17], 1885. (La Paz, Lower California, [México]). Coasts of Baja California, north on the Gulf to San Lucas, lat. 27° 14′ N, and on the Pacific to Magdalena Bay and San Jorge, lat. 25° 45′ N.

Dendroica erithachorides hueyi van Rossem
SAN IGNACIO MANGROVE WARBLER

Pacific coast of central Baja California at San Ignacio and Pond lagoons, lat. 27° N.

Specimens examined.—*rhizophorae*, 29 from Sinaloa (Mazatlán) 4, and Sonora (Agiabampo; Tóbari Bay; Guaymas; Kino Bay; Tepopa Bay), 25. *castaneiceps*, 78 from Baja California (La Paz; San José Island; Espíritu Santo Island; Concepción Bay; San Lucas at 27° 14′ N; Magdalena Bay, including Santa Margarita Island, Santa Magdlena Island, and San Jorge). *hueyi*, 10 from Baja California (San Ignacio Lagoon, 6; Pond Lagoon, 3; La Paz, 1).

I am indebted to the Curators at the Chicago Natural History Museum, the Los Angeles Museum, the Museum of Vertebrate Zoology (Berkeley), the Museum of Zoology (Ann Arbor), and the Natural History Museum (San Diego) for use of the material under their care, and to Laurence M. Huey and Max M. Peet for the privilage of inspecting their private collections.

TRANSACTIONS
OF THE
SAN DIEGO SOCIETY OF NATURAL HISTORY

VOLUME XI, No. 4, pp. 53-56 JANUARY 31, 1949

THREE NEW RACES OF POCKET GOPHERS (THOMOMYS) FROM BAJA CALIFORNIA, MEXICO

BY

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Field work in the more remote sections of central Baja California on both the Gulf and Pacific Coast sides has revealed three unknown races of *Thomomys*.

When the writer published his account, "The Pocket Gophers of Baja California, Mexico, with Descriptions of Nine New Forms" (Trans. San Diego Society of Natural History, Volume 10, pp. 245-268, Map, August 31, 1945), he suggested the possible existence of yet undiscovered races of *Thomomys* in remote unexplored sections of the peninsula.

This suggestion has been verified. Small collections made on two short trips have brought to light the following undescribed races:

Thomomys bottae ruricola subsp. nov.

SANTA CATARINA POCKET GOPHER

Type.—From 4 miles north of Santa Catarina Landing, Baja California, Mexico, lat. 29° 35′ N., long. 115° 17′ W.; No. 15944, collection of The San Diego Society of Natural History; adult male; collected by Laurence M. Huey, June 27, 1947.

Characters.—Compared with *Thomomys bottae abbotti*, *T. b. ruricola* is less brightly colored on the back and sides, tending toward a grayer cast. The black auricular spot is much smaller than that of either *T. b. abbotti* or *T. b. catavinensis*, the ranges of which are north and eastward. Cranially, the spread of the zygomatic arches of *T. b. ruricola*, when viewed dorsally, gives the appearance of being more nearly circular and not angular, as in *abbotti*. The rostrum is shorter and has an accentuated ridge at the junction of the premaxilla-zygomatic plate. The molariform teeth are smaller, with the pterygoid fossa wider and more U-shaped. The bullae are flatter, less inflated, but flare outward anteriorly. Compared with *T. b. catavinensis*, *T. b. ruricola* is much lighter in color. This race has a larger, more rugose skull, with a wider spread anteriorly, but having less inflated bullae.

Measurements.—Type: Total length, 223; tail, 70; hind foot, 28; ear, 5. *Skull* (*type*): Greatest length, 38.9; spread of maxillary arches, 24.7; length of nasals, 13.8; interorbital constriction, 5.9; alveolar length of upper molar series, 8.9.

Range.—Known only from the type locality.

Remarks.—The region in which this specimen was taken has the appearance of being uninhabitable by gophers and it was with considerable surprise that this specimen was captured with a mouse trap set for kangaroo rats, *Dipodomys*. Further search failed to reveal the presence of a single gopher mound. It has been the writer's experience that in arid regions a fairly large *Thomomys* population can spend long periods underground without showing any surface activities, such as dirt mounds, that would reveal their presence to a mammalogist. During these subsurface periods they exist on roots of different shrubs and larger plants and often a dead cactus will prove to have had its root system completely eaten away while over the nearby surface of the ground not a single gopher indication is visible.

Specimens examined.—1 (the type) from 4 miles north of Santa Catarina Landing, Baja California, Mexico. *Thomomys bottae abbotti*, 17 from 1 mile east of El Rosario, Baja California; 2 from San Fernando Mission, Baja California. *Thomomys bottae catavinensis*, 12 from Cataviña, Baja California.

Thomomys bottae rhizophagus subsp. nov.

LOS ANGELES BAY POCKET GOPHER

Type.—From Las Flores, 7 miles south of Bahía de Los Angeles, Baja California, Mexico, lat. 28° 50′ N., long. 113° 32′ W.; No. 15710, collection of The San Diego Society of Natural History; adult male; collected by Laurence M. Huey, April 11, 1947.

Characters.—In dorsal coloration this form differs little from its nearest relative *T. b. borjasensis*, the range of which lies on the Pacific slope to the westward, but on the sides it is slightly more tawny. It is a member of the more dark-colored group of *Thomomys*, differing decidedly from the gray *T. b. russeolus* found to the southward over the Viscaino Desert. Cranially, however, there is wide divergence. The skull of *T. b. rhizophagus*, when compared with that of *T. b. borjasensis*, is seen to have a longer, heavier, and wider rostrum, with a rounder, more inflated braincase. The angle of the zygomatic arches is less flaring, giving the skull a longer, more streamlined appearance. The bullae are more compressed and less inflated. *T. b. rhizophagus* has a longer tooth row and a larger hind foot than *T. b. borjasensis*.

Measurements.—Type: Total length, 222; tail, 76; hind foot, 30; ear 5. *Skull* (*type*): Greatest length, 37.1; spread of maxillary arches, 21.9; length of nasals, 13.8; interorbital constriction, 6.2; alveolar length of upper molar series, 8.1.

Range.—Known only from the type locality, where it was extremely abundant, living in sandy soil, and feeding on the roots of desert apricot mallow, *Sphaeralcea ambigua*, which was growing in thicket-like patches over the dry, alluvial valley floor.

Remarks.—This is the first race of *Thomomys* to be found close to the Gulf shore north of La Paz. Further exploration, either north or south of Bahía de Los Angeles, may reveal other isolated gopher populations that will be of decided interest to the mammalogist.

Specimens examined.—11 from Las Flores, 7 miles south of Bahía de Los Angeles, Baja California (type locality). *Thomomys bottae borjasensis,* 1 (the type) from San Borjas Mission, Baja California.

Thomomys bottae homorus subsp. nov.

RANCHO LAGUNITAS POCKET GOPHER

Type.—From 1 mile east of Rancho Lagunitas, Baja California, Mexico, lat. 28° 20′ N., long. 113° 15′ W.; No. 15689, collection of The San Diego Society of Natural History; adult male; collected by Laurence M. Huey, April 6, 1947.

Characters.—Compared with *T. b. russeolus,* its nearest comparatum, *T. b. homorus* is slightly darker in color, having a tinge of brownish in the pelage, though it belongs to the gray-colored races usually found in more arid desert sections. Cranially, the differences are well pronounced. *T. b. homorus* has a narrower skull, with a rounder, more elongated braincase. The incisors are less procumbent and the premaxillary tongues extend well beyond the nasals, much farther than any specimen of *T. b. russeolus* examined. The bullae are slightly flatter with less inflation and the hamular processes much more fragile than those of *russeolus.*

Measurements.—*Type*: Total length, 227; tail, 73; hind foot, 30; ear, 5. *Skull* (*type*): Greatest length, 38.5; spread of maxillary arches, 23.2; length of nasals, 12.9; interorbital constriction, 6.4; alveolar length of upper molar series, 8.1.

Range.—Local populations found in suitable localities in hilly sections of extreme northeastern Viscaino Desert from vicinity of Calmallí (alt. 1200 feet) eastward to the summit of the Peninsular backbone near the type locality of this race, Rancho Lagunitas (alt. about 1900 feet).

Remarks.—Specimens from Calmallí were determined as not being typical of the race *T. b. russeolus* when the earlier paper, herein mentioned, was written. These specimens are now found to be nearer *T. b. homorus* and represent the western limits of the range of this race.

Specimens examined.—4 from Calmallí, Baja California; 8 from Rancho Union, 15 miles east of Calmallí, Baja California; 8 from Rancho Lagunitas, (lat. 28° 20′) Baja California. *T. b. russeolus,* 19 from Campo Los Angeles, Viscaino Desert, Baja California.

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THE RELATIONSHIP OF CROTALUS RUBER AND CROTALUS LUCASENSIS

BY

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The close relationship of *Crotalus ruber* and *Crotalus lucasensis* has long been recognized, for both are obviously derived from *Crotalus atrox,* as shown by lepidosis, pattern, and hemipenes. The problem of their relationship would have been settled long ago were it not for the fact that the gap that lies between their ranges is almost inaccessible. This is the Sierra de la Giganta in southern Baja California, along the Gulf of California coast. This range of mountains is quite suitable in character to occupation by either *ruber* or *lucasensis,* but the only north-south road in that section of the peninsula skirts far to the west of these mountains, in a desert not so much to the liking of these diamondbacks. Even so, *lucasensis* has been collected in this desert as far north as Yrais (Hiray), and 8 miles south of El Refugio; and there is a questionable record from 40 miles south of Comondú. *Ruber,* for its part, is found along the shores of Bahía de la Concepión, the most southerly specimen having been taken at the head of the bay, near La Cruces.

In July, 1938, Robert S. Hoard collected a series of 7 diamondbacks, which obviously show intergradational tendencies, at Loreto, near the north end of the Sierra de la Giganta about 60 miles southeast of Las Cruces. I had hoped that further specimens might be forthcoming from elsewhere in these mountains, but, after waiting 10 years without securing more, have now decided to see how strong a case for intergradation may be built upon them. Fortunately, both *ruber* and *lucasensis* are well represented in collections, so that their characters can be firmly established; the scale counts are available for 372 specimens of *ruber* and 348 of *lucasensis.* Of the *ruber* series, 72 are from Baja California, the rest from southern California.

C. ruber and *lucasensis* differ in scutellation and pattern. None of the scale differences is sufficiently restrictive or consistent to be useful as a key character, for there is much overlapping, but we can draw inferences from the trends in the Loreto specimens.

C. lucasensis has fewer scale rows, on the average, than *ruber:* 76 per cent of *lucasensis* have 27 or fewer, whereas 83 per cent of *ruber* have 28 or more. It is to be noted, however, that the Baja California specimens of *ruber* have a reduced percentage with 28 and more, only 65 per cent having the higher number. Of the Loreto specimens, 6 have 27 rows and one 29, thus favoring *lucasensis* in this character.

On the average, *ruber* has about 5 ventrals more than *lucasensis*, the figures being: *ruber* males 193.8, females 197.3; *lucasensis* males 188.8, females 192.6. The Loreto males have 188, 190, 192, 192; and the females 193, 195, and 196. In this respect the Loreto specimens are intermediate, with a slight leaning toward *lucasensis.*

The differences between the species in subcaudals and labials are of insufficient extent to be of value in diagnosis.

C. ruber has a somewhat higher percentage of divided first infralabials than *lucasensis* (91 to 87), and all of these scales in the Loreto specimens are divided; however, *lucasensis*, itself, runs so high in having this division that this cannot be considered of importance. The minimum scales between the supraoculars are slightly higher in *ruber* than *lucasensis* (averages 6.5 and 5.9), and here the Loreto specimens somewhat favor *ruber*, for 3 specimens have 7 scales in this series and the others 8.

The majority of *ruber* specimens have single loreals (mean 1.22 per side), while *lucasensis* usually has 2 or more (mean 1.96 per side). The Loreto specimens have single and paired loreals in equal numbers, so that they are intermediate in this character.

The body blotches in *ruber* average 36.3, in *lucasensis* 29.9. The Loreto specimens number 28, 29, 30 (4 specimens), and 31, thus definitely resembling *lucasensis.*

As to pattern and color, *ruber* tends toward red or red-brown, *lucasensis* toward yellow- or olive-brown.

Of the two, *lucasensis* is lighter and more brightly marked; the light scale rows bordering the dorsal diamonds are more accentuated,* the head marks clearer, and the lateral angles of the blotches sharper, more diamond-like, and less often hexagonal or round as in *ruber*. *C. lucasensis*, more often than *ruber*, has light areas in the centers of the dorsal blotches. Light cross-marks on the supraoculars are more apparent in *lucasensis* than in *ruber;* and the light preocular stripe is wider, being usually 3 or more scales wide

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*This is also true of the desert specimens of *ruber* in San Diego County, California.

(at the second row of scales above the supralabials), rather than 2 or fewer as in *ruber*.

Surveying the 7 Loreto specimens with respect to these criteria, we find them intermediate. In color they are dark red-brown, somewhat more like *ruber* than *lucasensis*, but the light blotch-borders are more prominent than is usual in *ruber*. While the blotch shapes favor *ruber*, the light blotch centers characteristic of *lucasensis* are present, although less accentuated than is customary in the southern species. The light supraocular cross-marks are clearly present in 3 specimens, but faint or absent in the others. The light preocular stripes are clear in all specimens, and in none is the stripe less than 3 scales wide, thus showing an affinity for *lucasensis*.

Summarizing, it is my opinion that the Loreto specimens are intermediate, with a slight leaning toward *lucasensis*. Loreto is only 60 miles southeast of the head of Bahía de la Concepción, where pure *ruber* occurs, although admittedly not precisely the same in all characters as the *ruber* of San Diego County. But at least we now have evidence of an unbroken cline from the Santa Ana Mountains of southern California to Cape San Lucas at the southerly tip of Baja California, and only a single species should be recognized. The northern race should be known as *Crotalus ruber ruber* Cope, 1892; and the southern as *Crotalus ruber lucasensis* Van Denburgh, 1920.

Crotalus r. lucasensis is more like *C. atrox* than is *C. r. ruber*, notwithstanding their separation by the Gulf of California, whereas the *ruber* and *atrox* ranges approach each other closely at several points. Indeed, it is quite likely that they overlap in the vicinity of La Quinta and Indian Wells, Riverside County, California. But there are no suggestions of intergradation either here or at other points where the ranges are closely contiguous. However, I should not be surprised were the future to bring forth an occasional hybrid.

Despite my recent treatment of certain island forms, in considering them subspecies of mainland forms with which they can no longer intergrade, I do not believe it desirable to join *exsul* of Cedros Island with *ruber* of the mainland as a single species. Although the relationship between the two is readily apparent, I think that the known character differences are sufficient in extent to justify a continued specific separation. *C. exsul* is a better-differentiated form than the other island races that I have considered subspecies.

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SOME NEW AND REVIVED SUBSPECIES OF RATTLESNAKES

BY

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TABLE OF CONTENTS

SOME NEW AND REVIVED SUBSPECIES OF RATTLESNAKES

BY

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INTRODUCTION

For the past several years I have been engaged in writing a paper on the habits and life histories of the rattlesnakes. While the proposed paper will not involve a taxonomic study of these snakes, I do hope to include a key and nomenclatorial summary; and in order that the larger work may contain the most recent views respecting the subspecies to be recognized, I think it advisable to publish, first, some conclusions entailing the further subdivision of several hitherto valid forms into additional subspecies, some of which are island races.

A SUBDIVISION OF THE PACIFIC RATTLESNAKE

For some time the Pacific Rattlesnake, *Crotalus viridis oreganus*, has been considered a single subspecies, ranging along the Pacific slope from southern British Columbia into northern Baja California, with an isolated population inhabiting the mountains of central Arizona. I am of the opinion that there would be a practical advantage, facilitating reports and discussions, if further nomenclatorial subdivisions were made in this widespread subspecies, and that such a segregation is warranted by consistent regional differences. No new names are required except for an island form, it being only necessary to retrieve from synonymy some of the names hitherto proposed. The subspecies of the northern Pacific Coast, from south-central California northward, will continue to be known as *Crotalus viridis oreganus* Holbrook, 1840; the southern California and Baja California population will become *C. v. helleri* Meek, 1905; and the Arizona subspecies will be *C. v. cerberus* (Coues), 1875. With regard to the segregation of these populations, it may be said that differences in pattern separate the first pair. When from their centers of distribution—say central Washington and San Diego County, California—it is possible to make allocations that will prove accurate in better than 98 per cent of the individuals, employing the width and color of the posterior tail rings as distinguishing criteria. But the zone of intergradation (and therefore of uncertainty) between the two, in south-central California, is fairly broad, especially in the Coast Range. Also, the differences in the life zones inhabited by these snakes have led to the formation of local varieties, which, while not justifying nomenclatorial recognition, are sufficiently divergent to lead to some confusion and overlapping in defining each subspecies as a whole.

The differences between *helleri* and *cerberus* are based somewhat less on pattern and color, and to a greater extent on average differences in head scales, especially the loreals and the contacts between the first supralabials and the prenasals. In this case there is no intergrading, for the ranges of these two subspecies, at their nearest points, are separated by 200 miles of desert, uninhabitable to them; however, there is some overlapping of the characters used in segregation, and only a subspecific differentiation is warranted, despite the impossibility of territorial intergradation.

The differences between *oreganus* and *helleri* are probably as important and consistent as those between either and other subspecies of *Crotalus viridis* such as *lutosus* and *viridis*. The *helleri-cerberus* differences are somewhat less consistent, but in this case we have the added weight of a complete territorial separation.

To indicate the similarity of the three subspecies in scale-counts and pattern, I have set forth in Table 1 the statistics of three example populations: a series of 615 specimens of *oreganus* from near Pateros, Okanogan County, Washington; 645 of *helleri* from the vicinity of San Diego, California; and 97 of *cerberus* from Arizona. Unfortunately, I have no large series of the latter from a single locality, so that the last series involves some regional variability. Altogether, of the forms previously considered to comprise the single Pacific rattlesnake subspecies *C. v. oreganus*, over 2000 specimens have been available for this study.

In Table 1, it will be observed that there are no important subspecific divergences in these primary characters. The differences are relatively greatest between the *helleri* and *cerberus* tail rings, the coefficients of divergence being, for the males, 34.5 per cent, and for the females 33.8. Actually, however, these differences are of little practical interest, as the tail rings of these subspecies are often too ill-defined to permit accurate counting.

TABLE 1

COMPARISON OF EXAMPLE SERIES OF RATTLESNAKES: MEAN SCALE AND BLOTCH COUNTS

Character	Pateros *oreganus*	San Diego Co. *helleri*	Arizona *cerberus*
Scale rows	25.51	25.45	25.12
Ventral scutes, males	173.31	173.24	171.23
females	177.98	177.97	175.41
Subcaudal scutes, males	22.99	24.00	23.58
females	18.84	19.44	19.07
Supralabials	15.22	15.17	15.47
Infralabials	16.18	16.03	16.03
Body blotches, males	33.20	34.84	35.24
females	33.19	35.39	35.71
Tail rings, males	5.50	4.27	6.05
females	4.47	3.29	4.63

The coefficients of sexual divergence (the difference between the means of each sex, divided by half their sums, expressed as a percentage), are as follows:

Character	Pateros *oreganus*	San Diego Co. *helleri*	Arizona *cerberus*
Ventral scutes*	–2.7	–2.7	–2.4
Subcaudal scutes	19.8	21.0	21.1
Body blotches*	0.0	–1.6	–1.3
Tail rings	20.6	25.9	26.6

It will be observed that these sexual differences are quantitatively consistent throughout the subspecies. The sexual dimorphism in body blotches is found to be negligible, and therefore no sexual segregation will be made in this character in the subsequent discussion.

Since these three subspecies have not hitherto been segregated in published accounts, I present the following descriptions of the forms as newly delimited:

Crotalus viridis oreganus Holbrook

NORTHERN PACIFIC RATTLESNAKE†

Plate 4, fig. 1.

(Alternative names: Pacific Rattlesnake, Oregon Rattlesnake, Northwestern Rattlesnake).

1840. *Crotalus oreganus* Holbrook, North American Herpetology, ed. 1, vol. 4, p. 115. Type locality: Banks of the Oregon or Columbia River [probably between Walla Walla, Wash., and the Pacific Coast]. Type specimen ANSP 7158.

1842. *Crotalus oregonus* Holbrook, North American Herpetology, ed. 2, vol. 3, p. 21.

1852. *Crotalus lucifer* Baird and Girard, Proc. Acad. Nat. Sci. Phila., vol. 6, p. 177. Type locality: Oregon and California. Type specimen: USNM 7762 (Oregon).

1859. *Crotalus lecontei* (part) Hallowell (not of Hallowell, 1852), Pac. RR. Surv. (Williamson route), vol. 10, pt. 4, no. 1, p. 18.

1860. *Caudisona lucifer* Cope, in Mitchell, Smithsonian Cont. Knowl., vol 12, art. 6, p. 121.

1868. *Crotalus Hallowelli* Cooper, in Cronise, Nat. Wealth Calif., p. 483 (*nomen nudum*).

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*Negative values indicate that the female means are higher than the male.

† Among the vernacular names used locally are diamond-back rattler, black diamond, timber rattler, mountain rattler, green timber rattler, green rattler, and gray rattler. The belief is quite general throughout its range that there are two separate species—a lighter, slimmer, lowland form, and a darker, heavier, and more pugnacious mountain species. In many areas the young are called sidewinders, while in others only the lighter, lowland specimens are referred to as sidewinders. However, this subspecies only approaches (but does not overlap) the range of the true sidewinder, *Crotalus cerastes cerastes*, at the southeastern foot of the Tehachapi Mountains.

1883. *Crotalus oregonus* var. *oregonus* Garman, Mem. Mus. Comp. Zoöl., vol. 8, no. 3, p. 173.
1883. *Crotalus oregonus* var. *lucifer* (part) Garman, Mem. Mus. Comp. Zoöl., vol. 8, no. 3, p. 173.
1883. *Crotalus confluentus lucifer* Cope, Proc. Acad. Nat. Sci. Phila., vol. 35, p. 11.
1896. *Crotalus confluentus* (part) Boulenger, Cat. Snakes British Mus., vol. 3, p. 576.
1929. *Crotalus confluentus oreganus* (part) do Amaral, Bull. Antivenin Inst. Amer., vol. 2, no. 4, p. 92.
1936. *Crotalus viridis oreganus* (part) Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.

Diagnosis.—This subspecies is characterized in most areas by a generally lighter color than *helleri* or *cerberus;* and by hexagonal or circular blotches, compared with the diamonds prevalent farther south. It has more sharply outlined head marks and lateral secondary blotches. The dark tail rings are of uniform width and are clearly defined, whereas in the other two subspecies the last dark ring is about twice as wide as the others and is ill-defined. In *oreganus*, especially the juveniles, the terminal tail ring is usually darker than those that precede it, and the matrix of the rattle button is generally black; in *helleri* and most specimens of *cerberus* the terminal tail ring in the juveniles is yellow and so is the button. The rattles are of smaller average dimensions in *oreganus* than in *helleri.* From *viridis viridis* and *nuntius, oreganus* differs in having a wider postocular light stripe and fewer tail rings. It is not vermilion or orange in color like *abyssus*, and has less widely separated body blotches than *lutosus.* It is larger and darker than *decolor.*

Nomenclatorial and Systematic Problems.—For about forty years (1860-1898) the rattlesnakes of the Pacific Coast were referred to the species *lucifer* Baird and Girard, 1852. However, in 1898 (p. 141) Van Denburgh had an opportunity to examine the type of Holbrook's *oreganus*, 1840, and correctly determined that this name must supersede *lucifer*. Garman had deduced the close relationship between the two as early as 1883 (p. 173); and in the same year Cope (p. 11) became convinced of the subspecific relationship between the prairie and Pacific rattlers, as subsequently verified by do Amaral (1929, p. 92) and the writer (1930a, p. 123).

Gill (1903, p. 910) called attention to the previously overlooked fourth volume of the first edition (1836-1840) of Holbrook's North American Herpetology, in which the name of this snake is spelled *oreganus*, instead of *oregonus* as in the second edition of 1842. Holbrook's work has been further discussed by Schmidt and Davis (1941, p. 12) and by Schmidt (1942, p. 53). It is evident that Holbrook was dissatisfied with the imperfections of the first edition of his work and sanctioned the destruction of most of the copies. It may be presumed, from the correction that Holbrook himself made, that the *oreganus* of the first edition is a *lapsus calami* and ought to be changed to the *oregonus* of the second, in accordance with Art. 19 of the International

Rules. However, since *oreganus* has been used almost universally during the past quarter of a century, and as a proposal to modify the rules in cases such as this has recently been discussed,* I deem it inadvisable to make the change at this time.

Redescription of the Type Specimen.—The type specimen is Acad. Nat. Sci. Phila. 7158 (old number 840). It is a juvenile male, badly dried and with the surface skin flaked away. No scale counts can be made with complete assurance of accuracy. There are 25 scale rows at mid-body, about 175 ventrals, and 24 subcaudals. The supralabials are 16—16, and infralabials 15—15; the first infralabials are undivided. The scales contacting the rostral probably number 9 and the scales around the canthus 8. There are probably 4, but may be 3 internasals; the canthals are 2—3. There are about 20 scales on the top of the snout anterior to the supraoculars, and the minimum bridge between is 4+5. There may be a row of small scales between the prenasal and the first supralabial on the right only. The nasals are 2—2 and the loreals 1—1. The postnasals contact the upper preoculars, which are undivided. There are no intergenials or submentals. The rostral is higher than wide. The length over-all is about 337 mm., and the tail length 20 mm. The rattle retains only a single ring, which is badly shrunken.

The body blotches number 32 and the tail rings 3 or 4, all of which are black. While the marks are still to be seen, it is impossible to determine what the dorsal color once was; at present it is a light bluish-gray, with black lines between scales. It was probably heavily mottled below. The postocular light stripe is two scales wide. Holbrook's figure shows a pattern of irregular dark-edged hexagons on a gray-green ground color.

The specimen contains mammal hair.

Material.—This study of the subspecies *oreganus*, as newly defined, is based on the scale counts of 1038 specimens, of which 559 were males, 450 females, and the rest indeterminate. Pattern notes were made on about 150 additional specimens. Because of the large series from near Pateros, Washington,—326 males, 289 females, 615 total—the numerical statistics contained in the description that follows have a northern complexion. I have seen well over 1000 rattlesnakes of this subspecies alive.

Description of Subspecies.—This is a snake of the usual *viridis* habitus. Like the other *viridis* subspecies, it differs from all other rattlesnakes in usually having more than 2 internasals; out of 998 specimens only 13.4 per cent had less than three internasals.

The longest specimen of the series I have studied was a female measuring 1320 mm.; a male of proportionate size would be about 1550 mm. Without doubt 5-foot specimens occur occasionally in some areas. The shortest specimen measured was 221 mm., but specimens under 250 mm. are unusual. It is believed that in most areas the young average about 270 mm. at birth.

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* R. E. Blackwelder, J. B. Knight, and C. W. Sabrosky, Science, vol. 106, no 2753, pp. 315-6, Oct. 3, 1947; vol. 108, no. 2793, pp. 37-38, July 9, 1948. Wichterman, Science, vol. 106, no. 2760, p. 491, Nov. 21, 1947.

In this subspecies individuals having 25 scale rows at mid-body predominate, the distribution in per cent (in parentheses) of those examined being 23(1), 24(1), 25(71), 26(7), 27(20), 28(*), and 29(*). The mean scale rows number 25.44, the coefficient of variation being 3.5 per cent. Specimens having even scale rows at mid-body comprise 7.9 per cent of the total.

The ventrals in the males vary from 161 to 190, although most specimens fall between 168 and 182. The interquartile range is 170.9 to 176.6, the mean 173.72, and the coefficient of variation 2.4 per cent. The ventrals in the females vary from 167 to 194, although most specimens fall between 170 and 189. The interquartile range is 175.4 to 181.1, the mean 178.24, and the coefficient of variation 2.4 per cent. The subcaudals in the males vary from 18 to 29, but most specimens have from 20 to 27; the interquartile range is 22.3 to 24.6, the mean 23.42, and the coefficient of variation 7.2 per cent. The females range from 15 to 24, although few have less than 16 or more than 22; the interquartile range is 17.9 to 20.0, and the mean 18.95, with a coefficient of variation of 8.1 per cent.

The rostral is higher than wide. There are from 1 to 7 internasals, most specimens having 4 (59 per cent), or 3 (20 per cent). Thirteen per cent have 2, and one per cent 1, and would thus fail to key out as belonging to a *viridis* subspecies. The canthals are usually 3—3, but may be 2—2 or 4—4. The scales on the snout, anterior to the supraoculars, range from 10 to 46, the mean being 24.3, and the coefficient ot variation 23.0 per cent. These scales cannot be counted with accuracy in this or any other *viridis* subspecies since there is no well defined line across the anterior edge of the supraoculars such as characterizes *C. scutulatus*, *C. molossus*, and certain other forms of rattlesnakes. The minimum scales bridging the gap between supraoculars vary from 2 to 9, most specimens having 6 (33 per cent), 5 (30 per cent), or 4 (17 per cent). The loreals most often number 2 (54 per cent), or 1 (45 per cent); rarely there are 3, 4, or more. The rostral, first supralabial, and prenasal meet at a point in 80 per cent of the specimens; in 6 per cent there is a group of small extra scales at this point; and in the other 17 per cent these scales are carried back far enough to separate completely the prenasals from the supralabials.

The supralabials range from 11 to 18, but most specimens have from 13 to 17; the interquartile range is from 14.5 to 15.7, the mean 15.08, and the coefficient of variation 5.8 per cent. The most prevalent counts are 15 (48 per cent), 16 (24 per cent), or 14 (20 per cent). The infralabials range from 13 to 20, with an interquartile range of 15.4 to 16.7, a mean of 16.08, and a coefficient of variation of 5.9 per cent. The most frequent counts are 16 (41 per cent), 17 (27 per cent), or 15 (23 per cent). The first infralabials are undivided, and there are normally neither intergenials nor submentals. Usually 3 or 4 infralabials contact the mentals .

The body blotches range from 20 to 41, although most specimens have from 26 to 39. The interquartile range is 31.3 to 34.8, the mean 33.05,

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* Present, but less than one per cent. One freak specimen has 33 scale rows.

and the coefficient of variation 7.8 per cent. The tail rings of the males range from 3 to 10, but nearly all fall between 4 and 7, with a mean of 5.61. The females range from 3 to 8, although only one specimen has 8 and only 4 have 7. The mean is 4.50.

The following pattern description is based on this subspecies as it occurs in the vicinity of the type locality in eastern Washington.

In the juveniles the head is brown on top, somewhat mottled with gray posteriorly. There are two light cross-marks, the first just posterior to the upper edges of the postnasals, the other crossing the supraoculars and the frontal area between. On the sides there is a broad dark stripe from the eye to a point above the commissure. Below this, the side of the head, including the supralabials, is light, except that there are aggregations of brown dots from the prenasal, backward and downward, past the pit, to the labials below the eye. Above, the ocular dark streak is bordered by a light line two scales wide that begins at the upper corner of the eye.

The lower jaw is mostly clear, but the mental and first infralabials are punctated with brown. There is usually a clump of dots on the fourth and fifth infralabials, and another group on the fourth and fifth anterior to the commissure.

In the adult snakes the light cross-lines disappear, the head becoming uniformly brown or olive on top. The upper postocular light stripe also tends to disappear, so that the postocular dark streak merges with the dark color of the upper surface. The side of the head below the postocular dark streak remains light, although considerably punctated anteriorly about the nasals and the pit. The dark postocular streak terminates rather abruptly above the commissure, and there is usually, at the angle of the jaw, a white patch that encroaches onto the top of the head. This, together with the light area anteriorly, gives a characteristic "white-faced" appearance to the snakes of this subspecies in many areas. It is, for example, conspicuous in the adult snakes of the Coast Range of northwestern California, being accentuated in the largest adults.

The body pattern in the juveniles comprises a series of brown dorsal blotches about 11 scale rows in width, separated by light interspaces 1 to 2 scales long. The blotches are darkest at their edges, and also the light areas surrounding them are lightest where they border the blotches. The blotches may be round, square, or hexagonal. Laterally, between each pair of dorsal blotches, there is a slightly darkened area of the ground color, but not dark or definite enough to be considered a subsidiary series of spots. Below these, there are two series (the lower smaller than the one above) of dark auxiliary spots; these are, in fact, darker than the dorsal series. The lowest of these lateral spots mark the outer edge of the ventrals. Between blotches, the lateral areas are buff or clay-color, punctated with brown. The ventrum is cream, buff, or yellow, punctated or mottled with gray or brown, especially posteriorly. The dorsal and lateral blotches merge posteriorly to become cross-bars, and the tail is also crossed or ringed by these bars, the last being the darkest of the series. The last tail ring is no wider than those that precede it. The button matrix is dark, at least anteriorly.

In the adult snakes the lateral secondary spots merge into the ground color, especially anteriorly, so that the lateral areas become almost uniform gray, often with a greenish tinge. The lack of lateral blotches makes the dorsal series the more conspicuous; they are usually brown, and may be round, square, or hexagonal. The light line of scales that edges the dark blotches in the juveniles tends to disappear laterally in the adults. To this extent the snakes of this area resemble *cerberus* rather than *helleri*. Posteriorly, the blotches become darker (dark-brown or even black) and join the lateral series to become cross-bars, or even complete rings. The interspaces are lighter caudad, so that these posterior rings are clearly and definitely outlined, giving a black-and-white effect not evident anteriorly. The last ring is no wider than its fellows, and is, in fact, often narrower, thus differing from *helleri*. The matrix of the proximal rattle is usually black. The ventrum is heavily mottled or punctated with dark-gray, brown, or black, especially toward the tail.

Intrasubspecific Trends.—In this subspecies the snakes having the lowest ventral scale counts are to be found in the vicinity of San Francisco Bay, and those with the highest in the central Sierra Nevada; the difference between the areas is about 12 scales in either sex, the average coefficient of divergence being 7 per cent, which is quite material for an intrasubspecific difference. The snakes of other areas have ventral counts that fall between these two extremes. Specimens from California more often have a single loreal than two, while the reverse is true in Oregon and Washington; also the scales between the supraoculars average lower in California than in the more northerly snakes.

While *oreganus* is quite variable in pattern and color, there are several local phases that are rather consistent and worthy of mention.

Along the northwestern coast of California there is a white-faced variety that is quite distinctive. Probably the center of this phase, where the most conspicuous representatives are found, includes northeastern Sonoma, Lake, and western Colusa counties. In these snakes the area below the dark diagonal line that crosses the eye is unmarked, whereas, in specimens from most other areas, this space on the side of the head is grayish.* Also, there is an expanded light patch posterior to the angle of the mouth, which even encroaches on the normally dark area on top of the head. The dark ocular streak in these snakes merges uninterruptedly with the dark fronto-parietal area, whereas, in most populations of *oreganus*, there is usually a light streak between. This white-faced effect is not evident in the juveniles, but comes on gradually with age. It is usually present in the snakes of Oregon and Washington, but not to so conspicuous a degree as in northwestern California.

Another color phase is to be found at the south end of the San Joaquin Valley, particularly along the more arid west side. Here the snakes are

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* This darkening is particularly evident near the pit, below the light streak that comprises the lower border of the dark ocular stripe.

considerably lighter than elsewhere, the ground color being yellowish or tan, and the blotches brown. There is a brown patch on top of the head, with ill-defined outlines. In both color and pattern these snakes are reminiscent of *lutosus*. They merge with the more normally paterned *oreganus* in the foothills or mountains bordering the valley.

In the Marysville Buttes, Sutter County, there is a phase that is markedly green in color, and white-faced as well. The tail rings, however, are sharply contrasting black and white.

I have heard of a red phase occurring in the Trinity Mountains, but have not seen any that answered this description, although some of the snakes of that area have large red-brown dorsal blotches. In the southern Sierra Nevada the specimens from the higher altitudes are darker than those from the foothills; the dorsal blotches are black, just as is the case with *helleri* in the mountains of southern California. An altitude of at least 11,000 feet is reached by *oreganus* in Fresno and the adjacent counties of the southern Sierra Nevada.

Intersubspecific Relationships and Areas of Intergradation.—*C. v. oreganus* intergrades with three of the other *viridis* subspecies—*viridis viridis*, *lutosus*, and *helleri*. All of these are much alike in scale counts and scale arrangements, the differences in squamation between them being no greater than some of the differences found to exist between certain of the local population segments that comprise each subspecies as an entity. The dependable subspecific differences are largely matters of pattern, such as the narrow postocular light stripe and numerous tail rings that characterize *viridis*; the drab ground color, short dorsal blotches, and obsolescent lateral spots of *lutosus*; the larger and darker blotches of *oreganus*, and its wider postocular light stripe (compared to *viridis*); and the wide posterior tail ring of *helleri*.

From these criteria it is evident that *oreganus* is intermediate between *lutosus* and *helleri*. While the northeastern specimens show some slight effect from the direct *viridis* contact, the *oreganus-viridis* relationship is not as close as that of *oreganus* with *lutosus*. *C. v. helleri* was probably derived from *oreganus*, although it may represent an independent invader from an ancestral form in southern Arizona, with a subsequent meeting and re-amalgamation in the central California area where *oreganus* and *helleri* now intergrade.

The direct contact between *oreganus* and *viridis viridis* is a rather tenuous one, the only certain connection being along the Salmon River in central Idaho. The subspecies *viridis* is found in the Lemhi Valley, but in a phase already somewhat modified from the more typical *viridis* of the main body across the Continental Divide in extreme western Montana. As we pass down the Lemhi and Salmon rivers, along which rattlers occur, there is noted a gradual change from *viridis* to *oreganus*, until, eventually, quite typical *oreganus* is encountered in the vicinity of Florence and Riggins, Idaho County, Idaho. There may be a similar connection down the Selway River. The forest rangers of that area agree that the rattlesnakes are largely restricted to the water courses.

The band of intergradation between *oreganus* and *lutosus* is a much broader one. It begins in western Idaho near Council and Payette, and runs westerly through eastern Oregon, past Malheur Lake to the Cascades. Thence it turns south along the crest of the Cascades to the California line, and from there southeastward following the crest of the Sierra Nevada. Along this boundary, where the mountain passes are low, there is intergradation; where the barriers are high there is none. The broadest contacts are probably to be found in western Modoc and Lassen counties, California. At any rate, the continuing subspecific relationship of *oreganus* with *lutosus* is established by the presence of intergrades at a number of localities along this boundary, such as Council, Adams County, Idaho; between Pleasant Valley and Durkee, Baker County, Owyhee, Malheur County, Camp Harney and Princeton, Harney County, and Summer Lake, Deschutes County, Oregon; and Alturas, Modoc County, California. It should be understood that these localities are not to be taken as establishing a sharp line between the subspecies; rather, they are localities from which intergrades have been noted, but they represent only a few points in a broad band of intergradation and may lie near either the *oreganus* or *lutosus* edge of this band.

Whether *oreganus* filters through any of the mountain passes south of Lassen County, California, to intergrade with *lutosus*, I do not know. This could occur as far south as Mono County, for *lutosus*, in typical form, is common in the foothills west of Mono Lake. Rattlers are said to be absent from the vicinity of Lake Tahoe, but I have records that indicate the continued presence of a few specimens in that vicinity, and I suspect that intergradation may occur northwest of the lake, and also to the south. One small specimen in the collection of the University of California (MVZ 17022), from 6 miles north of Fernley, Washoe County, Nevada, has a pattern somewhat more like *oreganus* than *lutosus;* however, this is far into *lutosus* territory and, in the absence of others showing this peculiarity, is to be deemed only a non-modal *lutosus*.

To determine the areas of intergradation between *oreganus* and *helleri*, it is necessary to restate the differences and note that there are several sequences by which one may be transformed into the other. At all ages *oreganus* has uniformly dark and narrow terminal tail rings, and the anterior lobe of the rattle matrix is black. In *helleri* the last tail ring is about twice as wide as the rings that precede it, from which one may deduce that it really comprises two rings fused together, as, indeed, is verified by a study of intergrades. In addition, this wide terminal ring is bright-yellow when the snakes are young, turning to gray, or even black, as they age. The same color change affects the anterior lobe of the rattle matrix. In general, in *oreganus* the final tail rings are darker than those that precede them, while in *helleri* the final ring, at least, is lighter.

In a Sierran area of intergradation, particularly in Kern County but also to some extent in Fresno County, the intergrades, when juvenile, have dark terminal rings and rattle matrices—in color they are *oreganus*. But there is a tendency here toward a narrowing of the light space between the last two tail rings, this light space being invaded by dark punctations, particularly on the dorsum. As the snakes age, this separating light ring is further narrowed and obscured by the dark adjacent rings, with the result that a snake, which as a juvenile was clearly *oreganus*, might, as an adult, be allocated to *helleri*. Specimens showing this tendency, particularly the partial obliteration of the final light interspace, became increasingly evident from Madera County southward, although they are hardly an appreciable part of the population until at least as far south as Kern County. I have examined 37 specimens from various points in Kern County and found that only 4, whether from the mountain areas or the floor of the San Joaquin Valley, were nearer *helleri* than *oreganus*. The Antelope Valley, a westerly extension of the Mohave Desert, forms a wedge in the *oreganus-helleri* range, for neither form is found on the floor of the desert. Since almost pure *oreganus* inhabits the Tehachapi Mountains to the northwest of this valley, and pure *helleri* the San Gabriel Mountains to the southwest, it is logical to expect intergradation at the point where these mountains meet, that is, in the vicinity of Fort Tejon and Lebec in extreme southern Kern County, and this is found to be the case. This, then, may be taken as a starting point of the boundary between the subspecies.

In the Coast Range, the *helleri* influence is important much farther north than in the Sierra Nevada. This is especially true in the ranges bordering the Pacific—that is, the Santa Cruz and Santa Lucia mountains. A considerable proportion of the juvenile snakes found in San Mateo, Santa Cruz, and western Santa Clara counties have yellowish tails, although this character is virtually absent on the eastern side of San Francisco Bay and the Santa Clara Valley, in Contra Costa, Alameda, and eastern Santa Clara counties. These northern specimens possessing this *helleri* character usually have the yellow tail bar split transversely by a white ring, with the result that they would key out as *oreganus* when adult, after the yellow has turned to gray or black, and would, in fact, as juveniles also, if the width of the last ring were given precedence over the color of the last two.

Tabulating the available material (48 specimens), I find that, while some specimens from San Mateo, Santa Cruz, and Santa Clara counties will key out as *helleri*, especially the juveniles, the majority are *oreganus*, and I therefore assign these areas to the latter subspecies. From Monterey and San Luis Obispo counties I have had an insufficient number of specimens (18) to draw any final conclusions. Probably these represent areas of a fairly even balance between the forms. The specimens from along the edge of the San Joaquin Valley are usually *oreganus*, and those that I have seen from Santa Barbara County were all *helleri*. Tentatively I should fix the approximate boundary between the two subspecies as a line from Lebec, Kern County, via the Carrizo Plain to Shandon, San Luis Obispo County, and thence to the northwestern corner of that county. By such a line I do not, of course, suggest that this really separates the subspecies; rather, it is my intention to indicate that south of this line *helleri* will predominate, and north, *oreganus*.

One might presume, from the stress that I put on the pattern of the tail, that this is a minor difference upon which to justify the segregation of two subspecies. But other differences of pattern are also apparent, although less easily defined and therefore less useful in a key. And, although the tail-band criterion is troublesome in intermediate territory, as is always the case with characters defining intergrading forms, it will correctly segregate practically every specimen from the areas where the subspecies are typical, that is, *oreganus* in northern California, Oregon, Washington, British Columbia, and western Idaho; and *helleri* in southern California and Baja California.

Range.—*C. v. oreganus* ranges along, or close to, the Pacific Coast, from British Columbia to south-central California. It is the only rattlesnake occurring in British Columbia or Washington; and it is the only rattler found throughout the rest of its range—neglecting intergradation with other *viridis* subspecies—although there may be a narrow overlap with *C. mitchellii stephensi* through the Sierra Nevada passes along the southern border between Tulare and Inyo counties, and a similar fringe overlap with *C. s. scutulatus* and *C. c. cerastes* in the desert foothills southeast of the Tehachapi Range in Kern County, California.

In British Columbia, *oreganus* occurs from the line Lillooet-Hat Creek-Kamloops-Shuswap Lake, south to the U. S. border, with an eastward extension just north of the border to Christina Lake and possibly Waneta. I have had no reports of specimens in the vicinity of Yale or Hope, or from these points south or southeast to the border.

In Washington, *oreganus* occurs only to the east of the Cascade Range. Along the Columbia River it has penetrated as far west as Carson, Skamania County. East of the Cascades it seems to range throughout the state; however, it is absent from the extreme northeast; at least I have no records from Pend Oreille County or eastern Spokane County.

In Idaho, *oreganus* ranges along the western border from the southern end of Lake Coeur d'Alene south to near Council and Weiser, in the vicinity of which there is intergradation with *lutosus*. Also, from this westerly fringe there are extensions eastward up the Clearwater and Salmon rivers and their tributaries toward narrow areas of intergradation with *viridis viridis*.

In Oregon, *oreganus* occupies the northern and western sections of the state; the southeast, with the limits that I have discussed under intergradation, being inhabited by *lutosus*. In the northern part of the state, *oreganus* is plentiful on the lower east slopes of the Cascades, and thence eastward across the state, but to the west it is not so prevalent, although scattered through the Willamette Valley, at least from Cottage Grove north to Amity. It is apparently absent between the Willamette Valley and the coast. South of Cottage Grove it is increasingly plentiful in the mountains that lie between the crest of the Cascades and the coast, the unoccupied coastal area gradually narrowing until it almost disappears at the California line.

In California, *oreganus* occurs everywhere west of the Sierra Nevada and its area of intergradation with *lutosus* through the passes of that range, as discussed elsewhere, and north of its area of intergradation with *helleri*. It is seldom found in the coastal redwood belt from Sonoma County northward through Mendocino, Humboldt, and Del Norte counties; yet an occasional stray, possibly carried seaward by a river flood, is picked up in this section, sometimes within 10 miles or less of the coast. The subspecies, however, seems unable to establish itself permanently in the coastal redwood belt. There are large areas in the state, especially in the Central Valley and the coastal valleys, and about centers of population, where rattlers have now become exterminated; but these were once occupied, as their continued presence in adjacent parks and wildlife refuges demonstrates.

This subspecies occurs on Morro Rock, a small rocky island off the coast of San Luis Obispo County, now connected by an artificial causeway with the mainland. Such specimens as I have seen from the island were apparently stunted.

Crotalus viridis helleri Meek

SOUTHERN PACIFIC RATTLESNAKE*

Plate 4, fig. 2.

1859. *Crotalus lecontei* (part) Hallowell (not of Hallowell, 1852). Pac. RR. Surv. (Williamson route), vol. 10, pt. 4, no. 1, p. 18.
1859. *Crotalus lucifer* Cope, Proc. Acad. Nat. Sci. Phila., vol. 11, p. 337.
1863. *Crotalus adamanteus* var. *lucifer* Jan, Elenco. Sist. degli Ofidi, p. 124.
1870. *Crotalus Hallowelli* Cooper, Proc. Cal. Acad. Sci., vol. 4, part 2, pp. 64, 68 (*nomen nudum*).
1883. *Crotalus confluentus* var. *lucifer* (part) Cope, Proc. Acad. Nat. Sci. Phila., vol. 35, p. 11.
1883. *Crotalus oregonus* var. *lucifer* (part), Garman, Mem. Mus. Comp. Zoöl., vol. 8, no. 3, p. 173.
1898. *Crotalus oregonus* (part) Van Denburgh, Proc. Amer. Philos. Soc., vol. 37, no. 157, p. 141.
1905. *Crotalus helleri* Meek, Field Col. Mus., Zoöl. Ser., vol. 7, no. 1, pub. 104, p. 17. Type locality: San José [Lat. 31° N.], Baja California. Type specimen: CNHM 1272; paratypes: CNHM 1727 (3).
1917. *Crotalus oreganus* (part) Grinnell and Camp, Univ. Calif. Pubs. in Zoöl., vol. 17, no. 10, p. 194.
1929. *Crotalus confluentus oreganus* (part) do Amaral, Bull. Antivenin Inst. Amer., vol. 2, no. 4, p. 92.
1936. *Crotalus viridis oreganus* (part) Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.

Diagnosis.—This subspecies usually has diamonds on the back, instead of hexagons as in *oreganus*. The last dark tail ring in the adults is more than

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* Has such alternative local names as black diamond-back, gray diamond-back, Pacific rattler, San Diegan rattler, timber rattler, black rattler, and mountain rattler. Young specimens are often referred to as sidewinders.

1½ times as wide as the preceding dark ring, while in *oreganus* the rings are equal. In the juveniles the end of the tail in *helleri* has a wide yellow ring, gradually turning to gray or black as the snakes age; in *oreganus* the terminal cross-band is dark from birth and is no wider than the rings that precede it on the tail. The button matrix is usually yellow in juvenile *helleri* and black in *oreganus.*

C. v. helleri differs from *cerberus* in having a single row of light scales completely bordering the dorsal diamonds, whereas in *cerberus* the dorsal blotches laterally merge directly into the ground color. A majority of specimens of *helleri* have single loreals, while *cerberus* has two. Most *helleri* specimens have no scales between the prenasal and the first supralabial at the rostral; in *cerberus* such scales are generally present, at least at the rostral. The differences from the other *viridis* subspecies are similar to those cited under *oreganus.*

Nomenclatorial and Systematic Problems.—If the subspecies of *Crotalus viridis* found in southern California and Baja California is to be separated from the snakes of the northwest and Arizona, *helleri* Meek, 1905, is the oldest available name, although Meek described it as new only because of his unfamiliarity with the snakes of the San Diegan region; for those of the type locality differ in no important particular from the San Diegan snakes, which were well known (as *C. lucifer*) in 1905. It is to be regretted that the long-used name *lucifer* cannot be revived for the southern race, but although Baird and Girard did not originally specify a type in 1852 (the type locality was given as Oregon and California), and specimens from southern California may have been available to them, they did set up a type, from Oregon, in 1853 (p. 8). *C. lecontei* of Hallowell, 1859, although in part from southern California, is not available, as the original description (Hallowell, 1852) was based on a specimen of *C. v. viridis* from Cross Timbers, in what is now Oklahoma (Stejneger, in do Amaral, 1929, p. 87). *Crotalus hallowelli* of Cooper, 1868, cannot with certainty be assigned to southern California, and besides is a *nomen nudum.* This I have cited under the synonymy of *oreganus*, since he mentions its presence in the Sierras. Cooper's second mention of *hallowelli* (1870, pp. 64, 68) leaves little doubt that he had in mind the Pacific Coast subspecies of *viridis*, since only this snake is present in both the Sierras and the San Diegan region. As the first mention (1868) referred to the Sierran range, it is probable that the name, if valid, would have to be assigned to the northern race, for which it would be preceded by both *oreganus* and *lucifer.* But, in any case, it is a *nomen nudum* for lack of a type specimen, type locality, or any description. This is to be regretted, as Hallowell's distinguished work on the herpetology of the West might well be recognized by associating his name with this snake. Cooper, in his 1870 paper, by the use of the initials Cp. after the name *Crotalus Hallowelli*, indicated that he considered himself the describer. He must have known that neither the mention of the snake in Cronise's book nor in his 1870 paper constituted description, from which one may infer that he actually presented the description in a paper that remained unpublished or that has been overlooked.

Redescription of the Type Specimen.—The type specimen is CNHM (formerly Field Museum) 1272, from San José (Lat. 31° N.), Baja California. Comparing it with specimens from Meling's Ranch at San José, I should say, from its dark color, that it was probably collected on the mountain slope to the east. It is an adult male, with a length over-all of 957 mm., and a tail length of 60 mm. The scale rows at mid-body are 25, ventrals 173, and subcaudals 25. All supra- and infralabials number 15. The rostral is higher than wide; it contacts 8 scales. The internasals number 4 and the canthals 2—3. The minimum scales between the supraoculars are 5+5. There are no small scales touching the rostral between the first supralabials and the prenasals. The junction of the postcanthals and the loreals prevents a contact between the postnasals and the upper preoculars, which are undivided. There are 2 to 3 scale rows between the supralabials and the orbit.

The head is almost black, both the supraocular and postocular light marks being obsolete. There are 32 body diamonds, and 4 rings on the tail, the last being wide and black. The body blotches are quite black anteriorly and somewhat brownish toward the tail; they are outlined by straw-colored single rows of scales.

There are 5 rattles, a broken string.

Material.—The description which follows is based on 892 mainland specimens, of which 645 were from San Diego County. There were 473 males and 399 females, the rest being heads, skins, or otherwise indeterminate. There have been 22 specimens available from Santa Catalina Island. I believe I have seen well over 3000 rattlesnakes of this subspecies alive.

Description of Subspecies.—This is a snake of the usual *viridis* shape. Like other subspecies of *viridis*, it differs from all other rattlesnakes in usually having more than 2 internasals; in 893 specimens, 81, or 9.1 per cent, had 2 internasals or less.

The longest specimen I have measured was 1371 mm. It is thought that fully adult males are usually about 1200 mm. in length. At birth the young specimens normally measure about 275 mm., although occasionally they are as short as 225 mm.

Most specimens of this subspecies have 25 scale rows at mid-body, the distribution in per cent being 23(1), 24(1), 25(71), 26(5), 27(21), 28(*), 29(1). The mean is 25.43 and the coefficient of variation 3.6 per cent.

The ventrals in the males vary from 162 to 184, but all but a very few specimens fall between 166 and 181. The interquartile range is 171.2 to 176.1, the mean 173.67, and the coefficient of variation 2.1 per cent. The ventrals in the females vary from 166 to 189, although most specimens fall between 170 and 187. The interquartile range is 175.7 to 180.7, the mean 178.23, and the coefficient of variation 2.1 per cent. The subcaudals in the males vary from 19 to 29, all but a few specimens falling between 21 and 27; the

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* Present, but less than 1 per cent.

interquartile range is 23.0 to 25.1, the mean 24.08, and the coefficient of variation 6.3 per cent. The females range from 15 to 25, with all but a few specimens falling within the range 16 to 23; the interquartile range is 18.3 to 20.5, the mean 19.39 and the coefficient of variation 8.4 per cent.

The rostral is higher than wide. There are from 1 to 8 internasals; most specimens have 4 (73 per cent), 3 (15 per cent), or 2 (9 per cent). The canthals usually number 2 on each side, but are often 3, or rarely 4. The scales on the snout, anterior to the supraoculars, range from 7 to 45, although most specimens fall between 13 and 33. The mean is 23.4 and the coefficient of variation 22.1 per cent. These scales cannot be counted with particular accuracy in this subspecies since there is no well-defined line at the anterior edge of the supraoculars. The minimum scales bridging the gap between the supraoculars vary from 1 to 9, most specimens having 4 (34 per cent), 5 (28 per cent), 6 (17 per cent), or 3 (12 per cent). The loreals most often number 1 (82 per cent), or 2 (18 per cent). An occasional specimen may have 3. In this subspecies, in 69 per cent of the specimens, the prenasal touches the first supralabial at their common point of contact with the rostral; however, in 17 per cent of the specimens there is an extra scale or two at this tripartite junction, and in the other 14 per cent a complete row of small scales separates the prenasal from the initial supralabial.

The supralabials range from 12 to 18; the interquartile range is from 14.8 to 16.1, the mean 15.14, and the coefficient of variation 6.3 per cent. The most prevalent counts are 15 (46 per cent), 16 (26 per cent), or 14 (20 per cent). The infralabials range from 13 to 20, with an interquartile range of 15.3 to 16.6, a mean of 15.96, and a coefficient of variation of 6.1 per cent. The most frequent counts are 16 (41 per cent), 15 (25 per cent), or 17 (24 per cent). The first infralabials are undivided, and neither intergenials nor submentals are usually present.

The body blotches vary from 27 to 43, nearly all specimens falling between 29 and 41. The interquartile range is 33.5 to 36.8, the mean 35.14, and the coefficient of variation 7.0 per cent. The tail rings in the males range from 3 to 8, with a mean of 4.52, and in the females from 2 to 6, with a mean of 3.44.

In the young of this subspecies the colors are sharply contrasting. The head is dark-brown above, with a light mark across the supraoculars and the frontal area. There is often a second thinner line across the head at the posterior ends of the central internasals, and a light longitudinal line joining the two cross-lines. The rostral is usually edged with light, but is otherwise dark-brown. On the side of the head a wide light stripe passes backward and downward, just touching the lower edge of the orbit; it widens at the supralabials, so that these are light from below the center of the eye backward almost to the commissure. Bordering this light streak above, there is a wide dark streak from the eye to the commissure, and this in turn is bordered above by a light streak two scales wide, which starts at the posterior outer edge of the supraocular, and is directed backward and downward to the angle of the jaw. On the underside, the mental and first supralabials are dark, and so are the genials along their line of contact. The posterior infralabials may all be spotted, or some may be clear. There is often a collection of spots marking the gulars, anterior to the first ventrals. All dark areas on the head are usually chocolate-brown; the light are cream or buff.

As the snakes age, the light head marks gradually disappear, until, in the adults, only the preocular light streak is left and even this is often obscured by punctations. Thus the head becomes uniform dark-brown or black above, and quite dark on the sides. The markings of the lower jaw are little changed with age.

A somewhat similar change takes place in the body marks, the juveniles being clearly marked, while the adults are duller and darker.

In the young the pattern comprises a series of dark-brown blotches, about 9 or 11 scale rows wide, separated by interspaces of buff or light-gray extending over 1½ to 2 scales end-to-end. The blotches are rather irregular, but are usually diamonds or hexagons. They are slightly lighter in the centers than on the edges, and are bordered with light scales, laterally as well as dorsally. On the sides, between blotches, there are brown areas which may be considered a first secondary series, or may be viewed as patches of ground color. Below these there are one or two other series of darker-brown and more evenly edged secondaries. The lowest touch the outer edges of the ventrals, which are mottled or punctated with dark, especially toward the tail, on a buff or yellow background.

Toward the tail the dorsal blotches tend to merge with the secondaries to become dark cross-bands. However, the last tail band, having about twice the width of those that precede it, is bright-yellow in color, and so is the matrix of the button.

As the snakes age the contrast between the light and dark areas is less accentuated, only the light scales that border the dorsal blotches remaining fairly clear, although even these are often darkened at the anterior end of each scale. These light blotch-borders remain in evidence, not only middorsally, but laterally as well; in this respect, this subspecies differs from *cerberus*. The yellow terminal tail ring of the juveniles, so conspicuously different from the rest of the coloration, gradually darkens, beginning at about the time the second rattle is acquired, until, when the snake is fully grown, it is dark-gray or black, and thus does not differ from the preceding rings, except that it retains its double width. In the adults, in some areas, a faint light ring may suggest the beginning of a division of this terminal ring, thus suggesting the relationship with *oreganus*. The blotches in the adults are often black, compared with the dark-brown of the juveniles; and the reduction of the light areas between blotches makes the adults generally darker. This is accentuated in mountain specimens.

This description is based primarily on the snakes of the San Diegan area.

Intrasubspecific Trends.—*C. v. helleri* has a smaller and more uniform range, ecologically speaking, than either *oreganus* or *cerberus;* and, as might be expected, is more homogeneous. There is a slight tendency toward a higher number of ventral plates and a greater subdivision of the head scales, as one proceeds northward and westward. A similar moderate increase is to be observed in the number of body blotches. Contrasting with those from the lowlands, specimens from the mountains are generally darker, often almost black, thus justifying the popular name, black diamond.

The few individuals available from the desert foothills are decidedly light-colored. One of the two southernmost specimens—that from Playa María Bay, Baja California—has some peculiarities of pattern, particularly in the head marks and the way in which the tail rings are interrupted laterally in a manner reminiscent of *exsul*. It is conspicuously light in color. The other, from northwest of Bahía Angeles on the Gulf coast, is peculiar in having long, narrow blotches on the neck.

Intersubspecific Relationships.—*C. v. helleri* contacts no subspecies of *viridis* other than *oreganus*, intergradation with which has already been discussed. Although *helleri* no longer has a physical contact with *cerberus*, its relationship with that subspecies seems as close as with *oreganus*, since occasional specimens will be found in the territory of either that are quite like the mode in the other. In fact, it is to be noted that *helleri* and *cerberus* are alike in the character that I have used to separate *helleri* from *oreganus*, that is, the width and color of the posterior tail rings. These and other similarities are evidence that there must at one time have been a direct contact of the two populations across the area now occupied by the Colorado and Yuma deserts. *C. v. helleri* is more closely related to *oreganus* and *cerberus* than to any other *viridis* subspecies.

Range.—*C. v. helleri* is found only in southern California and northern Baja California. The area of intergradation with *oreganus* has already been discussed (p. 74). *C. v. helleri* is the sole subspecies of the western rattlesnake, *Crotalus viridis*, occurring in southern California. Neglecting areas of intergradation with *oreganus*, it is found from the north line of Santa Barbara, Ventura, and Los Angeles counties, southward through southwestern San Bernardino, Orange, western Riverside, San Diego, and extreme southwestern Imperial counties, into Baja California, where it occurs as far south as Latitude 29 N. In this area, except where it has been exterminated by the encroachment of cities and intensive agricultural developments, it is quite common from the coast across the mountains. In the desert foothills it becomes increasingly rare as the descent is made to the desert itself, and in the desert it is absent. Altitudinally it ranges from sea level to the peaks of the highest mountains. It has been collected a few feet below the peak of San Jacinto (10,805 ft.), and as only one mountain (San Gorgonio, 11,485 ft.) within the *helleri* range is higher, it may be assumed that altitude is nowhere a serious impediment to its occupancy.

In Baja California it has been taken at a large number of points from the coast to the crest of the Sierra Juárez and Sierra San Pedro Mártir, and as far south as Socorro (Lat. 33° 20′ N.). No specimens are yet available from the desert slopes of these mountains, but no doubt it occurs there sporadically, as it does in California. South of Socorro two specimens have been taken; one at Playa María Bay, some 120 miles below Socorro, on the Pacific side; the other, 10 miles northwest of Bahía Angeles on the Gulf of California side, a rather surprising find in such arid surroundings, for it was taken by Lewis W. Walker in desert mountains, amid an elephant-tree association.

C. v. helleri occurs on Santa Catalina Island, Los Angeles County.

Crotalus viridis cerberus (Coues)

ARIZONA BLACK RATTLESNAKE*

Plate 5, fig. 1.

1866. *Caudisona confluenta* var. *confluenta* (part) Cope, Proc. Acad. Nat. Sci. Phila., vol. 18, p. 307.
1866. *Caudisona lucifer* Cope, Proc. Acad. Nat. Sci. Phila., vol. 18, p. 307.
1875. *Crotalus lucifer* (part) Yarrow, Surv. W. of 100th Mer. [Wheeler], p. 529.
1875. *Crotalus confluentus* (part) Yarrow, Surv. W. of 100th Mer. [Wheeler], p. 530.
1875. *Caudisona confluenta* (part) Coues, Surv. W. of 100th Mer. [Wheeler], p. 604.
1875. *Caudisona lucifer* var. *cerberus* Coues, Surv. W. of 100th Mer. [Wheeler], p. 606. Type locality: San Francisco Mountains, Coconino County, Arizona. Type specimens: Field numbers 509 (=ANSP 7085?) and 511 (=ANSP 7088).
1883. *Crotalus lucifer* (part) Yarrow, Bull. U. S. Nat. Mus., no. 24, p. 76.
1883. *Crotalus oregonus* var. *cerberus* Garman, Mem. Mus. Comp. Zoöl., vol. 8, no. 3, p. 173.
1913. *Crotalus oregonus* Van Denburgh and Slevin, Proc. Cal. Acad. Sci., ser. 4, vol. 3, p. 428.
1917. *Crotalus oreganus* (part) Grinnell and Camp, Univ. Calif. Pubs. in Zoöl., vol. 17, no. 10, p. 194.
1930. *Crotalus confluentus oreganus* (part) Klauber, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 3, p. 130†
1936. *Crotalus viridis oreganus* (part) Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.

Diagnosis.—*Cerberus* is a subspecies characterized by its dark color and a marked subdivision of the scales of the snout. It differs from the newly delimited *oreganus* and *helleri*, with which it was formerly merged under the name *oreganus*, in usually having paired loreals (Klauber 1930b, plate 1, fig. 2), while they have single loreals (figs. 1, 3, or 4). Also, most specimens of *cerberus* have one or more scales at the rostral between the anterior nasal and the first supralabial (*loc. cit.*, fig. 6 or 7), while such

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* Has the alternative local names of brown rattlesnake, black rattlesnake, black diamond, mountain diamond-back.

† Do Amaral (1929, p. 95) considered the Arizona specimens to be *confluentus* (= *viridis*) x *oreganus* intergrades.

scales are usually absent in *helleri* and *oreganus* (fig. 5). *C. v. cerberus* has a wider terminal dark tail ring than *oreganus*. The dorsal body blotches are without lateral light borders, such as are generally present in *helleri*.

Nomenclatorial and Systematic Problems.—While Coues did not describe his new subspecies, *cerberus*, except to call attention to its black head, he did specify type specimens, so there is no question as to the validity of his name, if segregation from the California forms be justified, as I now believe to be the case.

There is some uncertainty with respect to these types of *cerberus*. Coues had at least six specimens from the San Francisco Mountains and Fort Whipple. Four he assigned to *Caudisona lucifer*. At least one of these must have been *molossus*, judging by his description; of the others, two, ANSP 7086 (original number 510) and ANSP 7087 (original number 572?), are *cerberus*, but were not assigned by Coues to his new subspecies, as they were browner than the types. But it is now known that there is some color variation in the snakes of the type locality.

Coues mentioned only two types by number, although stating that he had others from the type locality. Of these two cotypes, No. 511 is now ANSP 7088, and 509 is believed to be ANSP 7085. Since Coues did not describe his types, no comparisons with his descriptions can be made. The following descriptions are of these two, imperfect as they are.

Redescription of the Type Specimens.—ANSP 7085 is a skin in rather poor condition. It is a male with a length of about 850 mm. The scale rows at mid-body are 27, ventrals 167, subcaudals 26. The supralabials number 17, the internasals 6; there are 14 scales in contact with the rostral. Although the prenasals touch the rostral, they are separated from the first supralabials, as is characteristic of this subspecies. There are two loreals on each side. The intersupraoculars number 7+9.

There are 5 tail rings, all black. The body blotches cannot be counted accurately. They are quite black, and, in fact, the entire dorsal surface is almost black, except for a few straw-colored scales between the blotches, mid-dorsally.

There are six rattles, an incomplete string; the width of the proximal rattle is 15.5 mm.

Of ANSP 7088 only the head and neck remain. The supralabials are 16—15 and infralabials 15—15. There are 9 scales around the rostral, which is higher than wide. There are 5 internasals, which come well down the sides but do not completely separate the rostral from either prenasal. The prenasals are not separated from the anterior supralabials, nor are there extra scales at the rostral-prenasal-supralabial junction. The canthals are 4—4; there are about 45 scales before the supraoculars, and 3+5 scales between. The loreals are paired.

The head is brown, the usual marks being obsolete. The initial dorsal blotches are brown, with dark punctations.

Material.—Of this subspecies 98 specimens have been available for study, one from New Mexico, the rest from Arizona. Several additional specimens with questionable locality data have been omitted from the statistics of the description that follows. Some 50 snakes have been seen alive.

Description of Subspecies.—This is a snake of average *viridis* proportions. Like others of the *viridis* subspecies, it differs from all other rattlesnakes in usually having more than 2 internasals; only 2 per cent of this subspecies have 2 internasals.

The longest specimen of the series I have studied is a male measuring 1032 mm.; the shortest 287 mm. I have a brood that is presumably of this subspecies, but not certainly, as there were several mothers in the cage when they were born. Of this brood of 13, the shortest is 265 mm., the longest 288 mm., and the mean 273 mm.

Most specimens of this subspecies have 25 scale rows at mid-body, the distribution in per cent (in parentheses) being 23(4), 24(6), 25(76), 26(2), 27(12). The mean scale rows are 25.12, the coefficient of variation is 3.4 per cent.

The ventrals in the males vary from 161 to 180, although most specimens fall between 166 and 176. The interquartile range is 168.6 to 173.9, the mean 171.23, and the coefficient of variation 2.3 per cent. The ventrals in the females vary from 164 to 184, although most specimens fall between 171 and 183. The interquartile range is 172.1 to 178.7, the mean 175.41, and the coefficient of variation 2.8 per cent. The subcaudals in the males vary from 20 to 26, interquartile range 22.6 to 24.5, mean 23.58, coefficient of variation 5.9 per cent; the females range from 16 to 24, interquartile range 17.7 to 20.5, mean 19.07, coefficient of variation 10.9 per cent.

The rostral is higher than wide. There are from 2 to 8 internasals; most specimens have 4 (59 per cent), 3 (20 per cent), or 5 (11 per cent). Only two per cent have 2, and would thus fail to key out as a *viridis* subspecies. The canthals are usually 3—3, but are often 2—2 or 4—4. The scales on the snout, anterior to the supraoculars, range from about 20 to 50, the mean being 35, and the coefficient of variation 20.4 per cent. These scales cannot be counted with accuracy in this subspecies since there is no well-defined line at the anterior edge of the supraoculars, thus differing from *C. scutulatus* and certain other forms of rattlesnakes that have definite boundaries between the prefrontal and frontal areas. The minimum scales bridging the gap between the supraoculars vary from 2 to 9, most specimens having 6 (26 per cent), 5 (24 per cent), or 7 (21 per cent). The loreals most often number 2 (65 per cent), followed by 1 (23 per cent), or 3 (9 per cent); the extreme variation is 1 to 6. While the prenasals usually contact the rostral, this contact is prevented by rows of small scales in 17 per cent of the specimens. The percentage having this *mitchellii*-like characteristic is higher than in any other *viridis* subspecies. *Cerberus* is also exceptional in

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* This characteristic is evident in some of the diamond-backs, notably the Cedros Island species, *C. exsul,* and to a less extent in *C. r. ruber.* and *C. r. lucasensis.*

another scale arrangement, the presence of a small row of scales interposed between the prenasals and the first supralabials.* This row is complete in 72 per cent of the counts, and in an additional 8 per cent there are one or more extra scales at the junction of the rostral, prenasal, and first supralabials, thus partly interrupting the contact.

The supralabials range from 13 to 18; the interquartile range is from 14.8 to 16.1, the mean 15.47, and the coefficient of variation 6.2 per cent. The most prevalent counts are 15 (44 per cent), 16 (33 per cent), or 17 (10 per cent). The infralabials range from 13 to 19, with an interquartile range of 15.3 to 16.8, a mean of 16.03, and a coefficient of variation of 6.8 per cent. The most frequent counts are 16 (38 per cent), 15 (25 per cent), or 17 (21 per cent). The first infralabials are undivided, and there are neither intergenials nor submentals.

The body blotches vary from 25 to 46, although nearly all specimens fall between 29 and 42. The interquartile range is 32.9 to 37.9, the mean 35.39, and the coefficient of variation 10.3 per cent. The tail rings of the males range from 3 to 9; most fall between 5 and 8, with a mean of 6.05. The females range from 3 to 7, although only one specimen has the latter number; the mean is 4.63.

The head marks in the adults of *cerberus* are virtually obsolete, the heads being usually uniform, or mottled, brown or black. The preoculars are often lighter and occasionally a preocular light streak, to the angle of the mouth, may be faintly seen. A postocular light stripe, while ordinarily obsolete, is sometimes present. These marks are usually faintly evident in the specimens from the Santa Catalina and Rincon mountains, in gray against a black background. The infralabials, mental, and genials are punctated with brown; the lower jaw is otherwise clear buff, although there may be aggregations of brown dots scattered about.

In the juveniles the head marks are not unlike those of the coastal specimens. There are preocular and postocular light streaks sloping downward and backward, separated by a dark ocular stripe. The postocular mark is two scales wide. A light supraocular cross-dash is also present.

The body pattern in the adults consists of a middorsal series of round, elliptical, or hexagonal blotches. These may be brown, red-brown, dark-brown, or black, the edges usually somewhat darker than the centers. The blotches are from 9 to 15 scale rows wide, most often 11 or 13. They are close together, being separated by one to two transverse lines of lighter scales, which range in color from yellow to light-brown. On the sides there are two rows of subsidiary blotches, smaller and less conspicuous than the dorsals, for they are not sharply differentiated from the ground color, which is usually brown, or dark-brown, but may be gray. The light scales which separate the dorsal blotches are clearest and most evident middorsally; laterally these light bordering scales become increasingly clouded, so that, in adult specimens, the blotches on the sides are without the light bordering row, and thus merge directly into the ground color. This is a distinguishing characteristic from *helleri*, in which the light lateral borders of the blotches are usually evident. In fully adult specimens from the Catalina and Rincon mountains the light separating lines may be reduced to a half-dozen light scales middorsally; these are often bright-yellow in life.

The tail is crossed by brown or dark-brown bars, imperfectly set off by the ill-defined lighter areas between. The last bar is usually about twice as wide as the others, but this may not be true, especially in the northwest area of the range; here the last ring may be no wider, but may be distinctly darker than the others.

The lower surface is buff or yellow, heavily blotched or mottled with gray, brown, or black. This mottling is accentuated posteriorly.

The young specimens are lighter and brighter, with the pattern better defined. The light edges of the dorsal blotches are evident laterally. The secondary spots, especially the lower row, are more contrasting with the ground color. The final tail ring is yellow, or gray with a tinge of yellow, much like the coastal *helleri*.

Intrasubspecific Trends.—There is a considerable pattern and color variation in *cerberus*, particularly in the montane-island groups in the southern part of the range, in the Santa Catalinas, Rincons, and Pinaleños.

Probably the most distinctive are the black rattlers of the Santa Catalina Mountains. When adult these are handsome jet-black snakes, the dorsal blotches being distinguishable only through the presence of small groups of yellow middorsal scales, which represent the obsolescent remnants of the usual light interspaces. These snakes, and, in fact, nearly all *cerberus*, change considerably on preservation, the interspaces and the lateral areas becoming somewhat lighter, so that both the main dorsal series and the auxiliaries on the sides become more evident than in life.* I have found that this same color change may be effected to a lesser extent by increasing the temperature of a live snake; I have seen a specimen under varying conditions, with the dorsal blotches at times much more conspicuous than at others.

In some areas the snakes are dark-brown, rather than black, with large round or oval dorsal blotches, set close together. The sides are lighter-brown.

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* The following color notes were made Aug. 2, 1930, in the course of preserving 4 *cerberus*, 2 from Gleed and the others, somewhat larger, from Iron Springs and Hillside, Yavapai County, Arizona: "They vary from quite black with no evident dorsal blotches and only a few light-tipped scales—in the larger specimens—to gray-brown in ground color with dark-brown blotches outlined in punctated buff. The head is almost unicolor, except that the side stripes can be faintly seen in the smaller specimens. After their deaths on the following morning—by drowning in alcohol—the color changes are almost beyond belief, especially in the two larger specimens. The black dorsal blotches have become brown, interspersed with some gray. The lateral ground color has become light-gray. The blotches are now very clearly outlined, whereas before they could be distinguished only when viewed with the light at a particular angle. The yellow scale tips along the dorsum remain unchanged as an evidence of the only light areas that were once apparent, for all else was black before. The ventrums have also become lighter." From these notes it is evident that preserved specimens of this subspecies do not afford an accurate idea of the coloration in life. It explains why *cerberus* is so generally called the "black rattlesnake" in Arizona, whereas preserved specimens are often blotched with brown or gray.

This is true of most specimens of the Skull Valley-Prescott area, although some from here are black. I have seen an occasional specimen with bright-red (not red-brown) on the lower lateral scale rows. This color disappeared completely in preservation.

Toward the northwest the snakes are often grayish. In the San Francisco Peaks they are black or brown.

I have too few specimens to demonstrate any important geographical trends in ventrals, subcaudals, or labials. The Santa Catalina and Rincon mountain snakes have head scales less divided than in those from the center of the range; that is, they have fewer paired loreals, fewer scales in the inter-supraocular area, and less often have the prenasals separated, or partly separated, from the first supralabials. All of these divisions are characteristic of *cerberus* as compared with *helleri*.

The Santa Catalina snakes, in spite of their dark color, retain evidences of the pre- and postocular light streaks to a greater extent than specimens from the central area. The snakes of the northwestern part of the range quite often have terminal tail rings no wider than the anterior, possibly an effect of a *lutosus* or *nuntius* infusion. However, the light separating rings are not greatly different in shade from the rings themselves; there is not the sharp contrast evident in most *oreganus*.

Intersubspecific Relationships.—It is uncertain whether, today, *cerberus* intergrades with any other *viridis* subspecies; yet its relationship with *helleri*, which is a member of an uninterrupted *viridis* chain, is so close and obvious that it should not be considered a separate species, regardless of its present isolation.

There is a possibility of intergradation between *nuntius*, as found at Valle, Coconino County, and *cerberus* at Crookton and Gleed, Yavapai County, Arizona (see map, Klauber, 1935). A number of the latter show some *nuntius* tendencies, particularly in head scales and narrow posterior tail rings. These localities are only about 35 miles apart, and the intervening territory offers no barrier to rattlesnakes. I should expect intergradation to be eventually demonstrated here, were it not for the fact that there may be an overlap without intergradation at another point. This is in Medicine Valley, just northeast of the San Francisco Peaks, where *nuntius* occurs, while *cerberus* has been taken at a slightly higher elevation along the southern border of the valley, and these specimens do not show intergradient tendencies. Further collecting in this vicinity will be necessary to settle these problems of overlap *vs.* intergradation.*

Of the other subspecies, hitherto considered *oreganus*, *cerberus* seems to be nearest the southern specimens of *helleri*, particularly to the darker individuals found at the higher elevations of the Peninsula ranges of southern California and Baja California, including the Sierra Juárez and Sierra San Pedro Mártir. Surprisingly, the snakes of the Santa Catalina and Rincon

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* In the previous discussion of this problem, *loc. cit.* p. 86, read supralabials instead of supraoculars, near the end of the second paragraph.

mountains of Pima County, Arizona, although more distant from California than those from near Prescott, are more like *helleri* in color and head scales.

Range and Locality Records.—*C. v. cerberus* is found only in Arizona and extreme western New Mexico, from the Hualpai Mountains and Cottonwood Cliffs, southeastward to the Santa Catalina, Rincon, Pinaleño, and Blue mountains of southeastern Arizona, and Steeple Rock, New Mexico. The range is not continuous, for this snake is absent from intervening low-lying arid areas, it being essentially a resident of the Transition Zone. Although I had previously reported *cerberus* in Sonora, Mexico (1930a, p. 131), this record is to be judged highly questionable, and is to be suppressed unless verified by additional specimens.

The detailed locality records* available are as follows—ARIZONA: *Apache County*—White Mountains, 5 mi. s. of Greer, Apache Forest (may be Greenlee County); *Coconino County*—Tule Basin (6 mi. sw. of Coleman Lake), Coon Hill (9 mi. s. of Williams), Sunshine Spring (10 mi. s. of Williams), Round Mountain (14 mi. s. of Williams), 2 mi. n. of JD Dam, San Francisco Mountains (type locality), Medicine Valley (ne. side of San Francisco Peaks), Oak Creek, Oak Creek Lodge, Stoneman Lake (6500 ft.), Apache Maid Mountain at 6200 ft., Long Valley, Canyon Creek (26 mi. n. of Young on Holbrook road—may be Navajo County); *Gila County*—2 mi. ne. of Pine, near Payson (elev. 6000 ft.), Tonto Forest (north of Roosevelt Dam), Workman Creek, Workman Creek Trail at 6500 ft. (Mt. Aztec), Sierra Ancha, Salt River (15 mi. n. of McMillanville), bet. Roosevelt Dam and Globe, 6 mi. w. of Globe on US 180; *Graham County*—Pinaleño Mountains near Fort Grant, Mount Graham, Shannon Creek (2 mi. ne. of Arcadia Ranger Station, Pinaleño Mountains); *Greenlee County*—near Hannagan, KP Creek (White Mountains, at 8000 and 8200 ft.), north slope of Rose Peak (Blue Mountains), Eagle Creek at 5000 ft. (20 mi. nw. of Clifton); *Maricopa County*—Cave Creek; *Mohave County*—Hualpai Mountains, 10 mi. e. of Hackberry, near Peach Springs; *Pima County*—Mount Lemmon at least to 9000 ft., (Santa Catalina Mountains), Kellogg Peak (Santa Catalina Mountains), near Spud Rock Ranger Station (Rincon Mountains at 5500, 7000, and 7400 ft.), Manning Camp (Rincon Mountains at 8000 ft.); *Pinal County*—Superior, 2 mi. n. of Pinal Ranch (midway between Superior and Miami), 6 mi. se. of Oracle (n. slope Santa Catalina Mountains); *Yavapai County*—Nelson, Crookton, Gleed, Drake, Hillsdale, Grand View, Kirkland, Skull Valley, foothills bet. Skull Valley and Ramsgate, Ramsgate, Iron Springs, Prescott, near Prescott at 6000 ft., Fort Whipple, Crown King, Senator Mountains (=Senator Mine?, 10 mi. s. of Prescott). NEW MEXICO: *Grant County*—Steeple Rock.

The following localities are to be considered quite doubtful unless verified by additional specimens: Florence, Pinal County; Fort Buchanan, Santa Cruz County; Sonora, Mexico, 20 mi. se. of Sasabe, Pima County, Arizona. The Florence specimen could well have come from the mountains to the

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* The locality records are given for this subspecies only, because of its discontinuous range.

northeast, in the vicinity of Superior. Of the Fort Buchanan specimen, only the head is available; it was sent to the U. S. National Museum by Dr. J. B. D. Irwin and comprises one of a troublesome accession of specimens that have led to unwarranted range extensions of other reptile species in the past; for while they are credited to Fort Buchanan, from which place they were sent to the Museum, they were probably collected in southern California, since they include such other non-Arizona forms as *Masticophis lateralis* and *Coluber constrictor mormon*. The Sonora specimens were taken by a collector whose records later proved to be unreliable.

A NEW ISLAND SUBSPECIES OF *Crotalus viridis*

I believe the stunted rattlesnake found on South Coronado Island, Mexico, to be worthy of subspecific recognition and therefore describe it as

Crotalus viridis caliginis[*] subsp. nov.

CORONADO ISLAND RATTLESNAKE

Plate 5, fig. 2.

1877. *Crotalus adamanteus atrox* Streets, Bull. U. S. Nat. Mus., no. 7, p. 40.
1895. *Crotalus atrox* (part) Van Denburgh, Proc. Calif. Acad. Sci., ser. 2, vol. 5, p. 156.
1895. *Crotalus lucifer* (part) Stejenger, Ann. Rept. U. S. Nat. Mus. for 1893, p. 445.
1896. *Crotalus confluentus* (part) Boulenger, Cat. Snakes. Brit. Mus., vol. 3, p. 576.
1905. *Crotalus oregonus* Van Denburgh, Proc. Calif. Acad. Sci., ser. 3, vol. 4, no. 1, p. 18.
1922. *Crotalus oreganus* (part) Van Denburgh, Occ. Papers Calif. Acad. Sci., no. 10, vol. 2, p. 930.
1929. *Crotalus confluentus oreganus* (part) do Amaral, Bull. Antivenin Inst. Amer., vol. 2, no. 4, p. 92.
1936. *Crotalus viridis oreganus* (part) Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 191.

Type Specimen.—No. 2800 in the collection of L. M. Klauber. Collected June 2, 1930, on South Coronado Island, off the northwest coast of Baja California, Mexico, by E. H. Quayle, and preserved June 10, 1930.

Diagnosis.—A stunted form closely related to, but smaller than, *helleri* of the nearby mainland, and having those features of body proportionality characteristic of stunted races (Klauber, 1938, p. 29) as compared to their larger congeners.

Description of the Type.—An adult male. The fact that it is adult is shown by its possession of an incomplete string of 8 rattles, the oldest of which is no smaller than the proximal ring. The length over-all—measured

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[*] A dweller in the fog. I have Dr. Carl L. Hubbs to thank for this appropriate name for the rattlesnake of this fog-enshrouded island.

before shrinkage in preservative—was 674 mm. and the tail length 52 mm.; ratio of tail to total length .077. The head dimensions were 33 mm. long by 29 mm. wide.

The scale rows are 29-27-25-27 (mid-body) -25-23-22. There are 17 rows at the middle of the tail. The middorsal rows are strongly keeled, the lateral rows less so, and the three lowest rows on each side are practically smooth. The ventral plates number 171; the anal is entire; the subcaudals are 25, only the last being divided. The 8 elements of the rattle string average 11.3 mm. in width; they are substantially equal in size, the greatest difference between any two being 0.2 mm. The supralabials number 16—15, the infralabials 14—15. The first infralabials are undivided, and there are neither submentals nor intergenials. The rostral is higher than wide. Ten scales contact the rostral, there being 4 internasals, and a small extra scale on either side at the rostral-prenasal-supralabial junction. The canthals number 2—3. There is no line of demarcation between the scales in the prefontal and frontal areas; the former number about 23. The minimum scales between the supraoculars number 6+6. The supraoculars are pitted but not sutured. The nasals are divided, the anterior being much the larger. There is but one loreal on either side, the upper preocular contacting the postnasal above it. There are 6 small scales on the right and 5 on the left between the nasals and the pit border. The 2 preoculars on either side are undivided. Nine scales on each side contact the eye. There are 3 to 4 scales between the supralabials and the orbit.

The head is uniform dark-brown above. A preocular light stripe begins at the upper preocular and passes diagonally downward, to end at the angle of the mouth; its anterior section is finely stippled with brown and is less apparent than the posterior, which is almost clear buff. The remnants of what was once a postocular light stripe are to be seen on either side below the canthus. The underside of the head is buff, but the mental, anterior infralabials, and the inner edges of the genials are heavily punctated with gray.

The body pattern comprises some 34 dark-brown dorsal blotches, hexagonal to round anteriorly, but changing into cross-bands toward the tail. The dark dorsal blotches are edged with rows of gray scales, the blotches being separated dorsally by about 1½ light-colored scales. On the sides, in the angles between the main dorsal series of blotches, the scales are darkened, forming an irregular secondary series of blotches of smaller size; below these there is another row of spots that are somewhat darker and more regular than those above. Posteriorly these become confluent with the main dorsal series to form rings. The undersurface is buff, heavily punctated with gray, becoming increasingly dark posteriorly. The tail is crossed by 4 dark-brown rings, separated by narrower light-gray interspaces. The last ring, in characteristic *helleri* fashion, is more than twice as wide as the anterior 3 and is a trifle lighter. The anterior lobe of the rattle matrix is punctated with brown; the posterior lobes are buff. The hemipenes are of characteristic *viridis* form with short spines on the outer shoulders.

Material.—In addition to the type, 30 specimens have been available from the Coronado Islands. Twenty-six specimens are designated as having been collected on South Coronado Island, one on East Coronado, and the other 3 merely from the "Coronado Islands". However, all probably came from South Coronado, for this, the largest island in the group—it is about 1¾ miles long and reaches a peak 672 feet above the ocean—is not only the most southerly, but the most easterly as well (see U. S. Navy Hydrographic Sheet No. 5195). North Coronado, which is also the westernmost of the group, and the second largest, is 2½ miles from South Coronado. The other two islands, currently known as Big Middle and Little Middle, are but rocks lying between the larger pair. I doubt that rattlesnakes have ever been collected on any but South Coronado, and that East Coronado was merely another name applied to that island.

The paratypic series includes the following: California Academy of Sciences 13476, 13583-7, 13603, 63734; LMK 2801-4, 4924-6, 7538-40, 20077-8; Museum of Vertebrate Zoölogy, University of California 5404; San Diego Society of Natural History 11177-8, 13711-5; Stanford University 6681; U. S. National Museum 8564.

Description of Subspecies.—The following description is a summary of the data on 31 specimens, including both the type and paratypes. There are 11 males and 20 females. Fortunately, both juveniles and adults have been available.

This is a snake of normal *viridis* proportions. Like others of the *viridis* subspecies, it is distinguishable from all other rattlesnakes in usually having more than 2 internasals; only 2 out of 31 specimens of *caliginis* have 2 internasals.

The longest available specimen is a male measuring 683 mm.; the longest female is 647 mm. The shortest juvenile measures 220 mm. The ratio of the tail length to the length over-all in the adults averages .079 in the males, and .067 in the females.

Most specimens have 25 scale rows at mid-body, the distribution being 25(23), 26(1), 27(6), 30(1).* The average is 25.58, and the coefficient of variation 4.0 per cent.

The ventrals in the males vary from 167 to 174; the interquartile range is 168.5 to 171.3, the mean 169.90, and the coefficient of variation 1.3 per cent. The ventrals in the females range from 171 to 179. The interquartile range is 173.3 to 176.8, the mean 175.06, and the coefficient of variation 1.5 per cent. The subcaudals in the males vary from 22 to 28, with an interquartile range of 22.7 to 25.4, mean 24.0, and coefficient of variation 8.3 per cent; the females range from 15 to 23, interquartile range 17.6 to 20.1, mean 18.85, and coefficient of variation 10.1 per cent.

The rostral is higher than wide. There are from 2 to 6 internasals; most specimens (23 out of 30) have 4. Two specimens out of 30 have only 2

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* High for any *viridis* subspecies; evidently a freak.

internasals and would fail to key out as belonging to a *viridis* subspecies. The canthals are usually 2—2, but there are occasionally 3 on one or both sides. The scales on the snout, anterior to the supraoculars, range from 18 to 30, the mean being 22.8. Since there is no sharp line between these scales and those in the frontal area, observers might differ in counting them. The minimum scales across the space between the supraoculars vary from 3 to 7, most specimens having 4, 5, or 6. Usually there is a single loreal on each side, but sometimes there are 2, and, rarely, none. The prenasal usually contacts the first supralabial, but this contact is prevented by a row of small scales in 3 counts, and in 16 other cases out of 59, there are one or more small scales at the junction of the prenasal, first supralabial, and rostral.

The supralabials range from 12 to 16; most specimens have 14 to 16, the mean being 14.53. The infralabials range from 13 to 18, but most specimens have 15 or 16, the mean being 15.14.

The body blotches vary from 28 to 37; the interquartile range is 31.2 to 34.7, the mean 32.90, and the coefficient of variation 7.9 per cent. The tail rings of the males range from 4 to 6, with a mean of 5.18; and the females from 3 to 5, with a mean of 4.20.

In the juveniles, the head is brown on top, becoming somewhat darker posteriorly. A faint light line crosses the middle of the prefrontal area, and another, better defined, crosses the supraoculars and the frontal area between. A faint middorsal light line usually connects these two cross-lines. On the sides a preocular light stripe begins at the upper preocular, and passes backward and downward to engage the posterior supralabials. A second light band, about 2 scales wide, arises behind the eye and runs back to end at the hinge of the jaw. Otherwise the side of the head is dark-brown, the dark stripe lying between the two light stripes being somewhat darker than the rest. Below, the head is light-gray, except that the mental and first supralabials are stippled with dark-gray.

As the snakes age, the head marks lose much of their definition. The two transverse lines on the crown virtually disappear; and the light streaks on the sides are invaded by gray and brown punctations, so that they become ill-defined and less striking.

The body pattern comprises a series of dark-brown blotches on a gray background. The blotches are quite irregular in shape, but approach hexagons. They are darker on the edges than in the centers. They are about 11 or 12 scale rows wide and 3 scales long (end to end). The gray interspaces are 1 to 1½ scales long. In the lateral angles formed by the light blotch borders, there is a series of secondary brown blotches on each side; and, below these, another darker, better-defined series that engages the edges of the ventrals. Posteriorly, these combine with the main series to form transverse bands. The tail is crossed by similar bands, the last of which is much wider than the others. The ventral scutes are punctated or mottled with gray or brown, especially toward the tail, otherwise the ground color below is buff.

The juvenile body pattern is somewhat brighter and more contrasting, between the light and dark areas, than the adult. Also, the wide terminal tail ring is yellow in the juveniles but becomes brown in the adults.

Of the 20 females, 4 were gravid and contained 2, 3, 3, and 4 eggs.

A hemipenial lobe contains from 36 to 42 short spines and terminates in from 30 to 32 fringes. The organ is typically *viridis* in character.

Intersubspecific Relationships.—C. v. caliginis is obviously derived from *helleri* of the nearby mainland, yet it has evidently been separated from the mainland population for a considerable time. This is to some extent substantiated by the presence on South Island of two other reptiles peculiar to Los Coronados*; *Gerrhonotus multicarinatus nanus*—found on the other three islands as well—and *Pituophis catenifer coronalis* also of South Island.

South Coronado Island is somewhat over 8 miles from the nearest point on the Baja California mainland; and the intervening channel, which is rough and cold, is about 100 feet deep. While rattlesnakes are occasionally found floating in the Pacific a short distance off shore, it is to be doubted whether one could successfully survive this crossing or make a landing upon arrival, for the island is rocky, with precipitous cliffs, and the beaches are few and limited in extent. The winds blow almost continuously from the island toward the mainland. The conditions are quite different from those existing off Florida and Texas, where rattlesnakes (*adamanteus* and *atrox*, respectively) are often found swimming at considerable distances from shore, and there is an unquestioned exchange of population elements between mainland and islands, for the water there is warm and the islands flat, so that landings may be easily made. This difference is substantiated by the number of other islands off Baja California, which, notwithstanding their being only a few miles off shore, are inhabited by reptile forms not occurring on the mainland. Of these, South Todos Santos and San Martín may be cited as examples.

But while the evidence points to a long isolation of *caliginis*, I am unable to find any consistent differences between it and *helleri* in squamation or pattern. The former may be a trifle lighter and grayer—as to ground color—and the latter browner and darker. *C. v. helleri* retains the light head marks of youth at a size at which *caliginis* has lost them. But this is a mere incident of stunting.

This raises the question of how real and important these size differences are. Every evidence points to the fact that they are real, and when consistent in such an isolated form as this, I think they should be recognized just as they have been for many years in the case of birds and mammals. Heretofore it has been said that snakes are different from mammals and birds, in that they do not reach a size limit upon becoming adults. It has, in fact, been believed that snakes grow continuously until death, and that the largest

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* Not to be confused with Coronado, a city on the Coronado Peninsula, across the bay from San Diego, California. South Coronado Island is 20 miles south of Coronado, and is on the Mexican side of the international boundary.

specimens are merely the oldest. But with the acquisition of much larger series in collections, and the observations on specimens kept alive for long periods in zoos, we now know that this is true only to a minor degree. Reptiles certainly do not attain a growth limit as suddenly as mammals; they may, indeed, continue to grow slowly throughout life. But in any case, this adult growth is minor in extent, so that the longest snakes of a subspecies are not necessarily the oldest, but are merely variants of the same character as tall men.

No *caliginis*, regardless of age or intrasubspecific variation, would ever grow to the size of an average adult mainland *helleri*. Six specimens out of 31 *caliginis* exceed 600 mm. and none reaches 700. In *helleri* 1100-mm. specimens are not at all exceptional, and considerably longer ones have been recorded. If we were to compare, visually, a 650-mm. *caliginis* with a 1100-mm. *helleri*, we would find the difference far more striking than is indicated by these figures, for the *helleri* would have 5 times the bulk of the smaller snake.

Further evidence of the stunted nature of *caliginis* is to be found in the sizes of the gravid females among the paratypes. These have lengths of 528, 547, 560, and 647 mm. Gravidity does not generally appear in *helleri* until a considerably larger size is reached; the smallest gravid specimen I have seen in a very much larger series was 596 mm. in length.

Another evidence of the stunted character of *caliginis* is head proportionality, which I have discussed elsewhere (1938, p. 29). Another is the size of the rattle when parallelism is reached; this is at a width of about 10 mm. in female *caliginis*, and 11 mm. in the males. The corresponding dimensions, in normal mainland *helleri*, are about 15 mm. in females and 17 in males. The average widths of the first 6 rattles in an unbroken string in *caliginis* are 6.3, 7.2, 8.2, 8.9, 9.5, 9.9,* whereas in *helleri* they average 6.6, 8.2, 9.7, 11.2, 12.5, 13.3 mm. It will be noted that there is an increasing proportional divergence with age, the *helleri* rattle being only 5 per cent larger at the button stage, but is 34 per cent larger at the sixth-rattle stage.

I have examined 22 rattlesnakes from Santa Catalina Island, Los Angeles County, California. They are somewhat larger and darker than the snakes of South Coronado, and I therefore prefer to consider them *helleri*. They have typical *helleri* tail rings. The rattle dimensions, however, are more like *oreganus* than *helleri*.

Food Habits.—C. v. caliginis differs from the mainland *helleri* in feeding primarily on lizards, and this in spite of the fact that South Coronado Island is well populated with rodents that an adult *caliginis* could cope with quite successfully. I am told by L. M. Huey that the Coronado Island white-footed mouse (*Peromyscus maniculatus assimilis*) is relatively abundant on the island. *Helleri*, on the mainland, feeds primarily on mammals, although lizards comprise an important part of the diet of the juveniles. But *caliginis*

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* Sexual dimorphism does not become important until the seventh or eighth rattle.

does not modify its propensity for lizards even when it has reached a size adequate to eat mice. Of the 20 specimens examined that contained recognizable food remains, only one had mammal hair, and this is the more remarkable since hair is recognizable until the feces are voided, which is not always true of lizard scales. The other 19 contained lizard remains; 6 could be recognized as *Gerrhonotus multicarinatus nanus*, 3 as *Eumeces skiltonianus*, and one as *Uta stansburiana hesperis*, the other 9 being too far digested to be identified. A large alligator lizard is a full meal for an adult *caliginis*. Mr. Huey advances the plausible theory that the rattlesnakes may be forced by the climate—which is cold and foggy—to be largely diurnal, as are the lizards, while the mice are nocturnal. The mice have their daytime refuges in rock crevices and cactus, and are probably not so easy for the snakes to catch as are mice on the mainland, where the rattlers may seek their nocturnal prey down ground holes in the daytime, during those seasons in which the snakes themselves are not nocturnal.

A NEW ISLAND SUBSPECIES OF *Crotalus mitchellii*

For years I had heard, from ornithologists and others visiting the islands of the Gulf of California, that rattlesnakes were quite common on one island from which no museum had secured specimens, this being "San Luis". In 1946 arrangements were made with Messrs. Lewis W. Walker and Charles H. Lowe, Jr., to visit this island, Mr. Lowe, particularly, having the primary purpose of securing rattlesnakes. In this, the expedition was quite successful, many interesting herpetological specimens, including rattlesnakes, being collected. However, the rattlesnakes do not occur on the island designated as San Luis on the maps, although they are on one of the islands that have been called the San Luis group*, which lies in the Gulf of California, just off the Baja California coast, at Lat. 30° N. The island known to the Mexican fishermen as San Luis is off Willard Point (see U. S. Navy Hydrographic Sheet No. 0619, 53d edition) in San Luis Gonzaga Bay; the one named San Luis on the maps is farther off-shore; it is the largest island of the group and is called La Encantada Grande by the fishermen. Proceeding along the archipelago, in a northwesterly direction from La Encantada Grande, the other islands, according to Mr. Lowe and other recent visitors, are known to the Mexicans by the following names: Pomo, Islote, Cholludo, Coloradito, El Muerto, and Huérfanito. El Muerto,† although much smaller than La Encantada, is next in size; and this is the island where the rattlesnakes occur. It lies about 3 miles from the nearest mainland, east of El Mármol. It is probably the island referred to in the previous accounts, since rattlers have not been discovered on any of the other islands by recent expeditions and they are quite plentiful on El Muerto. Subsequent to the

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* The fishermen usually refer to this group as Las Islas Encantadas, while some maps call it the San Luis and others the Salvatierra group.

† El Muerto is not designated by this name on any map known to me. When named at all, it is called Miramar, Link, or, to add to the confusion, La Encantada. The other islands of the group are also assigned several alternative names, but I shall not compound the perplexity by listing them.

Walker-Lowe expedition, Joseph R. Slevin and Wallace F. Wood visited there in May, 1947, and secured specimens for the California Academy of Sciences.

The El Muerto rattlesnake proves to be a dwarfed race of *Crotalus mitchellii.* I deem it worthy of subspecific recognition and describe it as

Crotalus mitchellii muertensis subsp. nov.

EL MUERTO ISLAND SPECKLED RATTLESNAKE

Plate 6, fig. 1.

Type Specimen.—No. 37447 in the collection of L. M. Klauber. Collected June 6 or 7, 1946, on El Muerto Island, Gulf of California, Mexico, by Charles H. Lowe, Jr., and preserved June 22, 1946.

Diagnosis.—A dwarfed island race, allied to *C. m. pyrrhus* of the mainland, from which it differs in its small size and in having 24 or fewer scale rows more often than 25, while the contrary is true of *pyrrhus;* also in having a higher average number of body blotches. In adult head proportions, *muertensis* resembles *C. m. pyrrhus* rather than *C. m. mitchellii.* It differs from all other rattlesnakes, except *pyrrhus* and *m. mitchellii,* in usually having the rostral separated from the prenasal by a row of granules.

Description of the Type.—An adult male. The length over-all, as measured before shrinkage in preservative, was 633 mm. and the tail length 42 mm., the ratio being .0663. The head (also measured in life) was 26.9 mm. long, being contained 23.5 times in the length over-all.

The scale rows number 27–23–19, with 14 around the middle of the tail; all rows are keeled, except the lowest lateral row, which is also the largest. The ventrals number 177 and the subcaudals 22, of which the last 2 are divided. The anal is entire. There are 17—17 supralabials and 16—16 infralabials. The first infralabials are undivided and there are neither intergenials nor submentals. The rostral is triangular, and of equal height and width. As is usual in the *mitchellii* subspecies, the scales on the snout are much broken up so that few can be assigned the customary names with assurance. The rostral is separated from the prenasal on both sides by rows of granules; also, the small scales anterior to the pit are carried forward to the rostral so that the anterior nasal is separated from the supralabials. The area usually occupied by the upper preoculars in most rattlesnakes contains 4 scales on each side, indicating that this scale has been split both horizontally and vertically. There are 3 to 4 scale rows on either side between the supralabials and the orbit. There are about 26 small scales in the internasal-prefontal area; the minimum scales across the frontal area number 6+6. The supraoculars are by far the largest scales on the head; they are indented by a crease that may be the beginning of a suture on the right, and a pit reminiscent of *stephensi* on the left. The mental is triangular. The first infralabials meet on the median line; altogether, 3 infralabials contact the genials on either side.

The head is gray above, somewhat darkened with irregular brown blotches anteriorly. A few of the posterior scales on the head contain black dots. There is some evidence of a dark-gray postocular stripe, with a lighter stripe below, but these are by no means definite. The mental and infralabials are punctated with gray, but otherwise the undersurface of the head is cream.

The ground color of the dorsum is light-pink, marked by 37 gray-brown blotches that become cross-rings posteriorly. The edges of the blotches are not well defined. The blotches have brown centers and gray edges; the brown areas are speckled with dark-brown or black dots, and the gray with darker-gray. Anteriorly, a series of secondary lateral blotches is in evidence; posteriorly these spots merge with the dorsal series to form transverse bars. The sides are much suffused and speckled with gray. The ventral surface is cream anteriorly and buff toward the tail, the outer edges of the ventrals being often stippled with gray, especially posteriorly. The tail is gray, with two gray-brown rings, followed by a pair of irregular black marks. The rattle matrix is mottled with black and gray.

Material.—In addition to the type, 18 specimens have been available, all from El Muerto Island. The paratypes are as follows: LMK 37442-4, 37446-49, 38040; and CAS 81354-63.

Description of Subspecies.—The following description is based on 19 specimens, the type and paratypes taken together. There are 9 males and 10 females. All are adults or adolescents, no juveniles being available.

This is a rattlesnake of the usual *mitchellii* form, characterized by the interposition of a row of small scales between the rostral and prenasal, and the extreme subdivision of the other head scales, those on the crown being convex.

The longest individual is a male measuring 637 mm.; the longest female is 534 mm. Four males out of 9 are above 600 mm., and 3 females out of 10 over 500 mm. The shortest snake is a female measuring 431 mm. The ratio of the tail length to the length over-all averages .067 in the adult males, and .053 in the females.

The majority of specimens have 23 scale rows at mid-body, the distribution being as follows: 11 or 58 per cent have 23; and 8 or 42 per cent have 25. The average is 23.8. The head-length equation is approximately $H=.0336L+6.5$, where H is the head length and L the length over-all, both expressed in millimeters.

The ventrals of the males range from 175 to 184 with a mean of 179.7; and in the females from 174 to 181 with a mean of 178.3. It is to be doubted whether larger series would validate this superiority of the males, for in all other rattlesnake subspecies of which adequate series are available the females average from 1 to 7 ventrals higher than the males. It is to be noted that the sexual dimorphism is lower in *mitchellii* than in other species and subspecies. Returning to *muertensis*, the subcaudals in the males vary from 21 to 24 with an average of 22.9; and in the females from 16 to 18 with a mean of 17.4.

The rostral is about as high as wide, being slightly higher in some individuals and wider in others. All specimens except two have the rostral separated from the prenasals by small scales or granules in the manner so characteristic of all *mitchellii* subspecies except *stephensi;* in the exceptional specimens the contact is complete on one side. The separation of the prenasal from the supralabials, by the extension to the rostral of the small scales anterior to the pit, is not so universal, for at least a partial contact is made in 17 out of 38 cases. The crescent-shaped postnasal, characteristic of all rattlesnakes, is sometimes divided into a small upper and a larger lower part.

The loreal-preocular area is usually occupied by a number of small scales or granules, so that it is no longer possible to identify the large upper preocular, or the single or paired loreals characteristic of most rattlesnakes; where homologues can be recognized, it is evident that the upper preocular has usually been divided both vertically and horizontally. The narrow crescent-shaped lower preocular, that comprises the upper border of the pit in most species of *Crotalus*, is sometimes in evidence, but is often broken up into smaller scales. In all except one specimen out of 19 there are blemishes on the supraoculars. Usually these take the form of pits or small sutures at the outer edges. In only 2 specimens out of 19 are these as prominent as is normal in *stephensi;* nevertheless they are more prevalent in *muertensis* than in *m. mitchellii* or *pyrrhus*.

The scales in the internasal-prefrontal area are so broken up that they cannot be counted with accuracy. Most of them are decidedly convex. The minimum scales between the supraoculars vary from 4 to 8, with 5, 6, or 7 predominating; the average is 5.7.

The supralabials range from 14 to 18, most specimens having 14 to 17; the mean is 15.9. The last supralabial is about as long as the others. The infralabials number 14 to 19, most specimens having 15 to 18, with a mean of 16.5. The mental is triangular and is often sharply pointed posteriorly. The first infralabials meet on the median line and are followed by a single pair of enlarged genials. No first infralabials are divided, and no specimen has submentals or intergenials. The supralabials are usually smaller than the row of scales above them. The considerable enlargement of the last supralabial that characterizes most *m. mitchellii* is not evident.

The body blotches vary from 32 to 39 with a mean of 35.7. The tail rings in the males vary from 3 to 6, with a mean of 4.3; and the females from 2 to 5, with a mean of 3.3.

C. m. muertensis gives a general impression of grayness, the color being applied to a considerable extent in the form of small spots or punctations characteristic of the *mitchellii* subspecies, and with the indefiniteness of blotch outlines evident in all the subspecies except *stephensi*.

The head is usually gray above, occasionally with a pinkish tinge, and with some evidences of irregular brown spotting. There are always some black dots scattered over the crown. On the sides there usually remain some traces of a postocular dark stripe bordered with lighter streaks above and below. The mental, the infralabials, and the fronts of the genials are speckled with gray, otherwise the underside of the head is cream, although there may be a few gray dots scattered about.

The dorsal pattern comprises a series of indefinitely outlined blotches, tending toward hexagons anteriorly and toward cross-bands posteriorly, where they become confluent with the lateral series and are somewhat more contrasting with the ground color. The blotches usually have brown centers and gray edges, but both areas are often speckled with dark-gray, dark-brown, or black dots. Dorsally, between blotches, there are usually pinkish spaces, which are sometimes moderately clear of punctations. Laterally there is a gray suffusion, so that the secondary lateral series is often ill-defined, especially anteriorly. The ground color of the lowest rows of lateral scales is cream or pink, and the punctations here become darker, being often black. The undersurfaces of the body vary from cream to buff, always becoming darker posteriorly, and with considerable dark mottling or stippling, particularly at the edges of the ventrals.

The tail is gray, with an anterior ring or two of brown or dark-gray, stippled with black, and several posterior black rings that are generally irregular in shape. The rattle matrix is mottled gray and black. The rattle widths in the adults, after parallelism is attained, vary from about 10 to 11 mm. in the males, and 8.5 to 9.5 mm. in the females. I have seen only two buttons in *muertensis;* one measured 6.1 mm. in width, the other 5.5 mm.

Intersubspecific Relationships.—That *muertensis* is a dwarfed form is indicated in four ways. First, a sample of 19 specimens collected by two parties failed to locate any individual longer than 637 mm. (25 inches). A similar collection on the mainland would certainly have resulted in larger specimens being found. For comparative purposes I give the record lengths known to me of the three mainland subspecies: *mitchellii*, 939 mm.; *pyrrhus* 1295 mm.; and *stephensi*, 943 mm. It should be recalled that a snake 50 per cent longer than another is more than 3 times as bulky.

Second, we have the evidence of the gravid females, of which 6 *muertensis* are at hand, measuring respectively 431, 456, 482, 489, 515, and 533 mm. The smallest gravid *mitchellii* I have seen measured 797 mm., the smallest *pyrrhus*, 786; and the smallest *stephensi*, 674 mm., and this in much larger series.

Then there are the rattles, which reach parallelism in the male *muertensis* at a width of about 10 to 11 mm., and in the females at 8.5 to 9.5 mm. In *mitchellii*, which is noted for its large rattles, proportionate to the size of the snake, the corresponding figures are about 15 mm. for the males and 14 mm. for the females; and in *pyrrhus* about 14 and 13 mm.

Finally, the head proportions indicate stunting; for while the adult head-to-body ratio in *muertensis* is about the same as that of *pyrrhus*, at similar body lengths the *muertensis* head is smaller than that of *pyrrhus*, as is always true of dwarfed races for reasons that I have discussed elsewhere (1938a, p. 29). For example, an average *muertensis* head in a 600-mm. snake would have a length of 26.8 mm., while a *pyrrhus* of this size would have a head measuring about 29.2 mm.

As might be expected from geographic considerations, *muertensis* more nearly resembles *pyrrhus* than *stephensi* or *mitchellii* in most characters. Data on the previously recognized subspecies will be found in Klauber, 1936a.

Although superficially like *mitchellii* in color and pattern, *muertensis* trends strongly toward *pyrrhus* in other important features. It resembles that subspecies in adult head and tail proportions, *mitchellii* having a relatively smaller head and longer tail. The spines in the cleft of the hemipenes in *muertensis* are like those of *pyrrhus*, in that they do not approach as close to the sulcus as they do in *mitchellii*. *C. m. muertensis* shows no particular likeness to *stephensi*, except that the frequency of supraocular pits or sutures characteristic of *stephensi* is much higher in the island form than in mainland *pyrrhus*. But *muertensis* is sharply differentiated from *stephensi* in the almost universal separation of the rostral from the prenasals. The *muertensis* pattern, also, is much more like that of *pyrrhus* than *stephensi*, in that the blotch outlines are vague.

As to the particular geographical phase of *pyrrhus* that *muertensis* resembles, it apparently is more closely allied to the Arizona than to California or Baja California snakes, judging from the frequency of 23 as opposed to 25 scale rows, for the lower number is more prevalent in the Arizona snakes than in those from California. On the other hand, *muertensis* is high in ventral scale counts, and in this respect more nearly approaches the California snakes—which is all the more notable since stunted forms usually have a tendency toward fewer ventrals. The average number of body blotches in *muertensis* somewhat exceeds the mean in either California or Arizona specimens. Another criterion in which *muertensis* is closer to the Arizona *pyrrhus* than to the California stocks—particularly those that come from south of the Riverside-San Bernardino county line—is in the splitting of the preoculars both horizontally and vertically. This occurs in almost every *muertensis* and it is characteristic of the Arizona *pyrrhus* as well. The San Diego County snakes often have these scales entire, or split only horizontally or vertically, rather than in both directions.

The rattlesnake species *mitchellii* occurs off Baja California on islands other than El Muerto, but on none of the other islands do specimens show any tendency toward *muertensis;* all resemble, as might be expected, the nearest mainland forms. Those from Ceralvo, Espíritu Santo, San José, and Santa Margarita islands are to be classified as *m. mitchellii*, since they have the head and tail proportions of *mitchellii*. It is interesting to observe that, although only a single specimen representing each island has been available from Ceralvo, San José, and Santa Margarita, and 3 from Espíritu Santo, yet every one of these islands has produced a larger snake than the largest of the 19 specimens from El Muerto, another proof of the relatively small size of *muertensis.**

Beside El Muerto, Angel de la Guarda Island is the only other island off *pyrrhus* territory known to be inhabited by a *mitchellii* subspecies. The snakes of this island are clearly allied to *pyrrhus* and are very large, which is unusual for island inhabitants; they may, in fact, prove to be larger than any mainland *pyrrhus* and are thus quite different from *muertensis.*

Field Notes.—The following field notes were compiled by Charles H. Lowe, Jr., when he collected the first specimens of *muertensis* on June 6 and 7, 1946:

"Of the 9 specimens taken, 5 were collected during evening twilight; 3 were crawling when found and 2 coiled. The other 4 specimens were found in the morning, from shortly after sunrise until as late as 7:30 A.M.; all were coiled among rocks. This snake seems, therefore, to be crepuscular, which may be correlated in part with its lizard feeding habits.

"It is interesting to note that all 9 specimens, when found, were within approximately 20 feet (usually less) of safe retreats in rocky crevices or holes. The intense daytime heat and the lack of shading vegetation makes it imperative that they stay near satisfactory shelters from the sun. An indication of the intense daytime heat in the open sunlight is seen in the fact that the two lizards inhabiting the island, *Uta mearnsi* and *Uta stansburiana,* when observed sitting on rocks after 8:30 to 9:30 A.M., were always in the shade, never sunning themselves.

"The night of June 6-7, 1946, was warm. The air temperature that night on El Muerto probably dropped but little, if any, under 80° F., as indicated by the 9:30 P.M. (June 6) temperature of 86° F., and the 4:30 A.M. (June 7) temperature of 80° F. The rattlers, observed coiled on rocks and apparently asleep early in the morning just as the rising sun was reaching them, appeared to have been there for some time, awaiting the sun to warm them. Perhaps they had remained coiled in the same place since the previous evening.

"All 9 rattlesnakes showed vicious dispositions. They rattled continuously from the moment they saw or heard someone approaching, and for a considerable time after being sacked. When touched, they thrashed their bodies about wildly. One snake bit the dirt three or four times when held down by the neck. Another thrashed so violently and suddenly after being picked up by the neck that it threw itself out of my grasp and onto the ground. Their actions upon the approach of an intruder leads one to believe that they have some important enemy; perhaps a bird of prey. Ospreys and duck hawks live on the island.

"The rattlesnakes were found from the beaches to the ridge of the island, some 626 feet in elevation. Likewise, at least one of the two species

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* The Santa Margarita specimen was destroyed in the San Francisco fire but the length is of record.

of lizards, both of which the rattlers somewhat greedily ate, is found on all parts of the island where the rattlers were taken. *Uta stansburiana* is restricted to the beach area and *Uta mearnsi* to the sides and tops of the island, not being found on the beach rocks.

"A recently dropped sample of snake feces, found near one of the rattlesnakes taken on the beach, contained rodent hair. A few other indications that mice inhabit the island were found. None could be trapped by using peanut butter as bait. There were indications that one rodent on the island is a pocket mouse. The following incidents, on June 7th, indicate that the snakes feed upon the two species of lizards inhabiting the island, when possible:

> "At 5:05 A.M., a *Uta mearnsi* of medium size was shot and placed (dead) in a white snake-sack. At 5:30 a medium-sized *Crotalus* was placed in the same sack with the *Uta*, and the dead *Uta* was eaten sometime that morning before 9:30.
>
> "At 5:25 P.M., a large *Crotalus* was caught on the southeastern beach. Five minutes later an adult male *Uta stansburiana* was shot a few feet from where the rattler was found. At 6:15 P.M. the *Uta*, having been dead for ¾ hour, was placed in the sack with the rattlesnake, whereupon the rattler swallowed the lizard in the next 10 minutes.
>
> "The rattlesnakes are hard to see, although the rocks on which they are found are multicolored."

J. R. Slevin reported that he got one rattler on a boulder-strewn beach as the snake was moving inland to escape the tide. Two specimens contained mice (*Peromyscus*).

Upon examining the snakes comprising the type series, I found mammal hair in 6 and lizard scales in 4 others. Evidently *muertensis* welcomes either food and does not strongly prefer lizards, as does *caliginis* on South Coronado Island.

THE BLACK-TAILED RATTLESNAKE OF SAN ESTÉBAN ISLAND

Schmidt (1922, p. 697) was the first to mention the presence of *Crotalus molossus* on San Estéban Island in the Gulf of California. From the single specimen then available he pointed out some of the differences as compared to the mainland snakes. Subsequently, when I examined this specimen, I thought that some of its peculiarities might be due to its poor state of preservation, which later proved to be the case when a live specimen was secured in 1937, through the courtesy of Capt. G. Allan Hancock. Evidently these snakes are not common on the island, as several other expeditions, asked to be especially on the lookout for them, have failed to find any.

Some 10 years ago (1938b, p. 193) I expressed the opinion that the subspecific recognition of this snake was not justified. However, since then I have revised my opinions with regard to island subspecies, the taxonomic importance of stunting in snakes, and the practical benefits accruing from the nomenclatorial segregation of island races. For these reasons I have decided to name the San Estéban black-tail

Crotalus molossus estebanensis subsp. nov.

SAN ESTÉBAN ISLAND RATTLESNAKE

Plate 6, fig. 2.

1922. *Crotalus molossus* (part) Schmidt, Bull. Amer. Mus. Nat. Hist. vol. 46, art. 11, p. 697.

1936. *Crotalus molossus molossus* (part) Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 249.

Type Specimen.—No. 26792 in the collection of L. M. Klauber. Collected on San Estéban Island, Gulf of California, Mexico, by an expedition under Capt. G. Allan Hancock, and preserved April 17, 1937. Paratype USNM 64586, April 18, 1911, C. H. Townsend, collector.

Diagnosis.—A stunted island *molossus*, related to the nearby mainland form, from which it differs in pattern and in body proportions. The blotches are lighter, smaller, and more numerous than in typical *molossus;* it also lacks the darkening of the internasal-prefrontal area.

Description of the Types.—The holotype is an adult female. The fact that it is adult is shown by the presence of eggs, and its having a broken string of 5 rattles that are uniform in size. As measured before setting in preservative, the length over-all was 737 mm., the tail length 41 mm., and the head 33.7 mm. The rattles vary from 9.6 to 9.8 mm. in width.

The scale rows are 33–27–21, with 13 at the middle of the tail. The dorsal rows are keeled; the 3 lowest lateral rows are smooth; the row adjacent to the ventrals is larger than any others of the dorsal series. The ventrals number 192; the anal is entire; there are 22 subcaudals, of which the first and last 2 are divided. The scales in the prefrontal area total 6, comprising 2 long slim internasals, each of which is almost broken to produce an internasal and a canthal; a pair of small scales between the internasals; and a pair of large prefrontals. The scales between the supraoculars are quite small, the minimum bridge being 5, followed by 6. The supraoculars are undivided. The rostral is slightly wider than high. The prenasal is almost separated from the first supralabial by the small scales anterior to the pit on the right, and is separated on the left; these small scales number 8 on each side. There are 2 loreal scales on each side, and 2 extra scales in the subcanthal area; these are difficult to classify in *molossus*. There are 2 preoculars on either side; and 5 post- and suboculars on the right and 7 on the left. There are 3 to 4 rows between the supralabials and the orbit, these counts including the suboculars. The supralabials number 18—18 and the infralabials 16—17. The first infralabials are undivided and there are no intergenials or submentals. Three infralabials contact the mentals on either side.

The head is unicolor olive-brown on top, although some evidences remain of darker blotches. On the sides there is faint evidence of an ocular dark stripe passing backward above the angle of the mouth. Below this there is an almost obsolete light streak. The supralabials are punctated with brown anteriorly, but become clearer toward the angle of the mouth. The mental and infralabials are also punctated with brown, although the 6th to 8th on each side are almost clear; the undersurface of the head is otherwise buff.

The dorsal pattern comprises 41 olive-brown blotches with grayish interspaces.* The blotches are of the usual *molossus* character, that is, they are open on the sides, are bounded by unicolor scales, and often have a few light-colored scales at their centers. The first 8 blotches are closed by light borders laterally; but those that follow are open and are extended laterally, in the form of single rows of zig-zag brown scales, to the ventrum. Posteriorly, the light scales bordering the dorsal blotches become darker, while the blotches themselves become lighter, until the contrast has declined to such an extent that the posterior 10 blotches are virtually obsolete. They can only be counted by recourse to their lateral extensions, which remain in evidence. The belly is cream-colored, with brown punctations on the scutes adjacent to the lateral blotch-extensions. The punctations on the lower surface increase posteriorly. The tail marks comprise 6 rings, brown anteriorly, but changing to dark-brown, and then to black at the rattle. The last 3 interspaces, which are grayish, are evident only on the sides. Below, the tail is gray anteriorly, but otherwise black. The rattle matrix is black.

The paratype is a juvenile male in a rather poor state of preservation. The length over-all is 466 mm., the tail length 35 mm., and the head 23½ mm. The scale rows are 31–27–21, the ventrals 189, and the subcaudals 26. The rostral is wider than high. The supralabials number 17—19, and the infralabials 17—16. The scales in the crown comprise 2 internasals and 2 prefrontals. The minimum scales between the supraoculars number 4—4. The group of small scales anterior to the pit is carried forward to the rostral, thus preventing a contact between the prenasal and first supralabial. There are 2 preoculars and 2 loreals on either side. The upper preoculars are undivided. There are from 2 to 4 rows of scales between the labials and orbit.

The general color is grayish. The dorsal blotches, which are olive-gray, are too faint to be counted with accuracy, especially posteriorly; this may, in part, be due to the condition of the specimen. The tail rings are faintly in evidence through the lightening of the interspaces; they are almost black.

Intersubspecific Relationships.—San Estéban Island lies in the middle of the Gulf of California in Lat. 28° 40′ N. It is a barren and rocky island about 3½ miles in diameter. The nearest land is Tiburón Island 6½ miles to the northeast, and San Lorenzo Island 12½ miles to the west. *Crotalus atrox* is found on Tiburón and *C. r. ruber* on San Lorenzo; so far as is known, *C. molossus* occurs on neither. Besides this new rattlesnake, San Estéban is

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* In life these colors at mid-body, using Ridgway's Standards, 1912, were Brownish Olive and Reed Yellow.

known to harbor 5 other reptiles, 2 of which, *Cnemidophorus estebanensis* and *Sauromalus varius*, have differentiated sufficiently from their nearest relatives elsewhere to be deemed valid species.

As might be expected, *Crotalus m. estebanensis* is much nearer *C. m. molossus* than *C. m. nigrescens;* it has the lighter color, higher number of ventral scales, and lateral blotch extensions that characterize the former subspecies.

From *molossus molossus* the differences are only matters of degree, and some may not be substantiated when more specimens of *estebanensis* become available. It is stunted and has the morphological differences characteristic of dwarf races. Thus the head of the adult type is somewhat shorter than that of a *molossus* of similar size; and the rattle has reached parallelism at a width considerably less than that noted in adult females of *molossus* from Sonora and Arizona, the relative figures being about 9.7 and 14.5 mm. Furthermore, the rattles are peculiarly compressed both longitudinally and transversely, making them quite different in shape from the usual *molossus* rattle. This is another characteristic of some dwarfed forms.

In pattern, the new form differs from *molossus* of the mainland in having smaller, lighter, and more numerous dorsal blotches. Lowland *molossus* are less brightly patterned, with less color contrast between the dorsal blotches and the interspaces, than those from the higher elevations, especially in the mountains of southern Arizona; but the type of *estebanensis* is particularly light-colored, and with the dorsal blotches quite obsolete posteriorly. Whether the same condition originally existed in the paratype cannot be determined because of its condition. Best of all the characters, from the standpoint of a key, is the high number of dorsal blotches. The type has 41; out of 144 specimens of *m. molossus* available, only one specimen reaches this number. and only 3 have more than 38, the mean being 31.3. A further difference in the type of *estebanensis* is the absence of a dark-brown patch on the crown of the head in the internasal-prefrontal section. This is evident, and even prominent, in most mainland *molossus*.

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I am appreciative of the courtesies extended to me by the many individuals and institutions whose collections I have been privileged to examine in the course of these studies, or who have furnished me with specimens or data. I desire particularly to mention Mr. Charles M. Bogert, American Museum of Natural History; Mr. Joseph R. Slevin, California Academy of Sciences; Messrs. Karl P. Schmidt and Clifford H. Pope, Chicago Natural History Museum; Dr. Howard K. Gloyd, Chicago Academy of Sciences; Dr. Howard R. Hill, Los Angeles County Museum of History, Science and Art; Mr. Arthur Loveridge, Museum of Comparative Zoology, Harvard University; Dr. Robert C. Stebbins, Museum of Vertebrate Zoology, University of California; Dr. George S. Myers and Miss Margaret Storey, Natural History Museum, Stanford University; Dr. Waldo L. Schmitt and Dr. Doris M. Cochran, United States National Museum; Dr. Raymond B. Cowles, University of California at Los Angeles; Mrs. Helen T. Gaige, then of the Museum of Zoology, University of Michigan; Dr. Emmett R. Dunn, Academy of Natural Sciences of Philadelphia; Dr. E. H. Taylor, University of Kansas; Dr. Henry S. Fitch, U. S. Fish and Wildlife Service; Mr. Charles H. Lowe, Jr., Mr. Lewis W. Walker, Captain G. Allan Hancock, Mr. Waldo G. Abbott, and Mr. R. M. Williams.

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SUMMARY

In a resurvey of the widespread Pacific rattlesnake, *Crotalus viridis oreganus*, geographical differences are found to warrant recognizing two additional subspecies, one involving the southern California and northern Baja California population, the other that in Arizona. For these, names long in synonymy are now revived, the California subspecies to be known as *Crotalus viridis helleri* Meek, 1905; and the Arizona form as *C. v. cerberus* (Coues), 1875. Territorial boundaries and subspecific differences are discussed.

Three new rattlesnake subspecies are described, dwarfing being considered an important justification for the recognition of three island subspecies: These are *Crotalus viridis caliginis* of South Coronado Island, off the northwest coast of Baja California, Mexico; *Crotalus mitchellii muertensis* of El Muerto Island, off Baja California near the head of the Gulf of California, Mexico; and *Crotalus molossus estebanensis* from San Estéban Island in the central Gulf of California.

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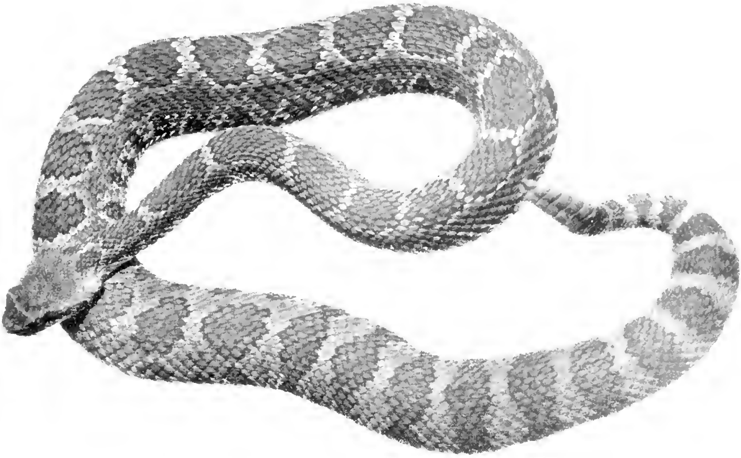

Fig. 1. *Crotalus viridis oreganus* Northern Pacific Rattlesnake
Young adult male from near Wenatchee, Chelan County, Washington.

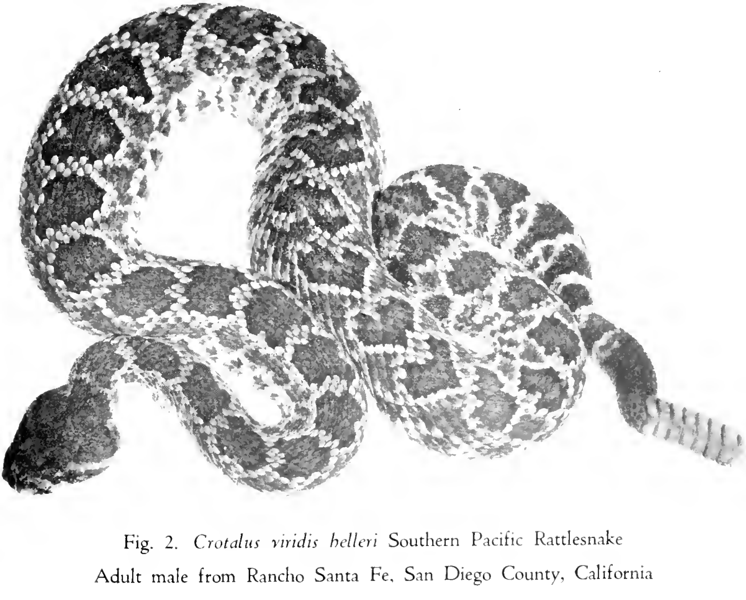

Fig. 2. *Crotalus viridis helleri* Southern Pacific Rattlesnake
Adult male from Rancho Santa Fe, San Diego County, California

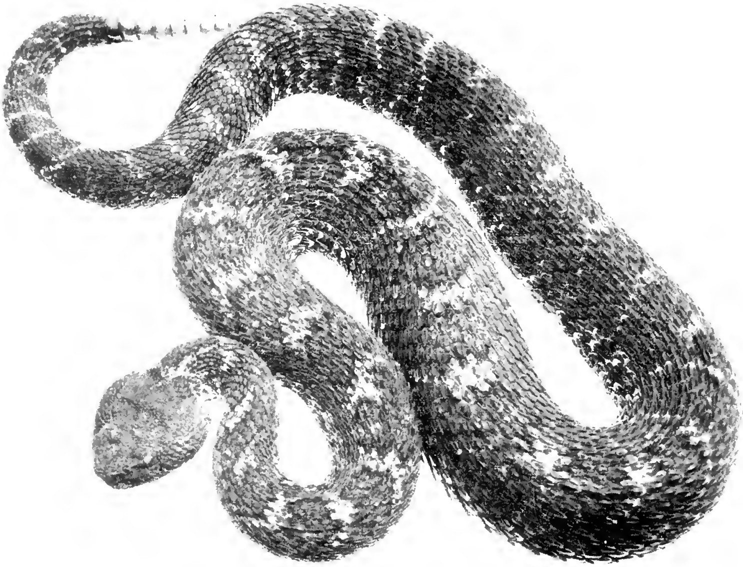

Fig. 1. *Crotalus viridis cerberus* Arizona Black Rattlesnake.
Adult male from Hillside, Yavapai County, Arizona

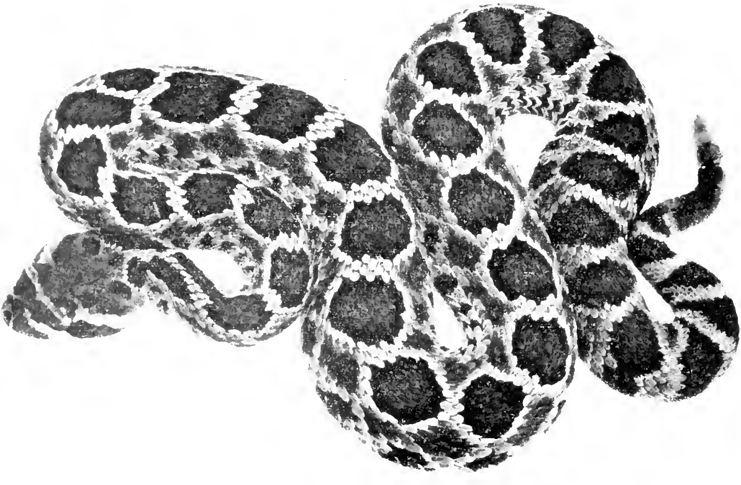

Fig. 2. *Crotalus viridis caliginis* Coronado Island Rattlesnake.
Young male from South Coronado Island, Pacific Coast of Baja California, Mexico.

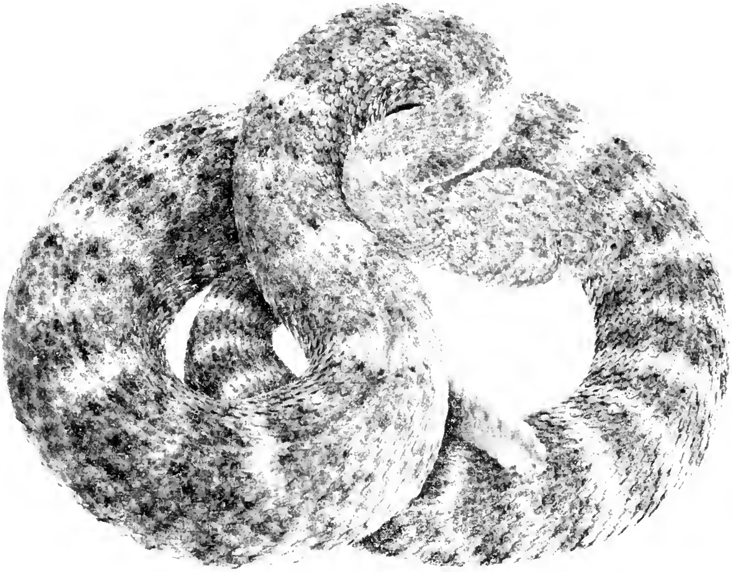

Fig. 1. *Crotalus mitchellii muertensis* El Muerto Island Speckled Rattlesnake. Adult male from El Muerto Island, Gulf of California, Mexico.

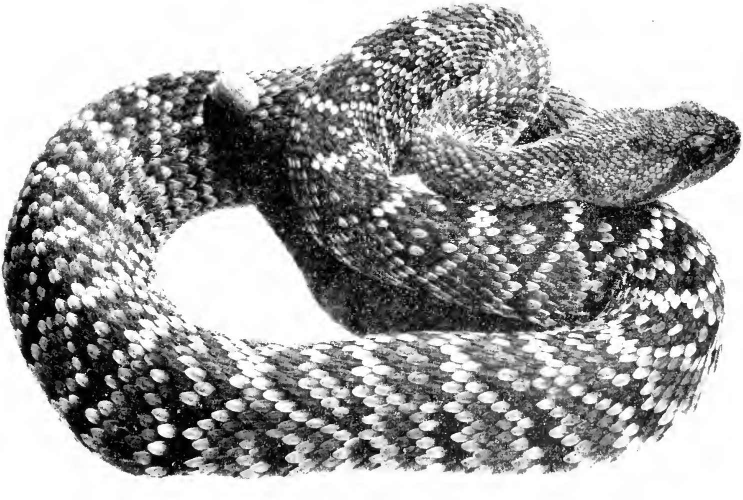

Fig. 2. *Crotalus molossus estebanensis* San Estéban Island Black-tailed Rattlesnake.

Adult female (type specimen) from San Estéban Island, Gulf of California, Mexico.

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A NEW FOSSIL CHILOPOD FROM THE LATE CENOZOIC

BY

RALPH V. CHAMBERLIN

The present account of a fossil chilopod is based upon a single specimen found in an onyx marble pen base prepared by the Southwest Onyx and Marble Company. The specimen was sent to me for study through Prof. A. Petrunkevitch of Yale University at the request of Mr. Clinton G. Abbott, late director of the San Diego Natural History Museum.

The pen base as received was broken in such a way as to divide the elongate specimen into two parts. This of itself has in no way increased the difficulty of the study. It is, however, very unfortunate that the head as well as the caudal end of the body, the two regions affording ordinarily the most significant diagnostic characters, are so far disintegrated and the fragments lost that nothing can be found excepting portions of the two antennae. Nevertheless, the great interest and importance attaching to fossils from this new source seem to justify a description, even though incomplete, of the specimen and an indication of its probable systematic position.

The fossil centiped, as well as those of an arachnid already described and named by Prof. Petrunkevitch*, was discovered by Mr. J. W. Fisher, president of the Onyx company mentioned above, through whose courtesy they have been made available for study. For a detailed account of the quarry the interested person may consult the account by Prof. E. D. McKee quoted in the paper by Prof. Petrunkevitch here cited. This quarry is located "in a canyon on the north side of Black Mesa, about ten miles southwest of Ashfork, Arizona. . . . The age of the deposit is definitely 'post-faulting', which means since the middle of Cenozoic time, but deposition might have been any time from then up to the present. Similar deposits of travertine are forming today in many parts of the region where there are permanent or semipermanent flows of water."

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* A. Petrunkevitch, "*Calcitro fisheri*, a new fossil arachnid." Amer. Jour. Sci., 1945, vol. 243, p. 320.

While the features of the mouthparts are unknown, the form of the antennae and the general structure of the body segments render its place in the Geophilidae as highly probable. The new form may thus be systematically treated as follows.

Order GEOPHILIDA

Family Geophilidae

Genus CALCIPHILUS new

Apparently lacking pleural suprascutella and otherwise agreeing with Geophilus in having the antennae filiform and the tergites bisulcate. Differing from that genus and related forms in having the legs proportionately longer. *Generotype:* **Calciphilus abboti** new species.

The disintegration and nearly complete loss of the head and posterior end of the body prevents a more adequate diagnosis.

Calciphilus abboti new species

Long and slender, its length much exceeding that of any living species of **Geophilus** sens. str. of the Southwest and also apparently somewhat longer than the conspicuous **Linotaenia laevipes** (Wood) common in California and belonging to the closely related family Linotaeniidae. The total length of the holotype is estimated to be 115 mm. or more, with the width 1.5 mm., though in some parts of length less than this from shrinking. In comparison with this the legs of a typical segment of middle region of body are 2.3 mm. long. Because of the coiling and the partial disintegration of the posterior portion of the body the number of pairs of legs cannot be determined accurately but must be 115 pairs or more.

The legs are proportionately long with joints of the relative proportions shown in the accompanying figure; terminal claw with two accessory claws or spines. Sternites with complete paired longitudinal sulci spaced as shown in the figure. It has been impossible in the present state of preservation of the specimen to detect any ventral pores although such may have been present. The tergites also seem to be bisulcate as in typical Geophilus.

Of the head only portions of the two antennae remain, eight articles of the right and three of the left being preserved in situ while two other segments are in the matrix at a distance. The form and proportions of the middle and distal articles of the antennae are shown in the figure. The length of the eight segments of the right antenna is 1.8 mm., which would normally mean a total length of a complete antenna of close to 3.1 mm.

Type locality: Arizona: Bonner Quarry, near Ashfork.

Holotype: San Diego Society of Natural History

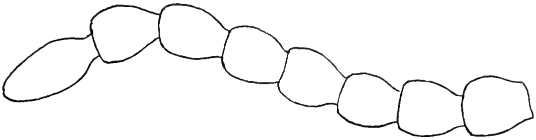

Fig. 1. Eight distal segments of an antenna.

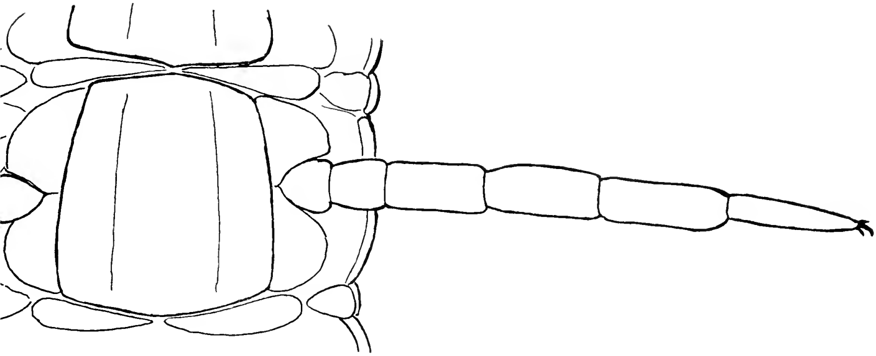

Fig. 2. Segment from middle region of body, ventral view.

TRANSACTIONS

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THE SUBSPECIES OF THE RIDGE-NOSED RATTLESNAKE, CROTALUS WILLARDI

BY

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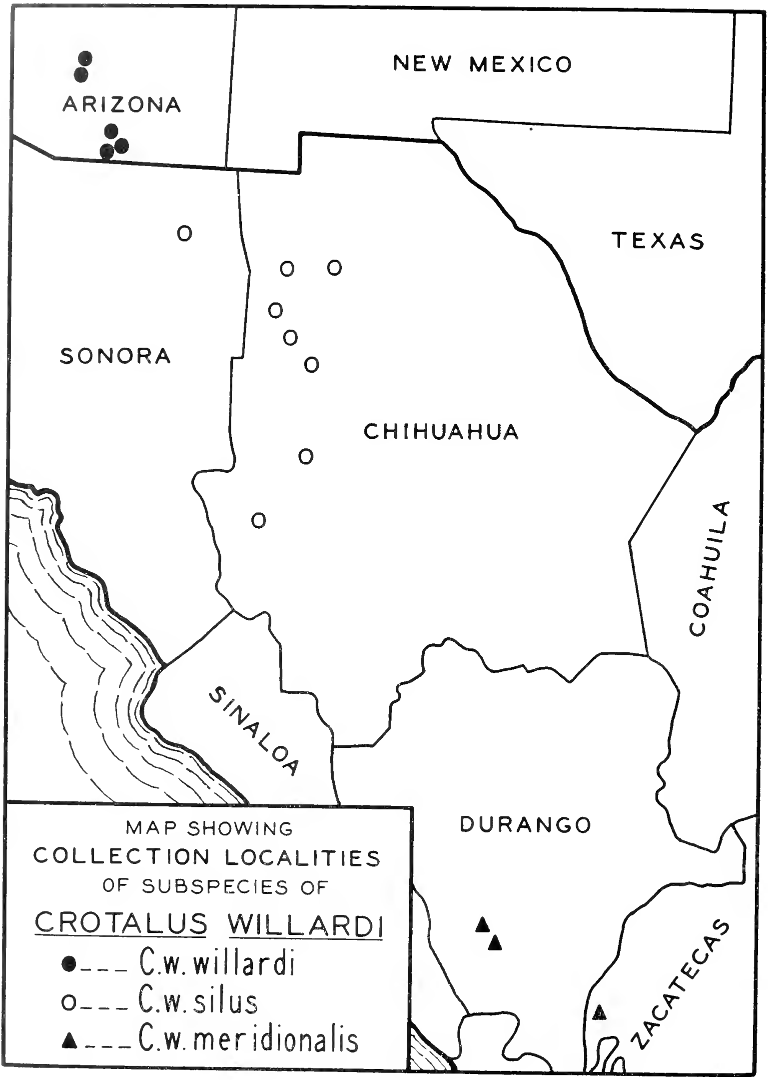
TABLE OF CONTENTS


NEW MEXICO
ARIZONA
TEXAS
SONORA
CHIHUAHUA
COAHUILA
SINALOA
DURANGO
ZACATECAS
MAP SHOWING
COLLECTION LOCALITIES
OF SUBSPECIES OF
CROTALUS WILLARDI
●--- C.w. willardi
o--- C.w. silus
▲--- C.w. meridionalis

THE SUBSPECIES OF THE RIDGE-NOSED RATTLESNAKE, CROTALUS WILLARDI

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The small, montane rattlesnake *Crotalus willardi* inhabits the ranges of the Sierra Madre Occidental, from the Santa Rita and Huachuca mountains of southeastern Arizona, southeasterly to southern Durango and western Zacatecas in central Mexico. It is a well-differentiated species, characterized, as its common name implies, by having an upturned ridge on the snout, a feature unique among the rattlesnakes. Other distinctive features of the species are dorsal blotches that, although well separated by light interspaces, merge with the ground color laterally; a tail partly blotched and partly striped; subcaudals that are white-edged where they contact the lateral scales; sharply pointed posterior scales feathering over the proximal rattle; and dark, decidedly rounded rattles. Viewed from above, the snout is particularly sharp.

With the availability of more specimens, it has become apparent that the central and southern populations of *C. willardi* are sufficiently different to deserve subspecific recognition. Curiously enough, the southern and northern races differ from the intermediate race in pattern more than they do from each other. In addition to describing the new subspecies, I shall redefine the typical (northern) subspecies as newly delimited.

Crotalus willardi willardi Meek

ARIZONA RIDGE-NOSED RATTLESNAKE

Plate 8, fig. 1.

1905. *Crotalus willardi* Meek, Field Columbian Mus., pub. 104; Zoöl. Ser., vol. 7, no. 1, p. 18.

Type Specimen.—No. 902 in the collection of the Field Museum (now the Chicago Natural History Museum). Collected by Frank C. Willard above Hamburg, in the middle branch of Ramsey Canyon, Huachuca Mountains (altitude about 7000 ft.), Cochise County, Arizona. Meek originally reported the type locality as Tombstone, Cochise County, but Swarth (1921, p. 83), on the basis of data secured from Willard, made the correction here accepted.

Diagnosis.—*Crotalus willardi willardi* usually has 25 scale rows while the other subspecies normally have 27. It has fewer body blotches than *meridion-*

alis; also more ventrals, fewer subcaudals, and a proportionately shorter tail. It differs from *silus* in having a conspicuous vertical light line on the rostral and mental, together with other head marks that *silus* lacks.

Material.—This description of the typical subspecies is based on 24 specimens, including the type; there are 11 males and 13 females. All were collected in the Huachuca and Santa Rita mountains of southeastern Arizona.

Description of the Subspecies.—This is a small rattlesnake characterized by having sharply uptilted internasals, and, to a less extent, raised anterior canthals, these forming the ridge bordering the snout that gives the snake its name.

The largest specimen that I have seen is a male 593 mm. (23¼ in.) long, collected by C. F. Kauffeld in Ramsey Canyon at 6800 ft. Three recently born young, 189 to 193 mm. (about 7½ in.) long, indicate the approximate size at birth. In adult males the tail length averages 10.2 per cent of the length over-all, and in the mature females 8.0 per cent. The head in the adults is about 5.2 per cent of the length over-all.

Most specimens have 25 scale rows at mid-body; 3 out of 24 have 27, and one has 26. The complete scale row formula is usually 29–25–19. The middorsal rows are keeled, but the lowest 3 rows on either side are smooth.

The ventrals in the males vary from 147 to 154, with a mean of 151.0; and the females from 152 to 159, with an average of 154.8. The subcaudals in the males range from 25 to 28, mean 27.2; and in the females from 21 to 25, mean 22.7.

The crown is definitely concave in well-preserved specimens, and the rostral slants backward below. The rostral is higher than wide, and does not curve backward above as it does in most rattlers. The two internasals are sharply creased transversely; their forward halves turn upward at right-angles with the top of the head, to form a ridge (fig. 2). The anterior canthals are also upturned, but to a lesser degree. The posterior canthals carry the ridge rearward in some specimens, but in others they are almost flat. The uptilted snout, accentuated by the internasal-canthal ridge, consistently serves to distinguish the subspecies of *willardi* from all other rattlesnakes. Also, when viewed from above, the snout is more pointed than in other species. The scales on the crown in the internasal-prefrontal area are quite small, numbering from 20 to 40; those of the frontal and prefrontal areas are not separated by a suture. The supraoculars are by far the largest scales on top of the head. The least number of scales between the supraoculars varies from 6 to 9. On the sides of the head the scales are of types common to many rattlers. The prenasal contacts the first supralabial in all specimens. The loreals may number 1 or 2, but the upper preocular does not contact the postnasal. There are at least 2 scales between the supralabials and the orbit. The preoculars are undivided, and neither divided first infralabials, intergenials nor submentals are present. The supralabials vary from 12 to 15, average 13.6, and the infralabials from 12 to 16, average 13.6.

Crotalus w. willardi is a small, brownish rattlesnake, notable for the lack of lateral borders of the dorsal blotches and the conspicuous light marks on the head. A white line, arising at the internasals, passes downward and backward across the nostril, the lower preocular, and the last 5 or 6 upper labials, to the angle of the mouth. This stripe is occasionally bordered by black dots and widens posteriorly. Above it there is a brown bar, somewhat darker than the ground color of the head, that passes from the eye to a point above the last supralabial. The upper edge of this dark bar is bordered by a light line that is almost obsolete in many specimens; in none is it as conspicuous or definite as the lower light line first mentioned. On the center of the rostral there is a vertical white line which, on reaching the lip, splits, to pass backward along the lower edges of the first 5 or 6 supralabials on each side. A similar vertical light line on the mental widens across the inner ends of the first infralabials, and continues, ever widening, across the genials and gulars, so that the entire lower surface of the head is light, except for a brown ellipse on either side, anteriorly, and a second pair of dark marks engaging the posterior infralabials and the adjacent gulars. (These blotches are less punctated in *w. willardi* than in *meridionalis*.) The brown areas of the head are often bordered by black dots, and the brown color itself results from dense stippling in various shades of brown. The top of the head is liberally sprinkled with irregular black dots.

Dorsally, the body of the snake is brown, marked by a series of blotches that are separated by clearly outlined light interspaces, usually buff in color. These interspaces are accentuated middorsally but not laterally; on the sides the dorsal blotches merge without a break into the brownish ground color. The dorsal blotches are darkened where they approach the interspaces, the inner borders being quite dark-brown or even black. The shading, from these dark edges back toward the blotch centers, is gradual, resembling color applied with an air brush. The dorsal blotches are about 5 to 8 scales long (end to end); the interspaces are only one scale wide. The color contrast between blotches and interspaces sharpens posteriorly. Lateral secondary blotches are seldom evident, except for an irregular row of about three times the number in the dorsal series marking the lowest lateral scale rows. Scattered about over the body, both dorsally and laterally, are many dark-brown or black dots. The ventrum is buff, heavily spotted or mottled with dark-brown or black. These markings become denser posteriorly.

The body blotches of the main series vary in number from 20 to 25, with an average of 21.8. As the tails are partly ringed and partly striped, the count of the rings has little significance.

Anteriorly the tail is crossed by from 1 to 3 crossbands similar to those on the body; posteriorly it is grayish, with a darker longitudinal line along the top. Spots and punctations are considerably in evidence. The outer edges of the lowest lateral rows of scales and of the subcaudals are light gray or even white.

The rattle matrix is brown or red-brown, often spotted with dark-brown or even black. The rattles themselves are darker than in most other rattlesnakes, and have a notably rounded conformation. The dorsal scales that feather out over the proximal rattle are particularly pointed. The rattles of the adults average 6.5 mm. in width, but may occasionally reach 7 mm.

The hemipenes exhibit no peculiarities when compared with those of other rattlesnakes. The spines on the shoulders are short and heavy, and the transition to reticulations quite sudden, as in all members of the genus *Crotalus* except *C. lepidus*. A few small spines are present within the crotch.

Well-preserved specimens from the Santa Rita Mountains are too few to allow it to be determined whether they differ significantly from those of the Huachucas. The Santa Rita snakes may be slightly grayer. There are no differences in squamation.

Range.—Thus far this subspecies has been collected only in the Huachuca and Santa Rita mountains of southeastern Arizona. The specific localities follow: Huachuca Mountains in Cochise County: Ramsey Canyon at 6500, 6800 and 7000 (Hamburg Mine), and 7500 feet; Carr Canyon (head of canyon at 7500 feet); also reported from Post Canyon, but no specimen available. Santa Rita Mountains in Santa Cruz and Pima counties: Mount Baldy at 8000 feet (also at the head of Temporal Gulch on Mount Baldy, Santa Cruz County); Madera (also known as White House) Canyon at 9000 feet, Pima County; has been reported in Florida (or Florita) Canyon (either Santa Cruz or Pima County) but no specimen available.

Crotalus willardi silus subsp. nov.

CHIHUAHUA RIDGE-NOSED RATTLESNAKE

1917. *Crotalus willardi* (part) Stejneger and Barbour, Check List of North American Amph. and Rept., [ed. 1], p. 111.

Type Specimen.—No. 46694 in the collection of the Museum of Vertebrate Zoölogy of the University of California. Collected August 13, 1948, by R. McCabe, on the Río Gavilán, 7 miles southwest of Pacheco, Chihuahua, Mexico, altitude 6200 ft.

Diagnosis.—A subspecies differing from the other two in not having a prominent vertical light line on the rostral or mental; other characteristic head marks are also absent. This subspecies usually has 27 scale rows while *w. willardi* normally has 25. *Crotalus w. silus* has more ventrals than *meridionalis*, and more subcaudals and a proportionately longer tail than *w. willardi*.

Description of the Type.—An adult male. The length over-all is 636 mm., and the tail length 67 mm.; ratio .105. The head measures 32.3 mm.; ratio .051.

The scale rows number 31–27–21, with 10 at the middle of the tail. The scales are moderately keeled middorsally; the 3 lowest rows on either side are smooth. Paired apical scale pits are faintly evident on some scales. The ventrals number 158 and the subcaudals 32, the last 6 of which are divided. The anal is entire. The supralabials number 15—15 and the infralabials 14—15. The first infralabials are undivided, and there are neither intergenials nor submentals. The rostral is higher than wide and is contacted by 9 scales:

paired first supralabials, prenasals, and internasals, a granule on each side at the supralabial-prenasal-rostral junction, and one on the right at the prenasal-internasal-rostral junction. The larger scales on the sides of the head comprise pre- and postnasals, 2 loreals, and upper and lower preoculars, the latter, as usual, thin and crescentic. There are 2 to 3 scales between labials and orbit. The scales on top of the head comprise a pair of sharply upturned internasals and, on each side, 3 canthals, of which the anteriormost is somewhat upturned to extend the ridge that characterizes this species. The scales on the crown are quite small, numbering about 40 anterior to the front edges of the supraoculars. There are 9+10 scales between the supraoculars. The mental is triangular. The first infralabials meet on the median line. Behind them 3 infralabials contact the genials on either side.

The rattles, of which there is an incomplete string of 7, measure 6.5 mm. across. They are dark-brown and have the rounded form characteristic of this species. The final scales on the tail are pointed and, as in the other *willardi* subspecies, feather out over the proximal rattle to a greater degree than in other rattlesnakes.

The head is brown on top, turning to dark-gray on the sides. Much of the color is applied by stippling, but there are also some larger black dots. The last 5 or 6 supralabials are lighter, with fewer punctations. The infralabials are punctated with gray, as are also the genials and the adjacent gulars.

The body pattern comprises a series of 25 round dorsal blotches on a brown background. The blotch limits are well defined only middorsally, for on the sides they merge into the ground color. Middorsally the interspaces are buff or light-brown, edged with irregular black spots. Posteriorly the middorsal light interspaces become more even and contrasting. No auxiliary lateral blotches are evident. The entire body is irregularly speckled with black or dark-brown dots. The lower surface is buff, heavily mottled with brown, especially toward the outer edges of the ventrals, and with more clouding evident posteriorly. The tail, anteriorly, is marked with two blotches like those on the body; posteriorly, it is unicolor, brown on top, changing to gray on the sides. At the junction of the lowest scale row with the subcaudals, the scales are edged with white. The undersurface is pinkish, mottled with brown.

Paratypes.—In addition to the type, 25 other specimens have been available, of which 13 are males, 9 females, and 3 indeterminate skins. Eight were from Sonora and the rest from Chihuahua. The paratypic series includes the following specimens: MZUM 78449-55*, MCZ 36889, MVZ 46692-3, 46695-6, USNM 26593, 42496-7, 42709, 46322-6, Prof. D. D. Brand 3 unnumbered.

Description of the Subspecies.—The following description is based on all available specimens, including the type. *Crotalus w. silus* is a small snake; the largest out of 26 is a male (the type) only 636 mm. (25 in.) in length. This specimen somewhat exceeds the longest *C. w. willardi*, which is 593 mm. (23¼ in.). The smallest juvenile measures 184 mm. (7¼ in.). A gravid female

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* There are two small specimens under the single number 78455.

containing well-developed embryos is 452 mm. (17¾ in.) long. The tail length of adult males averages 11.0 per cent of the length over-all, and in the adult females 9.1 per cent. The head is about 5.1 per cent of the length over-all in adults.

Out of 25 specimens, 16 have 27 scale rows at mid-body, 7 have 25, and 2 have 26. The usual scale-row formula is 29-27-19, with 9 or 10 at the middle of the tail. The dorsal rows are keeled, but the 2 or 3 lowest rows on either side are smooth. Paired apical scale pits are faintly evident on some scales.

The ventrals in the males range from 149 to 158, with a mean of 153.2; and in the females from 154 to 159, with a mean of 156.9. The subcaudals in the males vary from 29 to 35, average 30.9; and in the females from 25 to 30, average 26.8.

The top of the head is concave, due to the tilting up of the internasals and first canthals, and sometimes the second canthals as well. Except for the supraoculars, all scales on the crown are quite small, the minimum number across the frontal area varying from 6 to 10. The scales on the side of the head have no outstanding peculiarities. Usually there are 2 loreals. The upper preoculars are not split. There is often an extra scale at the rostral-prenasal-supralabial junction. There are 2 to 3 scales between the supralabials and the orbit. Submentals and intergenials are absent and the first infralabials are undivided. The infralabials vary from 13 to 16, average 14.1; and the infralabials from 13 to 15, average 14.1.

The head marks in *C. w. silus* are much less conspicuous than in *C. w. willardi* or *C. w. meridionalis*. The top of the head is brown, spotted irregularly, especially toward the snout, with dark-brown or black dots. An ocular dark band varying from dark-brown to speckled gray begins at the eye and runs backward and downward to a point above the last supralabial. The upper edge of this dark band is not definite; but below it is bordered by a grayish to white streak that begins at the pit, or somewhat posterior thereto, and runs backward to the last supralabial. This light streak is bordered above by black dots. Anteriorly it is usually gray, punctated with brown dots. These dots disappear posteriorly, so that on the last 5 or 6 supralabials the streak may be almost clear white or buff, the lightest area on the head. The rostral and mental are punctated gray or brown, showing no vestiges of the vertical light lines so conspicuous in *w. willardi* and *meridionalis*. The lower surface of the head is cream or buff, speckled with gray, particularly anteriorly and laterally. In some snakes these punctations form darkened areas reminiscent of the brown blotches so characteristic of *w. willardi*.

The dorsal pattern comprises a series of dark-brown blotches, edged at each end, but not laterally, with black, and separated by gray or buff interspaces. The main blotches are about 5 scales long (end to end) and the interspaces measure about one scale. The blotches vary in number from 20 to 27, with a mean of 23.4. They are not clearly outlined laterally, although there is somewhat more contrast in well-preserved specimens between the blotches and ground color than in *w. willardi.* The contrast between the blotches and interspaces is accentuated posteriorly. The entire dorsum is irregularly spotted with black and dark-brown dots. Lateral series of secondary blotches are evident in some specimens. The ventrum is buff, heavily speckled or blotched with gray, with an increase in maculations caudad.

Anteriorly, the tail is marked by from 1 to 3 blotches of the same character as those on the body; posteriorly it is punctated gray with a darker mid-dorsal stripe, and a lateral stripe on each side. In some specimens, these longitudinal lines are only faintly in evidence. The under surface of the tail is gray or pink, punctated or spotted with brown. The subcaudals and the lowest laterals usually have light edges, a characteristic of the *willardi* subspecies. The rattle matrix is buff or brown, sometimes with black spots. As in the other subspecies, the rattle is dark-brown and has a rounded contour, and the scales that sheathe the proximal rattle are sharply pointed. The maximum rattle width noted was 7.3 mm., but 6.5 mm. is a more usual adult dimension.

The Sonora specimens are somewhat lighter than those from Chihuahua, but show no conspicuous intergrading tendencies toward *w. willardi.* The light head marks so typical of the Arizona subspecies are not evident.

Range.—This subspecies has been collected only in northeastern Sonora and western Chihuahua, at the following specific localities: SONORA: Above the Santa María Mine in El Tigre Mountains. CHIHUAHUA: Río Gavilán (7 mi. sw. of Pacheco) at 5700, 6200, and 6700 feet; Sierra Madre (near the summit) at 2400 meters (7874 feet); near Colonia García; Río Piedras Verdes at 6900 feet (at the head of the canyon); half way between Nahuárachic and Las Varas at 7000 to 8000 feet; Tamarino; Distrito Guerrero at 2250 and 2365 meters (7382 and 7759 feet); Mojarachic.

Crotalus willardi meridionalis subsp. nov.

SOUTHERN RIDGE-NOSED RATTLESNAKE

1936. *Crotalus willardi* (part) Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 20, p. 231.

Type Specimen.—No. 6569 in the collection of L. M. Klauber. Collected in August, 1904, by Edmund Heller and Charles M. Barber at Coyotes, Durango, Mexico, at elevation 8000 ft. This is the Coyotes on the railroad to El Salto. The locality will be found on Am. Geogr. Soc. Millionth Map, sheet North F-13, where the altitude is given as 2574 m. (8445 ft.). The specimen was formerly one of a pair, carrying the single number 1493, in the Field Museum collection, now the Chicago Natural History Museum.

Diagnosis.—This subspecies differs from *w. willardi* in having a proportionately longer tail, more scale rows, more subcaudals, more body blotches, but fewer ventrals. From *silus* it differs in having a conspicuous vertical light line on the rostral and mental, and other head marks not evident in *silus.* On the average, it has fewer ventrals than *silus.*

Description of the Type.—The type specimen is an adult female with a length over-all of 562 mm. and a tail length of 53 mm.; ratio of tail to total length .094. The head length is 30½ mm., and the width 20½ mm. The fang length (point to lower end of upper lumen) is 5.8 mm. The rattle width (3 segments of equal size remain) is 6.1 mm. The rattles are more rounded than in most other rattlesnakes, as is characteristic of *willardi*.

The scale rows number 29–27–19, with 9 at the middle of the tail. The dorsal rows are strongly keeled, but the rows above the ventrals, which are also the largest, are smooth, and the next two rows only faintly keeled. Paired apical scale pits are faintly in evidence.

The ventrals number 149; the anal is entire; the subcaudals number 30, of which the last 3 are divided, the final row being feathered out into a ring of pointed scales that jut over the proximal rattle.

The rostral is flat, square-topped, and is higher than wide; it engages the first supralabials, a pair of large prenasals, and a pair of internasals. The latter are the most distinctive scales in this snake, for their anterior halves turn upward at right angles to form a ridge above the rostral, giving the snake its popular name. Behind each internasal there are 3 canthals; the first of each series is uptilted to form a posterior continuation of the ridge formed by the internasals; the second is the largest of the series and is slightly raised outwardly; the last, which is quite small, engages the supraoculars. The area between the canthals is concave and contains about 25 small scales. The frontal area is also filled with small scales, there being a minimum of 7 bridging the space between the supraoculars. The supraoculars are the largest scales on the head; they narrow to points anteriorly. On each side there is a large anterior nasal, followed by a smaller postnasal; 2 loreals, the upper smaller; and 2 preoculars, the upper larger and the lower long and thin, and forming, with the lower loreal, the upper border of the pit. There are 6 sub- and postoculars on the right and 7 on the left. There are 3 rows of scales between the labials and the orbit. The supralabials number 14—14 and the infralabials 14—15. The mental is triangular. The first infralabials are undivided; they meet on the median line behind the mental and are followed by a pair of enlarged genials, which are contacted by the first 3 infralabials on either side. There are no submentals or intergenials.

The condition of this specimen precludes a description of the body pattern with assurance, as the epidermis has been scraped from some areas.

The head is brown above, the color being applied in the form of very fine stippling. There are scattered black dots on the supraoculars, with some smaller, less prominent ones on the canthus. The sides of the head are strikingly marked with white lines on a brown background. There is, first, a thin vertical white line down the center of the rostral; upon reaching the lower edge of the rostral this line branches to right and left and becomes a narrow white border of the upper lip; it continues back to the fifth supralabial, where it disappears. A second white stripe begins at the upper center of each prenasal and passes backward and downward across the pit and below the eyes, to terminate on the last supralabials at the angle of the mouth. This streak widens posteriorly and is lined with dark-brown dots on some scales. The underjaw is also brightly marked with white streaks. Down the center of the mental there is a narrow white streak, which is a continuation of that on the rostral. This widens as it follows the median line between the genials. At the first gulars it diverges to the gulars adjacent to the last supralabials. The area between is irregularly spotted and blotched with gray, so that some gulars are white while others are gray. A second light line on each side begins as a narrow white edge on the lip at the third infralabial and passes backward, widening along the lip until about the ninth infralabial. Here it turns down, following the first row of scales below the infralabials, until the commissure is reached, where it branches, one part turning upward to the commissure, while the other passes back to the neck. Except for the white areas, the underjaw is gray-brown anteriorly and gray toward the neck.

The dorsal pattern comprises a series of 29 brown blotches on a lighter-brown ground color. The blotches are not well defined, although they are somewhat clearer medianly, where the contrast between the dark blotches and the light interspaces is accentuated. The lateral edges of the blotches are quite indefinite, but this may be due to the condition of the specimen. Posteriorly, the blotches form fairly well-outlined crossbands. There are a few widely spaced dark-brown or black dots scattered over the dorsum. The sides are somewhat grayish. The ventrum is buff anteriorly, increasingly punctated and blotched with gray toward the tail, so that two definite lines of gray mottling are formed.

The tail is crossed by 3 brown bands anteriorly, with light-brown interspaces. Posteriorly it is gray-brown on the dorsum and gray laterally. On the sides many of the scales contain a black spot posteriorly, and the lowest lateral row is edged with white. Below, the tail is light-gray, speckled and spotted with dark-gray or black. The rattle matrix is light-gray with a few scattered black spots.

Paratypes.—There are three paratypes: Chicago Natural History Museum No. 1493, one of a pair from Coyotes, Durango, of which the other is the holotype; Chicago Academy of Sciences No. 13953 from Weicher Ranch, 50 miles west of Durango, Durango (State); and U. S. National Museum No. 46332 from Sierra Madre, Zacatecas, Mexico.

The first is a male 510 mm. in length over-all with a tail 58 mm. long, and a head length of 29½ mm. It has 27 scale rows at mid-body, 146 ventrals, and 31 subcaudals. The supralabials number 17—15, and the infralabials 15—14. The minimum scales across the frontal space number 8. There are 28 body blotches.

The Chicago Academy specimen is a young male measuring 233 mm. over-all with a tail length of 27 mm. The head measures 16 mm. There are 27 scale rows at mid-body, 148 ventrals, and 34 subcaudals. The supralabials number 14—15 and the infralabials 14—14. The minimum count of scales between the supraoculars is 8. The body blotches are indeterminate because the skin is torn at the neck.

The National Museum specimen is a small female in rather poor condition. It is 257 mm. long, with a tail length of 28 mm. and a head length of 18.3 mm. There are 29 scale rows, 147 ventrals, and 30 subcaudals. The labials number 14—15, 14—15, and the minimum scales in the supraocular bridge, 8. The condition of the specimen is such that the blotches cannot be counted.

The patterns of the paratypes, to the extent that they can be determined, are much the same as in the type. The heads are brown above, with some black specks, which are particularly evident on the supraoculars and canthals. On the sides and below, the pattern of white streaks, as described in the type, is strikingly evident, especially the vertical line on the rostral and mental, and the side stripes marking the labials. Below there is a pair of divergent gray-brown blotches, punctated with black, that cover the anterior gulars.

The dorsum is marked with a series of square brown blotches separated by light-brown to buff interspaces. The anterior blotches are rather poorly defined, with little contrast between blotches and interspaces; posteriorly the contrast increases. All blotches are rather poorly defined on the sides. Below the main series on either side, 3 other series of small dark spots may sometimes be distinguished; these become darker as the ventrum is approached. Fine black or brown punctations are scattered over the dorsum. Larger spots often mark the edges of the light interspaces. The ventrum is heavily mottled with dark-gray to black, although the mid-ventral line is somewhat clearer.

The dorsal blotches are continued on the anterior third of the tail, but the final section is longitudinally striped, instead of being crossbarred. Laterally and below, the tail is gray. A thin serrated white line marks the outer edges of the subcaudals.

Intersubspecific Trends

Although the statistics of the subspecies *meridionalis* are uncertain because of the meagreness of the material, it appears that the subspecific trends are geographically consistent in most characters. Scale rows, subcaudals, labials, body blotches, and tail-length proportionality all increase from north to south, that is, from *w. willardi* through *silus* to *meridionalis*. An inconsistency is shown by the ventrals, for in *silus* these scutes apparently average slightly higher than in *w. willardi*, while in both the ventral count exceeds that of *meridionalis*. The most surprising inconsistency, speaking geographically, is to be found in the head pattern, for the two terminal forms have retained a striking pattern unique among the rattlesnakes, whereas the intermediate subspecies, although retaining some traces of what must have been the ancestral pattern, has reverted to a nondescript design without distinctive elements. Thus it has lost the vertical white lines on the rostral and mental; the clear white streak from the nostril to the last supralabial, except for a less-contrasting rear half; the second, but shorter, streak along the bottoms of the first five supralabials; also the two pairs of brown ovals on the lower jaw. All of these color features serve to make *w. willardi* and *meridionalis* the most strikingly marked of all rattlesnakes, as far as head pattern is concerned. It is surprising to observe the similarity of *w. willardi* and *meridionalis* in head marks, separated as these subspecies are by 600 miles of mountain chain, much of which is occupied by the race *silus* that has lost these marks. This is apparently an example of central rather than peripheral differentiation.

LIFE HISTORY AND MORPHOLOGY

Not much is known concerning the habits of *willardi*, since the relative inaccessibility of the mountain areas where it occurs has made it rare in collections. It is probably moderately common in some places, for such collectors as have reached its habitat — this being true particularly of *silus* — have been rewarded with a half-dozen or more specimens.

That it is consistently a mountain form, is indicated by the fact that none of the 50 or more specimens now available came from an altitude below 5700 feet. The maximum record is somewhat above 9000 feet. Kauffeld (1943, p. 355) refers to it as an alpine forest snake, and suggested that it is not as partial to rocky areas as *Crotalus lepidus klauberi*. However, the two specimens that he did collect in the Huachucas were found near or under rocks. Dr. D. D. Brand, who captured three at between 7 and 8000 feet in Chihuahua, found them coiled in rock ledges.

Crotalus willardi is known to feed on both mammals and lizards. Like most rattlesnakes of the smaller species, it is probable that lizards comprise a major part of the diet, particularly of the juveniles. A *Sceloporus*, probably *S. j. jarrovii*, was found in a specimen of *w. willardi*, and an alligator lizard, *Elgaria kingii*, in a *silus*. Mammal remains were found in all three subspecies. Kauffeld (1943, p. 355) had one strike and quickly kill a white mouse, from which he judged the venom to be relatively powerful. One of his two captive specimens took dead mice readily, but the other had to be force-fed. To Kauffeld it appeared that *willardi*, in captivity, showed some resemblance to specimens of *Agkistrodon* and *Bothrops*. It remained stretched out rather than assuming the typical resting coil of a rattler, and had the habit of turning to bite. It seemed quite inquisitive.

A specimen of *w. willardi* 481 mm. (19 in.) long contained 6 eggs; and a *silus* 452 mm. (17¾ in.) in length contained at least 2 well-developed embryos, which gives an idea of the size of the adult females. As in all rattlesnakes except *Crotalus cerastes*, the adult males exceed the females in length by about 10 to 15 per cent. The ratio of the size of the young at birth to the ultimate adult size (about .32) is high, as is usual in the smaller species of rattlesnakes, when compared to the larger. Proportionately, *willardi* has the largest head of any rattlesnake; the adult head length is about .052 times the body length. The typical subspecies has a slightly larger head than *silus* Also, it has a somewhat longer fang (relative to head length) than most other small species of rattlers. The rattles are distinctive in both form and color, being more rounded and darker than in other species. The terminal body scales that edge the proximal rattle are particularly pointed in this species.

KEY TO THE SUBSPECIES OF *Crotalus willardi*

A1	No white vertical line on the rostral or mental	*silus*
A2	A white vertical line on the rostral* and mental (fig. 3)	
B1	Scale rows usually 25; ventrals 150 or more; subcaudals in males 28 or fewer, in females 25 or fewer; body blotches 25 or fewer	*willardi*
B2	Scale rows more than 25; ventrals fewer than 150; subcaudals in males more than 28, in females more than 25; body blotches more than 25	*meridionalis*

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The following individuals and institutions have kindly permitted me to examine the specimens of *C. willardi* contained in their collections: Mr. Charles M. Bogert, American Museum of Natural History; the late Dr. Charles T. Vorhies, University of Arizona; Mr. Joseph R. Slevin, California Academy of Sciences; Mr. M. Graham Netting, Carnegie Museum; Dr. Howard K. Gloyd, Chicago Academy of Sciences; Messrs. Karl P. Schmidt and Clifford H. Pope, Chicago Natural History Museum; Messrs. Arthur Loveridge and Benjamin Shreve, Museum of Comparative Zoölogy, Harvard University; Dr. Robert C. Stebbins and Mr. Wade Fox, Museum of Vertebrate Zoölogy, University of California; Dr. Edward H. Taylor, University of Kansas; Dr. James A. Peters, University of Michigan; Dr. Donald D. Brand, University of Texas; Dr. Emmett R. Dunn, Academy of Natural Sciences of Philadelphia; Mr. Carl F. Kauffeld, Staten Island Zoölogical Society; and Dr. Waldo L. Schmitt and Dr. Doris M. Cochran, United States National Museum.

I am grateful to Dr. Carl L. Hubbs, and Messrs. C. B. Perkins and Charles E. Shaw for editorial criticisms and suggestions. I was assisted by Charles E. Shaw and Richard Schwenkmeyer in making scale counts. The sketches were prepared by Mr. Norman Bilderback; and the map and photograph by Mr. Leslie C. Kobler.

SUMMARY

The ridge-nosed rattlesnake, *Crotalus willardi* Meek, 1905, a distinctive montane species restricted to the Sierra Madre Occidental, is now divided into 3 subspecies, based on differences in lepidosis and pattern. These are *C. w. willardi* of the Santa Rita and Huachuca ranges of southeastern Arizona; and two new subspecies: *C. w. silus*, of northeastern Sonora and western Chihuahua, and *C. w. meridionalis*, of western Durango and southwestern Zacatecas, Mexico.

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* Sometimes abraded on specimens that have been long in captivity.

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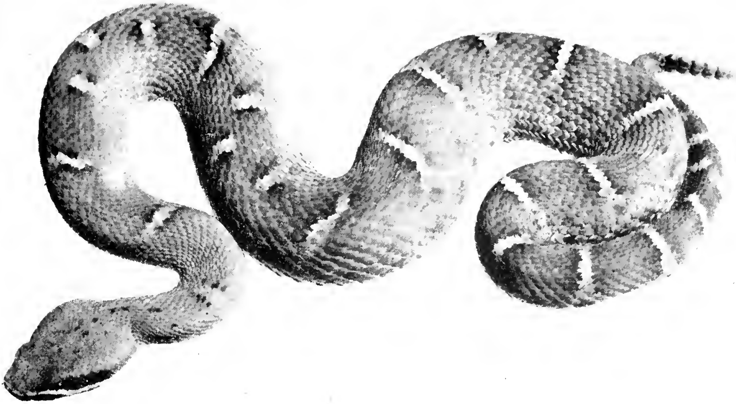

Fig. 1. *Crotalus willardi willardi* Arizona Ridge-nosed Rattlesnake. Adult male from Ramsey Canyon, Huachuca Mountains, Cochise County, Arizona.

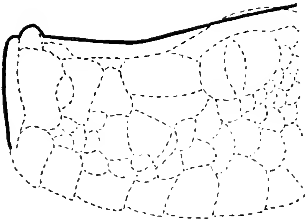

Fig. 2. Cross-section of head showing internasal ridge.

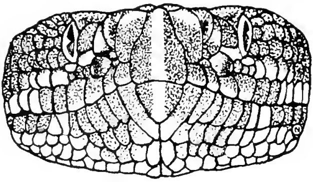

Fig. 3. Snout showing vertical light line on rostral and mental.

TRANSACTIONS

OF THE

SAN DIEGO SOCIETY OF NATURAL HISTORY

VOLUME XI, No. 9, pp. 141-204, plates 9-10

THE SHOVEL-NOSED SNAKE, CHIONACTIS WITH DESCRIPTIONS OF TWO NEW SUBSPECIES

BY

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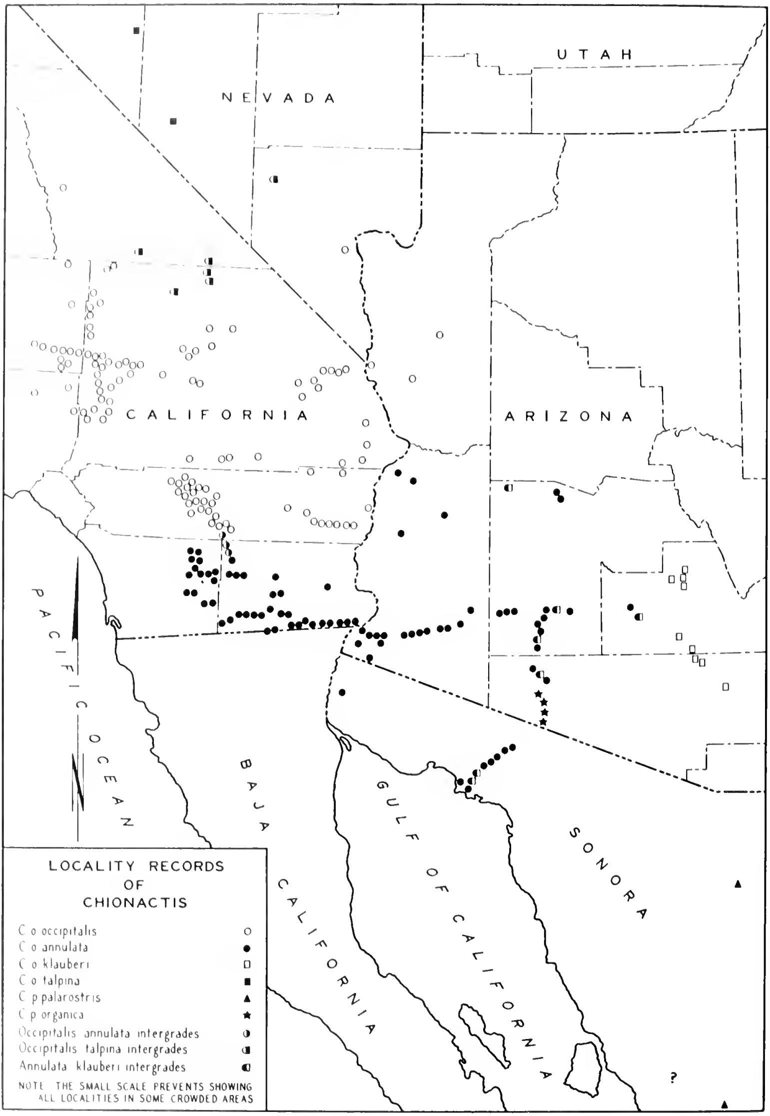
TABLE OF CONTENTS


UTAH
NEVADA
CALIFORNIA
ARIZONA
PACIFIC OCEAN
BAJA CALIFORNIA
GULF OF CALIFORNIA
SONORA
N
?
LOCALITY RECORDS OF CHIONACTIS
C. o. occipitalis ○
C. o. annulata ●
C. o. klauberi □
C. o. talpina ■
C. p. palarostris ▲
C. p. organica ★
Occipitalis annulata intergrades ◑
Occipitalis talpina intergrades ◧
Annulata klauberi intergrades ◐
NOTE: THE SMALL SCALE PREVENTS SHOWING ALL LOCALITIES IN SOME CROWDED AREAS

THE SHOVEL-NOSED SNAKE, CHIONACTIS, WITH DESCRIPTIONS OF TWO NEW SUBSPECIES

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INTRODUCTION

The shovel-nosed snakes of the genus *Chionactis* are small, nocturnal inhabitants of the deserts of the southwestern United States and northwestern Mexico. Like many other desert snakes, they were once thought to be rare, but within the past 20 years it has been found that they are quite common in many places. This discovery has resulted from a new method of collecting, that of driving on paved desert roads at night, when the nocturnal snakes crossing the highway are brightly set off against the dark background of the pavement by the headlights of the car, and may readily be caught. Through this device, the *Chionactis* material in collections has greatly increased in recent years, so that it is now possible to determine subspecific differences with greater assurance than heretofore; and specimens from areas not previously known to be within the range of the genus are at hand.

For some years past, Mr. William H. Stickel has had under way a survey of the snakes of the genus *Sonora.* The shovel-nosed snakes were considered to belong to this genus until Mr. Stickel pointed out differences from *Sonora* warranting their generic separation, and involving the revival for them of the genus *Chionactis* Cope. In the course of his study of *Sonora,* Mr. Stickel made important advances in our knowledge of *Chionactis.* Notwithstanding this work, he courteously agreed to confine his activity to the much more widespread genus *Sonora,* thus permitting me to undertake this study of *Chionactis* without infringing on his program. This generosity on Mr. Stickel's part is much appreciated.

HISTORICAL SUMMARY

The first shovel-nosed snake to be classified was collected by A. L. Heermann, the surgeon and naturalist who accompanied Lieut. R. S. Williamson's railroad-route exploring expedition in California in 1853. It was taken in the Mojave Desert, the exact locality being unrecorded. Although the type specimen is no longer available, a drawing of it is at hand (Hallowell, 1859, plate iv, fig. 2). Judging from the narrow crossbars, relative to the width of the interspaces, and the fact that the posterior bars do not cross the ventrum, we may presume it to have come from the western part of the Desert, no doubt from the general area of the Mojave River, in western San Bernardino County, where several other reptiles taken by the expedition are known to have been collected.

The new species was first described by Hallowell in 1854 (p. 95) as *Rhinostoma occipitale.* The genus *Rhinostoma* had been set up by Fitzinger in 1826 (p. 56) with the type species *rufofusca* from Dominica. In 1856, Hallowell decided that the new snake was not congeneric with Fitzinger's *Rhinostoma,* for reasons that he made clear later (1859, p. 16), and therefore he set up the new genus *Lamprosoma* for the shovel-nosed snake (Hallowell, 1856, p. 310). Subsequently, Cope (1860, p. 241) pointed out that the name *Lamprosoma* was preoccupied by a genus of Coleoptera and therefore substituted the name *Chionactis,* "having allusion to the refulgent whiteness of the scales" (*Chion* Gr. snow; *actis* Gr. a ray or beam of light).

Garman (1883, pp. 91, 164) placed the shovel-nosed snakes in the genus *Contia,* but this assignment did not receive wide acceptance. Subsequently, Van Denburgh and Slevin (1913, p. 412) combined them with the ground snakes of the genus *Sonora* and this view was almost universally adopted for the next 30 years.

Finally, Stickel (1943, p. 122) revived *Chionactis,* re-segregating the shovel-nosed snakes from *Sonora* by reason of a number of fundamental character differences, including the nasal valve, a feature of *Chionactis* that he himself had discovered, as well as the angled abdomen, the spadelike snout, fewer maxillary teeth, and hemipenial divergences. To the present writer, Stickel's re-establishment of *Chionactis* appears fully justified.

As has been stated, the first spade-nosed snake was collected in the Mojave Desert in 1853. To this Hallowell (1854, p. 95) assigned the specific name *occipitalis.* The earliest specimens from the Colorado Desert to reach scientific collections were 2 taken by A. Schott, while on the Mexican Boundary Survey in 1855; these became no. 2105* in the collection of the U. S. National Museum (Smithsonian Institution). They may have come from anywhere along the boundary, in what is now Imperial County, California, between the Colorado River on the east and the foot of the coastal mountains to the westward. While Kennicott (in Baird, 1859a, p. 21) considered them to

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*Although listed as nos. 2105–6 in the report, both specimens were apparently catalogued under no. 2105.

belong to Hallowell's species *occipitalis*, Baird himself (p. 22) pointed out certain differences, particularly the completeness of the body rings, and assigned them to a new species that he called *Lamprosoma annulatum*. Since then the Colorado Desert form has had a varied career, sometimes being viewed as a subspecies of *occipitalis*, as first suggested by Cope in 1875 (p. 36), but usually being considered synonymous with the Mojave Desert form. Finally, Stickel (1941, p. 135; 1943, p. 122), aided by new material, and making a more thorough study than any previously undertaken, revived *annulata* as a subspecies of *occipitalis*.

Two additional forms have been described recently. In 1937 (p. 363) I named *palarostris* from central Sonora as a full species, although this was subsequently relegated to subspecific status by Stickel (1941, p. 137). Finally, Stickel (1941, p. 138) described the subspecies *C. o. klauberi* from the Tucson area of Arizona. Thus four subspecies of *Chionactis occipitalis* are currently recognized: *occipitalis*, *annulata*, *palarostris*, and *klauberi*.

MATERIAL

The present study is based on specimens geographically derived as follows:

San Diego County	345	
Imperial County	58	
Riverside County	126	
San Bernardino County	94	
Kern County	14	
Los Angeles County	2	
Inyo County	3	
Total California		642
Clark County	5	
Nye County	1	
Esmeralda County	2	
Total Nevada		8
Yuma County	45	
Mojave County	2	
Pinal County	10	
Maricopa County	11	
Pima County	27	
Total Arizona		95
Total Sonora		19
Uncertain		6*
Grand Total		770

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*Including one doubtfully stated to be from Utah.

Of these specimens, about 60 per cent are contained in my own collection. I have had some field experience with shovel-nosed snakes, and have seen several hundred live specimens.

Character Variation and Sexual Dimorphism

Subspecific differences in *Chionactis* are largely confined to pattern and color, the squamation being relatively constant. Even the pattern is much less variable than in most genera of snakes. There is little doubt that this consistency is related to the circumstance that the ecological range of the genus is one of the most restricted of any snake inhabiting the southwestern United States.

As a preliminary to investigating specific and subspecific differences, I have made it a practice to determine the extent of intrasubspecific variations, using, as a basis of study, the largest available homogeneous population, in this case that from eastern San Diego County, California. This population, as a matter of fact, is not completely homogeneous, since the area inhabited, although including only the desert section of the county, varies somewhat in physiographic character, and likewise in altitude (from 85 to 2300 feet). Also, the population is not pure *annulata*, but shows some *occipitalis* influences. Nevertheless, I have used it in determining degrees of variation and the extent of sexual dimorphism, since this is the only series containing a really adequate number of females. The data on these specimens are as follows:

Number of specimens, males	234
females	106
Coefficients of variation, per cent	
Ventrals, males	2.12
females	2.06
Subcaudals, males	5.38
females	6.23
Body bands, males	9.40
females	10.64
Tail rings, males	12.69
females	13.88
Coefficients of sexual divergence, per cent*	
Ventrals	-5.94
Subcaudals	12.00
Body bands	-9.43
Tail rings	5.23
Correlation coefficient between body bands and tail rings, per cent	42.2

These results are quite consistent with those disclosed in other genera of snakes, for the coefficients of variation of the ventrals in homogeneous series

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*Positive if the males are higher, negative if the females are higher.

nearly always adhere closely to 2 per cent, the subcaudals to 5 or 6 per cent, the body bands or blotches to 6 to 10 per cent, and the tail rings or spots to 12 per cent or more.

The sexual differences are all highly significant, but with an order of significance corresponding inversely to their coefficients of variation—that is, the ventral-scale dimorphism is most significant and that of the tail rings least. In the subspecific descriptions and discussions that follow, I shall separate the sexes in presenting the statistics of ventrals and subcaudals, but shall seldom do so in pointing out differences in the number of body bands and tail rings, since sexual dimorphism in these characters is not statistically useful unless many specimens of the two populations to be compared are available, and adequate numbers of females are often lacking. Pattern differences in form and color are, in many cases, as useful as key characters as is the numerical variability in the number of bands across the body.

The scale rows are nearly always 15–15–15, and the ventrals, though showing some territorial variation, involve such inadequate differences as to be of little value in keys. The subcaudals also exhibit some subspecific differences, but these are not extensive, and, as key characters, suffer likewise from the fact that this genus does not possess a conspicuous terminal cone, and hence it is not always possible to determine with certainty whether the tail is complete. Neither the labials nor the other head scales are subject to any subspecific differences, at least none that I have found.

With this uniformity in squamation, taxonomic differentiation is largely reduced to a consideration of pattern, which, fortunately, is subject to much more variation, yet has sufficient constancy in each area to afford valuable differential characters.

Essentially, the *Chionactis* head pattern comprises a dark transverse crescent (black to brown) engaging the parietal region, and thence passing down and forward along the sides until the horns of the crescent terminate in the region of the nostril or the eye. The light ground color of the head is substantially the same as that on the body.

The body pattern involves a series of dorsal crossbands of black to brown, on a light ground color varying from white to cream or yellow. These crossbands may or may not extend to the ventrum to form partial or complete rings. The posterior bands much more often form complete rings than the anterior. The proportion that is complete is an important subspecific criterion. The dorsal bands usually narrow laterally; however, those that cross the belly re-widen ventrally. This is particularly true of the posterior bands.

In most specimens of *Chionactis* the widths of the bands are surprisingly uniform, especially at mid-body and when measured middorsally. One may take a pair of dividers, set it for a single band, and find that it measures accurately the widths of a number of adjacent bands. The same is true of the interspaces.

Bilateral asymmetry in pattern is rare in *Chionactis*, specimens with U- or Y-shaped blotches, such as are highly characteristic of *Hypsiglena* or *Arizona*, being evident in less than 1 per cent of the shovel-noses. I have yet to see a *Chionactis* with non-confluent spots on the two sides, a condition frequently observed in the two genera above mentioned. The middorsal joining of two successive blotches to form dumbbells is likewise rare in *Chionactis*.

Although well defined, the tail rings, which are nearly always complete ventrally, are inferior to the body bands as differential characters for two reasons: First, there is uncertainty as to the completeness of the tail; and, secondly, doubt often exists as to whether the small dark spot that usually terminates the tail should, or should not, be counted as a ring. For this reason, though I have given some tail-ring statistics, I prefer to omit them in deriving key characters. There is seldom a questionable blotch at the base of the tail, which cannot be allocated to the body or tail series, depending on its position with respect to the anal plate.

Although the proportion of dorsal bands that encircle the body is a diagnostic character of value, it is often difficult to tell whether a body ring is, or is not, complete. This is particularly true laterally, where the dark color may be carried only by the scale edges, and observers might differ as to whether the thread-like connecting maculations are, or are not, interrupted. In other specimens these lateral connections are punctated and faint. I have found the presence of a dark mark (however incomplete) on the ventrum opposite the position of a dorsal band, to be a much more objective criterion than the completeness of a ring. Stickel (1941, p. 138) found that *occipitalis* has, on the average, more crossbands than *annulata*; also, that the anterior rings in *occipitalis* are much less likely to be complete ventrally than the corresponding rings of *annulata*. To take advantage of both differences in a single character, he introduced the combination: "Total number of bands (on body and tail) plus the number of body bands not entirely encircling the body." In order to eliminate the uncertainty as to the completeness of the tail, to make incomplete-tailed specimens useful, and to avoid decisions involving doubtfully complete rings, I prefer to substitute the following combination character: "Total number of bands on the body plus the number of unmarked band positions on the ventrum." This criterion sharpens the differences as well as does Stickel's and is more objective in application.

Color is important in the classification of *Chionactis* subspecies, but unfortunately is too evanescent in preserved material to be as fully useful as might be hoped. Three colors are involved: the ground color, the band color, and the color of any suffusion or maculations in the interspaces. The ground color may vary in live specimens from white to various shades of cream, yellow, or buff, but all of these hues usually revert to white or nearly white in preservative.

The black or brown of the bands is also invariably lightened by time and the preservative, particularly if the specimen is not kept in darkness. But, as far as I know, neither black nor brown ever disappears, and thus the shape and arrangement of bands and maculations may always be determined, though the original hues may have changed. It may be noted that in this genus, as in many others, the dark marks are darker and more contrasting with the ground color in juveniles than in adults.

The most important and disappointing changes in the *Chionactis* colors take place in such suffusions as may color the interspaces, particularly their centers. These suffusions, often so definitely outlined that they may be deemed secondary blotches or saddles, may be yellow, orange, vermilion, salmon, or deep red. All of these colors disappear in preservative, the yellows earlier in formalin, and the reds earlier in alcohol, but in either preservative they vanish in time, leaving hardly a trace. A useful criterion is thus lost, even though the specimens have been kept in darkness.

Black or brown interspace maculations constitute another type of markings. These are important, both with respect to their extent and character; they may be dorsal, lateral, or ventral, or all three, and they may engage scale centers, scale edges, or both. As far as I know, these maculations never disappear in preservative, so that one may always know their character, if not their original color, and thus this valuable criterion is in part retained. When the ventrum is spotted, an additional type of marking sometimes present, it is usually not difficult to recognize the first blotch that is the ventral analogue of a dorsal band, this blotch being independent of the general spotting.

Dorsal bands are usually of solid color and even-edged. However, in the snakes from some areas the dark part of any scale that is half, or less than half, dark is lighter than the adjacent, completely dark scales. The blotch edge is thus given a serrated appearance. In some specimens the dark color of a band is carried beyond the normal edge of the band along the interstices between scales.

In determining the relative widths of dorsal bands and interspaces, I have usually employed a draftsman's bow dividers, measuring a sample series of 3 or 4 bands at mid-body. Counting scales end-to-end may also be useful, particularly if adults are to be compared with juveniles.

It will sometimes be found of interest to study the position and extent of the head crescent, particularly its forward edge with relation to the supraoculars and frontal, and whether posteriorly it extends beyond the parietals, or does not completely cover them. There is also some difference in the extent of the horns of the crescent, which in some subspecies terminate at the eye, but in others reach as far forward as the nasal scales. Another character sometimes useful is the number of light scales (end-to-end) between the posterior edge of the head crescent and the anterior edge of the first body band.

GENUS *CHIONACTIS*

Lamprosoma Hallowell, Proc. Acad. Nat. Sci. Phila., vol. 8, p. 310, Dec. 1856. Type species *occipitale*.

Chionactis Cope, Proc. Acad. Nat. Sci. Phila., vol. 12, p. 241, June 1860. Type species *occipitale*.

The snakes of this colubrid genus are small and of moderate body proportions. The maximum length attained in any area is somewhat over 400 mm. (15¾ in.). The head is only slightly distinct. The pupil of the eye is round. The tail length varies from 19 to 22 per cent of the length over-all in the adult males, and from 15 to 19 per cent in the females. The snout is quite sharp, with a horizontal cutting edge to facilitate progress through sand; other modifications favorable to an arenaceous existence are the presence of a nasal valve, and a protrusion at the tip of the mental plate which serves to close the apperture through which the tongue is thrust out. There is a sharp angle, represented by a bend in the ventrals, between the abdominal crawling surface and the sides of the body.

The rostral is sharply recurved and pointed posteriorly, but does not separate the internasals. It is somewhat raised above the adjacent plates and is deeply cleft on the under side. The plates on the crown follow the usual colubrid pattern. The parietals are the largest of the head plates, followed by the frontal. The nostril is placed in an undivided nasal, usually slightly forward and above its center. A small loreal, longer than high, is usually present; it is widest anteriorly. There is ordinarily a single preocular and 2 postoculars, of which the upper is the larger. The temporals are usually 1 followed by 2. The upper labials almost always number 7, the next to the last being the largest; the third and fourth touch the eye. The lower jaw is deeply inset. The lower labials usually number 7; the fourth is the largest. The quadrangular mental has an anterior protuberance that is centrally ridged, with a depression on either side. The anterior genials meet on the median line; the posterior, much reduced in size, are separated by gular scales.

The dorsal scales are smooth and rarely in other than 15-15-15 rows. Single apical scale pits are faintly evident on some scales, particularly on the sides of the body. The ventrals vary from 141 to 165 in the males, and 153 to 178 in the females. The anal is divided. The subcaudals range from 39 to 57 in the males, and 34 to 51 in the females. Normally all subcaudals are divided.

The pattern comprises a series of black or brown crossbands on a white to yellow ground color. These bands vary from 10 to 40 on the body and from 3 to 13 on the tail. The bands narrow laterally; some completely encircle the body, widening again on the ventrum. A characteristic black or brown crescent on the head usually engages the parietals, with the horns carried forward on the sides to the eyes or even to the nostrils. The dorsal bands may be either wider or narrower than the interspaces. The interspaces may be marked dorsally in various ways, either suffused with pink or red, or maculated with black or brown, so that in some specimens the secondary blotches or saddles are almost as definite as the primary. The ventrum is sometimes spotted, in addition to being marked by such bands as may be carried to the under surface.

There are 3 maxillary foramina and the maxillary teeth number 8+3 or 9+3 (Stickel). The hemipenis has a distal section of fine and almost uniform reticulations or flounces. The outermost part comprises two low mounds, otherwise the organ is undivided. The basal spinous section contains 2 large spines, one on each side of the sulcus, and about 30 much smaller spines. The transition from reticulations to spines is quite sharp. The sulcus passes diagonally from the spinous base across the reticulations to the top of one of the terminal mounds. It ends among the reticulations, there being no smooth area.

In the southwest, *Chionactis* is most often confused with *Chilomeniscus*, or with some of the crossbanded subspecies of *Sonora*. The separation from the first-named is simple, for in *Chilomeniscus* the nasals are merged with the internasals, whereas in *Chionactis* they are not. *Chilomeniscus* almost invariably has 13 scale rows and *Chionactis* 15. From *Sonora*, *Chionactis* differs in having a flatter snout, an angled abdomen, nasal valves, a protrusion on the mental, and a proportionately shorter tail. The bands on *Sonora* are less definitely outlined. In practice I have found that these characters serve readily to segregate *Chionactis* from banded forms of *Sonora*—some subspecies of *Sonora* are striped or unicolor—except when the specimens are badly preserved or dried juveniles.

SPECIES AND SUBSPECIES DESCRIPTIONS

Chionactis occipitalis occipitalis (Hallowell)

MOJAVE DESERT SHOVEL-NOSED SNAKE

Plate 9, fig. 1

1854. *Rhinostoma occipitale* Hallowell, Proc. Acad. Nat. Sci. Phila., vol. 7, p. 95. Type specimen unknown (figured in Hallowell, 1859, plate 4, figs. 2a, 2b, 2c); type locality Mohave Desert.

1856. *Lamprosoma occipitale* Hallowell, Proc. Acad. Nat. Sci. Phila., vol. 8, p. 311.

1859. *Lamprosoma occipitale* (part) Baird, Gen. Rept. Zoöl. Pac. R.R. Routes, vol. 10, part 3, p. 16.

1860. *Chionactis occipitalis* Cope, Proc. Acad. Nat. Sci. Phila., vol. 12, p. 241.

1870. *Chionactis occipitalis* (part) Cooper, Proc. Calif. Acad. Sci., vol. 4, part 2, p. 66.

1875. *Chionactis occipitalis occipitalis* Cope, Bull. U. S. Nat. Mus., no. 1, p. 35.

1883. *Contia occipitalis* var. *occipitalis* Garman, Mem. Mus. Comp. Zoöl, vol. 8, no. 3, pp. 91, 164.

1894. *Contia occipitalis* (part) Boulenger, Cat. Snakes Brit. Mus., vol. 2, p. 266.

1901. *Contia occipitale* (part) Brown, Proc. Acad. Nat. Sci. Phila., vol. 53, part 1, p. 68.

1916. *Sonora occipitalis* Camp, Univ. Calif. Pubs. in Zoöl., vol. 12, no. 17, pp. 503-544.

1917. *Sonora occipitalis* (part) Grinnell and Camp, Univ. Calif. Pubs. in Zoöl., vol. 17, no. 10, p. 182.

1941. *Sonora occipitalis occipitalis* Stickel, Bull. Chicago Acad. Sci., vol. 6, no. 7, p. 135.

Diagnosis.—A subspecies of *occipitalis* differing from the subspecies of *palarostris* in having more crossbands on the body and tail. It is distinguishable from the other *occipitalis* subspecies as follows: from *klauberi* and *talpina* in usually lacking dark maculations in the interspaces between the primary bands or, at least, in having such spots as may exist in these spaces generally small, scattered, and restricted to scale edges; and from *annulata* in having brown, rather than black, or nearly black, crossbands, and in having more crossbands, fewer of which, however, are carried to the ventrum anteriorly.

Nomenclatorial and Systematic Problems.—The type locality of this subspecies is not known definitely, having been recorded only as the "Mohave Desert" (Hallowell, 1854, p. 95). Whether the type specimen is still in existence is not known; fortunately, it was figured by Hallowell rather completely in a later paper (1859, plate 4, figs. 2a–2c). One may hazard the guess, based on the known itinerary of the collecting expedition and the character of the crossbands—their narrowness and their failure to cross the ventrum—that it probably came from the western Mojave, in the general vicinity of the Mojave River in the southwestern part of what is now San Bernardino County, California.

The most interesting problem with respect to the distribution and variations in this subspecies is the unusual relationship between the populations of the Colorado and Mojave deserts. In most reptile species, if a difference is evident between such populations, the Coachella Valley (Riverside County) population is found to belong to the southern (Colorado Desert), rather than to the northern (Mojave Desert), form, as would be expected, for the Coachella Valley is a northwesterly extension of the Colorado Desert. Of such a territorial pattern, the separation of the Mojave Desert forms *Pituophis catenifer deserticola* and *Crotalus cerastes cerastes* from the corresponding Colorado Desert *P. c. affinis* and *C. c. laterorepens* are examples. In both instances the Coachella Valley inhabitants belong to the southern race. But in *Chionactis,* the Mojave Desert form occupies the Coachella Valley and the eastern part of Riverside County as well. Under such circumstances one should expect at least some differences between the Mojave and Coachella populations, and I had hoped to find a character that might separate the two and thus interpose an additional subspecies between *occipitalis* and *annulata.* Average differences have been disclosed, but the overlaps are such that segregation does not seem advisable, at least there is no justification on the basis of any character that I have been able to discover. Such differences as there are will be discussed later.

Material.—The description of the subspecies *occipitalis* that follows is based on about 240 specimens; however, there is far from an adequate representation of all areas, since much more than half the material is from two sections, the western Mojave Desert and the Coachella Valley. The eastern and extreme southeastern sections of the range are poorly represented in collections.

Description of the Subspecies.—This widespread subspecies, which inhabits more than half of the total area assigned to the species *occipitalis* as a whole, is quite variable in pattern, but much less so in squamation.

The largest specimens that I have seen were 369 mm. (14½ in.) long; I have had both a male and female of this length. In the western Mojave, males 320 mm. (12½ in.) long are not uncommon; in the Coachella Valley they frequently reach 340 mm. (13½ in.). Having in mind the fact that the males in collections usually outnumber the females by 2 to 1 or more, I should say that there is no conspicuous difference between the sexes in the ultimate length attained. The shortest juveniles seen were Mojave specimens 121 and 122 mm. (4¾ in.) long. The ratio of the tail length to the length over-all in adult males ranges from 17 to 20 per cent, with a mean of 18.5 per cent; and in the adult females from 15.5 to 17.5 per cent, with a mean of 16.7 per cent. Juveniles have somewhat shorter tails, proportionately, than adults.

The scale rows number 15 at mid-body, with only one exception among all the specimens of this subspecies that I have examined. The aberrant specimen was one from the Coachella Valley having 14 rows. There are frequently 17 rows on the neck, but they are reduced to 15 at or near one head-length behind the head. Similarly, when there are, rarely, 13 rows just before the anal plate, this number persists for only a short distance.

The ventrals range from 146 to 165 in the males, mean 155.9; and from 154 to 176 in the females, mean 165.9. The subcaudals vary from 39 to 50* in the males, mean 44.7; and 37 to 48 in the females, mean 41.9. Occasionally a few subcaudals at the base of the tail are undivided.

The supralabials are normally 7–7, less than 2 per cent having 6. The third and fourth touch the orbit and the sixth is the largest. The infralabials are usually 7 on each side, but occasionally number 6 or 8. Because of the position of the last infralabials, it is sometimes difficult to decide whether or not the last scale should be included.

There is usually a single loreal on each side; however, about 5 per cent of the specimens have one or both loreals fused with the prefrontals, and one specimen has 2 loreals on one side. The preoculars are rarely divided (about ½ of 1 per cent), and a very few specimens have single or 3 postoculars, instead of the customary 2. The usual temporal formula is 1+2, but some specimens (about 2 per cent) have 1+1, and still fewer have 1+3 or 2+2.

The crossbands on the body vary from 25 to 40, mean 31.2; and on the tail from 6 to 13, mean 9.2. The bands may be wider than, equal to, or narrower than the interspaces; there is some territorial variation in this character, as is discussed below. Spotting in the interspaces is rather infrequent; when present it usually takes the form of dark edges on some of the lateral scales. Ventral spotting between the positions opposite the dorsal bands is unusual but occasionally noted.

This subspecies is characterized by the relative infrequency with which the anterior dorsal crossbands become complete rings, or involve correspondingly located dark blotches on the ventrum. The contrary is true in *annulata*. As *annulata* also has fewer bands than *occipitalis*, the combination criterion, dorsal bands plus unmarked blotch positions on the ventrum, serves as the best

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*Omitting two aberrants with 35 and 54, respectively.

numerical character in differentiating the subspecies. The statistics of *occipitalis* with respect to this character are: range 31 to 80, mean 54.7. About 20 per cent of the specimens number 44 or fewer, and thus fall within what may be considered the *annulata* range (p. 164).

Essentially, *occipitalis* is a snake with brown crossbands on a white or cream ground color, at least, this is the appearance of preserved specimens. The band color may vary from medium- to dark-brown. Rarely does it give the impression of being black, except in juveniles. Dorsally the bands do not differ greatly from the interspaces in width—they may be either somewhat wider or narrower. Laterally the bands narrow conspicuously, usually to terminate on the first or second row of scales above the ventrals. Even posteriorly, where they are often complete, the rings narrow laterally, although they may re-widen on the ventrum. The band color is darker dorsally than that it is below. The blotches are often even-edged, but in many specimens thin threads of the dark color of the blotches run out into the interspaces along the interstices between scales. Also, on the edges of the bands, scales that are partly light and partly dark often are not as dark in their dark section as are the adjacent scales that are entirely dark, thus giving an effect of serrations. In such partly dark scales the dark color consists of punctations.

The head crescent usually engages only the posterior halves of the frontal and supraoculars. The lateral horns are not often carried farther forward than the eye.

Regardless of whether the ventrum is marked on the body, the tail bands are nearly always complete rings. The anal, however, is rarely marked, even though there may be a dorsal band immediately above it.

As to live specimens, the following Ridgway colors are typical of adults from the western Mojave Desert and from the Coachella Valley:

	Western Mojave Desert	*Coachella Valley*
Snout	Sea-foam Green	Olive Buff
Head crescent	Blackish Brown (1)*	Bone Brown
Dorsal bands	Aniline Black	Bone Brown
Interspace centers	Ochraceous-Buff	Pale Chalcedony Yellow
Interspace edges	Marguerite Yellow	White
Ventral bands	Light Seal Brown	Natal Brown
Ventral interspaces	Ivory Yellow	Pale Olive Buff

The snout is usually darker and slightly greener than the interspaces on the body. The ventral surfaces are somewhat lighter than the dorsal, a characteristic of both the bands and the interspaces.

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*The numeral is a part of the color name, as Ridgway distinguishes between 3 tones of blackish brown.

In general, these live snakes may be described as having brown crossbands on a yellow or orange ground color.

Intrasubspecific Trends.—Of the subspecies *occipitalis* only two series that are territorially concentrated are available in sufficient numbers to justify numerical comparisons. These are a Coachella Valley series from Riverside County, and a series from the western Mojave Desert, within a radius of about 40 miles of Kramer Junction, San Bernardino County. The first series comprises 100 specimens, the second 65; males greatly predominate in both. The statistics follow:

	Western Mojave Desert series	*Coachella Valley series*
Ventrals, males, range	148–162	151–165
mean	155.3	156.8
females, range	159–169	160–176
mean	163.0	167.4
Subcaudals, males, range	40–49	41–49
mean	44.3	44.7
females, range	37–43	39–48
mean	41.0	42.2
Crossbands on body, range	24–39	25–40
mean	29.8	32.2
Crossbands on tail, range	6–11	6–12
mean	8.7	9.5
Crossbands on body plus unmarked ventral positions, range	37–78	31–76
mean	57.6	59.0
Per cent of specimens with no ventral blotches on body	39.5	29.3

It will be observed that the numerical differences between these series are relatively minor. Only in the percentage of snakes without blotches on the ventrum is there a distinct difference, the Mojave series being less maculated. The same is true if we take the proportion of the dorsal band positions that have opposite marks on the ventrum. In the Coachella series, of those with some ventral marks, specimens having from 40 to 70 per cent of the ventrum clear approximately equal in frequency those having 70 to 99 per cent clear. But in the Mojave series nearly all fall in the 70 to 99 per cent class, and very few below. Thus, in these characters indicating the relative absence of ventral maculations, the Mojave specimens are clearer and more sharply differentiated from *annulata* than are those of the Coachella Valley.

As to colors, the most important, from the standpoint of general appearance, are obviously those of the dorsal bands and the centers of the interspaces. The following Ridgway colors were noted in 20 live specimens from the western Mojave Desert and 12 from the Coachella Valley:

Dorsal Crossbands

Western Mojave Desert

Natal Brown
Blackish Brown (1)*
Blackish Brown (3)*
Sooty Black
Chaetura Black
Plumbeus Black
Fuscous Black

Coachella Valley

Light Seal Brown
Seal Brown
Hay's Brown
Bone Brown
Dusky Brown
Warm Sepia
Blackish Brown (2)*
Warm Blackish Brown
Aniline Black
Black

Centers of Interspaces

Chamois
Colonial Buff
Salmon Buff
Warm Buff
Apricot Yellow
Reed Yellow
Honey Yellow
Naples Yellow
Straw Yellow
Salmon Orange
Ochraceous Orange
Capucine Orange
Vinaceous Cinnamon
Ochraceous Salmon

White
Deep Colonial Buff
Cinnamon Buff
Buff Yellow
Sea-foam Yellow
Pale Chalcedony Yellow
Primrose Yellow

It will be observed that there is not much difference in the depth of the browns and dark-browns of the bands, but the interspaces are a brighter yellow in the Mojave snakes, with more of a tendency toward orange.

The dark bands, middorsally, are narrower than the interspaces more frequently in the Mojave specimens than in those from the Coachella Valley, for, in the latter, the dark bands are wider than, or equal to, the interspaces more often than narrower. There is no conspicuous difference in the number of uncolored dorsal scales between the head crescent and the first dark band on the body; in both series the range is from 3 to 6, many specimens having 4. In both series the head crescent usually extends to the posterior edge of the parietals, or slightly beyond; and, in both, the lower preoculars are ordinarily darkened by the horns of the crescent. Dark scale edges in the lateral inter-

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*Different colors in Ridgway's notation.

spaces are of moderate frequency in both series; and in each an occasional specimen is found showing considerable interspace maculations, a *klauberi* or *talpina* tendency. A single specimen from an altitude of 3000 ft. on the Palms-to-Pines highway, above the Coachella Valley, has particularly wide dark bands.

There is no marked difference between the Mojave and Coachella series in the relative tail lengths. Both have shorter tails than *annulata*.

The absence of important differences between the western Mojave and Coachella groups is the more surprising in view of the differences in their surroundings. The Coachella is a flatter, sandier basin, much of it below sea level. The western Mojave is rockier; the mean altitude of the section from which the example series came is about 2200 ft. It has a longer, colder winter. Both areas are extremely windy at night in the spring. It is to be presumed that *occipitalis* gained access to the Coachella Valley from the Mojave via the Morongo Valley to the north, or via the pass between the Cottonwood and Orocopia mountains to the east. Since the western Mojave and Coachella snakes more nearly resemble each other, in their lack of ventral maculations, than either resembles the snakes farther east, the Morongo route appears the more logical.

One may presume that the differences between the Colorado Desert *annulata* and Mojave Desert *occipitalis* are either not importantly fitted to ecological necessities, or that the invasion of the Coachella Valley by *occipitalis* has been comparatively recent. I judge the former to be the real reason why the Coachella snakes are not more like the snakes of the lower Colorado Desert, although I do think that the meeting of *occipitalis* and *annulata* along the westerly shore of the ancient Lake LeConte took place rather recently, possibly at the time of its latest subsidence.

Specimens from the vicinity of Boulder City, Clark County, Nevada, and from eastern San Bernardino and Riverside counties in California, are not available in sufficient numbers to permit a detailed analysis of territorial trends. They average slightly lower in the number of body bands, and the ventrums are more maculated—that is, the ventral blotches begin nearer the head, and fewer specimens are without at least some ventral marks on the body. In this character they show a tendency toward *annulata*. In the Clark County specimens, the dorsal bands are wider than the interspaces, whereas the contrary is true in those from the western Mojave.

It may be concluded that the population of *occipitalis* most widely differentiated from *annulata*, as well as from *talpina*, *klauberi*, and *palarostris*, is that inhabiting the extreme western section of the range, that is, the Mojave-Kramer-Adelanto-Palmdale quadrangle in the western part of the Mojave Desert. Geographically this is quite logical.

Subspecific Relationships.—*C. o. occipitalis* intergrades with two other subspecies, *talpina* and *annulata*, and possibly with a third, *klauberi*.

With the new subspecies *talpina*, it intergrades along the southern border of eastern Inyo County, California, and near the eastern edge of Nye County, Nevada, as will be discussed in more detail under *talpina*.

Although many specimens of the subspecies *occipitalis* and *annulata* are at hand, and the fact that they intergrade is unquestioned, the boundaries between their ranges cannot be defined with assurance, partly because of lack of specimens from critical areas, and partly because of the composite character of the material from eastern San Diego County. Pure *occipitalis* occurs in the Coachella Valley of Riverside County, and pure *annulata* in the Kane Spring–Westmorland section of Imperial County. The two subspecies apparently intergrade in the neighborhood of Travertine Rock and Fish Springs in extreme northwestern Imperial County. This is logical, especially if we assume that the two populations were originally separated by prehistoric Lake LeConte, which once filled what is now the Salton Basin, and that they re-merged when the lake dwindled to leave a flat margin between its western shore and the mountains. However, the snakes of eastern San Diego County are not pure *annulata*, as one might expect, but show a considerable infusion of *occipitalis* characters. Whether this has resulted from a southward migration of *occipitalis* around the lower end of the Santa Rosa Mountains into the Borrego Valley, or whether these characters were developed independently in the San Diego population because of its desert-mountain habitat is uncertain.

For the present, I shall consider the San Diego County population to be *annulata*, but of a non-typical character, and the western end of *occipitalis–annulata* line of intergradation to be near Travertine Rock, at the Imperial–Riverside county line. Eastward of the Salton Sea, we may assume the boundary to follow the crest of the Chocolate Mountains southeasterly to the Colorado River. Across the river, in Arizona, the dividing line may be tentatively placed at the Bill Williams River. Of the few specimens available from this section of Arizona, those from the vicinity of Parker and farther south in Yuma County are nearer *annulata*, while the only two from Mohave County favor *occipitalis*.

The only two specimens now at hand from northern Maricopa County are *annulata* or *annulata–klauberi*, rather than *occipitalis–klauberi* intergrdes. But it is not impossible that *occipitalis* and *klauberi* may intergrade somewhere along the line Yucca–Alamo–Wickenburg, if *Chionactis* occurs, as it may, in that relatively inaccessible region, in which there has been little or no collecting.

Range.—*Chionactis o. occipitalis* is found throughout the Mojave Desert of southwestern Inyo County, eastern Kern County, northeastern Los Angeles County, San Bernardino County (except the mountain and transmontane area in the southwest), Riverside County (from the desert slope of the San Jacinto Mountains eastward, including the Coachella Valley), and northeastern Imperial County (beyond the Chocolate Mountains), California; southern Clark County, Nevada; and southwestern Mohave County, Arizona.

Locality Records.—CALIFORNIA: *Inyo County*—Owens Lake, Goler Canyon (Panamint Mts.) (*talpina* intergrade), 11 mi. s. of Shoshone (*talpina* intergrade); *Kern County*—Brown, Garlock, Mojave (also 4, 6, 11, 17 mi. e.), Muroc (also 4 mi. se.), Muroc Dry Lake, Boron (also 1, 11, 12 mi. w.); *Los Angeles County*—20 mi. e. of Lancaster, 3 mi. n. of Palmdale, county line e. of Llano (about 9 mi. e.); *San Bernardino County*—Trona (also 2 mi. n.), 10 mi. s. of Salt Wells Jnct. (=5 mi. n. of Searles Sta.), Lava Mts., Red Mt. (also 13 mi. s.), Atolia (also 3 mi. n. and 11 mi. s.), Fremont (= 14 mi. n. of Kramer Jnct.), Kramer (also 1 mi. w.), Kramer Jnct. (U.S. 395 and U.S. 466) (also 1 mi. w. and 1, 3, 4, 6, 11, 12, 13, 14 mi. s.) Kramer Hills, Adelanto (also 1, 3, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17 mi. n., 7 mi. sw., and 11 mi. s.), Oro Grande (also 12 mi. n. = 1 mi. s. of Helendale), Victorville (also 3 mi. s.), Phelan (also 5 and 6 mi. nw.), 16 and 22 mi. s. of Shoshone (Inyo Co.) (= Ibex Pass and 7 mi. s.) (*talpina* intergrades), 1 mi. e. of Leach Lake (*talpina* intergrade), 16 mi. e. of Camp Irwin (near Red Pass Dry Lake), Baker, Midway (also 4 mi. e. on U.S. 91), Cronise, Alvord Mts., Jim Grey, Hawes, Hinkley (also 2 mi. w.), Mace, Lenwood, Barstow (also 2, 6, mi. w., and 15 mi. sw.), Minneola, Hector, 2 mi. n. of Mt. Pisgah Crater, Arimo, Fenner (also 10 mi. w.), Goffs (also 5 and 12 mi. e.), Homer, Piute Valley, 25 mi. s. of Needles on Cal. 95, 8 mi. n. of Rose (= Vidal Jnct.), ½ way bet. Rose and Grommet, Rice (= Blythe Jnct.) (also 1 mi. s.), Warren Wells (= Lone Star), Twentynine Palms (also 3 mi. w. and 19 mi. e.), Monroe Dry Lake (not located); *Riverside County*—Desert Hot Springs (also 3 mi. s.), near Seven Palms, Garnet (also 4 mi. n. and 5 mi. se.), Whitewater (also 3 and 5 mi. se.), Palm Springs R.R. Sta., Palm Springs (also 4, 5, 10 mi. n., 7 mi. nw., 4 mi. e., and 10 mi. se.), Palm Springs Airport, Tahquitz Canyon, Rimlon, Thousand Palms P.O. (also 5 mi. n. and 6 mi. w.), Thousand Palms, Edom, Cathedral City (also 1 mi. e. and 2 mi. s.), Date Gardens, Palm Village (also 3 mi. e.), Palms-to-Pines Highway (Cal. 74) just above 3000 ft. contour, also 2 mi. s. of Palm Village, Indian Wells (also 2 and 3 mi. e.), sand dunes 5 mi. n. of Indian Wells, Myoma, La Quinta (also 2 mi. e.), Indio (also 2, 4, mi. n., 3 mi. e., 6 mi. s., 5, 7, 10, 11, 16 mi. nw., and 5 mi. w.), Pushawalla and Berdoo canyons (Little San Bernardino Mts.), Coachella (also 5 and 6 mi. s.), Thermal, Mecca (also 2 mi. e. and 3 mi. sw.), 10 mi. n. of Riverside-San Diego county line (= Martinez), Caleb Siding, Oasis (also 7 mi. nw.), 1 mi. nw. of Travertine Rock (*annulata* intergrade), 15 mi. w. of Freda (San Bernardino County), Desert Center (also 11 and 16 mi. e.), Hopkins Well (also 2 mi. w. and 7 mi. e.), 6, 7, 10, 12, 16, 17, and 22 mi. w. of Blythe, 10 mi. n. of Blythe, Camp (= Dry Camp Siding?), Banning*; *Imperial County*—Travertine Rock (*annulata* intergrade), Fish Springs (*annulata* intergrade).

NEVADA: *Clark County*—near Indian Spring (*talpina* intergrade), Boulder City.

ARIZONA: *Mohave County*—Fort Mohave, Yucca, Hualpai Valley.

Chionactis occipitalis annulata (Baird)

Colorado Desert Shovel-nosed Snake

Plate 9, fig. 2

1859. *Lamprosoma occipitale* Kennicott in Baird, Reptiles of the Boundary, United States and Mexican Boundary Survey (Emory), vol. 2, p. 21.

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*An MCZ specimen; this locality should be considered doubtful until verified by additional specimens.

1859. *Lamprosoma annulatum* Baird, Reptiles of the Boundary, United States and Mexican Boundary Survey (Emory), vol. 2, p. 22, plate 21. Type specimens (2) USNM 2105*; type locality Colorado Desert.

1859. *Lamprosoma occipitale* (part) Baird, Gen. Rept. Zoöl. Pac. R.R. Routes, vol. 10, part 3, p. 16.

1870. *Chionactis occipitalis* (part) Cooper, Proc. Calif. Acad. Sci., vol. 4, part 2, p. 66.

1875. *Chionactis occipitalis annulata* Cope, Bull. U. S. Nat. Mus., no. 1, p. 36.

1883. *Contia occipitalis* var. *annulata* Garman, Mem. Mus. Comp. Zoöl., vol. 8, no. 3, pp. 91, 164.

1894. *Contia occipitalis* (part) Boulenger, Cat. Snakes Brit. Mus., vol. 2, p. 266.

1901. *Contia occipitale* (part) Brown, Proc. Acad. Nat. Sci. Phila., vol. 53, part 1, p. 68.

1913. *Sonora occipitalis* Van Denburgh and Slevin, Proc. Calif. Acad. Sci., ser. 4, vol. 3, p. 412.

1917. *Sonora occipitalis* (part) Grinnell and Camp, Univ. Calif. Pubs. in Zoöl., vol. 17, no. 10, p. 182.

1941. *Sonora occipitalis annulata* Stickel, Bull. Chicago Acad. Sci., vol. 6, no. 7, p. 136.

1943. *Chionactis occipitalis annulatus* Stickel, Proc. Biol. Soc. Wash., vol. 56, p. 128 [= 123].

Diagnosis.—*C. o. annulata* is a subspecies differing from *klauberi* and *talpina* in usually lacking maculations in the interspaces between the primary dorsal bands; such spotting as there may be is usually restricted to the sides of the body and to scale edges. From the subspecies *occipitalis*, *annulata* differs in having black, rather than brown, dorsal bands, and also in having a greater proportion of anterior bands carried to the ventrum. *C. o. annulata* has more crossbands and a sharper snout than the subspecies of *C. palarostris*.

Nomenclatorial and Systematic Problems.—The type locality of *annulata* was generalized as the "Colorado Desert", but it may be inferred, both from the itinerary of the collector and from the morphology of the types, that they were collected somewhere along the U.S.-Mexican boundary between the Colorado River on the east and the desert base of the coastal mountains on the west, along what is now the southern border of Imperial County, California.

The important problems of this subspecies concern not only its relationships with *palarostris*, *klauberi*, and *occipitalis*, but also the variations, within the subspecies, between the snakes from the east and west sides of the Colorado River, that is, between those from the Yuma and the Colorado deserts. Another

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*Although the original description in the Mexican Boundary Survey report lists two specimens as numbers 2105-6, I am advised by Dr. Doris M. Cochran that it is doubtful whether there ever was a number 2106, since both types were included under the number 2105.

problem is to consider whether the differences between the snakes inhabiting the flat expanses of the Colorado Desert and those from the desert foothills of the San Diego mountains seem to have been caused by ecological differences, or by an infusion of *occipitalis* around the southern end of the Santa Rosa Mountains into the Borrego Valley and beyond.

Material.—The data on this subspecies are derived from somewhat more than 400 specimens from California, 50 from Arizona, and 18 from Sonora. Unfortunately, a large part of the California material is from San Diego County, where the population does not represent pure and typical *annulata.*

Description of the Subspecies.—Like the other *occipitalis* subspecies, this is a snake of rather constant scale characters, but with observable intrasubspecific differences in pattern and color, some of which differences are territorially consistent.

The longest specimen thus far accurately measured is a female 407 mm. (16 in.) in length over-all.* The shortest is 130 mm. (5⅛ in.); two others are 132 mm. In Imperial County, where the genus seems to attain its maximum length, the females grow slightly larger than the males; females of 370 mm. (14½ in.) are not exceptional, whereas the longer males average only 350 mm. (13¾ in.).

The tail length in the adult males varies from 17.9 to 20.2 per cent of the length over-all, with a mode of 19.7 per cent. In the adult females, the range is from 15.7 to 18.4 per cent, with a mode of 17.0. The juveniles have proportionately shorter tails, the mode for the young males being 18.2 and for the females 15.0 per cent. In the San Diego County material, the regressions are fairly well represented by the following straight lines, in which T is the tail length and L the length over-all, both expressed in millimeters: males, $T = .207\,L - 3.35$; females $T = .185\,L - 5.00$. The snakes of the Imperial-Yuma area have slightly longer tails, proportionately, than those from San Diego County.

The scale rows are almost always 15 at mid-body; among more than 400 specimens, two have 16, and one has 14. There may be 17 or 16 for a short distance behind the head, and 14 or 13 just before the anus, but almost all specimens are 15–15–15 according to the usual method of scale-row expression.

The ventrals in the males vary from 143 to 164, mean 153.2; and in the females from 153 to 178, mean 163.5. The subcaudals vary from 40 to 57, with a mean of 47.4 in the males; and from 34 to 51, mean 42.4 in the females. These averages for the subspecies as a whole are somewhat reduced by the high proportion of San Diego County specimens.

The supralabials nearly always number 7, about one per cent having 6, and still fewer 8. As in the other subspecies, the third and fourth enter the orbit, the sixth being the largest. The infralabials also generally number 7, although a count of 8 on either or both sides is not unusual, and a few have 6.

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*I have a record of a live specimen about 425 mm. (16¾ in.).

It is often difficult to count the infralabials accurately, since the posterior termination is not definite.

In most specimens there is a single loreal on each side, but about 10 per cent are without loreals, these scales being fused to the prefrontals. Two loreals per side are rare. Although a single preocular is normal, 1 per cent of the specimens have 2. One postocular, instead of the normal 2, occurs in about 1 per cent; 3 on a side are rarely observed. The usual temporal formula is 1+2; some 3 per cent of the counts are 1+1, about 1 per cent 2+2, and still fewer 1+3.

The dark crossbands on the body vary from 18 to 35, with a mean of 24.9; and the tail rings from 5 to 12, mean 7.7. The bands in this subspecies may be either narrower or wider than the interspaces, but in most specimens the bands are the narrower. There may be some spotting in the interspaces, on the sides especially; this spotting is usually restricted to darkened scale edges, and becomes somewhat more frequent as the *klauberi* territory is approached. There is also occasionally present a type of ventral spotting that is independent of the body rings.

The subspecies *annulata* differs from *occipitalis* in the greater frequency with which the dark dorsal bands become complete rings by crossing the ventrum. In both subspecies the anterior bands are less often complete than the posterior, but in *annulata* the ventral blotches that complete the rings make their appearance nearer the head than in *occipitalis*. For reasons discussed elsewhere, I prefer to use, in differentiating the subspecies, the following combination criterion: the dorsal bands plus the anterior unmarked blotch positions on the ventrum, counting up to the first apparent ventral blotch. Only about 20 per cent of the specimens of *occipitalis* fall below 45 in this criterion, while in *annulata* only 9.6 per cent have 45 or more. In *annulata* the range is 22 to 59 and the mean 35.1. These values are rendered somewhat higher, both in range and average, because of the higher proportion of San Diego County specimens, which deviate from the subspecific mode (see below).

Superficially, preserved specimens of *annulata* are black-ringed snakes with a white or cream ground color. Actually, if one compares the bands of fresh specimens with the darkest colors of the Ridgway series, it will be found that they are seldom truly black; and they fade to a still lighter color on exposure to light. But on a casual examination, without comparative color guides, the rings in well-preserved material appear black. Many live specimens have varying degrees of pink or red suffusions in the interspaces, and some of these colors may be retained for a time after preservation.

The body bands may be even-edged or somewhat serrated. Anteriorly they usually end at the first to third scale row above the ventrals, their terminations being rather blunt; then, as one proceeds posteriorly, it will be observed that the bands become more pointed laterally, as if reaching out to contact the ventral blotches which correspondingly rise higher on the sides. Finally the dorsal and ventral sections of the bands become confluent and the rings are complete, usually on the anterior quarter of the body. But since the first lateral contacts between the dorsal and ventral bands are rather tenuous, it is difficult to decide which ring is to be counted as the first complete one. It is for this reason that I prefer to use the first ventral spot in the differential criterion, rather than the first complete ring.

The ventral marks are lighter than the dorsal. Posteriorly the ventral blotches widen considerably, sometimes darkening as many as 4 adjacent ventral scutes.

The black head crescent is rather narrow in this subspecies. Often the frontal remains unmarked, and the supraoculars are darkened only along their outer edges. Posteriorly the tips of the parietals may remain unmarked, or the dark color may be carried to the first dorsal scales. Laterally the horns of the crescent rarely extend forward of the eye. The light dorsal scales (end-to-end) between the head crescent and the first dark band on the neck vary from 3 to 9, with a mode of 5 or 6.

As to the typical representative colors of live specimens of this subspecies, I present the Ridgway colors of specimens from the mesas east and west of the Imperial Valley, in Imperial County, California:

	Dixieland	*Sand dunes 14 mi. w. of Yuma*
Snout (except rostral)	Yellowish Glaucous	Pale Chalcedony Yellow
Rostral	Grenadine	Peach Red
Head crescent	Dull Purplish Black	Black
Dorsal bands	Dull Purplish Black	Black
Interspace centers	Grenadine	Peach Red
Interspace edges	Sea-foam Green	Pale Chalcedony Yellow
Ventral bands	Vinaceous Slate	Warm Blackish Brown
Ventral interspaces	Sea-foam Yellow	Pale Chalcedony Yellow

In general, live specimens of *annulata*, when from the center of the range of this subspecies, are black-ringed, with bright suffusions of pink or red in the interspaces, on a cream or white background. The red is often even-edged, leaving a single row or light scales between the red and black. The red, however bright and clear it may be, and however much like a true ring dorsally, is never complete on the ventrum, but always terminates laterally one or more scale rows above the ventrals.

Intrasubspecific Trends.—The area inhabited by the most typical specimens of *annulata*, that is, those most widely differentiated from the other *occipitalis* subspecies, comprises the eastern and western borders of the Imperial Valley, in Imperial County, California; and the Yuma Desert as far east as Mohawk, in Yuma County, Arizona. Outside of this area *klauberi* and *occipitalis* influences are shown in several ways, particularly by the interblotch maculations in snakes from the eastern border, and a change from black to brown bands, with a suppression of the red interband suffusions or saddles in western specimens.

If the scale counts be restricted to the snakes of the central area, we have the following data: Ventrals, males, range 147 to 164, mean 156.6; females, range 161 to 177, mean 168.1; subcaudals, males, range 43 to 57, mean 50.5; females, range 41 to 51, mean 45.5.

Comparing these counts with those of snakes from border areas, we find that typical *annulata* has more ventrals and subcaudals, on the average, than the fringe populations, whether to the west in San Diego County, or to the east in southern Maricopa and western Pima counties. The differences in numbers of scales from the San Diego averages are as follows, the Imperial-Yuma specimens being always higher: Ventrals, males 4.0, females 6.2; subcaudals, males 3.6, females 3.9. These differences may be caused by the higher temperatures to which the Imperial-Yuma snakes are subjected, or to their larger size; it is known that both of these conditions lead to average increases in the number of scales. There are no conspicuous differences in ventral and subcaudal scales between the Imperial-Yuma snakes and those of northwestern Sonora.

The divergence in pattern between the populations from the fringe areas and those from the central Imperial-Yuma area is more marked than in squamation, the differences being not only numerical but of form and color as well.

The Imperial-Yuma snakes are characterized by well separated, black crossbands. The bands are almost never as wide as the interspaces; in fact, in the majority of specimens the interspaces are almost twice as wide as the bands. Also, in most specimens, an interblotch suffusion of pink or red is present in life to a marked degree, so definite, in fact, as to form a well-defined saddle. There is usually a spot of pink on the rostral. The head crescent is narrower than it is in the fringe-territory specimens; it often leaves both the frontal and the posterior edges of the parietals clear, and the lateral horns rarely reach the preoculars.

The statistics of the bands are given in the following summary, the San Diego County data being supplied for comparative purposes:

	Imperial-Yuma Counties	*San Diego County*
Body bands, range	18-35	19-35
mean	23.9	24.8
Tail rings, range	5-11	5-10
mean	7.7	7.6
Body bands plus unmarked ventral blotch positions, range	20-40	20-59
mean	28.0	36.7

It will be observed that the only important difference is in the combination category of body bands plus unmarked ventral blotch positions, for the first ventral marks in the San Diego series usually occur farther back than in the Imperial-Yuma snakes. This is apparently an *occipitalis* influence, as are some of the other divergences of the San Diego County snakes from the more typical

Imperial–Yuma population. Although the San Diego specimens usually have black dorsal bands, dark-brown bands are not rare. The dorsal patterns of the San Diego snakes are, in fact, particularly variable, the bands being diverse not only in color, but also in relative width. The superiority of the interspaces in width, as compared with the bands, as evident in the Imperial–Yuma series, is not so manifest in the San Diego population, wherein bands equal to, or exceeding, the interspaces in width are quite common. Snakes with wide bands are most frequent at the higher altitudes on the extreme western fringe of the range, at such mountain-foothill localities as Mountain Spring, La Puerta, and lower Sentenac Canyon. In some of these, the bands are so wide as to comprise large dorsal blotches; for example, in a specimen from Yaqui Pass, the dorsal blotches are 5 scales wide (end-to-end) and the interspaces only 2 scales. In contrast, a specimen from Clark Dry Lake, out on the flat area of the Borrego Valley, is exactly reversed, with bands 2 scales wide and interspaces 5. Another specimen has a superabundance of melanin resulting in a blackened snout, dark scale edges in the interspaces, and a heavily mottled ventrum between the normal ventral bands.

The interspace colors are also highly variable in the San Diego County series. The following Ridgway shades were observed in 20 live specimens; these may be compared with typical Imperial County colors listed on p. 165.

	Interspaces	
Dorsal bands	*Centers*	*Dorsal edges*
Dusky Purplish Gray	Colonial Buff	White
Blackish Brown (1)	Warm Buff	Ivory Yellow
Blackish Brown (2)	Cinnamon Buff	Sea-foam Yellow
Blackish Brown (3)	Ochraceous Buff	Naphthalene Yellow
Dull Violet-Black	Sea-foam Yellow	Light Chalcedony Yellow
Fuscous Black	Honey Yellow	Marguerite Yellow
Aniline Black	Flesh-Ochre	Martius Yellow
Black	Mikado Orange	Massicot Yellow
	Bitter Sweet Orange	
	Apricot Orange	
	Ochraceous Orange	
	Light Salmon Orange	
	Zinc Orange	
	Grenadine	
	Ochraceous-Salmon	
	Carrot Red	
	Carnelian Red	

Just as the bands become wider, with the transition from a flat, sandy habitat to one of rocky foothills, so also the reds of the interspaces are changed to yellow or buff.

On the opposite side of the *annulata* range, in the Gila Bend–Ajo area, there is, as might be expected, a *klauberi* influence. Compared with the Imperial–Yuma series, the ventrals and subcaudals are low, and the body bands somewhat high, in number. There is usually an orange suffusion in the interspaces with considerable dark spotting on the sides (the most evident *klauberi* influence). The interspace saddles, whether orange, or maculated with brown scale edges, are usually 1 scale wide dorsally, and 2 wide laterally.

Along the Sonoyta–Punta Peñasco road in northwestern Sonora, somewhat the same tendencies are to be observed; however, the snakes of this area differ from those of the Gila Bend–Ajo section in having more ventrals, in which character they are nearer to typical *annulata*. They are like the Gila Bend–Ajo series in the color and shape of the body bands, and in the presence of maculations in the lateral interspaces. The red or orange interspace saddles, whether or not carrying the brown maculations relating them to *klauberi*, are quite narrow—1 scale wide dorsally and 2 or 3 laterally.

The following were the dorsal body colors of 3 specimens from the vicinity of El Papalote, Sonora: Dark bands—Dull Violet Black, Dull Purplish Black, Black; interspace centers—Japan Rose (only 1 scale wide, with dark spots on anterior tips of scales), Carnelian Red (only 1 scale wide, mostly on the anterior scale tips), Grenadine Red; interspace edges—Naples Yellow, Naphthalene Yellow, Straw Yellow.

Specific and Subspecific Relationships.—The subspecies *C. o. annulata* intergrades with both *C. o. occipitalis* and *C. o. klauberi* in ways that have been indicated, both in discussing intrasubspecific variation in *annulata* and also in the treatment of the other two subspecies. There remain only the subspecies of *C. palarostris* to mention. Of all the subspecies of *C. occipitalis*, *annulata* most nearly resembles *C. palarostris* in pattern, for *annulata* is characterized by black rings, which are both narrower and fewer in number than in the other *occipitalis* subspecies, and has more red in the interspaces. Both of these characters are carried to a still further extreme in *palarostris*, although somewhat less so in *p. organica* than in *p. palarostris*. Were these details of pattern the only differences, one might expect an intergrading population to be found between *annulata* near Colfred and *organica* in the Organ Pipe Cactus National Monument, by way of Mohawk Valley. But *organica* is notably low in ventral scale counts, whereas *annulata* is high. In addition, the convex crown of *organica* contrasts with the flatter and sharper snout of *annulata*. For these reasons, although intergradation between *organica* and *annulata* is a possibility—which would make *Chionactis* monotypic—the present evidence is against the idea.

Range.—*Chionactis o. annulata* is found in the desert foothills and desert areas of San Diego County,* and in Imperial County (except northeast of the Chocolate Mountains), California; Yuma County, western and southern

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*USNM 59465 from the "San Diego River Valley" almost certainly has an incorrect locality assigned to it. In spite of the most intensive collecting during the last 30 years, no other cismontane specimen, not known to have escaped from captivity, has come to light in southern California.

Maricopa County, and northwestern Pima County, Arizona; and in Sonora, Mexico, from Sonoyta west and southwest. Although *annulata* has not yet been reported from Baja California, it certainly occurs there, as it has been taken within a mile or so of the border at several points between Calexico and Winterhaven. Tracks, quite probably of *Chionactis*, have been seen at San Felipe about 120 miles south of the border, on the Gulf of California coast.

Locality Records.—CALIFORNIA: *Riverside County*—1 mi. nw. of Travertine Rock (*occipitalis* intergrade); *San Diego County*—Clark Dry Lake (also 1.2 and 2 mi. s.), Beatty's (Borrego Valley), Borrego Spring, Christmas Tree Circle (Borrego Valley), Yaqui Pass (also 2 mi. ne.), foot of Sentenac Canyon, Yaqui Well, The Narrows, Bensons Dry Lake (= Ocotillo) (specimens have been collected on Cal. 78 every hundred yards or so from Yaqui Well via The Narrows to the County Line east of Ocotillo, a distance of 18½ mi.), San Felipe Wash, Halfhill Dry Lake (old San Felipe townsite), La Puerta, Vallecito, Agua Caliente Spring, Carrizo Spring; *Imperial County*—Travertine Rock (*occipitalis* intergrade), Sea View, San Felipe Wash, San Diego–Imperial County line at Cal. 78 (also 2 and 5 mi. e.), Kane Spring (also 1½, 3, and 5 mi. nw., and 4, 5, and 8 mi. w.), Calipatria, Alamorio, Brawley, Imperial, Mountain Spring (also 2 and 3 mi. e.), Coyote Wells, Plaster City, Dixieland (also 1 mi. w.), Seeley (also 3 mi. w.), Calexico (also 3 mi. w.), Bonds Corner, Meloland, Holtville (also 14 mi. se.), Drop 3 (on the All-American Canal), Midway Well (junction U.S. 80 and Cal. 98) (also 1 and 8 mi. w., and 6 mi. ne.), Grays Well (also 1, 2, and 5 mi. w.), Chocolate Mts., Winterhaven (also 10 and 14 mi. w.), 14 mi. w. of Yuma (Arizona), Pilot Knob, Pilot Knob R.R. Sta., Colorado River (near Pilot Knob).

ARIZONA: *Yuma County*—6 mi. s. and 15 mi. se. of Parker, 9 mi. s. of Quartzsite, 2 mi. e. of Dunn (= 10 mi. e. of Brenda), Yuma (also 5 mi. e.), Yuma Mesa, Monument 200 (= Arizona–Sonora boundary, 15 mi. e. of Colorado River), Dublin (also 7 mi. w.), south Gila Valley, Fortuna Wash (15 mi. e. of Yuma), Wellton Mesa, Wellton (also 4 mi. e.), Tacna (also 5 mi. e.), Lugar Bonita (= 12 mi. e. of Wellton), Pembroke, Mohawk (also 5 mi. e. and 7 mi. w.), Chrystoval (= Stoval), bet. Roll and Maricopa County line; *Maricopa County*—2½ mi. e. of Aguila, 7 mi. sw. of Wickenburg, Cactus Garden (= 3 mi. nw. of Morristown), Sentinel (also 2 mi. e.), Gila Bend (also 7, 15, and 28½ mi. s., and 12 mi. e.), 7 mi. s. of Black Gap, Midway (Black Gap and Midway are stations on the Tucson, Cornelia, & Gila Bend R.R.), 24 mi. n. of Ajo (Pima Co.); *Pima County*—7 mi. se. of Ajo, Gunsight Junction (= Ajo–Tucson–Sonoyta road junction) (also 2 mi. nw.).

SONORA: 25 mi. s. of San Luis, ½ way bet. Sonoyta and Punta Peñasco, 23 mi. sw. of Sonoyta, 11 and 20 mi. sw. of Pozo Sipiano, El Papalote (also 2, 6, and 14 mi. ne., and 1 and 4 mi. sw.), 6½, 9, and 16 mi. ne. of Punta Peñasco, 8 mi. n. of Rocky Point (= Punta Peñasco).

With regard to intergrades between *annulata* and *klauberi*, it should be stated that all of the snakes in the Wickenburg, Gila Bend–Casa Grande, Gila

Bend–Ajo, and Sonoyta–Punta Peñasco sections show *klauberi* tendencies in various degrees. Specimens from the following places show these tendencies to a sufficient degree to be considered integrades: *Maricopa County*—2½ mi. e. of Aguila, Gila Bend (also 15 mi. s.), and 24 mi. n. of Ajo; *Pinal County*—near Casa Grande (locality somewhat indefinite); *Pima County*—Gunsight Junction; *Sonora*—1 and 2 mi. sw. of El Papalote, and 6½ mi. ne. of Punta Peñasco (= 7½ mi. sw. of El Papalote). It appears that the *klauberi* influence is somewhat spotty, being concentrated in some areas of the general border between the subspecies. Even in these the effect is not uniform, for it is evident in some specimens but not in others collected at the same place.

Chionactis occipitalis klauberi (Stickel)

TUCSON SHOVEL-NOSED SNAKE

1941. *Sonora occipitalis klauberi* Stickel, Bull. Chicago Acad. Sci., vol. 6, no. 7, p. 138. Type specimen LMK 29647; type locality Tucson, Pima County, Arizona.

1943. *Chionactis occipitalis klauberi* Stickel, Proc. Biol. Soc. Wash., vol. 56, p. 124.

Diagnosis.—This subspecies of *Chionactis occipitalis* is characterized by dark secondary crossbands occupying the centers of the interspaces between the primary black crossbands. In the typical specimens the secondary bands are complete moddorsally. They widen laterally but do not reach the ventrum. The new subspecies *C. o. talpina* is the only other one having dark (non-red) secondaries; in *klauberi* the primary bands are black, or nearly so; in *talpina* they are brown. *C. o. talpina* has more ventral plates than *klauberi.*

Systematic Problems.—In the area from Tucson, Pima County, Arizona, northwest to Picacho, and thence north to Florence and Florence Junction, in Pinal Co., most specimens of *Chionactis* are typical *klauberi.* Intergradation with *annulata* begins at Casa Grande, and is noted as far west as Gila Bend, north to Aguila, and south to Ajo. Although most of the specimens from the Sonoyta–Punta Peñasco road in northwestern Sonora are to be considered *annulata*, some evince *klauberi* tendencies to a noticeable degree, which is all the more surprising, since a population of *palarostris organica* occupies the Organ Pipe Cactus National Monument, situated between these Sonoran intergrades and the *klauberi* headquarters in the Tucson–Florence area.

Material.—Of typical *klauberi* I have had 17 specimens available, of which 7 are females.

Description of the Subspecies.—This is a snake of the usual *Chionactis* form, with the inset lower jaw and sharp rostral characteristic of the genus. The shortest specimen at hand is a female 157 mm. in length; the longest, a male and a female each measuring 339 mm.

The tail in the adult males is about 19 per cent of the length over-all, and in the females about 16 per cent.

The scale rows number 15. The ventrals in the males range from 141 to 151, mean 145.8; and in the females from 153 to 159, mean 156.0. The corresponding subcaudal counts are 42 to 47, mean 44.4; and 38 to 43, mean 40.4. The labials, both upper and lower, number 7. The nasals, loreals, and preoculars are single; the postoculars paired, except in one specimen that has a single postocular on one side. The temporals are 1+2, except in one specimen having 1+1 on the left.

The black head crescent is quite broad on top; it not only marks the supraoculars, but is carried back to the first dorsal scales behind the parietals. At the frontal, there is often a deep light indentation or notch that serves to lighten the frontal itself. On the sides the points of the crescent are carried forward to mark the nasals. The ground color of the snout, anterior to the crescent, is somewhat darkened, compared with the rest of the ground color.

The primary rings on the body range in number from 23 to 29 with a mean of 26.7, and on the tail 7 to 11, mean 8.1. The body rings plus the unmarked ventral ring positions vary from 25 to 40, mean 30.1. The rings are usually narrower middorsally than the interspaces, but may be equal, or, rarely, wider. The dorsal marks narrow laterally, and then widen again on the ventrum. The first ring completely encircling the body ranges from the fifth to the twelfth ring. On the ventrum the rings again widen, more so, in fact, than in any other subspecies; posteriorly, they usually engage 3 or 4 ventrals. Between the primary rings there is a secondary dark series, more conspicuous in this than in any other subspecies. The secondary rings are narrowest middorsally; they are usually separated from the primary series by a single row of immaculate scales, and thus the secondaries widen on the sides where the primaries become narrower. Laterally, the secondaries end on the first or second row of scales above the ventrals. The dark color of the secondaries is never as dense as that of the primaries; often only the centers of the scales are darkened and thus some of the ground color may show through, or a pink suffusion may do so, particularly on the tail. Breaks in the secondary rings occur most often middorsally. The basic color of the secondaries may be black or brown, but the pink suffusion often gives them a purplish cast. The ground color is white, cream, or light-yellow.

Intrasubspecific Trends.—In the Tucson–Marana–Picacho–Florence–Florence Junction area, *klauberi* seems to be a rather consistent form. With a single exception, all of the specimens of *Chionactis* that I have seen from this territory clearly belong to this subspecies. True, only about half the specimens have complete secondary bands middorsally, but all have darkened scale centers in the lateral scales comprising the secondaries, whereas it is characteristic of most *annulata–klauberi* intregrades that only the scale edges are darkened. In the *klauberi* territory, the secondary rings are more often complete dorsally in the Florence area than farther south at Marana.

The single specimen from *klauberi* territory failing to agree with the others in pattern is No. 422 in the Woodin collection. This is said to have been taken on the San Xavier Road near Tucson (it was not collected by Mr. Woodin himself). It has none of the characteristics of *klauberi*, or even of *annulata*, but resembles *occipitalis* from Riverside Co., California. Unless there is some error in the locality record, it is a very queer specimen indeed.

Relationships with Other Subspecies—To the northwest of the *klauberi* territory comparatively few specimens are available. There are 2 from the general vicinity of Casa Grande, Pinal County,—the exact points of collection are not known—one of which favors *klauberi*, while the other shows an *annulata* affinity. From the Wickenburg area only 2 specimens are at hand; one is from Cactus Garden, northwest of Hot Springs Junction, and the other is from 2½ miles east of Aguila. Both show *klauberi* influences, the latter somewhat more than the former, although it was collected about 25 miles farther away from the *klauberi* territory.

From southern Maricopa County, south of Gila Bend, and thence south to somewhat beyond Ajo, in Pima County, a fairly adequate series is available. The interspaces are almost always spotted to some degree. I consider this to be an area of intergradation, in which most of the specimens favor *annulata* more than *klauberi*.

Southwesterly in Sonora, along the road between Sonoyta and Punta Peñasco, occurs another intergrading population. In these snakes, the dark color in the interspaces is nearly always restricted to scale edges. All fresh specimens show pink suffusions in the interspaces. Though the *klauberi* affinity is clearly evident, I consider this series nearer *annulata*.

Farther west in the vicinity of Yuma an occasional specimen shows faintly the *klauberi* secondaries; and even in California, as I have discussed elsewhere, this darkening to form secondary bands is sometimes evident to a moderate degree.

Locality Records.—Specimens of *klauberi* have been collected at the following points: ARIZONA: *Pima County*—Tucson (type locality), Marana (30 and 32 mi. nw. of Tucson); *Pinal County*—6.4 mi. se. of Red Rock, 3 mi. se. of Pichacho, 3, 4.7, and 10 mi. n. of Florence (7 mi. s. of Florence Junction), Magma Junction, 5.5 and 8.3 mi. s. of Florence Junction. To complete the locality list, the following are to be considered records of *annulata-klauberi* intergrades, as discussed more fully under the former subspecies; ARIZONA: *Maricopa County*—2½ mi. e. of Aguila, Gila Bend (also 15 mi. s.), and 24 mi. n. of Ajo; *Pinal County*—near Casa Grande; *Pima County*—Gunsight Junction; SONORA—1, 2, and 7½ mi. sw. of El Papalote.

Chionactis occipitalis talpina[*] subsp. nov.

Northern Shovel-nosed Snake

Plate 10, fig. 1

There have lately been collected in Nevada, considerably to the north of any specimens hitherto known from that state, and about 75 miles northeasterly of the nearest specimen from California, 3 specimens of *Chionactis* that justify subspecific segregation from their territorially closest relatives. Two of the 3 specimens are from a higher altitude than any previously known to be inhabited by *Chionactis*.

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[*] Mole-like, to denote its fossorial habit.

Type Specimen.—California Academy of Sciences number 81364. Found dead on the road by Joseph R. Slevin and Wallace Wood, 50 miles south of Goldfield on the highway to Beatty, in Nye County, Nevada, June 3, 1947.

Diagnosis.—A subspecies differing from the subspecies of *palarostris*, and from the other subspecies of *occipitalis* except *klauberi*, in having, in the interspaces between the main series of the crossbands, dark marks that give the effect of secondary brown crossbands. From *klauberi* it differs in having more ventrals, and in having brown, instead of black, primary bands.

Description of the Type.—An adult male. The length over-all is 284 mm. and the tail length 52 mm.; ratio .183. The body is of normal *Chionactis* configuration, and it has the important *Chionactis* characters of nasal valves, abdominal angle, and protruding flap on the mental. The pupil is round. The dorsal scale rows are 15–15–15, all smooth, and with single apical pits.

There are 153 ventrals, the anal is divided, and the subcaudals, all divided, number 44. The head scales are normal for the species, with one loreal on each side, one preocular, two postoculars (the upper larger) and the temporals 1+2. The supralabials number 7–7; the third and fourth enter the orbit, and the sixth is the largest. The infralabials are 7–7.

The body pattern comprises a series of dark-brown crossbands, 27 on the body and 7 on the tail. They are considerably wider than the interspaces, being about 4 scales long (end-to-end) while the interspaces cover 2. All bands except the first on the neck touch the ventrals, and all but the first 2 cross the ventrum and thus become complete rings. The bands narrow laterally; the posterior ones again widen at the ventrum. The primary bands are somewhat darker dorsally than on the sides and ventrum. In the interspaces the ground color is cream, but the central scales are heavily blotched with dark-brown, although the edges of the maculated scales are usually clear. On the sides, the secondaries widen somewhat, but the maculations become less intense at the lowest 2 rows of the lateral scales; on the ventrals the interspace maculations are represented by scattered punctations.

The head crescent is quite wide, extending from the middle of the supraoculars and frontal to the posterior edge of the parietals. The snout is somewhat punctated above, and there are several spots on the labials and lower jaw, where other forms of *Chionactis* are usually clear.

Paratypes.—There are 2 paratypes, LMK 39520–1, collected by Eric Comstock and Verne Larson 10 miles north of Goldfield, Esmeralda County, Nevada, on the road to Tonopah, in July, 1949. Although taken 60 miles north of the type locality, and at a higher altitude (about 5500 ft.), they are not as extreme in pattern as the type, for the characteristic brown maculations in the interspaces do not cross the dorsum. However, they have higher ventral counts.

No. 39520 is an adult male, length over-all 335 mm., tail length 66 mm. The scale rows are 15–15–15, the ventrals number 162 and the subcaudals 51, all divided. All labials are 7–7.

The head crescent extends across the parietals; its lateral horns extend forward to the nasals. There are 32 primary crossbands on the body and 9 on the tail. The anteriormost band marking the ventrum is the fourth, and the first comprising a complete ring is the sixth. The dorsal bands, wider than the interspaces, extend longitudinally for slightly less than 3 scales, end-to-end, while the interspaces measure 2½. Scales less than half maculated are usually lighter than their fellows in the bands. The bands narrow laterally, and are both lighter and narrower on the ventrum. Posteriorly, the bands on the ventrum become wider and darker. Between the main dorsal blotches the interspaces are maculated with brown, particularly at scale centers.

The colors in life (Ridgway) were as follows: The snout was Reed Yellow, the crescent Mummy Brown. The primary dorsal bands were mostly Warm Sepia, but Rood's Brown at their lower edges. The interspaces were Colonial Buff with spots of Light Ochraceous Salmon; the maculations were Rood's Brown. The ventral surface was Pale Olive-Buff and the rings Rood's Brown. There were Maize Yellow spots on the tail between the primary blotches. The eye was Black.

The second paratype, an adult female containing 3 eggs, has a length over-all of 340 mm. and a tail length of 56 mm. The ventrals number 162 and the subcaudals 43. There are 33 primary bands on the body and 11 on the tail. None of the primary bands crosses the ventrum; instead, the ventrals are generally speckled with brown. However, the rings are complete on the tail. The colors in life were much the same as in the other paratype, but the maculations in the interspaces are heavier.

Relationships.—Although *talpina* superficially resembles *klauberi* in having dark bands in the interspaces, it is doubtful whether the two are closely related, or that there is or ever has been any territorial interconnection between them. As *klauberi* intergrades with, and was evidently derived from *annulata*, so *talpina* intergrades with, and is apparently a darkened derivative of *occipitalis*. Southward and southeasterly of the *talpina* territory, intergrades are already at hand that comprise a logical geographic pattern. Southwesterly none is yet available.

MVZ 40977, from Indian Springs, Clark County, Nevada, is a faded specimen with some maculations in the interspaces. Farther to the southeast, at Boulder City in the same county, the snakes seem to be pure *occipitalis*. Southward of the *talpina* area, the nearest available specimens are Stanford 9218 and 9219 from 11 and 16 miles south of Shoshone, the first locality being in Inyo County, the second in San Bernardino County, California. Also there is CAS 65380 from Goler Canyon, Panamint Mountains, Inyo County, and LMK 35549 from 1 mile east of Leach Lake, San Bernardino County. All of these have brown spots in the interspaces laterally, although seldom middorsally; they are to be considered *talpina-occipitalis* intergrades. No other specimens are yet available from this area immediately below Death Valley, but to the extent that specimens are at hand, the pattern trend is quite consistent.

From the southwest of the *talpina* area only a single *Chionactis* (CNHM 1714, from Owens Lake, Inyo County) is available. Since this rather faded specimen shows no interspace maculations, it is to be considered pure *occipitalis*.

The question may well be asked as to the frequency of occurrence of *talpina*-type maculations among specimens of *occipitalis* available from southern and western San Bernardino County, and eastern Kern County, from which area I have at hand about 100 specimens. I find that snakes with a few scattered dots in the interspaces are by no means unusual; probably 25 per cent of the population have such dots. Of snakes with marked *talpina* tendencies, strong enough to be considered intergrades, were they from fringe areas, there are 4: LMK 31686 from Minneola, LMK 31687 from Hector, LMK 39961 from 6 miles north of Adelanto, and UCLA 506 from 2 miles west of Barstow. Of these, the Hector specimen is the most surprising, as it is heavily maculated across the dorsum. But I do not consider that these territorially inconsistent, aberrant specimens of *occipitalis* invalidate *talpina*, any more than *klauberi* is invalidated by the circumstance that scattered specimens of *annulata*, in San Diego and Imperial counties, have *klauberi* tendencies.

One other specimen, MCZ 9806, from a questionable locality, should be mentioned. It is reputed to have been collected in southern Utah, but Mr. Arthur Loveridge informs me that this is to be considered doubtful. No other *Chionactis* has yet been reported from that state. Superficially it looks like *talpina*, having brown primary bands, and lighter brown secondaries. Yet it could be a badly faded *klauberi*, since the ventrals are low for *talpina* (it is a male with 146), and it has two other *klauberi* characteristics—a frontal notch in the head crescent, and marked widening of the posterior rings on the ventrum.

Localities.—The subspecies *talpina* is known only from the type locality: 50 miles south of Goldfield, in Nye County, Nevada, on the Beatty road; and from 10 miles north of Goldfield, Esmeralda County, Nevada, on the Tonopah road.

Areas of intergradation with *C. o. occipitalis* are indicated by the following localities where intergrades have been collected: near Indian Springs, Clark County, Nevada; 11 miles south of Shoshone, and Goler Canyon, Panamint Mountains, Inyo County, California; and 16 and 22 miles south of Shoshone, and 1 mile east of Leach Lake, San Bernardino County, California.

Chionactis palarostris palarostris (Klauber)

SONORAN SHOVEL-NOSED SNAKE

1937. *Sonora palarostris* Klauber, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 27, p. 363. Type specimen LMK 26771; type locality 5 miles south of Magdalena, Sonora, Mexico.

1941. *Sonora occipitalis palarostris* Stickel, Bull. Chicago Acad. Sci., vol. 6, no. 7, p. 137.

1943. *Chionactis occipitalis palarostris* Stickel, Proc. Biol. Soc. Wash., vol. 56, p. 128 [= 123].

Diagnosis.—A subspecies having a more convex snout than any of the subspecies of *occipitalis*, also fewer ventrals (on the average), and fewer crossbands on the body and tail. It has fewer crossbands and relatively wider interspaces than the subspecies *palarostris organica.*

Systematic Problems.—I originally described this form as a full species. Subsequently Stickel (1941, p. 137) reduced it to subspecific status, on the inference that specimens from intermediate territory would demonstrate intergradation. At that time only two specimens of *palarostris* were available to him—the type and MCZ 36890 from Costa Rica Ranch, some 40 miles to the westward of Hermosillo, Sonora. Recently an additional population of *palarostris* has been discovered in the United States, through the activity of W. R. Supernaugh, M. Max Hensley, and others collecting in the vicinity of the Monument headquarters at the Organ Pipe Cactus National Monument, on the road from Ajo, Pima County, Arizona, southward to Sonoyta. These U. S. specimens, although not as extreme as the type in low blotch counts, do have the convex snout of *palarostris*, and have fewer body bands than *annulata.* They differ in these characters from 12 specimens of *annulata* (or *annulata-klauberi* intergrades) from Gila Bend to Gunsight, as well as from another series of 15 specimens of *annulata* collected between Sonoyta and Punta Peñasco, in Sonora. This newly discovered *palarostris* population is known to extend at least 20 miles along the highway through the Monument, from 2 to 22 miles north of the U.S.-Mexican border. The nearest specimen of *annulata* available from Sonora was collected only 26 miles distant from the southernmost of this *palarostris* population, yet there is no indication of intergradation between the two. In the interval of about 7 miles separating the populations of *palarostris* and *annulata* north of the Monument, there are some suggestions of intergradation in pattern, but the snout difference remains uncompromised. Therefore, I conclude that *palarostris* should be retained as a valid species, unless further collecting in this area should demonstrate intergradation. An actual overlap between the two populations is by no means impossible.

Of the two specimens of *palarostris* hitherto available from Sonora, the type, from 5 miles south of Magdalena, shows certain well-marked differences from both the Costa Rica Ranch specimen and the Organ Pipe population previously mentioned. During the past summer an additional west-central Sonoran specimen was collected by R. G. Zweifel and K. S. Norris, at a point 40.7 miles south of Hermosillo, or about 150 miles (straight-line distance) south of the type locality.* This has all of the outstanding pattern features of the type, thus indicating that these are characteristic of the population of that area. I have therefore decided to consider the Magdalena-Hermosillo population as subspecifically distinct from the Organ Pipe, assigning the new name *organica* to the latter.

Material.—Two specimens of the subspecies *palarostris palarostris* are available.

Description of the Subspecies.—This is a snake of the usual *Chionactis* configuration, except that the rostral is blunter, and the top of the head, from

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*The nearest named place to this locality is the hamlet of El Pocito some 3 miles northward. I shall hereafter refer to this as the Pocito specimen.

the center of the frontal to the snout, is distinctly convex, whereas in the subspecies of *occipitalis* it is virtually straight, or slightly concave, at the prefrontals.

Of the two specimens available, the type is an adult male with 144 ventrals and 39 subcaudals; the Pocito specimen is a female with 152 ventrals and 42 subcaudals. The scale rows in both number 15, the supralabials 7, infralabials 8, the nasals are undivided, the loreals and preoculars single, the postoculars paired, and the temporals 1+2 or 1+3. The ratios of the tail length to length over-all (both are adults) are .183 in the male and .166 in the female.

The pattern comprises alternating black and deep red blotches or saddles, separated by narrow borders of yellow ground color, which becomes white after preservation. In both specimens there are 10 black blotches on the body and 3 on the tail. The black blotches have a longitudinal extent of only 1/3 of the interspaces, the latter having a length of about 10 to 12 scales (end-to-end), whereas the black blotches cover 3 to 3½ scales middorsally, where they are widest. The red saddles have about 4 times the extent of the narrow yellow stripes that border them.

Both the black and red blotches narrow on the sides, so that laterally the ground color is more in evidence than dorsally. The black blotches rewiden ventrally, but the red saddles fade out at the first row of scales above the ventrals. Laterally the red saddles are maculated with black spots; these are much less prominent in the type than in the Pocito specimen, in which they are carried to the ventrum.

In this subspecies the snout is cream-colored. There is a large black parietal blotch covering the posterior 2/3 of the frontal and extending to the rear edges of the parietals; on the sides this blotch engages the eyes and the upper edges of the posterior supralabials. Although this blotch is analogous to the crescent characteristic of all subspecies of *occipitalis*, it is more rectangular in form. The underside of the head is cream. There are 14 to 16 scales, end-to-end, between the head blotch and the first dorsal body band.

Shortly after preservation, the type exhibited the following Ridgway dorsal colors: Black, Brazil Red, and Maize Yellow, with a Cream Color ventrum.

Intrasubspecific Trends and Relationships.—With only 2 typical specimens available, no conclusions respecting trends can be drawn. The most conspicuous difference between the Magdalena and Pocito specimens is the interspace maculations of the latter.

Based on the available material, *palarostris palarostris* is subspecifically distinct from the snakes of the Organ Pipe Cactus National Monument. I shall discuss this relationship under the new subspecies.

There remains MCZ 36890 from Costa Rica Ranch, Sonora, a locality some 40 miles west and slightly south of Hermosillo. In all important characters, particularly in the number and relative spacing of the blotches, this specimen resembles the new subspecies *organica*, rather than *p. palarostris*. It is a juvenile and the preservation is not good. It is not possible to tell whether the snout is sharp as in *occipitalis* or blunter as in *palarostris*. Only additional collecting in this relatively inaccessible area will determine whether this is a *palarostris* of unusual pattern, an *organica* involving a very long range extension, or an *annulata* far from its nearest relatives and with a sufficiently low blotch count to warrant a separate subspecific status. The latter is not an impossibility, having in mind the equally surprising territorial relationship between *C. o. annulata* and *C. p. organica* in western Pima County and northwestern Sonora.

Thus far, *Chionctis* has not been collected between a point only a few miles south of Tucson and Magdalena, although considerable night collecting has been tried on the road from Tubac south to Nogales. It seems rather doubtful whether a continuous *Chionactis* population exists over this direct line from Tucson to Magdalena via Nogales, hence there is little probability of a direct contact between the populations of *klauberi* and *p. palarostris* as represented by their most typical forms.

Range.—*Chionactis p. palarostris* has been collected 5 mi. s. of Magdalena, and 40.7 mi. s. of Hermosillo (near El Pocito), Sonora, Mexico. There is a specimen of uncertain status from Costa Rica Ranch, Sonora.

Chionactis palarostris organica* subsp. nov.

ORGAN PIPE SHOVEL-NOSED SNAKE

Plate 10, fig. 2

1950. *Chionactis occipitalis palarostris* Hensley, Trans. Kansas Acad. Sci., vol. 53, no. 2, p. 283.

Type Specimen.—LMK 40673. Collected by William R. Supernaugh and Grover E. Steele at 9:42 P.M., May 22, 1950, on the Sonoyta–Ajo road, 9 miles north of the U.S.–Mexican Border, in the Organ Pipe Cactus National Monument, Pima County, Arizona. Preserved July 19, 1950.

Diagnosis.—A subspecies differing from all *occipitalis* subspecies in having a blunter snout and fewer body blotches. From *palarostris palarostris* it differs in having more body blotches, and in possessing red saddles shorter than, or only equal to, the black blotches, whereas in *p. palarostris* the red saddles are more than twice the length of the black.

Description of the Type.—An adult male. The length over-all was 303 mm. and the tail length 58 mm.; ratio .191 (before preservation). The body is of the usual *Chionactis* shape, and it possesses the nasal valve, abdominal angle, and protruding flap on the mental characteristic of the genus. The snout is blunter and more convex on top than in *occipitalis*. The pupil is round. The dorsal scale rows are 17–15–15, all smooth.

There are 146 ventrals, a divided anal, and 42 subcaudals, all divided. There are 7 supralabials on each side; the third and fourth touch the eye, and the sixth is the largest. The infralabials also number 7. The nasals, loreals, and preoculars are single, the postoculars paired. The temporals are 1+2.

The body pattern comprises a series of 14 black blotches or saddles; there are 4 blotches on the tail. Middorsally the saddles engage 4 scales,

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*To indicate its habitat in the Organ Pipe Cactus National Monument.

end-to-end, while the interspaces comprise 6 scales. The anterior edge of the first blotch is 5½ scales back of the parietals. The black saddles narrow laterally and then rewiden on the ventrum. The first saddle to mark the ventrum is the third from the head, and the first to comprise a complete ring is the fifth. Between each pair of black blotches there is a vermilion saddle extending for about 3½ scales. Although bright and clear, the vermilion blotches are not as sharp-edged as the black; laterally they fade out on the second or third row of scales above the ventrals. A few of the vermilion scales have darkened edges.

The head crescent is quite wide, extending from the anterior third of the frontal and supraoculars almost to the posterior edges of the parietals. The anterior lateral points of the crescent reach the loreals. The ground color is cream, somewhat darker dorsally than below.

Paratypes.—There are 14 paratypes available, all collected on the Ajo–Sonoyta road between 2 and 22½ miles north of the International Boundary. These are Cornell 4073, Woodin 651, Illinois 5602–6, 5906, 10625, and 10630, and 4 specimens belonging to the Monument Museum. The following data were compiled from the type and paratypes taken together, comprising 12 males and 3 females.

This is a snake of the usual *Chionactis* configuration but with the blunt snout and convex crown characteristic of *palarostris*, as compared to *occipitalis*. The longest specimen is a female 391 mm.; the longest male is 308 mm. The shortest is 166 mm.

The tail in the adult males varies from 18.5 to 20.8 per cent of the body length over-all, with an average of 19.7; in the females it averages 16.5 per cent.

The scale rows number 15. The ventrals in the males range from 141 to 150, mean 145.6; and in the females from 156 to 161, mean 158.3. The subcaudals in the males range from 42 to 47, mean 44.5; and in the females are either 42 or 43. Both upper and lower labials usually number 7, but rarely there may be either 6 or 8. The nasals, loreals, and preoculars are single, and the postoculars paired. The temporals are 1+2.

The species *palarostris* is the most beautiful of all the forms of *Chionactis* because of the extent and depth of the red coloration in the spaces between the black crossbands. The subspecies *organica* is somewhat less spectacular than *p. palarostris*. The black head crescent, so characteristic of *Chionactis*, becomes almost a rectangle in *organica;* its anterior edge crosses the frontal and supraoculars at, or just behind, their forward edges, and it extends back as far, or nearly as far, as the posterior edges of the parietals. The lateral borders of the black mark follow the upper edges of the supralabials. The black engages the eyes and is carried forward to darken the preocular, particularly its lower half, and sometimes the loreal. There are 4 to 6 scales between the parietals and the anterior edge of the first black crossband; this compares with 14 and 16 in the two specimens of *p. palarostris*.

The black crossbands on the body are widest (measured along the snake) middorsally, narrowing laterally, but again widening—this is especially true posteriorly—on the ventrum. The bands are from 3 to 5 scales long (end-to-end) middorsally, and usually are narrower than the interspaces, which vary from 4 to 7 scales in length. All but the first 1 or 2 black bands are represented by complete or partial rings crossing the belly, except for one specimen, wherein the fifth blotch is the first one carried to the ventrum. Dorsally, the interspaces are colored with deep-red for lengths of 2 to 4 scales; these red saddles widen laterally (where the black bands narrow) but terminate 1 to 3 scale rows above the ventrals. The lowest red scales are often edged with brown. Dorsally and laterally there is a single row of ground-colored scales between the red and black; and, since the ground color is white or yellow, the snake is tricolored in bright, contrasting hues.* But the beautiful red of the live specimens is soon lost in preservation.

In *organica* there is undoubtedly sexual dimorphism in the number of black body blotches, for the 3 females have 18, 18, and 20 respectively, while the males vary from 13 to 16 with a mean of 14.2. The tail blotches number either 4 or 5 in both sexes.

Using the criterion of body bands plus the unmarked ventral spaces opposite the bands, the variation in *organica* is from 14 to 22, with an average of 16.5. This is considerably lower than in any subspecies of *occipitalis*.

Just after it had shed, an adult female of the Organ Pipe series had the following Ridgway colors: snout, Sea-foam Green anteriorly, Deep Sea-foam Green posteriorly; head crescent, Aniline Black; dorsal crossbands, Dull Violet-Black; interspace centers, Scarlet; interspace edges, Pale Chalcedony Yellow; ventral dark marks, Dull Purplish Black; ventral interspaces, Pale Chalcedony Yellow to Pale Dull Green-Yellow, depending on the color of the organs within, for the skin here is slightly translucent. A male, somewhat smaller, exhibited the following life colors: snout, Pale Chalcedony Yellow in front to Pale Dull Green-Yellow behind; head crescent, Dusky Purplish Gray; dorsal crossbands, Black; interspace centers, Scarlet; interspace edges, Pale Chalcedony Yellow; ventral dark marks, Dull Purplish Black; ventral interspaces, Pale Glass Green.

Relationships with Other Subspecies.—*Chionactis p. organica* differs from the subspecies of *C. occipitalis* in having a blunter snout, fewer ventrals, and fewer dorsal crossbands. Territorially, the nearest *occipitalis* specimens available, which belong to the subspecies *annulata*, are from two areas: those from along the Sonoyta–Punta Peñasco road (15 available specimens), and those from the road from Gila Bend south via Ajo to Gunsight. The former show no *organica* affinities; to the extent that they are not typical *annulata*, they tend toward *klauberi*, for they have a high number of narrow crossbands and maculations in the interspaces.

The specimens of *annulata* from the Ajo–Gunsight area, distant only 7 to 15 miles from the most northerly Organ Pipe locality of *organica*, are less conclusive, there being only 3 specimens available from below Ajo. For

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*For this reason *Chionactis*, particularly this species and *C. o. annulata*, is popularly confused with the Sonoran coral snake (*Micruroides euryxanthus*). Besides differences in squamation, it may be noted that the red bands of *Micruroides*, unlike those of *Chionactis*, cross the ventrum.

annulata, they are somewhat low in ventrals (males with 147, 149, and 156) but not in body bands (28, 27, 22). The snouts are fairly sharp, and the head marks more crescentic than in *organica*. The red bands in the interspaces are narrower and more maculated (a *klauberi* trend) than in *organica*. Altogether, I deem intergradation or hybridization between the snakes of the Organ Pipe and those from near Gunsight to be improbable, but not impossible.

There are strong morphological reasons for believing *palarostris* and *organica* to be conspecific, yet they are widely separated geographically and no intergrades are at hand. If *organica* is, as has been inferred, a northwesterly intrusion of *palarostris* between two *annulata* populations (Pozo Sipiano–Papalote and Ajo–Gunsight) then eventually *palarostris–organica* intergrades should be found in the vicinity of Altar, Caborca, and Tajitos. These places lie in a relatively inaccessible area, which will for some years lack the paved roads so necessary to facilitate the collection of *Chionactis*, and the solution of this problem may be long delayed. MCZ 36890 from Costa Rica Ranch has many *organica* characteristics and comes from near the range of *palarostris*, yet it is from a point that is territorially inconsistent with its being considered a *palarostris–organica* intergrade.

Locality Records.—At present *organica* is known only from the Sonoyta–Ajo road through the Organ Pipe Cactus National Monument, where it has been taken 2, 4, 4.3, 4.5, 6.5, 8.2, 9.8, 12, 16, 17.5, 18.4, and 22.4 miles north of the International Boundary.*

GENERIC RELATIONS AND INTRAGENERIC TRENDS

It is probable that *Chilomeniscus* is the nearest present-day relative of *Chionactis*. I say this, not because of the really remarkable superficial resemblance in color and pattern between *Chilomeniscus cinctus* and *Chionactis occipitalis*, but because the two genera have certain important characters in common that distinguish them from most other Colubridae, namely, possession of nasal valves, an angled abdomen, a notably sharp snout with a deeply inset lower jaw, and a mental protrusion to close the tongue orifice. These are characters in which both genera differ from *Sonora*; they are characters fitting them for a life on or beneath the surface of sand.

Chilomeniscus is a stouter-bodied, shorter-tailed snake than *Chionactis*, and the snout is even sharper with a more deeply inset under jaw. Although *Chionactis* has head plates conforming to the normal of most genera of Colubridae, *Chilomeniscus* has several distinctive deviations, including (usually) a contact between the rostral and prefrontals, the merging of the nasals and internasals on each side, and the prevailing absence of loreals. Thus, the two genera are quite distinctive; nevertheless, their mutual possession of certain unusual characters suggests a common ancestry.

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*The localities recorded by the collectors sometimes refer to the Boundary, and sometimes to the Monument Headquarters or Ajo. To secure uniformity I have referred all localities to the Boundary. The Monument Headquarters are 5 miles north of the Boundary, and Ajo is 38 miles north, these distances being measured along the road.

The nasal valve in *Chionactis* is hinged to the rear edge of the nostril. As it opens, it pulls back toward the eye and slightly inward. The movement can be easily seen in a live specimen. I am unable to determine whether the opening and closing are coincident with breathing. The valve was never seen to close entirely, as it may when the creature is submerged in sand. A drop of water does not cause complete closure.

The relative bluntness of the *palarostris* snout, as compared with *occipitalis*, is somewhat more evident in live than in preserved specimens. The point on the mental seems somewhat less conspicuous in the former species. The action of this tip in *occipitalis* indicates that there is some flexibility of the tip independent of the mental itself. There is a slot in the rostral into which this point fits, so that the aperture through which the tongue is extruded may be tightly closed.

The jaws are slightly opened when the tongue is protruded. The tongue of both species is black or dark-brown, with white tips back almost to the bifurcation. When the snake is appraising its surroundings, the tongue is vibrated through 180 degrees, from vertically upward to downward.

The pupil is round, the iris black, thus making the eye appear unicolor. *C. palarostris* may have a slightly larger eye, proportionately, than *occipitalis*.

As for intrageneric trends, the following will summarize the major differences: The form with the proportionately longest tail is typical *annulata* from Imperial and Yuma counties; the snakes of this subspecies have relatively shorter tails in the fringe areas both to the east of Yuma County, and in San Diego County to the west. *C. o. occipitalis*, alike in the Coachella Valley and in the western Mojave, is shorter-tailed than *annulata*, even shorter than the San Diego County population.

In ventral scale counts, the maxima are reached in the warmest areas, the central Colorado and Yuma deserts, the Coachella Valley, and the western Mojave. This variation conforms to the general rule that snake populations inhabiting warmer areas have more ventral scutes than individuals of the same subspecies in cooler places. The foothill snakes in San Diego County have lower counts, and the same is true of the Arizona population east of Yuma County. *C. p. palarostris*, *C. p. organica*, and *C. o. klauberi* have fewer ventral plates than the other groups. The subcaudals follow tail proportionalities, *annulata* being high, and *occipitalis* low, with the San Diego County and south-central Arizona populations intermediate.

The greatest variations are in pattern and colors. The snakes with the highest numbers of crossbands are those from the Coachella Valley, with the western Mojave *occipitalis* only a few below. *C. p. palarostris* has the fewest marks, *annulata* being intermedite. In the number of bands there is little difference between the Yuma, Imperial, and San Diego county populations. Farther east, in Arizona, including *klauberi*, the tendency is upward, so that the counts fall between those of *annulata* and those of *occipitalis* from the western Mojave.

In the color of the primary series of bands, *occipitalis* and *talpina* are generally brown; *annulata*, *klauberi*, *organica*, and *palarostris* black. The interspace suffusions run to yellow in *occipitalis* and to red in *annulata, organica,* and *palarostris.* Orange is occasionally observed in the western Mojave population. The most perfect *annulata* interspace reds are found in Imperial and western Yuma counties; here they are deep in color, and with even edges sharply contrasting with the white or buff ground color. Westward in San Diego County the interspace colors tend to be lighter, narrower, and less sharply bordered; at the higher elevations they are often absent. Eastward of Yuma County the interspace secondary bands become narrower and darker, reaching a climax in *klauberi,* in which the red is almost completely masked by maculations nearly as dark as the primaries. The same trend is noted from *occipitalis* northward toward *talpina,* except that in this case the maculations are brown. Both subspecies of *palarostris* have wider and deeper red secondary bands than any *annulata.*

The total dark pigmentation (whether black or brown) seems to increase at the higher altitudes. Thus, in San Diego County, the dorsal bands are wider, proportional to the interspaces, than in Imperial County, and the bands widen ventrally to a greater degree. In south-central Arizona the same tendency is manifested by increased maculations in the interspaces, plus a widening of the ventral bands; it reaches the ultimate in *klauberi.* In the same way the snakes to the north of the Mojave become darker at the higher altitudes, reaching the extreme in *talpina. C. o. occipitalis* tends, with considerable consistency, toward more dorsal but fewer ventral bands, as compared with *annulata.*

PHYLOGENY

I visualize the present geographical arrangement of the subspecies of *Chionactis* as, possibly, the result of three migrations from Sonora northward and westward. The first postulated migration was accompanied by the evolution of the brown, short-tailed snakes (*occipitalis*), of the Mojave Desert, and included an invasion of the Coachella Valley down to Lake LeConte by way of the Morongo route. *C. o. talpina* was a later northward extension and differentiation from the main *occipitalis* population in the south.

The second inferred migration, that of *annulata* into the Yuma Desert and into the Colorado Desert (except the Coachella Valley), probably occurred not long before the termination of the ancient main stage of Lake LeConte (Hubbs and Miller, 1948, p. 104). The lack of difference between the snakes of the east and west sides of what was once the bed of this lake—now represented by the East and West mesas bounding the Imperial Valley—indicates that these populations were not separated for any great length of time. The *occipitalis* tendencies observed in the San Diego County population of *annulata* suggest a merging of the two populations by reason of a drift of *occipitalis* around the southern end of the Santa Rosa Mountains during one of the Lake LeConte recessions. It seems probable that *occipitalis* was the later arrival in this area of composites since the isolated pockets, at La Puerta, for example, are nearer *annulata. C. o. klauberi* is an eastern offshoot of *annulata.*

The final invasion was that of *organica,* which has advanced to the point of producing an intrusion into the *annulata* area in the vicinity of Organ Pipe

Cactus National Monument, separating, around Ajo and Pozo Sipiano, two sections of an *annulata* population having some *klauberi* tendencies. The close similarity of the two *annulata* populations, particularly their *klauberi* peculiarities, suggests that they have not long been separated by the *organica* wedge.

ECOLOGY, LIFE HISTORY, AND HABITS

Ecological and Temperature Preferences.—As we survey the snake fauna of desert areas, we note various criteria that indicate the degree to which the several genera have become addicted to or tolerate the arduous conditions found there.

Some are clearly fringe invaders; that is, they filter into the edges of our southwestern deserts but are usually absent where the dry and barren conditions are most extreme. Typical of these are such forms as *Lampropeltis getulus* and *Lichanura roseofusca.* Others endure desert conditions, but show, by population increases when the conditions are ameliorated by agricultural development and irrigation, that it was toleration rather than preference which led them to an acceptance of the desert. Such, for example, are *Pituophis catenifer affinis* and *Masticophis flagellum piceus*, snakes that, though always present in the Imperial Valley, have increased greatly in numbers since the coming of irrigation.

Of the snakes that really thrive in the desert, some are represented by desert subspecies of much more widely distributed forms, among them *Arizona elegans*, *Rhinocheilus lecontei*, and *Crotalus scutulatus.* All three flourish in Upper Sonoran areas, *Arizona* and *Rhinocheilus* in California (and elsewhere as well), and *C. scutulatus* in Arizona.

Of those whose greatest populations—whose headquarters, as it were—are in the desert, there are three: *Phyllorhynchus decurtatus*, *Chionactis occipitalis*, and *Crotalus cerastes.* All three, as shown by roadside observations in the Coachella, Imperial, Yuma, and Blythe agricultural areas, are driven out by irrigation. And we are struck by the virtual identity of their ranges.

If we assume that *decurtatus*, *perkinsi*, and *nubilus* are all subspecies of *Phyllorhynchus decurtatus*—of which I am beginning to be rather doubtful—that species has somewhat the greatest range, for it reaches the Cape Region of Baja California, whereas the other two may not extend much below San Felipe on the Gulf coast. In San Diego County, *Phyllorhynchus* has reached San Felipe Valley, where it is found at the top of Sentenac Canyon, whereas the others stop at the bottom of the Canyon, some 4 miles farther down the slope. *Phyllorhynchus* is also found somewhat higher up the Palms-to-Pines grade in Riverside County than the other two. Yet on the Mountain Springs grade, on the San Diego-Imperial Border, *Chionactis* reaches a higher elevation than the others.

At the northeastern corner of the range, in southwestern Utah, it is probable that *Crotalus cerastes* considerably outranges the other two; on the other hand, in the Tucson area of Arizona, the *C. cerastes* range stops at Cortaro while the others continue into Tucson. The ranges of the species are imperfectly known in Sonora, but it appears that *C. cerastes* is the more restricted. But, by and large, despite these slight sorties of one or another species at the fringes, the congruence of their ranges is remarkable.

In general, these three desert snakes prefer dry and sandy areas. *Phyllorhynchus* is likely to predominate where scattered stones abound, whereas the others prefer a looser soil. Since all are small snakes, an extensive uniformity of terrain is not required; to whatever extent sand is preferred, a sufficient amount will be found in the dry washes threading their way amid rocky hills or sun-baked mesas. Areas of extreme barrenness, with an almost complete lack of vegetation, are not densely populated, probably owing to a scarcity of food. Thus we find these sand-dwellers to be rare where there is a superabundance of sand, in such places as the belt of sand hills some 17 miles west of Yuma, in Imperial County. They are virtually absent from some particularly barren stretches along the shores of the Salton Sea, although there is much sand about. The population of all three becomes more sparse as one proceeds eastward from Bensons Dry Lake, in eastern San Diego County, toward Kane Spring, Imperial County, a route along which the vegetation also becomes increasingly attenuated.

Scattered sand hummocks, crowned with mesquite or other desert shrubs, are favorite refuges of both sidewinders and shovel-noses. Hillocks of coarse sand constitute the typical habitats of sand-loving forms according to Cowles (1941, p. 125).

Since much hunting of *Chionactis* is done at night when the exact nature of the surroundings cannot be appraised, most specimens in my collection are not accompanied by ecological data. However, the following records will indicate the frequency of different surroundings under some rather broad generalizations:

Sandy desert	55
Barren desert	54
Brushy desert	39
Rocky desert	6
Grassy desert	3

Some of the particular situations noted were: Date grove, rocky gorge, creosote bush, burro weed, mesquite hummocks.

One of the earliest experiences that I had in *Chionactis* collecting was on the night of April 30, 1927, when 8 of us, with flashlights and Coleman lamps, hunted the mesquite hillocks in the vicinity of the old San Felipe Hotel in eastern San Diego County for two hours or more. We secured 3 of these little snakes, a meagre catch for the effort, and far less than would have rewarded the road-collecting method that was first tried a year or so later. The dark crossbands of these little snakes are admirably suited to blend with the shadows of the twigs scattered about on the sand, and we found them difficult to discover. On a dark, smooth pavement, picked out by the headlights of a car, they have no such protection.

These little snakes are sometimes trapped in fresh road tar. Hubbs and Walker (1947, p. 464) reported finding 3 in a stretch of 5.8 miles of road in the eastern Mojave Desert, among many other creatures snared the night before.

The air temperatures at which *Chionactis* has been found active on the roads at night are indicated in the following table:

AIR TEMPERATURE DEGREES F.	NUMBER OF SPECIMENS *C. o. occipitalis*	*C. o. annulata*
62-3		1
64-5	2	2
66-7	1	6
68-9	1	3
70-1		5
72-3	2	9
74-5	5	10
76-7	1	11
78-9	7	6
80-1	4	13
82-3	2	16
84-5		12
86-7	1	9
88-9	1	8
90-1		3
92-3	2	5
94-5		3
96-7	1	3
98-9	1	
	31	125

The collecting times were as follows:

TIME WHEN OBSERVED	NUMBER OF SPECIMENS *C. o. occipitalis*	*C. o. annulata*
5:00- 5:29 P.M.		1
5:30- 5:59		
6:00- 6:29		1

6:30- 6:59		1
7:00- 7:29	4	7
7:30- 7:59	7	14
8:00- 8:29	4	34
8:30- 8:59	8	31
9:00- 9:29	4	26
9:30- 9:59	2	21
10:00-10:29	1	17
10:30-10:59	2	9
11:00-11:29	1	4
11:30-11:59		3
12:00-12:29 A.M.	1	1
12:30-12:59		
1:00- 1:29		
1:30- 1:59		
2:00- 2:29		1
2:30- 2:59		
	34	171

These records indicate that *Chionactis* is most active at air temperatures between 70° and 90° F., and from 7:00 to 10:00 P.M., but certain cautions respecting the interpretation of the tables are necessary. As those of us who have written on the habits of our southwestern reptiles have frequently pointed out, the recorded air temperature is only an approximate indication of the temperature of the snake's body, for the creature is in contact with the ground and is subject to conduction of the ground temperature, and it is partly protected from the convection effect of the wind. In early evening, particularly in spring, the ground is almost invariably warmer than the air. It is probable that the snakes are abroad partly because of this fact.

As to the time of activity, though it is unquestionably true that in the spring the snakes avoid the late hours when the temperature is suboptimum, the lack of late-hour records in the summer, when such hours are likely to be most suitable in temperature, is merely the result of inadequate collecting, for our collecting forays rarely extend beyond midnight.

Our records certainly do prove definitely that all forms of *Chionactis* are almost exclusively nocturnal, for I have driven thousands of miles on desert roads in the daytime, and, in contrast with the many specimens recorded alive at night, those active diurnally have been rare enough to warrant individual mention. I found one on the east base of a large mesquite hummock at 6:10 P.M., just as the sun was cutting the horizon. This was in Imperial

County, 4 miles west of Kane Spring Junction, April 20, 1935. A week later another was caught crossing the road at 5 P.M., in bright sunlight, 1 mile west of Grays Well, Imperial County. Charles E. Shaw found a *C. o. annulata* crossing the road at 9:40 A.M., May 14, 1947, 20 miles southwest of Pozo Sipiano, Sonora. The air temperature was 69° F. and a strong wind was blowing. He also found a juvenile issuing from a hole near Clark Dry Lake, San Diego County, at 5:10 P.M., when the sum was still shining brightly. This was in the early spring, on March 29, 1941. Dr. R. B. Cowles informs me that in many hundreds of desert trips he has seen *Chionactis* abroad in the daytime only twice. After sundown catching them is not so unusual, yet even in the spring they do not reach maximum activity until dusk has turned to darkness.

That these little snakes reach their maximum activity in the early evening in the spring, when the later temperatures are much below the optimum, is easy to demonstrate, for the live specimens are found during the early hours, while later only DOR's remain as evidence of their earlier prevalence. In summer the best temperature conditions are undoubtedly reached just before sunrise, for, earlier in the evening, ground and air temperatures are too high for comfort and may even be lethal. However, so little collecting has been done after midnight in summer that we cannot say whether there is any considerable early-morning activity at that season. Since the snakes' prey is also forced to adopt a subterranean existence, food, to the limited extent that it is required, may be found below ground, without the risk of surface activity. Collecting up to midnight on several hot nights in June, C. B. Perkins had meagre results, but next morning a number of DOR's were found, indicating that there had been an accelerated post-midnight activity.

Although statistics based on air temperatures are not trustworthy proofs of optimum body temperatures, I should judge from field and laboratory experiences with *Chionactis* that such temperatures are probably in the range of 26° to 28° C. (78.8° to 82.4° F.). Cowles and Bogert (1944, p. 286) report the highest voluntarily accepted temperature in captivity as 31° C. (87.8° F.), the critical maximum at 37° C. (98.6° F.), with recovery appearing at 33° C. (91.4° F.). Under laboratory conditions, the snakes lost the power of co-ordinated action at 38° C. (100.4° F.). The minimum voluntary tolerance is given as 20° C. (68° F.).

The desert is usually windy on spring nights, but this does not completely discourage the nocturnal forays of these little snakes. I find among my notes the following designations of wind conditions at the time of the capture of *Chionactis* on the road: Windy, very windy, hard wind, strong wind, cold strong wind. Occasionally one sees these and other little snakes blown across the road, so strong is the gale.

Although specimens of *Chionactis* have been brought to the San Diego Zoo or Natural History Museum during every month of the year, it is probable that those representing the months of November to February, inclusive—about a dozen in 27 years—were not indicative of surface activity, but were dug out of their winter refuges in the course of agricultural or road work.

Probably a better criterion of seasonal activity is furnished by the following table showing when specimens have been found alive or dead on the road at night:

MONTH	NUMBER OF SPECIMENS *C. o. occipitalis*	*C. o. annulata*
January		
February		
March		4
April	2	16
May	75	161
June	49	107
July		23
August		5
September		5
October		2
November		
December		
	126	323

Of course, these figures, like our other statistics, are premised on the coincident activities of snakes and collectors, and it must be admitted that collecting is neglected in seasons other than spring. However, the reason for our summer inactivity is mainly the result and not the cause of the strong spring peak, for experience soon taught us that collecting was virtually fruitless after the end of June.

A more accurate criterion of relative seasonal activity may be derived from statistics of the shovel-noses encountered on the road (dead or alive) per mile of night travel. The following statistics are based on 20,768 miles of travel on desert roads at night in the months of March to October, inclusive, during which 324 specimens of *Chionactis* were recorded.* The resulting statistics in snakes per 100 miles of travel are:

MONTH	SPECIMENS OF *Chionactis* PER 100 MILES
March	.00
April	.47
May	2.00
June	2.09
July	.86
August	.69
September	.27
October	.00

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*The difference between the total number of snakes listed in this and the previous table results from the fact that the first table includes data on snakes found on night trips when mileage records were not kept.

It will be seen that there is a sudden rise in activity in May and June (the actual peak is probably during the first week of June), followed by a decline through the rest of the summer. Our experience indicates that the season is somewhat earlier in the Borrego area of eastern San Diego County than in the Mojave Desert. At the peak season in Borrego, and under favorable conditions of weather, the take will often exceed 10 shovel-noses per 100 miles of desert travel. The much lower average values result from unfruitful trips during the many unseasonable cold nights that are encountered on the desert in spring and early summer.

That autumn collecting is unrewarding, even when spring weather conditions are duplicated, has lately been verified by Charles E. Shaw. He cruised the road between Scissors Crossing and Bensons Dry Lake, in the Borrego area of eastern San Diego County, at weekly intervals from early spring to autumn. He found the road to be virtually barren of snakes on the autumn nights (2 snakes in 138 miles of travel on Sept. 23, 30, and Oct. 7) compared with the spring nights (40 snakes in 138 miles, on May 27, June 2 and 8), notwithstanding a similarity in temperature and other weather conditions. These statistics refer to snakes of all kinds, not *Chionactis* exclusively.

As an indication of the concentration sometimes reached, it may be noted that Shaw and the writer collected 10 specimens of *C. o. annulata* in 17 miles along the Yaqui Well–Bensons Dry Lake road in the Borrego area of eastern San Diego County on June 9, 1939. The best Mojave Desert record was made in the Mojave–Kramer–Adelanto area, where Shaw found 10 individuals of *C. o. occipitalis* in 43 miles of travel, on June 5, 1949. The following night 8 were taken.

William R. Supernaugh, Superintendent of Organ Pipe Cactus National Monument, reports that the *C. p. organica* specimens collected in that vicinity were found prior to June 20 and between the hours of 8:30 and 9:45 P.M.

I believe that *Chionactis* is somewhat less tolerant of unfavorable nocturnal weather conditions in the spring than are the other, larger common snakes of the desert, namely, *Rhinocheilus*, *Arizona* and especially, *Crotalus cerastes*.

Our collecting experiences on the desert indicate that all these nocturnal snakes prefer the dark of the moon to moonlight, though the available statistics do not yet supply absolute proof of this theory.

Relative Populations.—In many desert areas, *Chionactis* is one of the commonest snakes. The following statistics indicate the relative frequency of occurrence of the 5 most plentiful nocturnal snakes found in three desert areas of southern California, as indicated by records of specimens observed alive or dead on the road during the past 20 years:

WESTERN MOJAVE DESERT

Crotalus cerastes cerastes	132
Arizona elegans candida	96
Rhinocheilus lecontei lecontei	86

Crotalus scutulatus scutulatus	79
Chionactis occipitalis occipitalis	61

COACHELLA VALLEY, RIVERSIDE COUNTY

Crotalus cerastes laterorepens	59
Phyllorhynchus decurtatus perkinsi	51
Arizona elegans eburnata	50
Chionactis occipitalis occipitalis	42
Rhinocheilus lecontei clarus (or *lecontei–clarus* intergrades)	15

BORREGO AREA, SAN DIEGO COUNTY

Phyllorhynchus decurtatus perkinsi	523
Chionactis occipitalis annulata	397
Crotalus cerastes laterorepens	196
Arizona elegans eburnata	153
Rhinocheilus lecontei clarus (or *lecontei–clarus* intergrades)	105

The numbers of specimens recorded from the different areas are not to be taken as indicating the relative snake concentrations between districts; the high records from the Borrego area merely represent many more trips than were made to the Mojave or Coachella sections.

It will be observed that *Chionactis* falls within the first 5 in each area. It is probable that this small snake (and *Phyllorhynchus* as well) represents a somewhat higher percentage of the snake population than these figures indicate, since the small snakes are more likely to be overlooked, whether alive or dead, than the larger forms, *Crotalus*, *Arizona*, and *Rhinocheilus*.

Of course, these figures involve generalities based on areas of considerable extent and ecological diversity. Within these areas there are smaller, more uniform sections in which one or another species may predominate. For example, there is a short stretch of road at the top of the Sentenac Canyon, in San Diego County, where the worm snakes (*Leptotyphlops humilis* in the form of *L. h. humilis–cahuilae* intergrades) are exceedingly common, far outnumbering all other snakes taken together.

So it is with the other small desert snakes. It is probable that the *Chionactis* population exceeds *Phyllorhynchus* in the sandier sections of the Colorado Desert. For example, Cowles (1941, p. 134) reported that in an area of sand hummocks on the northeast side of Coachella Valley, out of 96 reptiles (including lizards) excavated by land grading operations during the season of hibernation, 41 were *C. o. occipitalis*. This census, probably representative of the population, indicated this snake, locally, to be much the most common form.

Locomotion.—Normally *Chionactis* uses the horizontal undulatory type of locomotion. In soft sand it leaves a sinusoidal track with wide side loops.

The sand is piled up on the rearward edge of each crest, so that it is easy to determine the direction of travel. Mosauer (1932, p. 77) pointed out that during motion the ventral plates are drawn in through action of the abdominal muscles and that this serves both to form a concave ventral surface and to sharpen the angle formed by the ridge at the outer ends of the ventrals, this ridge being characteristic of the genus. The ridge is thought to facilitate motion in the sand by reducing side slippage.

Chionactis will sidewind if badly frightened or stimulated by the discomfort of an uncomfortably warm surface. It will also attempt this type of locomotion on a smooth surface such as glass or paper. The loops formed are not as deep as those of the sidewinder (*Crotalus cerastes*), and though the writhing is rapid, the motion is not particularly effective in net travel. Even so, on the smooth surface of a paved desert road, *Chionactis* is more often successful in escaping than any other night snake encountered.

In its nightly cruises, it is evident that *Chionactis* spends most of its time on the surface. Although it can burrow with rapidity, and can progress below the surface of sand with good efficiency, it will not normally seek to escape by burrowing, as do some other sand-dwellers, *Chilomeniscus* and *Anniella* for example. Placed in a box containing yielding sand it will spend much time crawling about on the surface searching for a chance to escape up the sides. In so doing, the anterior part of the body is raised well above the ground, so that only the posterior part is used for progression.

These observations of locomotion are equally applicable to *occipitalis* and *palarostris*. Although the latter has a blunter snout, it was observed on several occasions to enter sand quite rapidly and with little apparent effort.

Fossorial Activity.—Mosauer (1932, p. 77) first expressed the opinion that *Chionactis* travels only short distances on the surface, spending more of its time in the sand, where it crawls below the surface using a horizontal undulatory motion. But later (1933, p. 15; 1935, p. 20; 1936, p. 13) he decided that most, if not all of its night cruising is done on the surface, as it travels from one shrub-covered hillock to another. He doubted whether more than 100 feet was usually covered in one night. Mosauer's observations were based on tracks, and it is now known that *Chionactis* tracks cannot always be distinguished from those of other small desert snakes, as has been verified by Cowles (1941, p. 139). However, there is no reason to doubt Mosauer's conclusion that although *Chionactis* burrows quite readily and efficiently in sand, often spending the day thus buried, and though it progresses through sand with ease, it does not normally move for as great distances below the sand surface as do some sand-dwellers among the snakes.

In seeking refuge in the daytime, *Chionactis* does not always burrow in sand; it may take to mammal holes or hide under debris. I have found shovel-noses under stones, boards, and cardboard signs. Wade Fox, Jr., advised me that he had dug two specimens from holes, an *occipitalis* near Garnet, Riverside County, and an *annulata* in the Sand Hills, 14 miles west of Winterhaven, Imperial County. He found them by following the tracks that showed in which burrows the snakes had taken refuge. He judged the holes to have been made by scorpions.

These little snakes are frequently plowed out during road work or land-leveling for agriculture, but in such cases it is usually impossible to tell whether they had been down holes or buried in sand. Cowles (1941, p. 134), in the experience previously mentioned, reported that the 41 specimens of *Chionactis* were taken during 4½ days of brushing or rough grading of hummocks and small sand dunes with a tractor and scraper near Edom, Riverside County. This was in the early spring during the season of hibernation. The depths of the few specimens whose location could be determined varied from 2 feet to only an inch. Most of them were within a foot of the surface.

More recently Cowles has stated (letter of March 3, 1949): "As I suggested in one of my earlier papers, we discovered that *Chionctis* inhabits the warm, near-surface layers of the sand during the daytime, and thus secures ideal temperatures in total darkness. The snakes were found 2 or 3 inches below the ground surface, at temperatures varying from 26° to 28° C. (78.8° to 82.4° F.)." In another letter, Dr. Cowles remarks: "We caught *Chionactis* through a new technique of raking down the warm surface of the sand early in the Spring and I think that, properly applied, it might be a profitable method for collecting spade-nosed snakes." This suggests a sort of subterranean basking that is even more efficient and certainly safer than surface basking, when air temperatures are below the optimum and a reptile seeks the benefits of direct solar radiation. For, by this habit there is no loss of heat through convection—particularly important if there be a breeze—and the decline in temperature from the surface downward permits the choice of whatever depth will produce the most comfortable body temperature.

The methods of burrowing used by *Chionactis* may be readily observed with captive specimens, especially when kept in a box with one glass side. First, it will be noted that the snakes do not immediately seek refuge in the sand; on the contrary, they may crawl about on the surface for an hour or more before going below. They cannot be frightened into the sand. However, if they once go into the sand, and then are disturbed by a probe jabbed near them, they will move elsewhere in the sand without emerging. If picked up and the fore part of the body is stuck into the sand, the snake will usually go in. Once in the sand, a snake will often remain for hours at a time. When crawling below the surface, *Chionactis* usually progresses at a depth of an inch or so; faint movements of the sand surface can often be seen, but the snake is too deep to leave a surface track as does *Chilomeniscus*, which often crawls just below the surface. Shovel-noses progress in the sand by an undulatory motion and seemingly with little more effort than when on the surface; the polished scales are no doubt a favorable factor in this type of locomotion, as pointed out by Mosauer (1935, p. 20). *Chionactis* can back up in sand without difficulty. If a snake has been buried in the sand and is dragged to the surface, it will usually crawl about the cage without going into the sand again. When watching the snakes through a glass sidewall of a cage, some will be seen to descend to a depth exceeding 6 inches.

Food.—I have records of scorpion, centipede, and insect remains in *Chionactis.* Richard Schwenkmeyer has advised me that, in his studies of the stomach contents of southwestern reptiles, he found the following in *annulata*: *Uta* (egg containing an embryo), Blattaria (Phyllodromidae), spiders, abdominal plates of Coleoptera, Coleoptera larvae, Hymenoptera (Formicidae), Lepidoptera pupa, unidentifiable insect pupa. Cowles (1941, p. 134) reported one that contained some form of Blattidae; in 1949 (p. 212) he stated that the diet comprises insects and other arthropods, including fairly large and powerful scorpions. Captive specimens ate centipedes. David Regnery found that shovel-noses would eat termites offered on the end of a stick. The type specimen of *palarostris* contained a large spider.

Charles E. Shaw has devised a successful method of keeping *Chionactis* alive in captivity. He reports:

> "At the Reptile House of the San Diego Zoo specimens of *Chionactis occipitalis annulata* are kept in a glass terrarium measuring 20 in. × 10½ in. × 10 in. A glass partition 7 in. high is inserted transversely to separate one-third of the tank from the remainder. About 6 in. of sand are placed in this smaller compartment, while the rest of the tank is filled with 6 in. of yellow cornmeal well stocked with mealworms (*Tenebrio molitor*). *Chionactis* will eat the larvae and pupae of *Tenebrio.* The snakes are liberated on the sand and are provided with cover in the form of a small board under which they may conceal themselves without burrowing, if they prefer. Most of the time, however, they remain beneath the surface of the sand. The snakes have no difficulty crossing the one inch of glass partition which extends above the surface of the sand and cornmeal and serves primarily to discourage the mealworms from crossing over into the sand. Kept in the manner described, 2 adults of *Chionactis o. annulata* are still in good condition after 36 months in captivity."*

It is somewhat difficult to cause *Chionactis* to drink; however, it will do so if the head be held under water.

Reproduction.—I have examined 7 females that contained enlarged eggs, the number varying from 2 to 4, average 3.1. The smallest gravid *annulata* measured 289 mm. (11⅜ in.). The largest eggs measured 14 × 4½ and 13 × 5 mm. Cowles (1941, p. 134) reported one *occipitalis* containing 6 and another 9 ova. A specimen of *organica* contained 4 eggs.†

On May 27, 1939, a live male *C. o. occipitalis* was found hovering over a DOR female as if endeavoring to mate. This was at 8:41 P.M., air temperature 24° C. (75.2° F.).

Defense.—When annoyed *Chionactis* stands its ground and lunges forward violently and repeatedly from a striking coil. Sometimes the mouth is

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*One of these was still alive at 42 months.

†I find no evidence of embryos as suggested by Hensley, 1950, p. 283. *Chionactis* is probably oviparous.

opened at the end of the strike, but often not. In daylight it can hit one's finger with considerable accuracy and will even follow it about, striking continuously. Presumably the strike might intimidate a small creature; the teeth are much too small to puncture the skin of one's hand. As do many other snakes, *Chionactis* sometimes voids excrement when handled.

Little is known concerning the senses of *Chionactis*. It can see well in bright light, since it will strike at a finger with fair accuracy, and will dodge hand movements. It can see such motions at a distance of a foot in dim light.

Enemies.—Presumably *Chionactis* is preyed upon by *Lampropeltis*, *Salvadora*, *Rhinocheilus*, and *Arizona*, which feed on snakes, among other kinds of food. Owls and coyotes may be assumed to eat them. One was killed by a tame cat at La Puerta. I have only one definite record of a shovel-nose becoming the prey of a wild creature; at Palm Springs Station, Riverside County, a red racer (*Masticophis flagellum piceus*) was found that had swallowed an adult *Chionactis o. occipitalis*. It is not known whether this diurnal snake had caught an early shovel-nose above ground, or had found it down a hole.

A KEY TO THE GENUS *Chionactis*

1a	Snout convex above; dark bands on the body usually fewer than 21; bands on the body plus unmarked anterior band positions on the ventrum usually fewer than 23* *(for subspecies continue on to 2)*	*C. palarostris*
1b	Snout flat-topped; dark bands on the body usually 21 or more; bands on the body plus unmarked anterior band positions on the ventrum usually 23 or more* *(for subspecies continue on to 3)*	*C. occipitalis*
2a	Black bands on the body fewer than 12, and less than half as wide (middorsally) as the interspaces; more than 8 scales (end-to-end) between the parietals and the anterior edge of the first black body band West-central Sonora, Mexico	*C. palarostris palarostris*
2b	Black bands on the body more than 11, and more than half as wide (middorsally) as the interspaces; fewer than 9 scales (end-to-end) between the parietals and the anterior edge of the first black body band Southwestern Pima County, Arizona	*C. palarostris organica*

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*The first criterion will place most specimens. If the dark body bands number 18 to 22, however, the second criterion should be used, as it will result in a higher accuracy of determination. With either criterion, tail bands are not included.

3a	Definite black or brown secondary bands in the interspaces between the primary bands, usually with scale centers maculated, and often crossing the dorsum	4
3b	Without black or brown secondary bands in the interspaces between the primary bands, such dark marks as there are being usually restricted to scale edges and rarely evident dorsally	5
4a	Primary bands black or very dark-brown; ventrals usually fewer than 152 in males and fewer than 160 in females. Southwest Maricopa, and Pima and Pinal counties, Arizona	*C. occipitalis klauberi*
4b	Primary bands brown; ventrals usually 152 or more in males and 160 or more in females Tonopah–Indian Springs area of Nevada, and southwesterly into the Death Valley region of California.	*C. occipitalis talpina*
5a	Dark bands on the body plus unmarked anterior band positions on the ventrum usually fewer than 45; bands usually black or almost black Eastern San Diego, and western and southern Imperial counties, California; Yuma, western and southern Maricopa, and northwestern Pima counties, Arizona; and northeastern Baja California and northwestern Sonora, Mexico.	*C. occipitalis annulata*
5b	Dark bands on the body plus unmarked anterior band positions on the ventrum usually 45 or more; bands brown The Mojave Desert, including southwestern Inyo, eastern Kern, northeastern Los Angeles, and San Bernardino counties in California; also desert part of Riverside County and northeastern Imperial County, California; southern Clark County, Nevada; and southwestern Mohave County, Arizona.	*C. occipitalis occipitalis*

SUMMARY

This is a survey of the shovel-nosed snakes of the genus *Chionactis* (Colubridae), small nocturnal snakes inhabiting sandy areas in the deserts of the southwestern United States and northwestern Mexico. There are 2 species, *C. occipitalis* and *C. palarostris*; *C. occipitalis* is, in turn, divided into 4 subspecies: *occipitalis*, *annulata*, *klauberi*, and *talpina*. The latter, occurring in southern Nevada and the Death Valley region of California, is newly described. *C. palarostris* comprises 2 subspecies, *palarostris* and *organica*. The latter is a new subspecies found in the Organ Pipe Cactus National Monument of southern Arizona. Relationships are discussed and life-history notes given.

ACKNOWLEDGMENTS

To the following individuals and institutions that have granted me the courtesy of examining specimens contained in their collections, I wish to extend my thanks: Mr. Charles M. Bogert, American Museum of Natural History; the late Dr. Charles T. Vorhies, University of Arizona; Mr. Joseph R. Slevin, California Academy of Sciences; Mr. M. Graham Netting, Carnegie Museum; Dr. Howard K. Gloyd, Chicago Academy of Sciences; Mr. Karl P. Schmidt and Mr. Clifford H. Pope, Chicago Natural History Museum; Dr. A. H. Wright, Mrs. Kay Kapp, and Mr. M. Max Hensley, Cornell University; Dr. Hobart M. Smith and Mr. W. L. Burger, University of Illinois; Mr. Victor H. Housholder of Phoenix, Ariz.; Mr. M. Sullivan, Lake Mead Recreational Area; Dr. Howard R. Hill, Los Angeles County Museum of History, Science and Art; Dr. Edward H. Taylor, University of Kansas; Dr. Norman Hartweg, University of Michigan; Mr. Arthur Loveridge, Museum of Comparative Zoology, Harvard University; Dr. Robert C. Stebbins, Museum of Vertebrate Zoology, University of California; Dr. Raymond B. Cowles, Mr. Charles H. Lowe, Jr., Mr. Kenneth S. Norris, and Mr. Richard G. Zweifel, University of California, Los Angeles; Dr. Emmett R. Dunn, Academy of Natural Sciences of Philadelphia; Mr. William R. Supernaugh, Organ Pipe Cactus National Monument; Mr. Wade Fox, Jr., University of Southern California; Dr. George S. Myers and Miss Margaret Storey, Natural History Museum, Stanford University; Dr. Waldo L. Schmitt and Dr. Doris M. Cochran, United States National Museum; and Mr. William H. Woodin III, of Tucson, Arizona.

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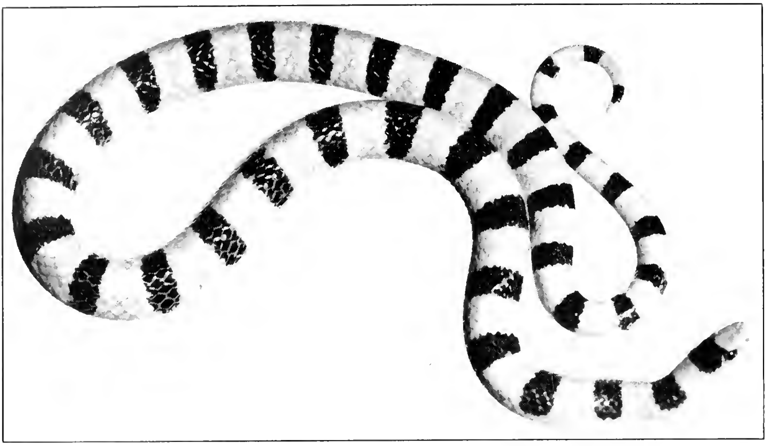

Fig. 1. *Chionactis occipitalis occipitalis* Mojave Desert Shovel-nosed Snake Adult male from the Alvord Mountains, San Bernardino County, California.

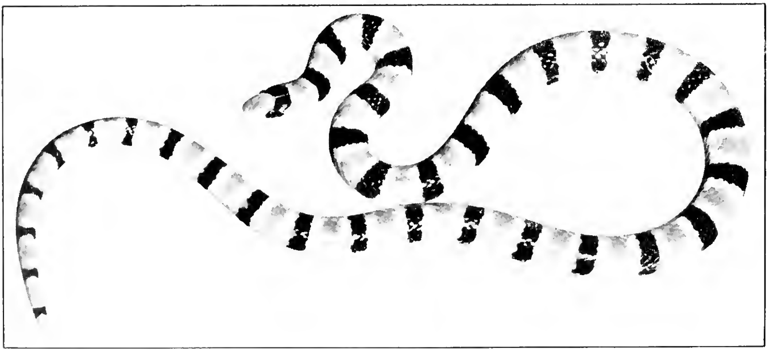

Fig. 2. *Chionactis occipitalis annulata* Colorado Desert Shovel-nosed Snake Adult male from 2 miles south of Clark Lake, Borrego Valley, San Diego County, California.

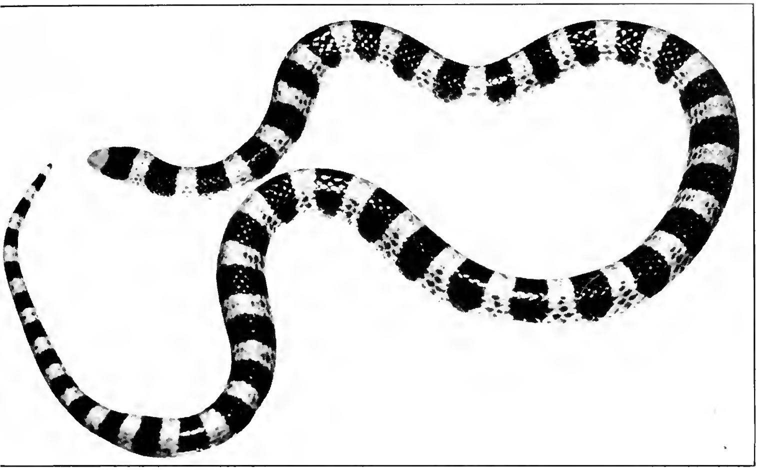

Fig. 1. *Chionactis occipitalis talpina* Northern Shovel-nosed Snake
Adult female from 10 miles north of Goldfield, Esmeralda County, Nevada.

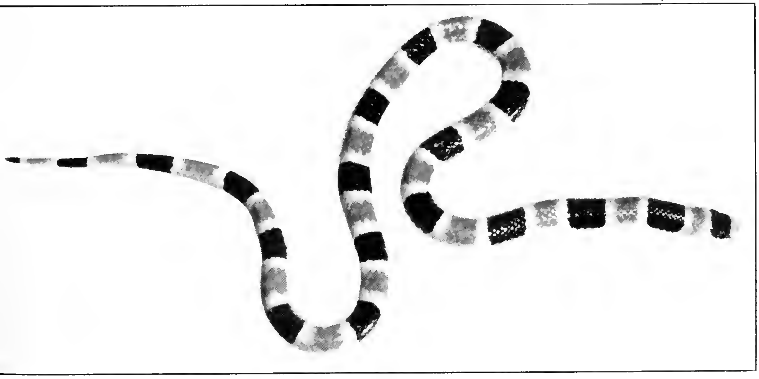

Fig. 2. *Chionactis palarostris organica* Organ Pipe Shovel-nosed Snake
Adult male from 9 miles north of U.S.–Mexican Boundary on Ajo–Sonoyta road, Pima County, Arizona (type specimen).

TRANSACTIONS

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Figs. 1-2, Maps 3-6, Tables 1-3

THE KANGAROO RATS (DIPODOMYS) OF BAJA CALIFORNIA, MEXICO

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TABLE OF CONTENTS

TABLE OF CONTENTS *(Continued)*

THE KANGAROO RATS (DIPODOMYS) OF BAJA CALIFORNIA, MEXICO

BY

Laurence M. Huey
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During the past two decades representative collections of kangaroo rats (*Dipodomys*) from many localities in Baja California have been made by collectors from the San Diego Society of Natural History. The localities range from the international boundary on the north to Cape San Lucas on the south.

There are few sections of Baja California wherein some members of this genus have not now been found. The writer has seen their tracks obliterated by the tides from the beach sands at San Felipe on the Gulf of California; he has dug out living specimens from their shallow burrows beneath driftwood on the sandy beaches within reach of the highest tides at Rosarita on the Pacific side near Tijuana; and his traps, set on the higher slopes of the Sierra Juaréz and Sierra San Pedro Mártir, have captured representatives of this genus from among the pine trees. Kangaroo rats are to be found along the international boundary from the Colorado River to the Pacific Ocean in the north, and in an irregular checkerboard pattern over the length of the peninsula to Cape San Lucas in the south. Two islands, one on either side of the peninsula, are known to be inhabited by kangaroo rats. The island on the western side, Santa Margarita, forms part of the seaward boundary of Magdalena Bay. The other one, San José Island, is located a few minutes of latitude northward, but on the Gulf side. Its shores are washed by the tepid tropical waters of the Gulf. The only areas on the peninsula that seem to be avoided by kangaroo rats are the rock-bound or lava-strewn mesas, like those over the length of the Sierra de la Giganta, sterile alkali plains, and the higher jungle-covered reaches of the Sierra de la Victoria in the southern Cape District. Careful work in the Cape sierra may still reveal remote pockets where these mammals occur.

Although the collections are not as yet complete, sufficient material has been accumulated to reveal the general systematic and distributional picture. The facts determined appear especially significant when considered in the light of the study that has been made of similar collections from California (Grinnell, Univ. Calif. Pub. Zool., 24: 1922).

Of the six groups of this genus listed by Grinnell from California, four have been found in Baja California, and a new group, *peninsularis,* is segregated from the *agilis* group. This newly proposed group is based on the form described by Merrian as *Perodipus simulans peninsularis* (Proc. Biol. Soc. Wash., 20: 1907). With but little material on which to reach his conclusion, Grinnell (Journ. Mam., 2: 1921) referred this on the form described by Merriam as *Perodipus simulans peninsularis* Today the writer, with magnificient collections at hand, believes that the elevation of *peninsularis* to specific rank, as the type of a new group, markedly simplifies the classification.

The five groups thus constituted occur in Baja California in the following order of probable population abundance: *merriami, agilis, peninsularis, deserti,* and *heermanni.* Future collections may well change this order and reveal other races as yet unknown. Setzer (Univ. Kans. Pub. Mus. Nat. Hist., 1 (23): 1949) has recently proposed some radical changes in Grinnell's classification. Until the proper material for the newer technique has been accumulated and studied, the writer believes that his purpose will be best served by adhering to Grinnell's natural groups.

When the assembled collections are examined, the range pattern of each of these groups proves to be of great interest. This is especially true of the two largest groups. The following account deals separately with each group.

Merriami Group

RANGE

The *Dipodomys merriami* group is most widespread in Baja California (Fig. 1). It extends from along the desert section of the international boundary south to the southernmost parts of the peninsula and occurs on at least two of the nearby coastal islands. However, high elevations are unsuitable; seldom is it found in areas above 4500′ altitude. Although it is essentially a desert mammal, *Dipodomys merriami* ranges onto the more humid Pacific slope west of the high coastal mountains in two places, one in southern California, and the other in northern Baja California. In California, San Bernardino Valley, with its contiguous desert-like areas, is the only area of such range expansion. A parallel extension is to be found in Baja California, where, by way of the San Matias Pass, the group invaded the semi-arid El Valle de la Trinidad and thence continued northwestward into the more arid sections of El Valle de San Rafael, which lies against the western base of the Sierra Juaréz.

Below the southern extent of the higher Sierra San Pedro Mártir, which terminates the long chain of lofty coastal mountains, the range of *Dipodomys merriami* reaches the Pacific side of the peninsula. From this section its range extends northward in a wedge along the coast to a point north of San Quintin. The coastal plain west of Santo Domingo Mission is, to date, the northermost coastwise record station. Southward, *Dipodomys merriami* occurs over the plains and valleys along the Pacific coast to about 24° latitude in the Cape district.

Paradoxically, below latitude 29° along the Gulf coast to La Paz, the positions of the desert and the more humid areas are reversed. In this central Baja California region the main stem of *Dipodomys* population is largely on the Pacific slope. Along the middle part of the Gulf side of the peninsula, the inhabitable areas are interrupted by rocky precipitous terrains where the higher mountains descend almost abruptly to the waters of the Gulf, leaving only occasional sections along the coastal shelf that are suitable for occupation by *Dipodomys merriami*. Three such areas are now known. The most extensive one extends from Bahía Los Ángeles in latitude 29° southward to Barril near latitude 28°. The topography of the northern region, between Bahía Los Ángeles and San Felipe, is, as yet, little known, and sufficient specimens from that section have not been available for this study. From Bahía Los Ángeles and proximity a good series of *Dipodomys merriami* is at hand, as are also specimens from Valle de Agua Amarga, a mid-way inland locality along the gently sloping pass that connects with the Pacific watershed.

Specimens from the Bahía Los Ángeles, Barril and San Francisquito area represent an unnamed race.

Farther south, near Santa Rosalía, is to be found another of these areas. Here, two occupied localities are known: one, a hanging valley, El Valle de Yaqui, lies a few miles west of the town, and the other, a much larger area, El Llano de San Bruno, is south of it. Near the southern end of Concepción Bay is the third region. Two inhabited localities are known in this region of open gravelly terrain, one, near the southern end of the bay and the other at Canipolé, ten miles farther south. The two latter localities appear to be isolated, but future exploration may reveal connecting channels. The systematic status of these populations is dealt with on page 218.

Westward from this central section of the Gulf coast rise the long chain of rugged lava mountains, La Sierra de la Giganta. Owing to the rough character of this area, transportation facilities, other than by pack animal, are almost nil. As a result, this section is but little known. However, when any near approach can be made, the general aspect of the terrain would seem to offer little that is suitable for habitation by this species.

Near latitude 24° the *merriami* chain again leaves the Pacific side and is found at La Paz and thence at different localities of low elevation along the Gulf side of the peninsula until, at the extremity, the range of the species extends westward again to the westernmost point on the tip, Cape San Lucas. There seems to be no record of this or of any other *Dipodomys* along the Pacific slope section of the peninsula west of the Sierra Victoria.

HABITAT

Soil conditions in the western desert regions below 4500′ altitude seem to be one of the main factors controlling the range of *Dipodomys merriami.*

It is commonly known to mammalogists who are acquainted with the habits of this species that its members are not good "diggers", that is, they cannot burrow into very hard soil. Some types of stone-bearing soil are tolerated, especially desert pavement, which is so common over the arid sections of the southwest. This terrain is most abundant over plains or llanos where the wind has blown the finer soil away, leaving a rock-bound surface that guards the arenaceous sub-surface soil. This is capital habitat for *Dipodomys merriami;* in fact, this species is the most abundant mammal in such regions.

However, the areas that support the densest populations are those where the soil is loose and sandy, and in which both annual and perennial growths exist. In these places burrows are easily dug, food is adequate, and protection from enemies is supplied.

CLIMATIC INFLUENCES

The highly diversified climate of the long narrow peninsula of Baja California is reflected in the divergent development of this rather homogeneous species.

The climatic differences, however slight in some places, are in no small part attributable to the influences exerted by the adjoining coastal waters. Per unit of land area Baja California has a greater proportion of coast line than most like-sections of the globe. The bordering waters differ considerably in temperature. The eastern coast line is washed by semi-tropical seas and the general aridity of this part of the peninsula is outstanding. Off the western coast a cool current sweeps southward from the more northerly climes to meet a north flowing warm current in the general region of Point Eugenio and much of the coastline is greatly cooled by upwelling.

The ocean influences along this western coastline are shown in the littoral and near-shore ocean flora: the mangroves of the tropics are found where the warmer waters lie, whereas the cool northern waters harbor fields of kelp. Both end abruptly where the ocean temperatures change most abruptly. The land flora of the peninsula likewise is affected, though the ranges are not so sharply terminated. The diverting influences of mountain chains on the atmospheric conditions created by the warmer or cooler ocean waters cause the areas of transition to be wider.

In the northern section of the peninsula the higher mountains separate the influences of the Gulf and Pacific waters, resulting in the two greatest extremes of color development in the entire *merriami* group.

The darkest race, *Dipodomys merriami quintinensis* (newly described herein), lives in the relatively cool and humid San Quintín region, whereas directly eastward on the torrid, arid desert east of the Sierra San Pedro Mártir, occurs the most pallid race of the group, *Dipodomys merriami arenivagus*.

Farther south, where the elevation of the backbone of the peninsula decreases, the climatic conditions are more evenly balanced by the combination of the influences of the Gulf and Pacific waters. This results in a more widely spread flora and fauna. Here the lighter

Dipodomys merges with the darker form of the cooler humid coastal section.

In the Vizcaíno desert region the lighter strains of *Dipodomys merriami* reach the Pacific side to replace the darker races of the northerly coastal section.

To illustrate these points and other interesting facts brought to light by this study, I assembled a series of topotypical specimens representing the different races from within the geographical limits of this report, along with two from north of the boundary in California. Commencing in the north with a series of topotypical specimens of *D. m. parvus* from the San Bernardino Valley region on the Pacific slope, and with a like series of *D. m. simiolus* from the northwestern Colorado desert section on the eastern side of the Coast Range of Southern California, representative series of specimens from all the type localities to the end of the peninsula of Baja California were arranged in their geographical position.

VARIATION

The kangaroo rats of the *merriami* group form three closely aligned color chains, which conform loosely to the geographical features of the regions under discussion (Fig. 1). The races occupying the Pacific drainage slope, where the aridity is ameliorated by the cool coastal waters, are darkest and have a general dorsal color tone of "*Avellaneous*" (Ridgway, Color Standards and Color Nomenclature, 1912).

Palest in dorsal coloration are the kangaroo rats in the region that extends from the Colorado desert area south along the eastern side of the high Coast Range, and thence, at a mid-peninsula point past the southern extent of the Sierra San Pedro Mártir, veers diagonally southwestward across the peninsula to the vicinity of Point Eugenio on the Pacific coast. This general region includes most of the arid parts of the Southern California and Baja California deserts, and conforms loosely to the area that is influenced largely by warm ocean waters. The dorsal color tone of the races occupying this arid belt is "*Pale Ochraceous Buff*". The races living in the Cape district present yet another dorsal tone of coloration, "*Pinkish Buff*".

Along each chain the specimens from the successive type localities give the impression that each race is a step in the color gradient. The

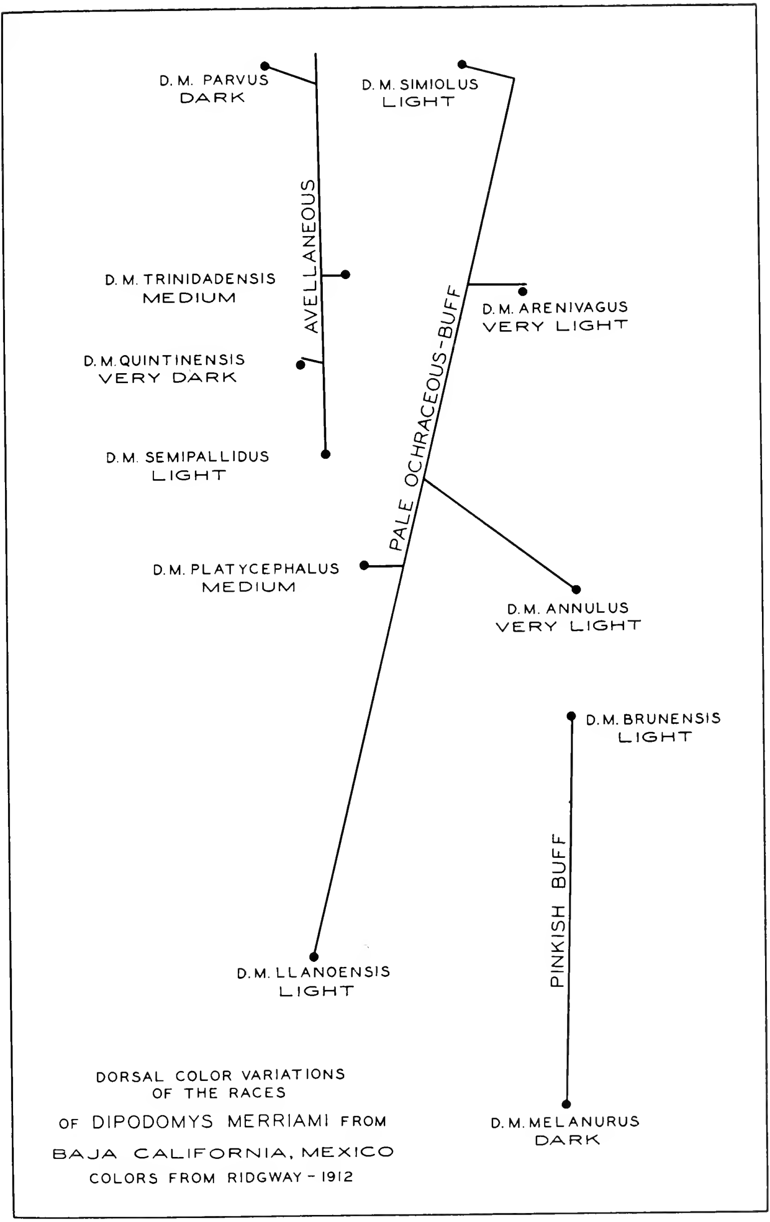

D. M. PARVUS
DARK
D. M. SIMIOLUS
LIGHT
AVELLANEOUS
D. M. TRINIDADENSIS
MEDIUM
D. M. QUINTINENSIS
VERY DARK
D. M. SEMIPALLIDUS
LIGHT
PALE OCHRACEOUS-BUFF
D. M. ARENIVAGUS
VERY LIGHT
D. M. PLATYCEPHALUS
MEDIUM
D. M. ANNULUS
VERY LIGHT
D. M. BRUNENSIS
LIGHT
PINKISH BUFF
D. M. LLANOENSIS
LIGHT
D. M. MELANURUS
DARK
DORSAL COLOR VARIATIONS
OF THE RACES
OF DIPODOMYS MERRIAMI FROM
BAJA CALIFORNIA, MEXICO
COLORS FROM RIDGWAY - 1912

Fig. 1

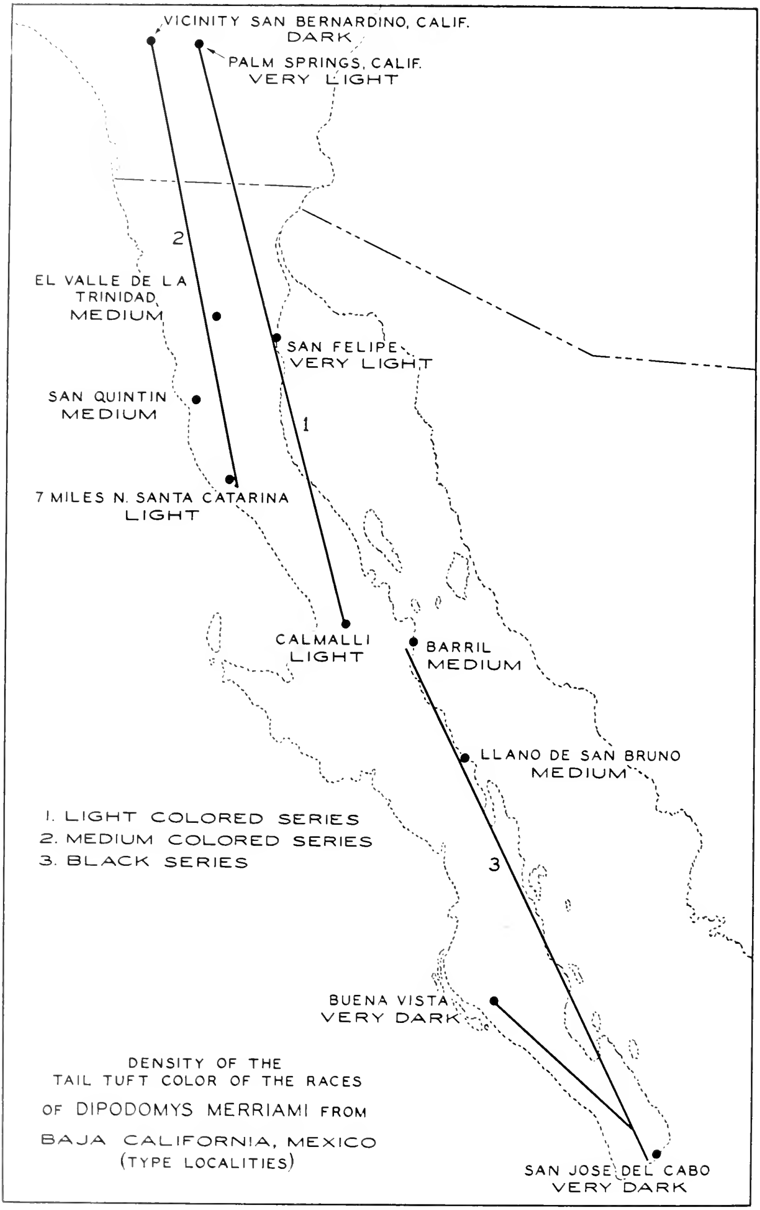

VICINITY SAN BERNARDINO, CALIF.
DARK
PALM SPRINGS, CALIF.
VERY LIGHT
2
EL VALLE DE LA TRINIDAD
MEDIUM
SAN FELIPE
VERY LIGHT
SAN QUINTIN
MEDIUM
1
7 MILES N. SANTA CATARINA
LIGHT
CALMALLI
LIGHT
BARRIL
MEDIUM
LLANO DE SAN BRUNO
MEDIUM
1. LIGHT COLORED SERIES
2. MEDIUM COLORED SERIES
3. BLACK SERIES
3
BUENA VISTA
VERY DARK
DENSITY OF THE TAIL TUFT COLOR OF THE RACES OF DIPODOMYS MERRIAMI FROM BAJA CALIFORNIA, MEXICO (TYPE LOCALITIES)
SAN JOSE DEL CABO
VERY DARK

Fig. 2

true situation is very different, for each race blends into the other, with broad overlap. Only from the vicinity of the key points along the chain can the clear color cast for the races be found.

Other characters than dorsal coloration help to define the races. Some have well-defined cranial characters. This is particularly true of the auditory bullae. In some races the bullae are bulbously inflated (Table I). In several the maxillary arch has developed into wide proportions. Other cranial characters, although minute or of only average significance, with much overlap, in the aggregate help to set the races apart and help to define their ranges with greater clarity.

Another character of importance shown by the assembled series is the color of the tail-tufts (Fig. 2) when the races are placed in the same geographical and type-locality sequence as was done for dorsal coloration. The color pattern of the tail tufts, like the dorsal color, presents three chains. The gradients do not parallel those shown by the dorsal coloration in one outstanding feature; only two colors are involved, black and white. The varying density of these two colors covers the entire range of variation of all the races. The variation shown by the tufts follows definite courses. As is to be expected, the specimens from the northern coastal section are darker than those from the more arid deserts, but, paradoxically, the specimens from the central Gulf coast and from the Cape districts have the darkest tails of all. There seems to be no logical explanation why the races occupying the central east-coastal section southward to the extreme peninsular position should have developed such an extremely black tail tuft, with a moderately light dorsal color, while the north-coastal races have developed the darkest pelage color, with less contrasting tail tufts. Just what relationships this unique transposition of color intensity indicates is not answerable.

In his "Geographical Study of Kangaroo Rats of California", (Univ. Calif. Pub. Zool., Vol. 24, 1922, pp. 12-18) Grinnell advanced the thought, with rather convincing evidence, that cloudiness is partly responsible for color intensity. Regarding pelage colors, this relationship would seem to hold as true in Baja California as Grinnell demonstrated it did in California. The dorsal coloration of the specimens at hand, together with a very vague knowledge of weather conditions in Baja California, would seem to substantiate this relationship, but the color of the tail tufts, particularly in the Cape San Lucas series, would seem to open the "cloudiness theory" to some question. Presumably some other important factor, as yet unappreciated, is involved.

In measurements as well as in coloration there is divergent development in the *merriami* group. Two measurements, total length of the specimen, made in the field at the time of preparation, and the greatest length of the cleaned skull, measured with visible dial calipers registering to 0.1 mm., amply confirm the variable development that has alreadv been shown in the color comparisons.

Dipodomys merriami is a composite of many similar races. There are no extremes of size, dwarfs or giants, in the assembly. The adherence of the species to certain circumscribed range conditions seems to have prohibited such development, yet there is a plasticity in the species that, as here demonstrated, responds, within limits, to certain environments. Baja California seems to provide, by far, more varied influences on the species for racial development than is done by any other similar area in the extremely large section of southwestern North America occupied by the species.

The changes are gradual, that is, there are no skeletal or color characters in different racial populations that change sharply (Fig. 2, Map 3). The transition from lighter coloration to darker or from smaller size to larger is always a matter of degree. However, in the three chains of relationship there are boundable areas wherein certain character combinations are definable and constant. In such areas, even though the characters are minute and even though the race is restricted in its range, designation of this population by name seems justifiable.

MATERIAL AND ACKNOWLEDGEMENTS

In preparing this report, 753 specimens of *Dipodomys merriami* from 83 localities in Baja California and 56 specimens from 7 localities in California have been examined. Of these 809 specimens 117 were borrowed from outside sources and 692 are in the Museums' collection. Fifty-one specimens from the Huey Collection were used to augment the Museum's series from localities in the north-central section of the peninsula. A much larger number of Californian specimens were available in the Museum's collection, but were not used. They were from many intermediate localities between the two California type localities and the international boundary. This is particularly true of the desert race *D. m. simiolus,* but no purpose would have been accomplished by their inclusion.

Through the generosity of the late Major E. A. Goldman of the Biological Survey, now known as the United States Fish and Wildlife Service, 39 specimens from 12 localities, including the type of *Dipodomys platycephalus,* taken on the famous trip made by Nelson and Goldman over the full length of the peninsula in 1905-1906, were loaned to the writer. Twenty-two specimens from two critical localities were loaned by the Museum of Vertebrate Zoology of the University of California at Berkeley by Dr. Alden H. Miller, and 3 specimens and 1 skull without skin, from Margarita Island, and 2 specimens from Santa Teresa Bay on the Gulf coast, were borrowed from the Dickey Collection at the University of California at Los Angeles through the kindness of the late Mr. A. J. van Rossem. To these institutions and the personnel, the writer wishes to express his gratitude.

The writer also wishes to acknowledge his indebtedness to the several departments and officials of the Mexican Government. Without their cordial cooperation in granting permits for collecting in Baja California and the many courtesies given at the international boundary at the different ports of entry, this work would not have been possible.

Lastly, the writer wishes to express his gratitude to Dr. Carl L. Hubbs for his interest in this paper and the many helpful suggestions in the preparation of this manuscript.

The present study has demonstrated the presence of two species and ten races of the *Dipodomys merriami* group within the confines of Baja California. Five races are herein described as new.

That so many forms should be found in this limited area seems at first incredible. In fact, more races of *Dipodomys merriami* live in Baja California than in all the rest of the vast range of the species. Without question such variety is due in no small measure to three factors—geographical, meteorological, and sequestrational. No better region than Baja California can be found to illustrate the effects of these factors on the differentiation of a plastic species.

Dipodomys merriami parvus Rhoads

SAN BERNARDINO KANGAROO RAT

Original Description.—Dipodomys parvus Rhoads, Am. Nat., Vol. 28, p. 70, January, 1894.

Type locality.—"San Bernardino, California" (= Reche Canyon, 4 miles southeast of Colton), California. The type and the small series of paratypes were taken by R. B. Herron at his old ranch in this canyon.

Distribution.—This race is limited to a few localities west of the Coast Range in San Bernardino and Riverside counties, California. It is not found in Baja California, but reference to this form in this account makes its inclusion desirable.

Specimens examined.—California: Herron's Ranch, San Bernardino Valley = Reche Canyon, 4 miles southeast of Colton, San Bernardino County (type locality), 4; 4 miles southwest of Perris, Riverside County, 6; Ethenac, Riverside County, 2; Aguanga, Riverside County, 19.

Dipodomys merriami simiolus Rhoads

ALLIED KANGAROO RAT

Original description.—Dipodomys simiolus Rhoads, Proc. Acad. Nat. Sci. Philadelphia, p. 410, January 27, 1894.

Type locality.—Agua Caliente (= Palm Springs), Riverside County, California.

Distribution.—Over the Colorado Desert in California east of the Coast Range at least to the Colorado River. In Baja California this race occupies a fringe along the international boundary from Jacumba Valley eastward to the Colorado River. Cultivated land in the desert section has restricted its range somewhat, but specimens from localities barely north of the boundary in California as at Pilot Knob, near the Colorado River in eastern Imperial County, Carrizo Creek and Jacumba Valley in eastern San Diego County, substantiate this statement. A short distance below the boundary this subspecies intergrades with *D. m. arenivagus*, particularly over the western desert section.

Specimens examined.—California: Palm Springs, Riverside County (type locality), 24 (10 from Huey Collection). Baja California: few yards south of international boundary near Jacumba, California, 1; Signal Mountain, 2; southeast base Signal Mountain, 1.

Dipodomys merriami trinidadensis subsp. nov.

TRINIDAD KANGAROO RAT

Type.—From Aguajito Spring, El Valle de la Trinidad, Baja California, Mexico; No. 11531, San Diego Society of Natural History; adult male; collected by Laurence M. Huey, March 13, 1936.

Characters.—Compared with *Dipodomys merriami arenivagus, D. m. trinidadensis* is darker in dorsal color, more closely resembling *D. m. parvus* and showing distinctly the effect on coloration of the Pacific slope environmental conditions (Fig. 2, page 00). The tail of *trinidadensis* is heavily striped above and below, in fact a greater area is covered by the darker dorsal and ventral stripes than by the white side stripes. This is in sharp contrast to the relative area covered by the ventral and dorsal stripes on the tail of *arenivagus*, in some specimens of which the ventral stripe is almost lacking. *D. m. trinidadensis* is smaller then *arenivagus* and larger than *parvus*.

Cranially the relationship with its desert relative is apparent, as there is a wide gap in general shape of the skull between *trinidadensis* and *parvus*. This is shown in a limited degree by the measurements (Table I, page 227), though the contour of the skull and the inflation of the bullae do not lend themselves well to measurements. Compared with *arenivagus, trinidadensis* has a more elongated skull, due to the more compressed mastoid bullae. The auditory bullae are larger, more inflated, and less trumpet shaped.

Measurements of type.—Total length, 243; tail, 144; hind foot, 38; ear, 10. Skull: greatest length, 35.5; width across bullae, 22.1; spread of maxillary arches, 19.5; greatest length of nasals, 13.0; width of maxillary arch at middle, 5.0.

Range.—Dipodomys merriami trinidadensis is found in El Vale de la Trinidad and the more arid parts of El Valle de la San Rafael, at least to Sangre de Cristo along the western base of the Sierra Juaréz. In pelage characters, specimens from San Matías Pass show definite intergradation with the desert race, *D. m. arenivagus,* though their size places them with *D. m. trinidadensis.*

Specimens examined.—Baja California: Sangre de Cristo, 31 (6 from Huey Collection); El Valle de la Trinidad (type locality), 29; summit of San Matías Pass, Diablito Spring, 9.

Dipodomys merriami arenivagus Elliot

SAN FELIPE KANGAROO RAT

Original description.—Dipodomys (merriami) arenivagus Elliot, Field Colum. Mus., Publ. 87, Zool. ser., Vol. 3, p. 249, December, 1903.

Type locality.—San Felipe, Baja California, Mexico.

Distribution.—The known range of *Dipodomys merriami arenivagus* covers the arid area east of the Sierra San Pedro Mártir and Sierra Juaréz from San Felipe northward almost to the boundry, excepting the region about the Colorado River delta. Specimens are at hand from the northern locality of Gaskill's Tank, which is located on the eastern base of the Sierra Juaréz within 25 miles of the international boundary. No specimens are available to determine the southern extent of the range of this race. It intergrades with *D. m. simiolus* near the international boundary and with *D. m. trinidadensis* on the desert slopes of San Matías Pass.

Specimens examined.—Baja California: San Felipe (type locality), 69 (11 from Huey Collection); 5 miles north of San Felipe, 43; 30 miles north of San Felipe, 1; 40 miles north of San Felipe, 2 (1 from Huey Collection); De Mara's Well, western side of Laguna Salada (Laguna Maquata on some maps), 12; Gaskill's Tank, east base Sierra Juaréz, 17.

Dipodomys merriami quintinensis subsp. nov.

SAN QUINTÍN KANGAROO RAT

Type.—From 5 miles east of San Quintín, Baja California, Mexico; No. 4205, San Diego Society of Natural History; adult male; collected by Laurence M. Huey, April 9, 1923.

Characters.—The pelage color of *D. m. quintinensis*, when viewed in series, is darker than in *D. m. parvus*, its nearest comparatum. This form furnishes a good demonstration of the need of mass series to arrive at color values in species that show considerable variation in this respect. Compared with *D. m. parvus*, *quintinensis* averages larger; its tail tuft is lighter in density of black, and it has a larger ear. It differs from *trinidadensis* in being darker and in having a slightly smaller skull. Compared with *semipallidus*, its intergrading relative and apparent ancestor to the southward, *quintinensis* is darker, both in pelage color and in tail tuft. In both body size and skull size it is smaller than *semipallidus*. Its differentiation, like that of *trinidadensis*, seems to have involved a reduction in size.

Measurements of type.—Total length, 240; tail, 148; hind foot, 39; ear, 10. Skull: greatest length, 36.4; width across bullae, 22.6; spread of maxillary arches, 20.1; greatest length of nasals, 13.0; width of maxillary arch at middle, 5.1.

Range.—Found over the coastal plain above San Quintín Bay, and as far north as the vicinity of Santo Domingo, which lies some 25 miles north of San Quintín. Santo Domingo is the northernmost point where any member of the *merriami* group closely approaches the Pacific Ocean. All the more northerly races live inland in areas that do not approach the coast. Specimens taken below El Rosario River are all referable to the more southerly race.

Remarks.—This form, like *parvus* and *trinidadensis*, provides another example of parallel development. All three branched separately from the desert stock line, with no known interconnecting links of relationship along the Pacific slope. In other words, they were separate invaders into an as yet completely unoccupied region of different climatic conditions. The effect of the change in climate is recorded in their differentiations. Could meteorological data be taken in the three localities for an adequate period and the differences correlated with the three races, parallel correlations would presumably be indicated between the climatic gradients and character gradients.

Specimens examined.—Baja California: Santo Domingo (lat. 30° N), 11 (3 from Huey Collection); 1 mile south San Ramón, 4 (1 from Huey Collection); north end San Quintín Plain, 7 (1 from Huey Collection); San Quintín, 8 (1 from Huey Collection); Santa María near San Quintín, 1; 5 miles east San Quintín (type locality), 1; mouth of Agua Chiquita Canyon, 2 (1 from Huey Collection); 7 miles southeast of San Quintín, 1; 3 miles east of El Rosario, 2; 8 miles east of El Rosario, 1.

Dipodomys merriami semipallidus Huey

MID-PENINSULA KANGAROO RAT

Original description.—*Dipodomys merriami semipallidus* Huey, Trans San Diego Soc. Nat. Hist., Vol. 5, No. 5, pp. 65-66, July 6, 1927.

Type locality.—7 miles north of Santa Catarina, Baja California, Mexico Lat. 29° 45′ N., Long. 115° 10′ W. Now (1948) known as Rancho La Ramona.

Distribution.—This race is found over a large triangular area having its northern boundary near El Rosario River Canyon on the west and the southernmost foothills of the Sierra San Pedro Mártir on the east, thence tapering southward to an apex on the Pacific Coast somewhere west of Punta Prieta. Specimens from this coastal point are not available. However, specimens are at hand from Punta Prieta and vicinity and northward in an oblique line toward the Gulf. Over this long section all samples show characters blending toward the race *D. m. platycephalus*. The specimens from the section just mentioned suggest that a very broad band of intergradation exists between the two races. The specimens demonstrate, as would be expected, that the range of this darker race extends farther south on the Pacific side and veers from the more arid regions near the Gulf side, with no hard or fast lines of demarcation.

Specimens examined.—Baja California: San Fernando, 1; 5 miles southeast of San Fernando, 1; 3 miles west of El Marmol, 3; Onyx (= El Marmol), 1; San Agustin, 16; 7 miles north of Santa Catarina (type locality), 14; 8 miles north of Santa Catarina, Rancho Ramona, 9; Santa Catarina Landing, 7; 10 miles north of Cataviña, 8; Cataviña, 6 (3 from Huey Collection); 13 miles northwest of Chapala, 2; 2 miles northwest of Chapala, 3; 25 miles north of Punta Prieta, 13 (not typical); Punta Prieta, 16 (6 from Huey Collection); San Andres, 8 (not typical; 2 from Biol. Surv. Collection).

Dipodomys merriami platycephalus Merriam

CALMALLÍ KANGAROO RAT

Original description.—*Dipodomys platycephalus* Merriam, Proc. Biol. Soc. Washington, Vol. 20, p. 76, July 22, 1907.

Type locality.—Calmallí, Baja California, Mexico.

Distribution.—*Dipodomys merriami platycephalus* occupies a larger area of the peninsula than any of the other races. Specimens have been examined from a wide range, mainly on the Pacific slope. The northernmost locality is San Francisquito, N. Lat. 29° 48′ (a Nelson-Goldman locality, not to be confused with San Francisquito Bay, N. Lat. 28° 30′). The range extends from this northeastern locality diagonally southwestward to Santa Rosalía Bay on the Pacific side and over the great Viscaíno Desert section. Specimens of *D. m. platycephalus* have not been examined from localities south of Campo Los Ángeles on the eastern side of the desert nor south of the south entrance of Scammon's Lagoon, though there are no geographic barriers that would interrupt a population until the area near 26° N. lat. is reached.

Specimens examined.—Baja California: San Francisquíto, 3 (from Biol. Surv. Collection); mouth of Calamahúe Canyon, 4 (from Biol. Surv. Collection); Ubai (= Yubay), 30 miles south of Calamahúe, 2 (from Biol. Surv. collection); San Borjas Miscsion, 2; Santa Rosalía Bay, 1; La Lomita María (Miller's Landing), 1; Santo Domingo Landing (N. Lat. 28° 15′), 11 (4 from Biol. Surv. Collection); mainland on south side of Scammon's Lagoon, 19; Mesquital, 3; 5 miles west of El Cañón (10 miles west of Calmallí), 2 (1 from Huey Collection); Calmallí (type locality), 39 (16 from Huey Collection); 4 miles east El Arco, 1; Pozo Altamirano, 1 (from Biol. Surv. Collection); Campo Los Angeles, 3 (1 from Huey Collection); 1 mile east of Rancho Lagunitas, 1; Valle de Agua Amarga, 17 (not typical).

Dipodomys merriami annulus Subsp. nov.

SAN FRANCISQUITO KANGAROO RAT

Type.—From Barril, Gulf of California, Baja California, Mexico, lat. 28° 20′ N., long. 112° 50′ W.; No. 15522, San Diego Society of Natural History; adult female (2 foeti, 35 mm.); collected by Laurence M. Huey, March 22, 1947.

Characters.—Compared with *Dipodomys merriami platycephalus*, *D. m. annulus* is nearly equal in size, but is paler dorsally and has a darker crest on its bicolored tail. In color tone *annulus* resembles *D. m. arenivagus* but is several shades darker. Here the resemblance ends, for *annulus* is larger and has the black tail of the Cape district races. Compared with *Dipodomys merriami brunensis*, *D. m. annulus* is more pallid and has a bicolored tail. In fact, as the name implies, it is the connecting link in the two racial chains, and has dominant characters of both. The skull of *annulus*, compared with that of *platycephalus*, is similar in size, but has more inflated mastoid bullae and several other minor unmeasureable characters, such as very sharply angled zygomatic arches and truncated auditory bullae, which set *annulus* apart from either *platycephalus* or *brunensis*.

Measurements of type.—Total length, 251; tail, 150; hind foot, 35; ear, 10. Skull: greatest length, 37.9; width across bullae, 23.8; spread of maxillary arches, 21.0; greatest length of nasals, 14.1; width of maxillary arches at middle, 5.5.

Range.—In typical form this race lives on the Gulf side of the peninsula, over the coastal plain bordering San Francisquito and Santa Teresa bays and thence northward into a nontypical population at Los Flores, near Los Ángeles Bay.

Remarks.—Oddly enough, the type locality of the darker form *D. m. platycephalus* on the Pacific slope is less than 40 miles distant and almost directly west from Barril. The presence of this pallid race so near, reflects the decidedly arid character of this Gulf coast region, and is further evidence of the differentiating influence of the elements within short distances along the climatically variable peninsula. It is of further interest to note that certain plants typical of the Cape region of the peninsula find their northernmost limit in this Gulf coastal area. Their wedge-shaped ranges taper northward from Cape San Lucas to this apex.

Specimens examined.—Baja California: Barril, at 28° 20′ N .Lat., (type locality), 25; Santa Teresa Bay, 2 (collection of Donald R. Dickey); San Francisquito Bay, 6; 7 miles west of San Francisquito Bay, 19; Los Flores, near Los Ángeles Bay, 37 (not typical).

Dipodomys merriami brunensis Subsp. nov.

SAN BRUNO KANGAROO RAT

Type.—From Llano de San Bruno, Baja California, Mexico: No. 6904, San Diego Society of Natural History; adult male, collected by Laurence M. Huey, March 24, 1928.

Characters.—In size *D. m. brunensis* closely resembles *D. m. platycephalus*, its nearest relative, at least geographically. In dorsal coloration, however, it is darker, in general color tone tending toward *Dipodomys merriami melanurus* of the extreme Cape region. The tail tuft color is blacker than that of *platycephalus*. Both the mastoid and tympanic bullae are larger and more inflated.

Compared with *D. m. melanurus*, *brunensis* has the same color tone, but is lighter and has a lighter colored tail. The difference in dorsal color is attributable to the climatic influences shown in the ranges of the two races. Both *brunensis* and *melanurus* occupy sections of the peninsula that are climatically different than the regions occupied by their relatives to the north and west.

The mastoid bulla of the skull of *D. m. brunensis* is more inflated than that of *D. m. melanurus*, and a number of the specimens have smaller ears. This ear character in *Dipodomys*, especially when the whole genus is considered, is directly related to the inflation or deflation of the mastoid bullae. As a general rule, the species having large inflated mastoids have smaller ears than do those whose mastoid bullae are moderate in size. In *Dipodomys merriami* this character is too variable and has too little racial stability to warrant its use as a major differentiating character between races.

Measurements of type.—Total length, 252; tail, 152; hind foot, 37; ear, 10. Skull: greatest length, 37.6; width across bullae, 23.8; spread of maxillary arches, 19.8; greatest length of nasals, 13.8; width of maxillary arch at middle, 4.8.

Range.—Three areas, all on the Gulf slope of the peninsula and in the Concepción Bay district, are known to be inhabited by this race. The hanging valley, El Valle de Yaqui, located about 8 or 10 miles northwest of Santa Rosalía, is the northernmost point of record, and incidentally, the highest in altitude. The Llano de San Bruno, south of Santa Rosalía, is the largest area inhabited by *brunensis.* The gradually rising region from the south end of Concepción Bay to Canipolé, is the third region populated by this form.

Specimens examined.—Baja California: El Valle de Yaqui, northwest of Santa Rosalía, 14 (6 from Huey Collection); Llano de San Bruno (type locality), 9 (3 from Huey Collection); San Bruno, 4 (Biol. Surv. Collection); south end of Concepción Bay, 15; Canipolé, 9.

Dipodomys merriami melanurus Merriam

CAPE SAN LUCAS KANGAROO RAT

Original description.—Dipodomys merriami melanurus Merriam, Proc. Calif. Acad. Sci., ser. 2, Vol. 3, p. 345, June 5, 1893.

Type locality.—San José del Cabo, Baja California, Mexico.

Distribution.—In its most typical form this race occupies a crescentic area, fringing the southern base of the higher foothills of the Sierra Victoria from Cape San Lucas to San José del Cabo, thence northward up the very wide valley at least to Agua Caliente. Between Agua Caliente and La Paz a mountainous area seems to interrupt the range, but isolated spots adjacent to the Gulf coast may be occupied. A good series from La Paz shows slight deviations, but within the degree allowable for this race. This is true also of a single available specimen from Tres Pachitas on the northwestern base of the Sierra Victoria. This specimen, though still considered to *D. m. melanurus*, has characters tending toward the population of *D. m. llanoensis* occupying the northern end of the vast Magdalena Plain.

From Tres Pachitas southward to Cape San Lucas there seem to be no areas from which *Dipodomys* has been reported. This precipitous, hilly area, in which the mountains abut the sea, is similar to the region just noted on the opposite side of the middle section of the peninsula, which also appears to be devoid of kangaroo rats.

Specimens examined.—Baja California: Cape San Lucas, 2 (Biol. Surv. Collection); San José del Cabo (type locality), 19 (9 from Biol. Surv. Collection and 2 from Mus. Vert. Zool. Collection); Santa Anita, 5 (Biol. Surv. Collection); 7 miles south of Miraflores, 6; Agua Caliente, 10 (Mus. Vert. Zool. Collection); La Paz, 15; Tres Pachitas, 1 (Biol. Surv. Collection).

Dipodomys merriami llanoensis subsp. nov.

MAGDALENA PLAIN KANGAROO RAT

Type.—From Buena Vista, Magdalena Plain, Baja California, Mexico, Lat.

24° 50′ N., Long. 111° 50′ W.; No. 14676, San Diego Society of Natural History; adult male: collected by Laurence M. Huey, November 15, 1941.

Characters.—This race differs from *D. m. melanurus* in having more pallid dorsal color and a very wide hip stripe, which on some specimens almost obliterates the hip spot. It differs from *D. m. platycephalus* in being slightly more pallid dorsally, resembling specimens from the western section of the Viscaíno Deseert in this respect, and in having the tail and tail tuft decidedly black as in *melanurus*. *D. m. llanoensis* is intermediate between *melanurus* and *platycephalus* in that it exhibits characters found in both. However, it has more inflated mastoid bullae than either. In some specimens this development has pinched the interparietal into extremely narrow proportions. This one character, large inflatted mastoid bullae, set *llanoensis* apart sharply from the nearby island species, *Dipodomys margaritae*.

Measurements of type.—Total length, 250; tail, 144; hind foot, 38; ear, 10. Skull: greatest length, 37.2; width across bullæ, 24.0; spread of maxillary arches, 20.5; greatest length of nasals, 13.1; width of maxillary arch at middle, 5.7.

Range.—This race is known only from San Jorge, on the northern end of Magdalena Plain, south to the area south of El Refugio, but without doubt it will be found farther southward, at least to the region of Arroyo Seco below Magdalena Bay.

Specimens examined.—Baja California: 9 miles south of El Refugio, Magdalena Plain, 8; Buena Vista, Magdalena Plain (type locality), 5; Matancita, Magdalena Plain, 1 (Biol. Surv. Collection); Santo Domingo (Lat. 25° 30′ N.), Magdalena Plain, 7; San Jorge, 6.

Dipodomys insularis Merriam

SAN JOSÉ ISLAND KANGAROO RAT

Original description.—*Dipodomys insularis* Merriam, Proc. Biol. Soc. Washington, Vol. 20, p. 77, July 22, 1907.

Type locality.—San José Island, Gulf of California, Baja California, Mexico.

Distribution.—Known only from San José Island.

Remarks.—The writer was tempted to treat this species and the one following as subspecies amid the chain of mainland races. In certain basic characters, however, such as the shape of the bullae, which are smaller than those of the mainland races, and the correspondingly large ears, general pelage color, and robust appearance, it contrasts so strongly with the geographically nearest mainland relative *brunensis*, that intergradation cannot be assumed.

The series of this species examined was ample to justify these statements and shows constancy in all its characters.

Specimens examined.—Baja California: 8 from "southwest side" and 4 from "southeast end" of San José Island, all from collection of Museum of Vertebrate Zoology, Berkeley.

Dipodomys margaritae Merriam
MARGARITA ISLAND KANGAROO RAT

Original description.—*Dipodomys margaritae* Merriam, Proc. Biol. Soc. Washington, Vol. 20, p. 76, July 22, 1907.

Type locality.—Santa Margarita Island, Baja California, Mexico.

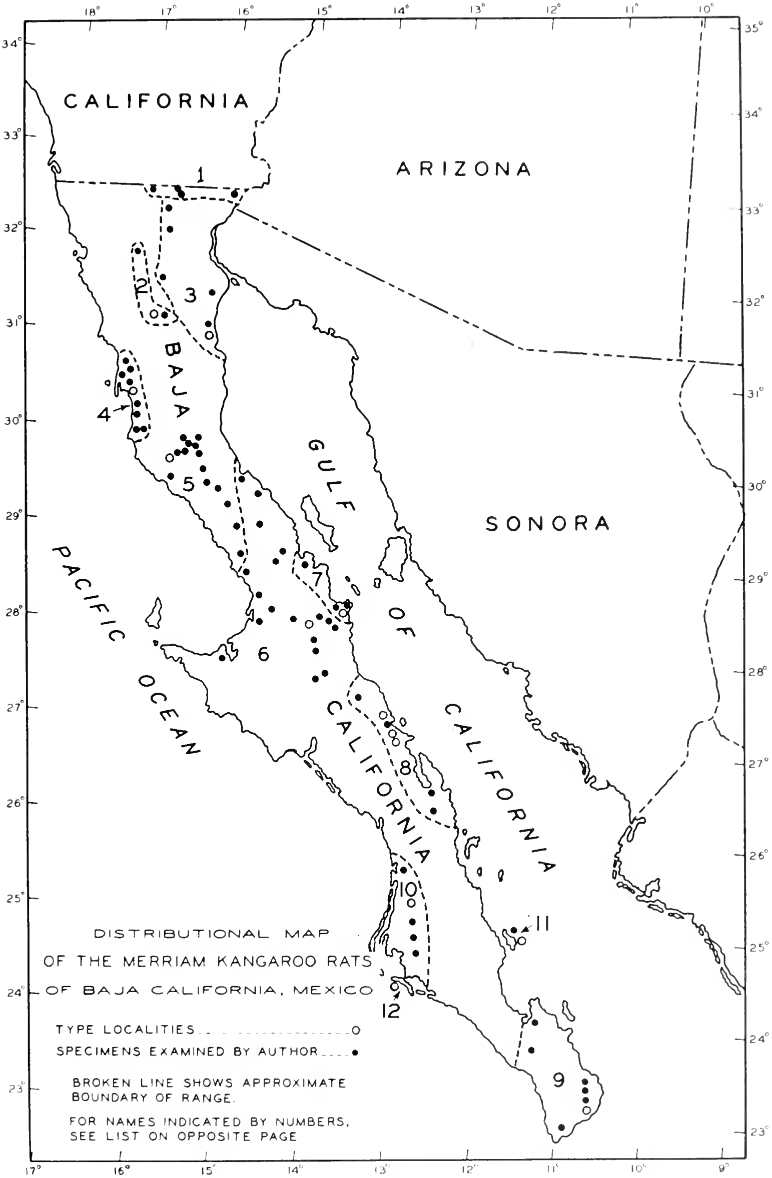
Distribution.—Known only from this island.

Remarks.—The range of variation shown by the limited available material of this species stands well beyond that shown by a good series from the nearby mainland. The bullae are much smaller and less inflated and the pelage is decidedly pale, as is the tail tuft. The ratio of tail to body length is smaller than that of the nearby mainland species. There seems to be no valid reason to reduce either this species or *D. insularis* to subspecific standing, for there is no evidence of intergradation.

Specimens examined.—Baja California: 3 skins with skulls and 1 skull from Santa Margarita Island, all from Dickey Collection of the University of California, Los Angeles.

MAP 3
DISTRIBUTION OF THE MERRIAM KANGAROO RATS OF BAJA CALIFORNIA

Name	*Type Locality*
1. *Dipodomys merriami simiolus*	Palm Springs, Riverside Co., Calif.
2. *Dipodomys merriami trinidadensis*	Aguajito Spring, El Valle de la Trinidad, Baja California.
3. *Dipodomys merriami arenivagus*	San Felipe, Baja California.
4. *Dipodomys merriami quintinensis*	5 Miles east of San Quintín, Baja California.
5. *Dipodomys merriami semipallidus*	7 Miles north of Santa Catarina (Lat. 29° 45′ N.), Baja California.
6. *Dipodomys merriami platycephalus*	Calmallí, Baja California.
7. *Dipodomys merriami annulus*	Barril, Gulf of California (Lat. 28° 20′ N.), Baja California.
8. *Dipodomys merriami brunensis*	Llano de San Bruno, Baja California.
9. *Dipodomys merriami melanurus*	San José del Cabo, Baja California.
10. *Dipodomys merriami llanoensis*	Buena Vista, Magdalena Plain, Baja California.
11. *Dipodomys insularis*	San José Island, Gulf of California, Baja California.
12. *Dipodomys margaritae*	Santa Margarita Island, Baja California.


CALIFORNIA
ARIZONA
SONORA
BAJA
GULF OF CALIFORNIA
PACIFIC OCEAN
GULF OF CALIFORNIA
1
2
3
4
5
6
7
8
9
10
11
12
DISTRIBUTIONAL MAP
OF THE MERRIAM KANGAROO RATS
OF BAJA CALIFORNIA, MEXICO
TYPE LOCALITIES ○
SPECIMENS EXAMINED BY AUTHOR ●
BROKEN LINE SHOWS APPROXIMATE BOUNDARY OF RANGE.
FOR NAMES INDICATED BY NUMBERS, SEE LIST ON OPPOSITE PAGE

Map 3

TABLE I

AVERAGE, MINIMUM AND MAXIMUM MEASUREMENTS OF ADULT SPECIMENS OF TWO SPECIES AND ELEVEN SUBSPECIES OF THE *DIPODOMYS MERRIAMI* GROUP FROM TYPE LOCALITIES IN SOUTHERN CALIFORNIA AND IN BAJA CALIFORNIA

Name and Locality MALES	Number of Specimens	Total Length	Tail	Hind Foot	Ratio of Tail to Body	Greatest Length of Skull	Breadth Across Bullae	Spread of Maxillary Arches	Greatest Length of Nasals	Width of Maxillary Arch at Middle
Dipodomys merriami parvus		233.6	139.8	36.4		34.2	22.1	19.1	12.3	4.8
San Bernardino,	5				147%					
California and vicinity.		222–2.40	135–148	35–38		33.4–35.0	21.5–22.7	18.4–19.5	11.9–13.0	4.6–5.2
Dipodomys merriami simiolus		249.8	149.6	38.4		35.6	22.4	18.0	12.4	4.5
Palm Springs, Riverside	5				149%					
County, California.		238–260	140–160	38–39		34.7–36.5	22.3–22.7	17.8–18.2	11.6–13.2	4.0–5.0
Dipodomys merriami trinidadensis		241.8	143.8	37.4		35.5	22.5	18.9	12.6	4.8
El Valle de la Trinidad,	5				146%					
Baja California.		234–255	138–154	36–38		35.4–35.9	22.1–23.1	18.4–19.5	12.4–12.9	4.7–5.0
Dipodomys merriami arenivagus		246.0	146.6	38.2		35.8	23.3	19.2	12.7	5.0
San Felipe,	5				146%					
Baja California.		235–256	140–155	37–39		35.0–36.7	22.8–23.7	18.6–19.6	12.2–13.4	4.6–5.2
Dipodomys merriami quintinensis		241.2	144.4	36.4		35.0	22.3	19.2	12.8	4.8
Vicinity of San Quintín,	5				148%					
Baja California.		235–246	140–148	35–39		33.6–36.5	21.7–22.7	18.8–20.1	12.5–13.4	4.5–5.1
Dipodomys merriami semipallidus		247.8	148.0	37.4		36.0	22.9	19.1	12.8	4.7
7 Miles North Santa Catarina,	5				149%					
Baja California.		240–258	145–155	36–38		34.8–37.2	22.0–24.0	18 2–20.1	11.8–13.5	4.2–5.1
Dipodomys merriami platycephalus		250. 2	148.4	37.4		36.4	23.2	20.0	13.0	5.1
Calmalli,	5				145%					
Baja California.		245–261	140–155	36–38		35.3–37.5	22.6–23.9	19.9–20.3	12.7–13.9	4.8–5.6
Dipodomys merriami annulus		248.2	145.6	39.4		36 4	23.4	20 2	13.5	5.3
Barril and 7 miles West	5				141%					
San Francisquito Bay, Baja California		244–252	140–150	38–40		35.3–37.2	22.3–24.3	19.5–21.1	13.0–14.0	5.2–6 0
Dipodomys merriami brunensis		251.4	154.6	38.0		37.0	23.9	20.1	13.7	5.0
Llano de San Bruno,	5				158%					
Baja California.		245–258	146–168	37–39		36.3–37 6	23.5–24.5	19.4–20.6	13.3–14.2	4.5–5.3
Dipodomys merriami melanurus		253.7	150.6	38.0		36.3	23 2	20.0	13.1	5.3
San Jose del Cabo,	5				145%					
Baja California.		243–260	141–160	37–39		35.6–36.7	23.0–23.3	19.4–20.6	13.0–13.4	5.1–5.7

Dipodomys merriami llanoensis		**252.0**	**150.4**	**37.0**		**36.6**	**23.4**	**20.0**	**13.1**	**5.3**
Buena Vista and Sto.	5				147%					
Domingo 25° N Lat. Baja California		248-257	144-160	36-38		35.9-37.8	22.9-24.0	19.4-21.3	12.5-13.8	5.0-5.8
Dipodomys insularis		255.6	150.6	40.2		36.4	22.6	20.9	13.4	5.6
San Jose Island,	5				142%					
Baja California		250-261	145-158	40-41		35.3-37.5	21.9-23.4	20.4-21.6	12.9-14.0	5.2-6.2
Dipodomys margaritae		244	144	38		35.4	22.0	19.5	12.5	5.6
Santa Margarita Island	1				144%					
Baja California										
FEMALES										
Dipodomys merriami parvus		232.5	138.7	36.0		33.9	21.9	18.4	12.2	4.6
San Bernardino,	5				147%					
California and Vicinity		230-240	133-143	35-37		33.1-34.6	21.1-22.3	17.8-19.0	11.5-13.0	4.3-4.9
Dipodomys merriami simiolus		237.8	140.4	37.8		34.9	22.2	18.2	12.2	4.6
Palm Springs,	5				154%					
Riverside County, California		230-249	135-145	36-39		34.0-36.2	21.5-22.9	17.6-18.1	11.7-13.0	4.4-5.2
Dipodomys merriami trinidadensis		240.8	142.6	37.0		35.6	22.6	18.7	12.8	4.6
El Valle de la Trinidad,	5				144%					
Baja California.		238-248	140-145	36-38		35.0-36.7	22.2-23.4	18.4-19.1	12.6-13.4	4.3-5.2
Dipodomys merriami arenivagus		242.0	141.6	37.2		35.7	22.9	19.0	13.0	4.9
San Felipe,	5				139%					
Baja California		233-253	132-151	36-39		34.5-37.0	22.6-23.8	18.1-19.7	12.0-13.8	4.7-5.0
Dipodomys merriami quintinensis		242.0	140.8	35.8		34.9	22.6	19.2	12.2	5.0
Vicinity of San Quintin,	5				137%					
Baja California.		231-250	134-148	35-37		33.3-36.3	21.2-23.1	18.7-19.9	11.8-12.8	4.9-5.3
Dipodomys merriami semipallidus		242.4	148.0	36.8		35.3	22.5	18.7	12.7	4.7
7 Miles North Santa Catarina,	5				157%					
Baja California		232-260	140-160	36-38		34.0-36.3	21.9-23.0	18.3-19.5	11.2-13.4	4.6-5.0
Dipodomys merriami platycephalus		247.0	145.4	37.4		36.5	23.1	20.1	13.4	5.3
Calmalli, Baja California.	5				142%					
		238-257	140-150	37-38		34.7-37.6	22.7-23.7	19.4-21.1	12.5-14.5	4.9-5.6
Dipodomys merriami annulus		250.2	149.8	38.4		36.4	23.4	20.2	13.5	5.3
Barril and 7 miles west	5				148%					
San Francisquito Bay, Baja California		250-251	148-151	37-40		35.9-37.0	22.9-23.9	19.0-21.0	13.0-14.1	5.0-5.5
Dipodomys merriami brunensis		249.0	151.0	39.0		37.1	23.0	20.0	13.8	5.0
Llano de San Bruno,	2 Skins 1 Skull				155%					
Baja California		248-250	151-151	38-40						
Dipodomys merriami melanurus		345.0	147.2	37.4		35.4	22.6	19.9	12.5	5.2
San Jose del Cabo,	5				150%					
Baja California.		237-255	138-160	36-38		34.0-36.8	21.3-23.6	19.4-20.8	11.9-12.7	4.9-5.7
Dipodomys merriami llanoensis		249.4	149.0	36.8		36.4	23.3	20.4	13.1	5.2
Buena Vista and Sto. Domingo	5				149%					
25° N. Lat., Baja California		245-255	147-150	36-37		35.8-37.0	22.5-24.2	19.4-21.4	12.9-13.5	4.9-5.7
Dipodomys insularis		248.8	148.8	38.4		35.8	22.1	20.4	13.2	5.6
San Jose Island,	5				148%					
Baja California		240-262	140-161	37-40		36.4-37.4	21.5-22.8	20.2-20.8	12.8-13.8	5.4-5.8
Dipodomys margaritae		240.0	142.0	38.0		34.6	21.4	19.1	13.0	4.9
Santa Margarita Island,	2 Skins 3 Skulls				144%					
Baja California		235-245	137-147	38-38		34.3-35.1	21.1-21.8	18.9-19.4	12.7-13.2	4.8-5.1

Agilis Group

Range and Habitat

Four races and one closely allied species of the *agilis* group are to be found in Baja California. Their ranges are confined to the northwestern section of the territory and are limited to the Pacific slope, except in a very small area on the northern end of the Sierra Juaréz, where the drainage is toward the desert side. No member of the *agilis* group, so far as is known, occurs on the arid desert slopes. Specimens of this group have been collected by the writer from the beach just above the tide line at Rosarito upward to the pine-studded meadows of Sierra San Pedro Mártir, at an elevation of over 7500 feet. The species occupies each of the three life zones on the Pacific slope of northern Baja California—Lower and Upper Sonoran and Transition. Thus the gamut of range is in bold contrast to that occupied by *D. merriami*, which is almost wholly confined to the Lower Sonoran zone.

It is perhaps more significant to state that *agilis* is essentially an inhabitant of the chaparral belt or brush-covered regions, for the range of the species and its races is limited mainly by this factor. In Baja California this type of ground cover, largely dominated by *Adenostoma*, reaches southward coastwise to a point some 50 miles below Ensenada, thence inland along the foothills of the higher mountains, where it gradually pinches out against the southern slopes of the Sierra San Pedro Mártir.

A great basin-like area south of the termination of the Californian chaparral belt is covered with more xerophilous growths. A species of wild rose (*Rosa minutifolia*) is the dominant plant of this belt, and in places forming large thickets almost excluding other species. This region, which might be called the San Quintín Subfaunal District, ends near the long and rather narrow El Rosario Valley, which extends eastward from El Rosario some 20 to 30 miles. South of this valley great thickets of mescal, *Agave Shawi*, form another type of ground cover, which is sparser than that of either of the two other types mentioned above. It is in this area that the *agilis* finds its southernmost and most arid habitat.

Two of the races of *agilis* found in Baja California range also over large sections of southern California. One, *Dipodomys agilis* *cabezonae,* which occupies an inland range south from San Gorgonio Pass in Riverside County along the backbone of the Coast Range, barely gets below the international boundary, where its range ends against the northern slopes of the Sierra Juaréz. The other, *Dipodomys agilis simulans,* the most widespread race of the *agilis* group, occupies a great coastal foothill area of San Diego County, thence southward across the California brush cover into the San Quintín region, ending near El Rosario Valley. South of this valley *Dipodomys agilis plectilis* is found. The range of this difficult race is not well known and is in an inaccessible region where little collecting has been done. Coastwise, in the vicinity of Santa Catarina Landing, *D. a. plectilis* occupies common ground with *Dipodomys paralius.* This too is an area of little brush and is the southernmost known limit of the *agilis* group.

In northern Baja California the range occupied by the *agilis* races is not as large, territorially, as is that occupied by the *peninsularis* group to the southward, but because of the nature of the vegetative cover it probably comprises the greater population.

CLIMATIC INFLUENCES

The climatic influences which are reflected in the physical variations of the populations of five-toed kangaroo rats of the *agilis* group in northern Baja California are not as marked as are those which affect the populations of the two other major groups, *merriami* and *peninsularis,* living on the peninsula to the southward. True, the regions which form the habitat of *agilis* range in elevation from sea level to over 7500 feet and are thus subjected to the more or less severe winter-summer extremes found in such location. However, this montane climatic variation does not influence the physical characters of the races of the *agilis* species as much as the varying oceanic temperatures influence the forms of either *merriami* or *peninsularis.* These latter groups are more diverse, despite the fact that the habitats they occupy are of much lower elevation and are more sparsely vegetated. Sufficient weather data are not available from Baja California to demonstrate these relations which, however, are amply demonstrated by an examination of the different characters of the several races among the three groups, and by a plotting of the contrasting botanical associations of the different regions in which the various races live.

MATERIAL

In the account of the *agilis* group the writer has examined 680 specimens from 42 localities; 73 specimens are from two localities in California and 607 are from 40 localities in northwestern Baja California.

Dipodomys agilis cabezonae (Merriam)

CABEZON KANGAROO RAT

Original description.—*Perodipus cabezonae* Merriam, Proc. Biol. Soc. Washington, Vol. 17, p. 144, July 14, 1904.

Type locality.—Cabezon, San Gorgonio Pass, Riverside County, California.

Distribution.—The metropolis of this race is in the higher semi-arid valleys and over the chaparral-covered mesas along the eastern elevated desert slopes of the mountains of Riverside and San Diego counties in California. It reaches the southernmost extent of its range a short distance below the international boundary, against the northern and northwestern slopes of the Sierra Juaréz in Baja California. This area comprises the southwestern part of Jacumba Valley, part of Nachoguero Valley, and surrounding brush-covered mesas. Specimens are available from three localities within this limited section.

Specimens examined.—California: Cabezon, Riverside County (type locality), 51. Baja California: Just south of the international boundary near Jacumba, California, 12; 3 miles northwest of Neji, 2; Tres Piños Mine, near Juaréz, 3.

Dipodomys agilis simulans (Merriam)

DULZURA KANGAROO RAT

Original description.—*Perodipus streatori simulans* Merriam, Proc. Biol. Soc. Washington, Vol. 17, p. 144, July 14, 1904.

Type locality.—Dulzura, San Diego County, California.

Synonym.—*Dipodomys agilis latimaxillaris* Huey, Proc. Biol. Soc. Washington, Vol. 38, p. 84, May 26, 1925 (type locality, 2 miles west of Santo Domingo Mission, Baja California, Mexico, Lat. 30° 45′ N.).

Distribution.—In Baja California this race ranges over a great coastal foothill area, from the western base of the Sierra Juaréz to the Pacific Ocean and from the international boundary directly south of Campo, California, as far south as Rancho San Pablo, 10 miles south of Álamo, thence diagonally southwest to San Quintin and the Pacific Ocean. All is more or less heavily overgrown with dense chaparral. The region from the mountains to the sea and from the international boundary south to San Vincente is clothed with several species of brush commonly found over this race's range in California, namely red shank (*Adenostoma sparsifolium*), chemise (*Adenostoma fascicu-*

latum), and some manzanitas (*Arctostaphylos* sp.). Many valleys filled with heavy stands of live oak trees bisect this area. Some of these valleys are lightly farmed, hay or grain being the principal harvests. Such conditions are conducive to a large population of kangaroo rats.

From San Vicente to the southernmost extent of the range, in the vicinity of San Quintín, a different type of brush cover is found. Here considerable cactus, a peculiar species of wild rose (*Rosa minuifoldia*), and other xerophilous shrubs form the chaparral.

Remarks.—Dipodomys agilis simulans has the densest population of any form of the *agilis* group living in northern Baja California and the center of *agilis* population of Baja California is to be found within its bounds.

Around the outer perimeter of this great range considerable variation is prevalent. The population on the eastern fringe from just below Campo southward, has a more pallid dorsal coloration, tending toward that of *D. a. cabezonae*.

Farther south, along this brush-covered region through Valle de San Rafael to Rancho San Pablo, the *cabezonae* tendencies give way toward a blending with *D. a. martirensis*. The population of the Rancho San Pablo mesa region has a dark coloration, most nearly like that of topotypic *simulans* from Dulzura, but it shows an average tendency toward more inflated bullae. The writer was tempted to describe and name this population, but decided that its characters were inadequate to justify subspecific separation. A similar population from the Santo Domingo-San Quintín coastal district to the southwestward had been named by him in 1925 and now, with specimens at hand from a wider area, the race is deemed untenable.

This population about the San Quintín coastal area does average darker in dorsal coloration than does the general series of topotypes from Dulzura when viewed in mass, and there is a tendency toward an inflation of the bullae, but both characters are of two slight divergence to warrant subspecific designation.

This "darker coloration tendency" is paralleled in the *merriami* group, but as *agilis* is in reality a coastal species, whose general habitat to the northward extends through zones of various coastal influences, the climatic effects of the slightly different San Quintín section were not as great upon it as they were on the desert living *merriami*.

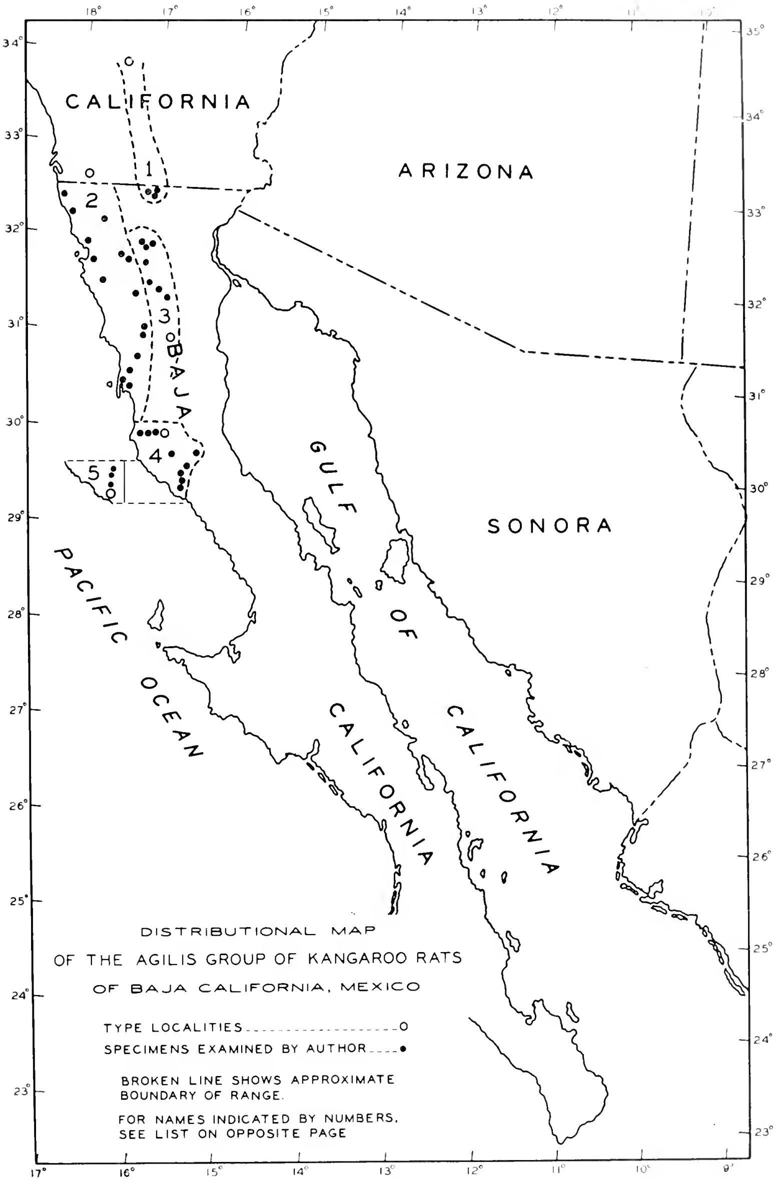
One specimen, a male (No. 11496, San Diego Society of Natural History), collected by the writer 3 miles east of Ojos Negros on March 12, 1936, is unique in having a white tail tip. In the large series examined, this is the only specimen that shows a markedly divergent character. No specimen yet examined lacks the fifth toe or hallax, which is occasionally revealed in some Californian species of *Dipodomys*.

Specimens examined.—California: Dulzura, San Diego County (type locality), 22. Baja California: Rosarita Beach, 1; north side of Descanso Bay, 2; Ensenada, 2; 14 miles south of Ensenada, 1; Santo Thomás, 6; Santo

Map 4

DISTRIBUTION OF
THE BAJA CALIFORNIA KANGAROO RATS OF THE *Dipodomys agilis* GROUP.

	Type Locality
1. *Dipodomys agilis cabezonae.*	Cabezon, Riverside Co., California.
2. *Dipodomys agilis simulans.*	Dulzura, San Diego Co., California
3. *Dipodomys agilis martirensis.*	La Grulla, Sierra San Pedro Mártir, Baja California.
4. *Dipodomys agilis plectilis.*	Canyon San Juan de Díos (Lat. 30° 7′ N), Baja California.
5. *Dipodomys peralius.*	Santa Catarina Landing (Lat. 29° 31′ N), Baja California.


CALIFORNIA
ARIZONA
SONORA
BAJA
GULF OF CALIFORNIA
PACIFIC OCEAN
1
2
3
4
5
DISTRIBUTIONAL MAP
OF THE AGILIS GROUP OF KANGAROO RATS
OF BAJA CALIFORNIA, MEXICO
TYPE LOCALITIES ---------- ○
SPECIMENS EXAMINED BY AUTHOR ---- ●
BROKEN LINE SHOWS APPROXIMATE BOUNDARY OF RANGE.
FOR NAMES INDICATED BY NUMBERS, SEE LIST ON OPPOSITE PAGE
18°
17°
16°
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14°
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Map 4

TABLE II

AVERAGE, MINIMUM AND MAXIMUM MEASURMENTS OF ADULT SPECIMENS OF FOUR RACES AND ONE SPECIES OF THE *DIPODOMYS AGILIS* GROUP FROM SOUTHERN CALIFORNIA AND BAJA CALIFORNIA

Name and Locality	Number of Specimens	Total Length	Tail	Hind Foot	Ratio of Tail to Body	Greatest Length of Skull	Breadth Across Bullae	Spread of Maxillary Arches	Greatest Length of Nasals	Width of Maxillary Arch at Middle
MALES										
Dipodomys agilis cabezonae		292.0	179.6	41.6		38.5	23.6	19.4	13.9	4.2
Cabezon, California.	5				158%					
(Topotypes)		285–305	175–188	41–44		37.8–39.2	23.4–39.2	19.1–19.7	13.1–14.3	3.6–4.9
Dipodomys agilis simulans		287.3	175.2	41.0		38.0	23.8	20.1	13.2	4.6
Dulzura, California.	5				156%					
(Topotypes)		283–296	170–186	40–42		37.7–38.4	23.1–24.5	19.3–20.8	12.9–13.8	4.4–4.7
Dipodomys agilis martirensis		273.0	160.5	41.5		38.8	24.2	20.0	13.4	4.9
Sierra San Pedro Martir,	4				141%					
Baja California. (Topotypes)		270–275	160–162	40–42		38.4–39.2	23.7–25.0	19.8–20.5	13.0–14.0	4.7–5.0
Dipodomys agilis plectilis		271.4	157.8	40.6		39.7	24.5	21.4	14.1	4.9
Mouth Canyon San Juan de Dios,	5				137%					
Baja California. (Topotypes)		259–280	150–173	40–41		38.5–40.7	24.1–25.1	21.1–22.0	13.4–14.8	4.8–5.1
Dipodomys paralius,		267.4	157.0	39.2		38.5	24.4	20.5	13.0	4.7
Santa Catarina Landing,	5				142%					
Baja California. (Topotypes)		250–290	150–170	38–40		37.5–39.0	24.2–25.1	19.6–21.9	12.5–13.6	4.6–4.9
FEMALES										
Dipodomys agilis cabezonae		293.2	178.8	41.4		38.6	23.7	20.2	14.0	4.6
Cabezon, California.	5				154%					
(Topotypes)		290–300	170–185	41–42		38.2–39.5	23.5–24.3	19.3–20.8	13.6–14.5	4.3–5.0
Dipodomys agilis simulans		290.4	179.0	41.4		38.4	24.2	20.2	13.8	4.7
Dulzura, California.	5				161%					
(Topotypes)		280–298	170–183	40–42		37.8–39.8	23.6–24.5	19.7–20.8	13.5–14.2	4.4–5.0
Dipodomys agilis martirensis		278.0	167.4	40.6		39.1	24.5	20.4	13.7	4.6
El Valle de la Trinidad,	5				150%					
Baja California. (Aguaito Springs)		271–292	159–180	39–42		38.7–39.7	24.0–25.0	19.8–21.5	13.3–14.0	4.3–5.1
Dipodomys agilis plectilis		274.4	163.8	40.0		38.3	24.1	20.5	13.5	4.7
Mouth of Canyon San Juan de Dios	5				146%					
Baja California. (Topotypes)		270–282	160–169	39–41		37.6–39.0	23.4–24.7	19 2–21.1	13.0–13.9	4.5–5.0
Dipodomys paralius		265.0	155.4	39.8		38.1	24.4	20.7	13.3	4.7
Santa Catarina Landing,	5				140%					

Domingo (Lat. 30° 45′ N.), 28; 1 mile south of San Ramón, 2; north end of San Quintín Plain, 1; San Quintín, 11 (2 from Huey Collection); El Valle de las Palmas, 7; Ojos Negros, 17; 3 miles east of Ojos Negros, 26; 10 miles southeast of Álamo, Rancho San Pablo, 33 (7 from Huey Collection); San José, 5; (not typical); Las Cabras, 2 (not typical).

Dipodomys agilis martirensis Huey

SIERRA KANGAROO RAT

Original description.—*Dipodomys agilis martirensis* Huey, Trans. San Diego Soc. Nat. Hist., Vol. 5, pp. 7-8, February 20, 1927.

Type locality.—La Grulla (east side of valley), Sierra San Pedro Mártir, Lower (= Baja) California, Mexico, altitude 7500 feet.

Distribution.—Known from the higher parts of the Sierra Juaréz, southward to the type locality in the Sierra San Pedro Mártir and westward along the higher foothill slopes of the range to the vicinity of San José, where the specimens taken are nearer to *D. a. simulans.* The southern extent of the range of this race is, as yet, undetermined. Specimens examined from localities east of El Rosario, near San Fernando Mission and El Marmol, are all assignable to other races or species.

Remarks.—In a series of 240 specimens from El Valle de la Trinidad, there is considerable variation, but no series could be picked out with characters that would justify separation from *D. a. martirensis.* This valley bisects the two mountain-top populations of this race. As a large portion of the valley is within the Lower Sonoran zone, *D. a. martirensis* inhabits three life zones. In this respect it is unique.

This long valley with its abundant *Dipodomys* population is perhaps one of the few outstanding examples of coastal-desert intergrading areas left untouched, biologically, by man. He has tampered some with his poisons (Huey, Journ. Mam. 18: 74, 1937), but agriculture and dense human settlement have made no scars. Starting in the extreme western end of the valley amid coastal willow, flowing streams and *Adenostroma* associations, one can drive directly eastward over a gently rising valley floor, passing, within 20 miles, through associations of screwbean, mesquite, and creosote, thence over the gradual lift of San Matías Pass, through varied cacti and other xerophilous vegetation, downward through creosote and cacti into one of the most arid, torrid deserts of North America. This valley, still unspoiled, is one of the few western spots left in its pristine state, an ecologist's paradise.

It was through such associations that this large series was collected. The greater portion could be placed within the known characters of *D. a. martirensis,* in spite of the fact that topotypical material was meager.

It is to be regretted that the race *martirensis* was named from a locality in the higher parts of the Sierra San Pedro Mártir. La Grulla Meadows is most inaccessable and lies on the very edge of the range of the race, in a region where it does not show its average characters. This factor has militated against a clear understanding of the characters of *D. a. martirensis* and has caused no end of difficulties in aligning the various five-toed kangaroo rat populations sampled over this interesting terrain.

Specimens examined.—Baja California: Laguna Hanson, 16; 1 mile east of Laguna Hanson, 1; El Rayo, Sierra Juárez, 19; Sangre de Cristo, 31; El Valle de la Trinidad, extreme western end, 14; (not typical); El Valle de la Trinidad, Aguaito Spring, 230; Summit of San Matías Pass, Diablito Spring, 35; La Grulla, Sierra San Pedro Mártir, 5 (including type).

Dipodomys agilis plectilis[1] subsp. nov.

EL ROSARIO KANGAROO RAT

Type.—From mouth of canyon San Juan de Díos (Lat. 30° 7′ N.). Baja California, Mexico: No. 4721, San Diego Society of Natural History; adult female; collected by Laurence M. Huey. May 1. 1925.

Characters.—This medium sized kangaroo rat has the lightest and most buffy color of any of the *agilis* forms. In dorsal coloration it approaches *Dipodomys paralius*, but it is larger and has a much larger ear. Its relationship is to the northward. with *Dipodomys agilis simulans* and *D. a. martirensis*, from which it differs in its smaller size and more buffy coloration. *D. a. plectilis* differs further from the two northern races in having a smaller skull with proportionately more inflated bullae.

Measurements of type.—Total length, 275; tail, 165; hind foot, 41; ear 13. Skull: greatest length, 38.8; width across bullae, 24.5; spread of maxillary arches, 21.2; greatest length of nasals, 13.6; width of maxillary arch at middle, 4.6.

Range.—Specimens are available from El Rosario Valley as far eastward as the type locality, the mouth of Canyon San Juan de Díos, a distance of about 10 miles airline, thence southward to Aguaito and El Marmol and thence coastwise to near Santa Catarina and Santa Catarina Landing. A broad area between these localities, consisting of foothill, mesa and coastal shelfland, is yet to be explored and will no doubt reveal considerable data for a better understanding of the incompletely known range of this perplexing race.

Specimens examined.—1 mile east of El Rosario, 5; 4 miles east of El Rosario, 6; 10 miles east of El Rosario, 4; mouth of canyon, San Juan de Díos (type locality), 20; Aguaito, 5; 5 miles southeast of San Fernando, 9; 3 miles west of El Marmol, 1; 8 miles north of Santa Catarina (Rancho La Ramona), 3; 7 miles north of Santa Catarina, 7; 4 miles north of Santa Catarina Landing, 5.

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[1] Latin—complicated, involved, intricate.

Dipodomys paralius[1] sp. nov.

SANTA CATARINA KANGAROO RAT

Type.—From Santa Catarina Landing (Lat. 29° 31′ N.), Baja California, Mexico: No. 4250, San Diego Society of Natural History; adult female; collected by Laurence M. Huey, April 13, 1923.

Characters.—This kangaroo rat is similar in color to *Dipodomys peninsularis pedionomus*, but it is smaller and has smaller ears. Cranially, it is widely divergent, with smaller, proportionately flatter, more inflated bullae and with slightly more angular and more widely spreading maxillary arches. This latter character is prominent and places this species very near to the broad-faced group of kangaroo rats. Compared with *Dipodomys agilis plectilis, D. paralius* is lighter in dorsal coloration and smaller in size, and further differs in the cranial characters mentioned above. The general outline of the skull is more nearly that of an equilateral triangle than that of an acute triangle, such as characterizes *D. a. simulans, D. a. plectilis* and other members of the *agilis* group. However, *paralius* is nearer to the *D. a. simulans-plectilis* chain than it is to the *D. peninsularis* group and it is best left under the *agilis* series.

Measurements of type.—Total length, 250; tail, 150; hind foot, 38; ear, 11. Skull: greatest length, 38.8; width across bullae, 24.3; spread of maxillary arches, 20.5; greatest length of nasals, 13.2; width of maxillary arch at middle, 4.7.

Range.—So far as known, from near Santa Catarina and around Santa Catarina Landing (type locality). Both localities are in a great basin-like coastal section of Baja California.

Specimens examined.—Baja California: 8 miles north of Santa Catarina (Rancho La Ramona), 12; 7 miles north of Santa Catarina, 2; 4 miles north of Santa Catarina Landing (type locality), 12 (including type).

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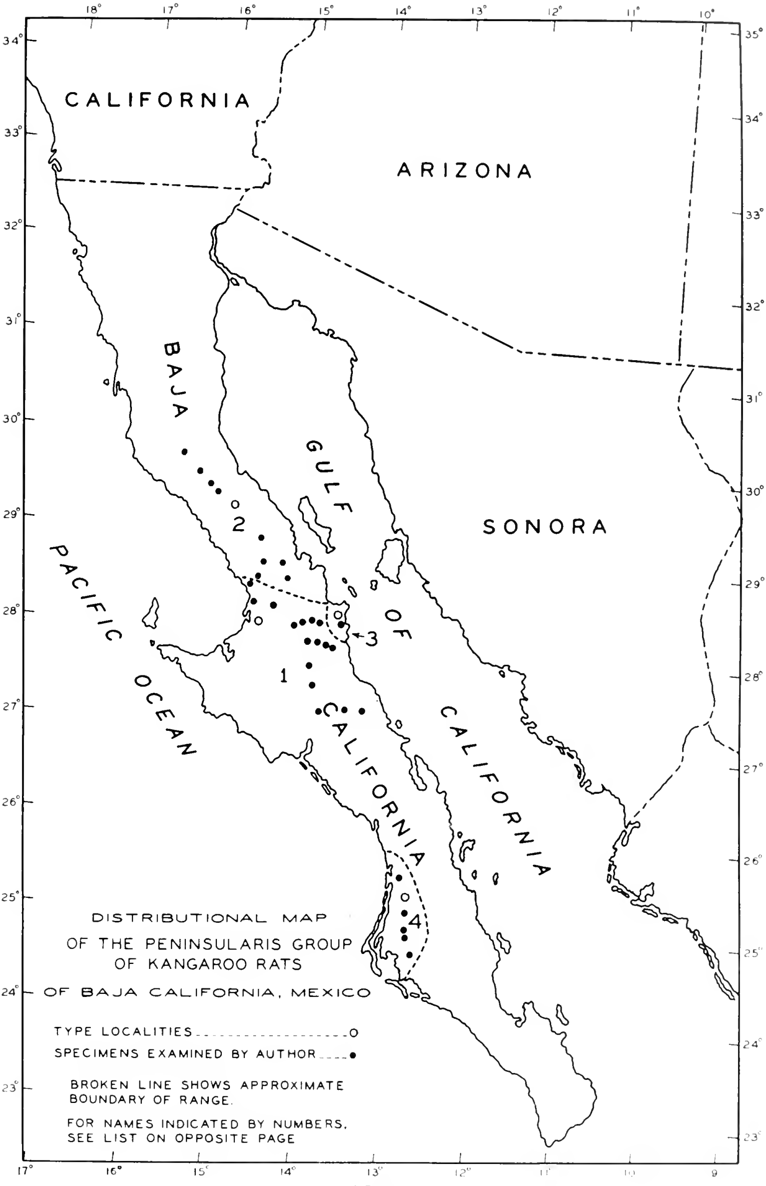
[1] Latin—that grows (lives) by the sea.

Map 5

Distribution of The Baja California Kangaroo Rats of the *Dipodomys peninsularis* Group.

	Type Locality
1. *Dipodomys peninsularis peninsularis.*	Santo Domingo Landing (Lat 28° 51′ N), Baja California.
2. *Dipodomys peninsularis pedionomus.*	2 Miles north of Chapala Dry Lake (Lat. 29° 30′ N), Baja California.
3. *Dipodomys peninsularis eremoecus.*	7 Miles west of San Francisquito Bay (Lat. 28° 30′ N), Baja California.
4. *Dipodomys peninsularis australis.*	Santo Domingo, Magdalena Plain (Lat. 25° 30′ N), Baja California.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23°
CALIFORNIA
ARIZONA
BAJA
GULF
OF
CALIFORNIA
SONORA
PACIFIC
OCEAN
CALIFORNIA
1
2
3
4
DISTRIBUTIONAL MAP
OF THE PENINSULARIS GROUP
OF KANGAROO RATS
OF BAJA CALIFORNIA, MEXICO
TYPE LOCALITIES ○
SPECIMENS EXAMINED BY AUTHOR ●
BROKEN LINE SHOWS APPROXIMATE BOUNDARY OF RANGE.
FOR NAMES INDICATED BY NUMBERS, SEE LIST ON OPPOSITE PAGE
17°
16°
15°
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10°
9

Map 5

Peninsularis Group

Range

The *peninsularis* group is the third largest group of kangaroo rats in the peninsula. At present it is comprised of four races of one species. It ranges from just south of latitude 30° to the middle section of the Magdalena Plain, near latitude 25° and thus occupies a large portion of the length of the peninsula but reaches neither end. With two exceptions, this kangaroo rat is confined to the western or Pacific drainage slopes and the species range is entirely within the Lower Sonoran Zone covering some of the most sparsely brushed sections of the peninsula.

In but very few places are the five-toed kangaroo rats of this group abundant. Through the Chapala region in the central northern section of its range, it apparently finds the center of abundance. Southward, toward the Magdalena Plain, it is very scattered in occurence and often rare. Through these southern portions of its range, areas that appear ideal for *Dipodomys* habitation are often devoid of these rats.

No insular occurence of this species is known, nor has the writer found it close to the sea coast, as he has found *Dipodomys agilis* to the northward.

So far as is known, *D. peninsularis* has not been found over the llanos approaching the Sierra Victoria though much territory on the north and northwestern sides seems to offer good ground for habitation.

Climatic Influences

Along the Pacific slope, this range, like that of the *merriami* group (Map 3, p. 227), spans the regions respectively influenced by cool and by warm coastal waters. The effect of this climatic influence is reflected largely upon the vegetative growth on and within which the mammal population live and which in turn is shown upon the mammalian life itself. By way of illustration, the color of the dorsal pelage and cranial development, shown in the two extreme races of this group, *australis* in the south and *pedionomus* in the north, are outstanding.

Variation

This group of kangaroo rats is outstanding in several characters. All four races are rather large and have thick, decidedly bicolored tails of medium length and extremely inflated mastoid bullae. The inflation of the bullae increases markedly from north to south, following the trend shown in other *Dipodomys* species, which range through brush cover grading from dense to sparse. It has been shown by Grinnell that the more open the brush habitat, the greater the bullae inflation. Three races of *peninsularis* are excellent examples of this trend. Some specimens from the southern end of the range of the species have such swollen, inflated mastoids that the interparietal and supraoccipital are almost crowded out, leaving only a narrow sulcus between the left and right bulli. That this character is not always due to age development is illustrated by a specimen just beyond the juvenal stage, in whose skull the interparietal is almost obliterated by the crowding of the inflated bullae. The fourth race *D. p. eremoecus,* provides an exception to the general trend, for it lives in very sparse vegetation, yet has the bullae less inflated than in either *D. p. australis* or *D. p. peninsularis.*

The dorsal color pattern of the *peninsularis* group progressively lightens as the habitat extends over the peninsula, from the cooler to the warmer more arid sections. The tail tuft likewise darkens, but from north to south. As in *merriami* the darkest and most striking pattern is found at the southern end of the range, in *D. p. australis.* The lightest tail tuft and dorsal color pattern, however, is found in the race *D. p. eremoecus,* which lives on the Gulf side of the central peninsula, in the most arid desert climate within the range of this species.

Certain basic characters found throughout the different populations of five-toed kangaroo rats living within the inland area of the peninsula from El Marmol southward, such as extremely inflated bullae, brightly colored and heavily boned tail and average dorsal color tones, set them apart from all forms of the *Dipodomys agilis* group living from Monterey in California to the coastal locality of Santa Catarína (Lat. 29° 40′) in Baja California. The writer has been wholly unable to adjust these outstanding characters into the *agilis* subspecies group and believes a clearer delineation is provided by elevating *Dipodomys agilis peninsularis* from the *agilis* races into specific characterization, as *Dipodomys peninsularis peninsularis.* This form typifies a closely related group of four races, with characters that are compatable with the geographic and ecological conditions under which they live.

Specimens of *D. agilis plectilis* and of *D. peninsularis pedionomus* have been taken in fairly close proximity, but not yet together. The inter-relationships of *agilis* and *pedionomus* may be determined when collections are made in a large area lying northward of the Llano Buenos Aires, on which San Agustín and El Marmol are situated. Friends who have flown over this region report having seen canyons in which large groves of fan palms were growing and state that this inland territory appeared extremely desert-like from the air.

MATERIAL AND ACKNOWLEDGEMENTS

In this study of the *peninsularis* group of kangaroo rats, 268 specimens have been examined, from 34 localities in Baja California. Of this number, 242 are in the collection of the San Diego Society of Natural History, 14 are in the Huey Collection, and 10, including the type of *Perodipus simulans peninsularis,* have been borrowed from the United States Biological Survey (now the Fish and Wildlife Service), through the generosity of the late Major E. A. Goldman, and 2 have been borrowed from the Dickey Collection, now at the University of California in Los Angeles, through the courtesy of the late A. J. Van Rossem.

Dipodomys peninsularis peninsularis (Merriam)

VISCAÍNO DESERT KANGAROO RAT

Original description.—*Perodipus simulans peninsularis* Merriam, Proc. Biol. Soc. Washington, Vol. 20, p. 79, July 22, 1907.

Type locality.—Santo Domingo (= Santo Domingo Landing), Lower (= Baja) California, Mexico, Lat. 28° 51′ N. Nelson recorded (Mem, Nat. Acad. Sci., Vol. 16, p. 30, 1921) that he and Goldman were camping on the date when this type specimen was collected, at the sight of the old well near the edge of a mesa-like shelf, some three miles inland from the landing beach, elevation about 50 feet.

Distribution.—The area inhabited by *D. p. peninsularis* is principally the Viscaíno Desert of the central part of the peninsula, from below Punta Prieta (at about Lat. 28° 40′) south to the vicinity of San Ignacio (Lat. 27° 20′), thence over the peninsula divide to El Valle de Yaquí, which lies between San Ignacio and Santa Rosalía on the Gulf slope.

Specimens from coastal regions west of San Ignacio are not available and to the writer's knowledge, no *Dipodomys peninsularis* has ever been collected coastwise between the type locality of *D. p. peninsularis* at Santo Domingo Landing, latitude 28° 15′, and San Jorge, latitude 25° 40′, the northernmost point of *Dipodomys peninsularis australis.*

Remarks.—Specimens from Santa Gertrudis Mission are slightly paler than those from the type locality and have slightly larger, more inflated skulls. Sufficient material might reveal an isolated race. A notable example of mastoid inflation is found in specimen No. 7010, San Diego Society of Natural

History, from Mesquital, April 13, 1928. These bullae are so expanded that the supraoccipital and interparietal are almost completely enveloped. The dorsal interspace between the left and right mastoids, a deep sulcus, measures less than 0.3 mm. Another specimen, No. 579, collection of L. M. Huey, from Campo Los Ángeles, March 31, 1928, has the cranium heavily perforated, almost like a sieve, by parasite borers. Similar examples have been found by the writer at El Valle de la Trinidad in northern Baja California and at Pellisier's Ranch in northern Owen's Valley, Mono County, California.

Specimens examined.—Baja California: 11 miles south of Punta Prieta, 1; La Lomita María, 2 (1 from Huey Collection); Mesquitál, 17 (3 from Huey Collection); Santo Domingo Landing, latitude 28° 15′ (type locality), 8 (2 from Biological Survey, including type); 5 miles west of El Cañón, 4 (1 from Huey Collection); Calmallí, 14 (5 from Huey Collection, 2 from Biological Survey Collection); 4 miles east of El Arco, 4; 5 miles east of El Arco, 4; 12 miles east of El Arco, Rancho Mira Flores, 8; Santa Gertrudis Mission, 3; Rancho Unión, 15 miles east of Calmallí, 3; 1 mile east of Rancho Lagunítas (Lat. 28° 30′), 3; Poso Altimisano, 1 (from Biological Survey Collection); Campo Los Ángeles, 9 (4 from Huey Collection); San Ignacio, 7 (1 from Huey Collection, 3 from Biological Survey Collection); 18 miles east of San Ignacio, 1; 10 miles west of Santa Rosalía, Valle de Yaqui, 3.

Dipodomys peninsularis pedionomus[1] subsp. nov.

CHAPALA KANGAROO RAT

Type.—From 2 miles north of Chapala Dry Lake, on Llano de Santa Ana, lat. 29° 30′ N., long. 114° 35′ W., Baja California, Mexico; No. 8363, San Diego Society of Natural History; adult male; collected by Laurence M. Huey, October 17, 1930.

Subspecific characters.—Compared with *Dipodomys peninsularis peninsularis, D. p. pedionomus* is darker on the sides, back and ears and has larger hip spots and correspondingly narrower hip stripes. The tail stripes are blacker and are about equal in color and size above and below. The white side striping is narrower than that found on the tail of *D. p. peninsularis. D. p. pedionimus* has a narrower, more elongated skull than *peninsularis* with less inflated mastoid bullae and more truncated, less bulbous tympanic bullae. Compared with *Dipodomys agilis martirensis* and *D. a. plectilis, D. p. pedionomus* shows the characters of the nominate race, namely, brighter color, heavily boned tail, brighter, more buffy dorsal color tones of pelage and extremely inflated bullae. Material examined by the writer so far shows no overlap in these characters.

Measurements of type.—Total length, 290; tail, 175; hindfoot, 42; ear, 13. Skull: Greatest length, 41.0; width across bullae, 25.0; spread of maxillary arches, 20.1; greatest length of nasals, 14.4; width of maxillary arches at middle, 5.0.

Range.—This is the northernmost race of the *peninsularis* group. It is

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[1] Greek—dwelling on plains.

found over the inland llanos from southeast of San Fernando Mission south to the valley region below Punta Prieta and eastward to Valle de Agua Amargá and San Borjas Mission.

Specimens examined.—Baja California: San Agustín, 22; 2 miles north Catariña, 5; 7 miles south Catarina, 11; 13 miles northwest of Chapala, 15; 2 miles northwest of Chapala (type locality, including type) 48; 25 miles north Punta Prieta, 9; Punta Prieta, 14; El Valle de Agua Amargá, 1; San Andrés, 1; San Borjas Mission, 6.

Dipodomys peninsularis eremoecus[1] subsp. nov.

Gulf-coast Kangaroo Rat

Type.—From 7 miles west of San Francisquíto Bay, lat. 28° 30′ N., Gulf of California, Baja California, Mexico; No. 15619, San Diego Society of Natural History; adult male; collected by Laurence M. Huey, March 31, 1947.

Subspecific characters.—Compared with *Dipodomys peninsularis peninsularis, D. p. eremoecus* is more pallid dorsally, with decidedly paler tail stripes and blacker terminal tuft. The under tail stripe is much lighter and narrower than the upper one and on some specimens is almost obsolescent. The hip stripe is very wide and the hip spot is proportionately reduced. The colored portion of the soles of the hind feet are much reduced in width and narrower than in any other member of the *peninsularis* group yet seen. The white spot above the eye is much larger than that of *D. p. peninsularis.* In cranial characters *D. p. eremoecus* resembles *D. p. peninsularis* but has slightly less inflated mastoid bullae with more elongated and less inflated tympanic bullae. The tooth row is shorter and molariform teeth are smaller.

Measurements of type.—Total length, 288; tail, 170; hindfoot, 44; ear, 14. Skull: Greatest length, 39.2; width across bullae, 25.2; spread of maxillary arches, 21.7; greatest length of nasals, 13.1; width of maxillary arch at middle, 4.7.

Range.—Known so far from the wide llano-like region that borders Santa Terésa and San Francisquíto bays on the Gulf side of Baja California, near latitude 28°.

Remarks.—This form is the lightest colored race of the *peninsularis* group and is the only member of the five-toed kangaroo rats whose population lives near the Gulf shores. The area in which this race is found is the northernmost growing range of a number of plants belonging to the flora of the Cape region. Some of the most noteworthy are as follows: Palo Blanco *Lysiloma candida;* Fig, *Ficus palmeri; Euphorbia xanti;* Blue morning glory, *Jacquemontia abutiloides* and *Desmanthus fruticosus.* The presence of these plants belonging to the cape flora indicates a definite climatical influence northward along the Gulf coast strong enough to permit their invasion. That this same condition has changed the characters of *Dipodomys peninsularis* is demonstrated in the pallid coloration of *D. p. eremoecus.*

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[1] Greek—desert inhabiting.

Specimens examined.—Baja California, Mexico: Santa Terésa Bay, Gulf of California, 2 (from the Dickey Collection); 7 miles west of San Francisquíto Bay, 21 (type locality, including the type).

Dipodomys peninsularis australis subsp. nov.

MAGDALENA PLAIN KANGAROO RAT

Type.—From Santo Domingo, Magdalena Plain, Baja California, Mexico, lat. 25° 30′ N.; No. 14734, San Diego Society of Natural History; adult male; collected by Laurence M. Huey, November 21, 1941.

Subspecific characters.—As compared with *Dipodomys peninsularis peninsularis*, its nearest relative to the northward, *D. p. australis* is slightly darker dorsally with darker ears and with the upper and under black tail stripes much blacker and well defined, extending into the tail tuft. The under tail stripe of *D. p. australis* in this character is far more constant than it is in the races to the northward. Soles of hind feet and ankles are black. This character too, like the undertail stripe, is decidedly more variable on specimens from the northern and central sections of the peninsula where the soles of the feet are often narrowly colored or of a faded grayish cast. Cranially *Dipodomys peninsularis australis* differs from *D. p. peninsularis* in having more massive, inflated mastoid bullae and more enlarged and swollen auditory bullae. The mastoid bullae protrude farther backward, leaving a deeper occipital sulcus between them, thus depreciating the size of both the supraoccipital and the interparietals.

Measurements of type.—Total length, 298; tail, 184; hindfoot, 42; ear 12. Skull: Greatest length, 40.2; width across bullae, 26.6; spread of maxillary arches, 21.1; greatest length of nasals, 13.1; width of maxillary arch at middle, 4.9.

Range.—So far as known this subspecies ranges over the Magdalena Plain from San Jorgé in the northernmost section, south to Matancita, a ranch inland from the mouth of Magdalena Bay at about latitude 24° 40′, the southernmost station yet recorded.

Remarks.—Toward the Cape district the *merriami* and *peninsularis* group show a remarkably parallel development of the black or blackish coloring of the tail tufts. The black coloring is particularly intense in this newly named race, however most of the races of *peninsularis* have dark or very dusky tail tufts but *australis* has the blackest tuft of all.

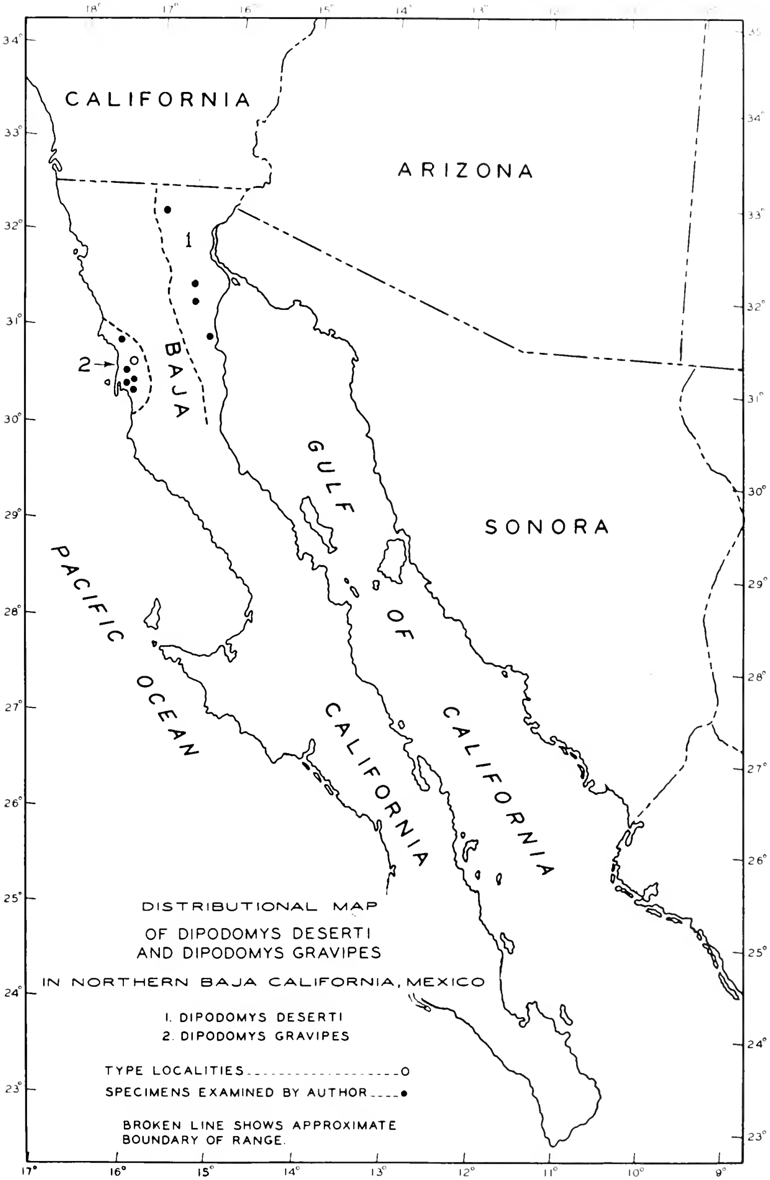
The extreme inflation of the mastoid bullae of this southernmost race is likewise notable, for it is another example of mastoid enlargement in races or species of *Dipodomys* living in sparsely brushed or brush-less regions, as compared with those living in heavily brush-covered areas. The progressive inflation of the bullae in races of the five-toed species from the international boundary southward through ever decreasing chaparral cover is very notable.

Specimens examined.—Baja California: San Jorgé, 1; Santo Domingo, lat. 25° 30′ N., 13 (including type); 7 miles north El Refugio, 1; 9 miles south El Refugio, 4; Matancito, 2 (from the Collection of the U.S. Biological Service, now Fish and Wildlife Service).

TABLE III

AVERAGE, MINIMUM AND MAXIMUM MEASUREMENTS OF ADULT SPECIMENS OF FOUR RACES OF THE *DIPODOMYS PENINSULARIS* GROUP FROM BAJA CALIFORNIA

Name and Locality	Number of Specimens	Total Length	Tail	Hind Foot	Ratio of Tail to Body	Greatest Length of Skull	Breadth Across Bullae	Spread of Maxillary Arches	Greatest Length of Nasals	Width of Maxillary Arch at Middle
MALES										
Dipodomys peninsularis peninsularis	3	291.0	176.3	42.0	153%	40.3	25.3	20.6	13.9	4.7
Santo Domingo Landing, Baja California. (Topotypes)		285–302	170–189	42–42		39.7–41.0	24.8–26.1	20.1–20.9	13.7–14.1	4.6–4.9
Dipodomys peninsularis pedionomus	5	282.0	167.4	40.6	145%	39.0	24.4	20.2	13.8	4.7
2 Miles North Chapala, Baja California. (Topotypes)		275–290	162–172	40–43		38.0–39.5	24.1–24.7	19.7–21.0	13.5–14.0	4.5–5.0
Dipodomys peninsularis eremoecus	5	292.4	176.2	43.2	151%	39.8	25.5	21.6	14.0	4.8
7 Miles West San Francisquito Bay, Baja California. (Topotypes)		288–302	170–182	42–44		39.2–41.5	24.5–26.7	21.0–22.4	13.1–15.0	4.7–5.0
Dipodomys peninsularis australis	5	292.2	175.8	42.2	149%	39.7	25.8	20.6	13.7	4.8
Vicinity Magdalena Bay, Baja California.		280–300	168–184	41–44		38.2–41.2	24.3–26.9	18.6–22.1	13.1–14.5	4.6–4.9
FEMALES										
Dipodomys peninsularis peninsularis	3	281.0	167.3	41.3	146%	39.6	25.5	21.5	13.8	4.9
Santa Domingo Landing, Baja California. (Topotypes)		274–287	162–173	40–42		39.3–39.9	25.3–25.7	21.1–21.8	13.8–14.0	4.5–5.3
Dipodomys peninsularis pedionomus	5	284.6	173.0	40.6	155%	39.3	25.0	20.7	13.9	4.7
2 Miles North Chapala, Baja California. (Topotypes)		278–290	167–175	40–42		38.5–40.3	24.5–25.6	20.1–21.6	13.5–14.6	4.5–4.9
Dipodomys peninsularis eremoecus	5	276.4	163.2	42.4	144%	39.1	25.0	21.0	13.4	4.8
7 Miles West San Francisquito Bay, Baja California. (Topotypes)		270–282	158–168	42–43		38.7–39.5	24.7–25.5	20.8–21.4	13.1–13.8	4.6–5.1
Dipodomys peninsularis australis	5	287.8	171.8	41.6	147%	40.1	25.6	21.0	13.8	5.0
Vicinity Magdalena Bay, Baja California.		280–302	165–185	41–42		39.5–41.3	25.1–26.3	20.7–22.1	13.2–14.2	4.6–5.6


CALIFORNIA
ARIZONA
SONORA
BAJA
1
2
PACIFIC OCEAN
GULF OF CALIFORNIA
DISTRIBUTIONAL MAP
OF DIPODOMYS DESERTI
AND DIPODOMYS GRAVIPES
IN NORTHERN BAJA CALIFORNIA, MEXICO
1. DIPODOMYS DESERTI
2. DIPODOMYS GRAVIPES
TYPE LOCALITIES ○
SPECIMENS EXAMINED BY AUTHOR ●
BROKEN LINE SHOWS APPROXIMATE
BOUNDARY OF RANGE.

Map 6

Deserti Group

This group is one of the most specialized groups of the whole genus *Dipodomys,* if not the most specialized. It is formed of one species divided into two races. *Dipodomys deserti* is one of the largest of the kangaroo rats and the common name "Big Desert Kangaroo Rat" is thoroughly descriptive.

A small portion of the range of the nominate race *Dipodomys deserti deserti* reaches into the most arid section of northeastern Baja California and the species is known to occur as far south as San Felipe.

Dipodomys deserti is truly a child of the desert. Its habitat niche, always confined to the Lower Sonoran Zone, is restricted to the most silty or sandy soils or aeolean dunes of the hottest deserts. Wherever such soil conditions are found over the deserts of eastern California, southern Nevada, western and southwestern Arizona, northeastern Baja California or western Sonora, this species is usually present. At some localities, where sand dunes border the extreme northwestern and the northeastern shores of the Gulf of California, the species can be found almost to the water's edge.

A section of the range occupied by *deserti* in Sonora, Mexico, approaches the arid Tropical Zone and within this area, color characters sufficient for racial determination have been developed. This pelage trend is toward darker dorsal coloration and is paralleled in the development shown by populations of *D. merriami* that approach the arid tropical zone of the Cape of Baja California.

A further resemblance to other members of the genus is shown in the predilection of *deserti* to inhabit an area towards a zone below its main zonal niche rather than the zone above it.

This is a four-toed species, with ponderously developed auditory bullae and correspondingly small ears. Its pelage is extremely pallid. These outstanding characters all reflect the open, almost grassless, sandy regions of its habitat.

Dipodomys deserti lives in loose colonies and occupies large conspicuous burrows, the openings of which are never plugged. These open burrows invite many coinhabiting enemies which no doubt take great toll. Members of this species are great trail makers. Their padded tracks can be followed easily in the soft sand even by a novice, and prove to be a positive index to the inhabited burrows in which, according to the writer's experience, but a single adult lives.

This habit also offers some light on the amount of inter-burrow social calling that is made nightly by the various colony members. So persistently do these big kangaroo rats follow their trails, which, as before stated, are most often made on soft wind blown sand, that an observer is forced to believe that they are possessed of rather keen eyesight, for surely no other faculty would guide them so unerringly along these trails on dark moonless nights.

At this point, it might be well mentioned that moonless nights are the nights of greatest activity amongst all forms of *Dipodomys.* This statement has been proven by the writer on many occasions when trap lines set during the full moon would yield poor catches and lines set over the same ground on dark nights would have the opposite results.

MATERIAL

In the account of this group, 14 specimens of *Dipodomys deserti deserti* from 4 localities in Baja California have been examined (Map 6).

Dipodomys deserti deserti Stephens

BIG DESERT KANGAROO RAT

Original description.—Dipodomys deserti Stephens, Am. Nat., Vol. 21, No. 1, p. 42, January 1887.

Type locality.—Mojave River, California (= Mojave River, 3 or 4 miles from and opposite Hesperia, San Bernardino County, California.)

Distribution.—In Baja California, where proper arenaceous ground is to be found, from the vicinity of Pilot Knob westward along the international boundary to the base of the Coast Range Mountains, thence southward along the eastward edge of the Pattie Basin (See Map, Plate 2, in The Salton Sea, MacDougal, Carnegie Inst. Wash. Pub. 193, June 1914), skirting the desert base of the Sierra San Pedro Mártir at least to the latitude of San Felipe. The great salt flats and the vegetated regions of the Colorado River delta, determine its eastern limit of range in the peninsula. In all probability *Dipodomys deserti* will be found farther south in the narrowing, wedge-shaped, arid region bordering the Gulf of California below San Felipe. This section of the peninsula is exceptionally difficult of access and to the writer's knowledge, it remains, as yet, unexplored by mammalogists.

Specimens examined.—Baja California: 40 miles north of San Felipe, 1; 30 miles north of San Felipe, 1; San Felipe, 7; De Mara's Well on western side (old beach line) of Laguna Salada, 35 miles below international boundry, 5.

Heermanni Group

This group of broad-faced kangaroo rats is represented in Baja California by a single endemic species, *Dipodomys gravipes,* which has an extremely limited range.

The *heermanni* group as defined by Grinnell, is composed of 8 species, one of which comprises nine races. All but two species of this lot are found north of latitude 34° 30′ in California, north of the mountain chain which runs roughly in a west to east direction from Point Conception in Santa Barbara County to the San Bernardino Mountains in San Bernardino County.

The broken range and scattered and varied geographical localities in which a number of species of the *heermanni* group live, when compared with the almost continuously occupied range of the more homogenous *agilis* group, offers some evidence of fact that the *heermanni* group is older, that it had occupied its range long before the *agilis* group began its expansion. At present, mountain ranges and rivers offer unsumountable barriers that bisect the ranges of members of the *heermanni* group. Thus the region must have been occupied before these geological barriers came into existence, or at least, before the avenues of expansion were closed as they are today.

One basic character, the broad face, is common to all members of the group. This, in itself, indicates that, at one time in their history, all forms of this group were closely interrelated, possibly as races. Yet today there are to be found species within this group having such divergently developed characters as: light colored pelage and dark colored pelage, white-tipped and non-white-tipped tail, and even the threatened loss of a toe, with one member of the group. These differences it would seem are attributable to isolation.

The two species of the *heermanni* group that live south of the Sierra Madre barrier in California are *Dipodomys stephensi,* which is found in San Jacinto Valley in Riverside County, and *Dipodomys gravipes,* which occurs 250 miles to the southward in the vicinity of San Quintín, Baja California. Both occupy extremely limited ranges and both are found in areas also inhabited by races of the *agilis* group. In fact, the *agilis* group, of which several races are involved, blanket the entire coastal area from the Sierra Madre in California south to the vicinity of El Rosario in Baja California. These two species of the *heermanni* group living in their midst are like small islands in a great sea.

The superficial resemblance between *Dipodomys stephensi* and *D. gravipes* in some characters and the present distance between their ranges, would indicate that they had occupied the intervening area at some remote time, much as do the forms of *agilis* today. Thus it seems that the more virile *agilis* group had, either by more rapid reproduction or by food competition, reduced the range of this declining *heermanni* group until today it occupies small and remote areas, in which, through isolation, characters sufficient for species determination have been developed.

In their invasion of Baja California the representatives of the *deserti* and the *heermanni* groups have reached approximately the same latitude and both have apparently been checked in their advancement by some biological or geological barrier. The fact that the range of the *heermanni* representative is now decidedly restricted in bounds whereas that of *deserti* is still connected to the main body of its population would argue for the *heermanni* being the older group of the two. However, there are as yet no dependable bases from which the age of either could be computed.

MATERIAL

In this group 30 specimens of *Dipodomys gravipes,* from four locations in Baja California, have been used (Map 6).

Dipodomys gravipes Huey

SAN QUINTÍN BROAD-FACED KANGAROO RAT

Original description.—*Dipodomys gravipes* Huey, Proc. Biol. Soc. Washington, Vol. 38, p. 83, May 26, 1925.

Type locality.—2 miles west of Santo Domingo Mission, Baja California, Mexico (lat. 30° 45′ N.).

Distribution.—So far as known from the vicinity of the type locality south over the llano and foothills east of San Quintín, a distance of about 20 miles, and north over the Llano de Camalú to the San Telmo River.

Specimens examined.—Baja California: 3 miles south of San Telmo, 2; 2 miles west of Santo Domingo Mission (type locality, 17 (6 from Huey Collection); mouth of Agua Chiquitá Canyon, 11 (4 from Huey Collection); Santa María near San Quintín, 1; San Quintín, 1; mile south of San Ramón, 1. (For map see page 250.)

TRANSACTIONS

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THE VOGDES COLLECTION OF TRILOBITES

BY

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SAN DIEGO, CALIFORNIA

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TABLE OF CONTENTS

NORTH AMERICAN FAMILIES

PAGE

EUROPEAN FAMILIES

TABLE OF CONTENTS *(Continued)*

THE VOGDES COLLECTION OF TRILOBITES

by

B. F. Howell

Professor of Geology and Paleontology, Princeton University

From 1904 to 1920 General A. W. Vogdes, the eminent bibliographer on North American trilobites, served as President of the San Diego Society of Natural History. At his death in 1923 his large collection of trilobites was, in accordance with the terms of his will, presented to the Society. Some of the trilobites in this collection are type specimens and others are of sufficient importance to merit discussion and illustration. In order that interested students may know the location of these types and the other trilobites in the collection, an annotated list of them is here presented, together with detailed descriptions and illustrations of the more important specimens.

The writer is indebted to Dr. Joshua L. Baily, Jr., Research Associate of the San Diego Society of Natural History, to the late Mr. Clinton G. Abbott, Director of the Society, to Professor Arthur F. Fischer, the present Director, and to Professor Baylor Brooks, of San Diego State College (where this collection was deposited on loan when the writer examined it) for the opportunity to study these fossils. To these gentlemen he expresses his gratitude for the many courtesies which they extended to him. The writer is grateful also to Miss Alice W. Barlow, former Librarian of the San Diego Scientific Library, for her cooperation. He made much use of the Vogdes Library of Geology and Paleontology, which was in her care.

The Vogdes collection of trilobites consists of a miscellaneous assortment of North American Cambrian, Ordovician, Silurian, Devonian, and Caboniferous specimens (including the types of some of the species described by General Vogdes and of one species described by A. F. Foerste), a smaller number of specimens from the Cambrian, Ordovician, Silurian, and Devonian rocks of England, Scandinavia, Germany, and Bohemia, and some forty specimens from Silurian beds in New South Wales, identified and presented by the Australian paleontologist, John Mitchell. It includes representatives of 120 species.

The North American specimens will be listed and discussed first. Two of them are described as new species.

The Vogdes Collection catalog number of each series is given.

NORTH AMERICAN SPECIES

Order Hypoparia

Family Trinucleidae

Cryptolithus tessellatus Green

Cryptolithus tessellatus Green, Mon. trilobites N. Amer. 1832, p. 73, cast 38, pl, 1, fig. 4.

Cryptolithus tessellatus Green, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, pp. 295–296 (gives full bibliography to 1910).

Cryptolithus tessellasus Green, Raymond. Ottawa Naturalist, vol. 26, 1913, p. 4.

Cryptolithus tessellatus Green, Shimer and Shrock, Index fossils N. Amer,. 1944, p. 643, pl. 267, figs. 2–5.

Cryptolithus tessellatus Green, Wilson, Canadian Geol. Surv. Bull. 9, 1947, p. 13, pl. 1, fig. 3.

Four cephala, one a young shield, are labelled "Lower Silurian, no locality". As they are preserved in pieces of black limestone that also contain the brachiopod, *Zygospira recurvirostris* (Hall), they are probably from the middle Ordovician Trenton Formation of New York. No. 146.

Several dozen other cephala, associated with a number of different species of bryozoans and an unidentified *Zygospira* on the upper surface of a block of grey limestone that is labeled as having come from the "Cincinnati Group" are probably from the Upper Ordovician of Ohio or an adjacent state. No. 141

Order Opisthoparia

Family Olenidae

Triarthrus becki Green

Triarthrus becki Green, Mon. trilobites N. Amer. 1832, p 87, cast 34, pl. 1, fig. 6.

Triarthrus becki Green, Bassler, U. S. Nat. Mus., Bull. 92, vol. 2, 1915, pp. 1286–1287 (gives full bibliography to 1910).

Triarthrust becki Green, Shimer and Shrock, Index fossils N. Amer. 1944, p. 654, pl. 252, figs. 17, 18, pl. 276, fig. 22.

Five cranidia (one of them very large) and an almost entire test, in black Upper Ordovician "Utica Slate" from New York, No. 151.

A small cranidium, and a hypostome and associated thorax and pygidium, probably from the Utica Formation of New York. No. 152.

Several cranidia and entire tests, associated with tests of *Ogygites canadensis* (Chapman), in gray weathering black "Utica Slate" (Collingwood Formation) from Georgian Bay, Ontario. Nos. 139 and 140.

Several small cranidia and pygidia and a small entire test, in Upper Ordovician gray shale form the vicinity of Cincinnati, Ohio. Nos. 147 and 152.

Family Dikelocephalidae

Subfamily Richardsonellinae

Richardsonella unisulcata Rasetti

Plate 1, fig. 1.

Richardsonella unisulcata Rasetti, Jour. Paleont., vol. 18, 1944, p. 256, pl. 39, figs. 54–56.

A cranidium in a gray Upper Cambrian limestone from Point Lévis, Quebec, appears to be referable to this species. It is one of five specimens from this locality, all in the same kind of limestone, that were associated in the Vogdes Collection. Each of the five is in a separate piece of rock; but all probably came from a single Upper Cambrian pebble in the Ordovician Lévis Conglomerate that crops out at this locality. The two other species of trilobites found in the other four pieces of limestone are described below. All five specimens are numbered 104 in the Vodges Collection. They all appear to be members of the late Late Cambrian, Trempealeauian, *Hungaia magnifica* Fauna. The specimen of *Richardsonella unisulcata* is numbered 104A.

Loganellus macropleurus Rasetti

Plate 1, fig. 2.

Loganellus macropleurus Rasetti, Jour. Paleont., vol. 18, 1944, p. 247, pl. 38, figs. 15–17.

A cranidium, in gray limestone at Point Lévis, Quebec, and presumably from the same Upper Cambrian pebble in the Ordovician Lévis Conglomerate that yielded the cranidium of *Richardsonella unisulcata* that is described above, is believed to be referable to this species. This specimen is numbered 104B.

Family Lloydiidae

Lloydia parva, new species

Plate 1, figs. 3–4.

Three pygidia in gray limestone from Point Lévis, Quebec, which probably came from the same Upper Cambrian pebble in the Ordovician Lévis Conglomerate as did the cranidia of the two species discussed above, appear not to be referable to any known species and are therefore here described as new. They are small, averaging 8 mm. long and 9 mm. wide. The entire pygidium is of moderate convexity, with the axis rising well above the pleural lobes and extending a little beyond the pleural lobes at the rear. There are four well defined segments in the anterior half of the axis and indistinct traces of two or three more in the rear half, the posterior part of which shows no segmentation. There is a convex border, about 1 mm. wide, which is separated from the pleural lobes by a marginal furrow. The surface of the entire pygidium is smooth.

Location of Types.–The pygidium chosen as the holotype is no. 104C. The other two pygidia, numbered 104D and 104E, are paratypes.

Discussion-Because of their association with the cranidia of *Richardsonella unisulcata* and *Loganellus macropleurus*, species that have been described by Professor Rasetti as members of the Upper Cambrian, Trempealeauian, *Hungaia magnifica* fauna of the Lévis region, it is believed that *Lloydia parva* is also a member of that fauna.

It is possible that the three pygidia that are here referred to this new species, *Lloydia parva*, are in reality pygidia of one of the other species described by Professor Rasetti from Upper Cambrian pebbles in the Lévis conglomerate in volume 18 of the Journal of Paleontology, for many of Professor Rasetti's species are known only from their cranidia. However, none of Professor Rasetti's cranidia appear to be referable to the genus *Lloydia* or to any other genus that has a cranidium similar enough to the cranidium of *Lloydia* so that it is likely to have had a pygidium like the pygidia here described.

Lloydia is more commonly found in Lower Ordovician than in Upper Cambrian rocks; and *L. parva* is perhaps one of the oldest species of the genus yet discovered. Our pygidia are smaller than most of the pygidia of the Lower Ordovician species of *Lloydia* whose tail shields are known. It is just such a pygidium as one would expect to find in a very early form of the genus or in a genus ancestral to *Lloydia*. It is of about the same size as the pygidium of *Lloydia seelyi* (Walcott), of the Upper Cambrian Potsdam Sandstone of New York; but it has a smaller and less completely segmented axis and a wider border than the New York species. It also has a narrower axis and a wider border than *L. brevis* Raymond, of the Highgate Formation of Vermont.

Family Bathyuridae

Bathyurus extans (Hall)

Plate 1, figs. 5–7.

Asaphus? extans Hall, Pal., New York, vol. 1, 1847, p. 228, pl. 60, figs. 2. 2a–c.

Bathyurus extans (Hall), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p 105 (gives full bibliography to 1913).

Bathyurus extans (Hall), Shimer and Shrock, Index fossils N. Amer., 1944, p. 639, pl. 267, fig. 37.

Bathyurus extans (Hall), Wilson, Canadian Geol. Surv. Bull. 9, 1947, pp. 16, 17, pl. 2, figs. 5, 6.

An associated thorax and pygidium and a free cheek and cranidium that may have belonged to the same individual, in black limestone of the Middle Ordovician Black River Formation from Great Bend, Jefferson County, New York. No. 122.

Family Asaphidae

Ogygites canadensis (Chapman)

Plate 1, fig. 8; plate 2, figs. 1-2.

Asaphus canadensis Chapman, Canadian Journ., vol. 1, 1856, p. 482.

Ogygites canadensis (Chapman), Bassler, U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 869 (gives full bibliography to 1913).

Nine large and small entire tests, a cephalon, and a number of cranidia and pygidia, all in black shale of the Ordovician Collingwood Formation of Georgian Bay, Ontario. Two of the small tests and the cephalon are figured here. Nos. 121, 139, 140, 172, 176, 182, 184, 185, 190-192, 198-200.

One slab of shale from the Collingwood Formation of Georgian Bay in the Vogdes Collection (no. 176) that contains pygidia and other fragments of *Ogygites canadensis* holds also a fragment of a thoracic segment of a huge trilobite, presumably an *Isotelus* and probably *Isotelus gigas* DeKay. Further mention of this is made in the discussion of *I. gigas* below.

Isotelus gigas DeKay

Plate 2, fig. 3; plate 3, fig. 1, plate 4, fig. 1-2.

Isotelus gigas DeKay, Ann. Lyceum Nat. Hist. New York, vol. 1, 1824, p. 176, pl. 12, fig. 1, pl. 13, fig. 1.

Isotelus gigas DeKay, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, pp. 676-677 (gives full bibliography to 1914).

Isotelus gigas DeKay, Shimer and Shrock, Index fossils N. Amer. 1944, p. 647 pl. 268, figs. 2-3.

Isotelus gigas DeKay, Wilson, Canadian Geol. Surv. Bull. 9, 1947, p. 24, pl. 3, figs. 2a-c, 3.

Two entire tests and one pygidium in black limestone of the Middle Ordovician Trenton Formation. One of the tests, the small one that is figured here, is from Herkimer County, New York (no. 183). The other is from Crab Island, Lake Champlain (no. 180). The pygidium has no label, but is probably from somewhere in New York (no. 195).

Two entire tests, two cranidia, two free cheeks, a hypostome, and several fragments from Ordovician limestones in Kentucky and possibly adjacent states. The largest test (no. 186) is from Lexington, Kentucky, and a note on its label states that it shows Panderian organs. A somewhat smaller one (no. 189), which is here figured, is from Kentucky also (probably from Lexington). The hypostome (no. 188) is labeled as having come from Lexington, and all the other specimens (nos. 179, 196 (a doublure), 197, and 200) except two are probably also from that city. Of these two, one, an enrolled test of a small individual (no. 178), is labeled as having come from Cincinnati, Ohio, and another, also a pygidium (no. 181), has no label, so that its locality is unknown.

This last pygidium is accompanied by a sheet of paper on which are printed the figure and description of a cross section of the shield which are reproduced on plate 4. Three cross section slices of this shield are in the Vogdes Collection (no. 181).

The writer has tried without success to discover whether the above printed figure and description were ever published. The box containing the pygidium and the sheet describing it were probably mailed to Professor James D. Dana some time during the eighteen-seventies, for it has, pasted on one side, Professor Dana's address and on another side postage stamps that were issued during that period. But a careful search of the bibliographies and the literature of that time has yielded no evidence of the publication of such a description or figure.

The rock in which the specimen is preserved resembles that in which the specimens from Kentucky and the Cincinnati region were found, and the specimen probably came from that general area. The markings which are interpreted as traces of the internal anatomy of the trilobite may not actually be such.

All the above specimens are referred to *Isotelus gigas* because none of their free cheeks bear spines, the feature which is said to be characteristic of the related species, *Isotelus maximus* Locke.

As noted above, in the discussion of *Ogygites canadensis,* there is, in a slab of black shale from the Ordovician Collingwood Formation of Georgian Bay, Ontario, in the Vogdes Collection a single fragment of a thoracic segment of a huge species of trilobite that is probably *Isotelus gigas*. The trilobite of whose test this segment was a part must have been two feet or more in length.

Isotelus maximus Locke

Isotelus maximus Locke, 2nd Ann. Rept. Geol. Surv. Ohio, 1838, p. 246, figs. 8, 9.

Isotelus maximus Locke, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, pp. 678-679 (gives full bibliography to 1914).

Isotelus maximus Locke, Wilson, Canadian Geol. Surv. Bull. 9, 1947, p. 26, pl. 3, fig. 1.

Two fragments of hypostomes (no. 194) are preserved in a piece of gray limestone that also holds shells of the Lower Silurian (Richmondian) brachiopod, *Catazyga headi schuchertana* (Ulrich) and the free cheek of an unidentified species of trilobite. As *Catazyga headi schuchertana* is a characteristic species of the Richmondian Waynesville Formation, the two hypostomes are probably from that formation. As *Isotelus gigas* is said not to range up into Richmondian beds, while *I. maximus* has been recorded from such beds, there hypostomes are probably referable to *I. maximus*.

Vogdesia vigilans (Meek and Worthen)

Plate 2, fig. 4.

Asaphus (Isotelus) vigilans Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1870, p. 53.

Nileus vigilans (Meek and Worthen), Bassler, U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 857 (gives full bibliography to 1913).

Vogdesia vigilans (Meek and Worthen), Shimer and Shrock, Index fossils N. Amer., 1944, p. 654, pl. 268, figs. 20, 21.

Four enrolled tests, one of them a young one (figured here), from the Lower Silurian (Richmondian) Lower Maquoketa Formation of Fayette County, Iowa (no. 120). The eyes of the young test are less prominent than those of the two largest tests. The eyes of the test that is intermediate in size between the two largest tests and the small test are intermediate in their prominence also.

Family Illaenidae

Bumastus insignis (Hall)

Illaenus insignis Hall, adv. sheets 18th Rept. New York State Cab. Nat. Hist., 1865, p. 27, figs. 5–6.

Bumastus insignis (Hall), Bassler, N. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 141 (gives full bibliography to 1910).

Bumastus insignis (Hall), Shimer and Shrock, Index fossils N. Amer., 1944, p. 639, pl. 269, figs. 10–12.

Two cranidia in gray dolomite of the Middle Silurian (Niagaran Racine Formation, one from Bridgeport, Illinois (no. 105), and one from Wauwatosa, Wisconsin (no. 96), have the elongate, relatively narrow, form and long dorsal furrow that are characteristic of this species. Two pygidia from the same formation at Wauwatosa (no. 97) also appear to be referable to the species.

Bumastus chicagoensis (Weller)

Plate 3, fig. 3.

Illaenus chicagoensis Weller, Chicago Acad. Sci. Bull. 4, pt. 2, 1907, pp. 220–222, pl. 16, figs. 10–12.

A single pygidium (no. 105) in gray dolomite of the Middle Silurian (Niagaran) Racine Formation at Bridgeport, Illinois, agrees exactly with Weller's description of the tail shield of this species. As Weller did not figure the pygidium of *B. chicagoensis* and it has apparently not been illustrated by any other author, a figure of our specimen is presented here, although the shield is not complete.

Bumastus armatus (Hall)

Plate 3, fig. 4–6.

Illaenus armatus Hall, adv. sheets, 18th Rept. New York State Cab. Nat. Hist., 1865, p. 26, figs. 3–4.

Bumastus armatus (Hall), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, pp. 139–140 (gives full bibliography to 1910).

Two cephala (no. 102) and a pygidium (no. 103) from gray dolomite of the Middle Silurian (Niagaran) Racine Formation at Bridgeport, Illinois, are referable to this species. The pygidium is evenly convex throughout and has a median ridge that extends one-third of the way forward from the rear edge of the shield. This pygidium and the two cranidia are figured here. The dorsal furrow is more deeply impressed toward the front on the smaller cephalon (which may be an immature shield) than it is on the larger cephalon.

It is just possible that the pygidium here referred to *B. armatus* may be a tail shield of the species which Weller (Chicago Acad. Sci. Bull. 4, pt. 2, 1907, pp. 224–225, pl. 16, figs. 7–9) called *Illaenus transvarsalis*, for the pygidium of that species must have been very similar to that of *Bumastus armatus*. It is, however, not probable that this is the case, for cranidia of the *Bamastus* occur at the locality where our pygidium was found.

The possibility that Weller's "*Illaenus transversalis*" may be a *Bumastus* rather than an *Illaenus* raises another question, however, for in 1903 Weller (Geol. Surv. New Jersey, Pal., vol. 3, p. 195, pl. 14. fig. 14) gave the name *Bumastus transversalis* to an Ordovician species from New Jersey, and, if the Niagaran species is also a Bumastus, its name will have been preoccupied and it will require a new one. The writer has not been able to locate in any museum a specimen of Weller's *Illaenus transversalis* that has any of the thorax preserved, so he has not been able to determine whether that Illinois Silurian species is actually an *Illaenus* or a *Bumastus*. He will be grateful for information concerning any specimen that will afford evidence as to the true generic position of the species.

Bumastus ioxus (Hall)

Bumastus barriensis Hall (not Murchison), Geol. New York, pt. 4, 1843, p. 102, fig. 4, p. 101, tab. org. rem., 10, fig. 4, and 19, fig. 2.

Illaenus ioxus Hall, 20th Rep. New Cork State Cab. Nat. Hist., 1867, p. 387, fig., pl. 22, figs. 4–11, pl. 23, fig. 1.

Bumastus ioxus (Hall), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 142 (gives full bibliography to 1910).

Bumastus ioxus (Hall), Shimer and Shrock, Index fossils N. Amer., 1944, p. 639, pl. 269, figs. 13, 14.

Two cephala, one large and one small, from gray dolomite of the Middle Silurian (Niagaran) Racine Formation at Racine, Wisconsin (no. 99).

Bumastus cuniculus (Hall)

Plate 3, fig. 7, plate 5, fig. 1.

Illaenus cuniculus Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 337, pl. 22, fig. 12.

Bumastus cuniculus (Hall), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 140 (gives full bibliography to 1907).

A large cephalon, a small cranidium, a right free cheek, and a small pygidium, all from gray dolomite of the Middle Silurian (Niagaran) Racine Formation at Wauwatosa, Wisconsin. Both the large and the small cranidia have the elongate, narrow, glabella and short dorsal furrows that are characteristic of this species. The cephalon and cranidium and the pygidium are no. 101; the free cheek is no. 100. The large cranidium shows the doublure. The cephalon and the cranidium are figured here. All are topotypes. Unfortunately the pygidium is partly covered by the small cranidium. Enough of it can be seen, however, to show that it, like the smaller cranidium, is of medium convexity throughout and is about as long as it is wide.

Bumastus? vogdesi, new species

Plate 3, fig. 2.

A single pygidium from Dug Gap, Walker County, Georgia, that was presumably collected from the Middle Silurian Clinton beds present at that locality, would seem to be that of a new species of Illaenidae, probably a *Bumastus*. It is described below as such and is named in General Vogdes' honor.

Pygidium, the only part of the test known, twice as wide as long, of low convexity, with the front corners evenly and obtusely rounded. No traces of an axis or dorsal furrow are visible on the single known specimen, which is exfoliated; but the axial portion of the front edge of the shield protrudes forward and clearly indicates the width of the axial part of the pygidium. The rear portion of the shield is not depressed, and there is no trace of a median ridge on our specimen.

Location of type–The holotype pygidium is no. 95 in the Vogdes Collection.

Formation and locality–Fine grained brown sandstone of Clintonian (early Niagaran, early Medial Silurian) age at Dug Gap, Walker County, Georgia.

Discussion–In its general form this pyidium resembles the tail shield of *Bumastus imperator* (Hall), of the late Niagaran (late Medial Silurian) Racine Formation; but it differs from the pygidium of *B. imperator* in being longer in proportion to its width and in not having the anterior end of the axis defined by dorsal furows. If we may judge from our single shield, *B. vogdesi* was also a smaller species than *B. imperator*.

A small piece of fine grained gray sandstone which accompanies the piece holding the holotype of *Bumastus imperator*, and which therefore probably came from the same formation and locality, contains internal molds of two Orthoid brachiopods and the right half of the cranidium of what is probably an undescribed species of *Acidaspis*. Unfortunately this last fragment is too incomplete and poorly preserved for identification or description.

Genus and species undetermined

A squeeze of an entire trilobite which may possibly be an illaenid of some kind, although its dorsal furrow is too well developed for that of a typical member of that family, is no. 50 in the Vogdes Collection. It bears no label, and its characters cannot all be clearly seen. It is possibly a squeeze of a specimen in some private collection that has never been figured. The writer hs not been able to identify it.

Family Proetidae

Proetus parviusculus Hall

Proetus parviusculus Hall, 13th Rep. New York State Cab. Nat. Hist., 1860, p. 120.

Proetus parviusculus Hall, Bassler U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 1039 (gives full bibliography to 1895).

An enrolled test from the Cincinnati region, and therefore presumably from the Upper Ordovician (Maysvillian) Corryville Formation (no. 24). The genal spines have been broken off because of their enrollment; but otherwise this is a good example of this small early proetid.

Proetus, Species undetermined

Plate 5, fig. 2.

A single small free cheek, referred by General Vogdes to *Calymenella rostrata*, but almost certainly the cheek of a small species of *Proetus*, is preserved in fine grained gray sandstone of Clintonian, Medial Silurian age from Taylor's Ridge, near Catoosa Station, Catoosa County, Georgia (no. 129). It is impossible to determine the species to which this free cheek belongs, and it may be the cheek of an undescribed form. It is figured here to call attention to the presence of a small species of *Proetus* at this locality. Doubtless future investigators will discover cranidia of the species there.

General Vogdes recorded "*Proetus*" from this locality (Amer. Jour. Sci. 3rd ser., vol. 18, 1879, p. 477), and his record may have been based on this free cheek, since there are no other examples of *Proetus* from Taylor's Ridge in his collection; but, if he did assign the cheek to that genus, he did not label it as such.

Proetus crassimarginatus (Hall)

Plate 5, fig. 3.

Calymene crassimarginatus Hall, Geol. New York, Geol. 4th Dist., 1843, p. 172, fig. 5.

Proetus crassimarginatus (Hall), Bassler, U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 1038 (gives full bibliography to 1909).

Proetus crassimarginatus (Hall), Shimer and Shrock, Index fossils N. Amer., 1944, p. 651, pl. 274, figs. 18, 19.

Two cranidia, a pygidium, and some fragments, labeled as having come from Vermont, but presumably collected somewhere in New York, appear to be referable to this species (no. 37). They are preserved in a fine grained light gray limestone that must be of Devonian age and is probably from the Middle Devonian Onondaga Formation. Two other pygidia (nos. 40 and 41) in the same kind of rock (presumably also from the Onondaga Formation) are labeled as having come from the Devonian of Columbus, Ohio (no. 40). and of Kelly Island, Lake Erie (no. 41), and the specimens labeled as having come from Vermont may also have come from one of these two localities.

Proetus clarus Hall

Proetus clarus Hall, 15th Rept. New York State Cab. Nat. Hist., 1862 pp. 99, 100.

A single pygidium, which accompained the specimens of *P. crassimarginatus* referred to above and is preserved in the same fine grained gray limestone, is believed to be a tail shield of this species (no. 37). Although its locality is given as "Vermont" and its formation is not recorded on its label, it is also probably from the Middle Devonian Onondaga Formation of New York.

Proetus doris Hall

Plate 3, figs. 8–9.

Proetus doris Hall, 13th Rep. New York State Cab. Nat. Hist., 1860, p. 112.
Proetus doris Hall, Weller, U. S. Geol. Surv. Bull. 153, 1898, p. 505 (gives full bibliographly to 1887).

Phillipsia doris (Hall), Herrick, Bull. Sci Labs. Denison Univ., vol. 2, 1887, p. 62.

A cast of one of Hall's type pygidia of this species and an additional cast of an almost entire test (both no. 26). Hall's types came from the Carboniferous "Goniatite Limestone" (Waverly Group) at Rockford, Indiana. The locality of the entire test is not indicated on the label, but is presumably also Rockford. These casts were probably used by General Vogdes in the preparation of his discussion of this species that was published in the Annals of the New York Academy of Sciences, vol. 4, 1887, pp. 90–91. In that paper

General Vogdes referred the species to *Phillipsia*, as had been done earlier by Alexander Winchell (Proc. Acad. Nat. Sci. Phila., 2nd ser., vol. 2, 1865, p, 133); but in his own personal copy of this paper, which is in the Vogdes Library, he has indicated that subsequent to the publication of the paper he decided that the species belonged in *Proetus*. His final opinion is probably the correct one, for Winchell states that the species has 11 thoracic segments, which is too many for a *Phillipsia*, but not too many for a *Proetus*, and the pygidium, while it is long for a *Proetus*, is also short for a *Phillipsia*. Winchell appears to have assigned the species to *Phillipsia* because of the weakness of the glabellar furrows; but that feature alone is not diagnostic in *doris*, for its glabella has faint furrows, like those of some species of *Proetus*. *P. doris* is, in general, intermediate between a typical *Proetus* and a typical *Phillipsia*, as might be expected of an Early Carboniferous proetid.

As this species appears never to have been figured, illustrations of our casts are presented here, although the casts are poor and difficult to photograph. The location of Hall's orginal types of the species is not known to the writer. They are not listed as being in either the collection of the New York State Museum or that of the American Museum of Natural History.

Proetus haldemani Hall

Plate 5, figs. 4–5.

Proetus haldemani Hall, 15th Rep. New York State Cab. Nat. Hist., 1862, pp. 102–103.

Proetus haldemani Hall, Hall and Clarke, Geol. Surv. New York, Palaeont. vol. 7, 1888, pp. 113–116, pl. 21, figs. 7–9, pl. 33, figs. 13–15 (gives full bibliography to 1887).

Proetus haldemani Hall, Shimer and Shrock, Index fossils N. Amer. 1944, p. 653, pl. 74, fig. 6.

A beautifully preserved enrolled example of this species, from the Middle Devonian Hamilton Formation at Judd's Falls, on the road between Cherry Valley and Sharon Springs, New York, is no. 39. The specimen is figured here.

Proetus bairdensis Wheeler

Plate 5, fig. 6.

Proetus ellipticus Meek and Worthen, Vogdes, Proc. Calif. Acad. Sci. (meeting), Oct. 17, 1892, Zoe, vol. 3, 1892, p. 274.

Proetus bairdensis Wheeler, Trans. San Diego Soc. Nat. Hist., vol. 8, no. 8, 1935, pp. 49–51, pl. 6, figs. 1–3 (gives full bibliography to 1894).

There is in the Vogdes Collection a trilobite, preserved in a fine grained brown sandstone from the Middle Carboniferous Baird Formation at Baird, on the McCloud River, in Shasta County, California, that is labeled "*Proetus ellipticus* Meek and Worthen" (no. 31). The specimen is a mold of the under side of the test and consists of the pygidium, most of the thorax, and the right free cheek. Although such parts of the test as are preserved indicate that the trilobite had the same general form as *P. ellipticus*, the following facts make is very probable that the Shasta County form is a distinct species: the axes of the thorax and pygidium appear to be narrower than the axes of that species (if one can judge from the published figures of the latter); the brim of the free cheek seems to have been wider; there must have been a brim on the pygidium (something which *P. ellipticus* did not have); *ellipticus* was described from Illinois, which is geographically so far distant from California that the species found in the two regions are not likely to be alike.

Wheeler, who examined other specimens of this trilobite from the Baird Formation of Shasta County some years ago, was also of the opinion that they were not referable to *P. ellipticus* and proposed* for them the new name "*Proetus bairdensis*".

Wheeler stated that reference to the specimen in the Vogdes Collection had been made in print†, but that the specimen was "no longer available for study", so he was apparently unaware that it was in the Vogdes Collection. As our specimen is in some respects a more complete one than the specimens on which Wheeler based his description of *P. bairdensis*, it is described in detail below.

Of the various parts of the cephalon, only the free cheek is known. As nearly as can be determined from our specimen this cheek resembles that of *P. ellipticus*, as figured by Meek and Worthen (Geol. Surv. Illinois, vol 3, 1868, pl. 14, fig. 8) and by General Vogdes (Ann. New York Acad. Sci., vol. 4, 1887, pl. 3, fig. 3), except that the brim is wider. The posterior portion of the genal spine is broken off, however, and the spine may well have been longer that it was in *ellipticus*.

The thorax of our specimen appears to have consisted of eight segments but presumably had nine, since Wheeler found nine in his specimens. The axial portion, which is more than one-third of the width of the thorax in *ellipticus*, is almost exactly one-third the width of the thorax in *bairdensis*.

The axis of the pygidium is at its widest part (the front end) hardly one-third the width of the shield (it is fully one-third in *ellipticus*), tapers evenly backward more rapidly than in *ellipticus*, and is a little longer than in the Illinois species, so that the rear end has a more pointed appearance. There appear to have been seven ribs on the pleural lobes (the rear ribs are indistinct—Wheeler says there are eight or nine ribs on his specimens), and there must have been ten or more segments in the pygidial axis (the exact number in our specimen cannot be determined because of damage). Wheeler states that there are about thirteen segments in his specimens. There must have

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* Wheeler, Harry E., "New trilobite species from the Anthracolitic of northern California", Trans. San Diego Soc. Nat. Hist., vol. 8, 1935, pp. 49-51, pl. 6, figs. 1-3.

† In Zoe, vol. 3, 1892, p. 274. The writer has not seen this reference.

been a margin on the pyidium that was not only thickened (as the brim of *ellipticus* is said to be) but was also of some width.

Location of plesiotype–No. 31 in the Vogdes Collection. Wheeler (op. cit., p. 51) states that a plastotype of one of his specimens is no. 272 in the trilobite collection of the San Diego Society of Natural History.

Formation and locality–Baird Formation, Carboniferous, Baird, McCloud River, Shasta County, California. Wheeler (op. cit., p. 51) states that the beds in which *P. bairdensis* occurs are probably of Early Moscovian age, Middle Carboniferous.

It is difficult to determine the exact proportions of the test of our specimen of *P. bairdensis* because the specimen is a mold of the under side of the test and all the furrows and the brims are accentuated. But, when we make all possible allowance for this fact, the species would seem to be distinct from *P. ellipticus*. Other differences from that species will probably be disclosed when the entire cephalon of *P. bairdensis* is known.

Cyphaspis christyi Hall

Plate 5. fig. 7–8.

Cyphaspis christyi Hall, Trans. Albany Inst., vol. 4, 1864, p. 220.

Cyphaspis christyi Hall, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 339 (gives full bibliography to 1889).

Cyphaspis christyi Hall, Shimer and Shrock, Index fossils N. Amer. 1944, p. 643, pl. 276, figs, 11–13.

An enrolled test, labeled as having come from the Middle Silurian Niagaran Group (no. 156). The label does not indicate the locality, but the specimen looks as though it had been collected from the Waldron Formation of Waldron, Indiana.

Brachymetopus lodiensis (Meek)

Phillipsia (Griffithides) lodiensis Meek, Pal. Ohio, vol. 2, 1875, p. 323, pl. 18, fig. 3.

Brachymetopus lodiensis (Meek), Weller, U. S. Geol. Surv. Bull. 153, 1898, p. 149 (gives full bibliography to 1888).

Brachymetopus lodiensis (Meek), Shimer and Shrock, Index fossils N. Amer. 1944 p. 639, pl. 275, fig. 28.

An incomplete test in gray shale from the Lower Carboniferous Cuyahoga Formation at Lodi, Ohio, the type locality of the species (no. 19).

Brachymetopus cuyahogae (Claypole)

Plate 6, fig. 1.

Dalmanites? cuyahogae Claypole, Geol. Mag. Dec. 3, vol. 1, 1884, p. 306, text-fig. A (p. 305).

An incomplete pygidium in black shale of the Lower Carboniferous Cuyahoga Formation from Akron, Ohio (no. 66).

This species was described by Claypole in 1884 on the basis of the pygidium alone. Claypole considered it to be a species of *Dalmanites*, but it is a *Brachymetopus*. Its pygidium is remarkable because each of the ribs of the pleural lobes ends in a spine; but other species of *Brachymetopus*, such as *B. armatus* Vogdes, in which the last pair of ribs on the pleural lobes are extended into spines, and *B. spinosus* (Herrick), which has short spines on each of the ribs of the pleural lobes, also have spinose pygidia.

As Claypole's figure of the holotype pygidium of this species would appear to be inaccurate in that the spines are made to appear too long and the edge of the shield too uneven, the pygidium in the Vogdes Collection is figured here, even though it is incomplete.

Phillipsia insignis Winchell
Plate 5, fig. 9.

Phillipsia insignis Winchell, Proc. Acad. Nat. Sci. Phila. 1863, p. 24.

Phillipsia insignis Winchell, Weller, U. S. Geol. Surv. Bull. 153, 1898, p. 421 (gives full bibliography to 1887).

Casts of three pygidia that are labeled as being this species and probably are such, from Curryville, Missouri (no. 34). As the species was described from the Lower Carboniferous Burlington Limestone these specimens probably came from that formation. Since this species appears not to have been figured an illustration of one of these casts is presented here.

Phillipsia major Shumard
Plate 6, figs. 2–3.

Phillipsia major Shumard, Trans. St. Louis Acad. Sci., vol. 1, 1858, p. 226.

Phillipsia major Shumard, Weller, U. S. Geol. Surv. Bull. 153, 1898, p. 422 (gives full bibliography to 1897).

A complete pygidium and an almost complete cranidium from a white Upper Carboniferous limestone at Kansas City, Missouri (no. 33). The pygidium agrees with the description of the tail shields on which the species is based. The cranidium has the glabella almost quadrate in form, but somewhat rounded in front and a little expanded at the rear. It is difficult to determine from our specimen, which is largely exfoliated, how many glabellar furrows are present; but there appears to be a pair of incomplete, backward-curving furrows opposite the front ends of the eyes and a pair of longer furrows that curve backward from a point opposite the middle of the eyes to the neck furrow to mark off large basal lobes. The preglabellar area is about as wide as the eye lobe, and the neck ring is about equally wide. The whole shield is moderately convex, and the test appears to have been smooth.

The writer has not seen an entire example of this species; but General Vogdes has left a manuscript description of such a specimen on the margin of page 85 of his personal copy of his paper. "The genera and species of North American Carboniferous trilobites" (Ann. New York Acad. Sci., vol. 4, 1887, pp–105, pls. 2 and 3) that reads as follows:

"Remarks on an entire specimen from collection of F. A. Sampson, Sedalia, Mo. Pygidium axis well marked with 16+ rings. Sides with 10 ribs, surface smooth. Thorax with 9 segments, test smooth. Glabella and fixed cheeks. Glabella convex, with nearly straight sides, slightly tumid, marked on both sides with 2 short furrows opposite the eyes and by well defined basal lobes. Occipital lobe prominent, below the plane of the glabella. Occipital furrow deep. Limb concave."

Phillipsia sampsoni Vogdes

Plate 6, fig. 4.

Phillipsia sampsoni Vodges, Trans. New York Acad. Sci., vol. 7, 1888, p. 248, 2 figs.

Phillipsia sampsoni Vodges, Keyes, Missouri Geol. Surv., vol. 4, 1894, p. 235.

Phillipsia sampsoni Vogdes, Weller, U. S Geol. Surv. Bull. 153, 1898, p. 423.

Phillipsia sampsoni Vogdes, Shimer and Shrock, Index fossils N. Amer. 1944, p. 651, pl. 276, figs. 1–3.

A beautiful small entire test in gray limestone of the Lower Carboniferous (Waverly Group) Chouteau Formation at Banks, Pettis County, Missouri (no. 36).

In his orginal description of this species General Vogdes stated that there were three pairs of glabellar furrows, althought his figure showed only two. A very faint trace of a fourth furrow can be seen on the glabella of our specimen. Whether this is due to the fact that our specimen is unusally well preserved, or whether it is due to its being somewhat smaller than (and therefore younger than) the specimen figured by General Vogdes, the writer is unable to say.

Phillipsia stevensoni Meek

Plate 6, fig. 5.

Phillipsia stevensoni Meek, 3rd Ann. Rept. Board Regents West Virginia Univ., 1870, p. 73.

Phillipsia stevensoni Meek, Vogdes, Ann. New York Acad. Sci., vol. 4, 1888, p. 88, pl. 3, fig. 6.

Phillipsia stevensoni Meek, Weller U. S. Geol. Surv. Bull. 153, 1898, p. 424.

A pygidium, with two thoracic segments attached, in gray shale of the Lower Carboniferous Chester Group from Monongalia County, West Virginia (no. 35).

Ditomopyge scitula (Meek and Worthen)

Griffithides scitula Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1865, p. 270.

Griffithides scitula Meek and Worthen, Weller, U. S. Geol. Surv. Bull. 153, 1898, p. 303 (gives full bibliography to 1897).

Ditomopyge scitula (Meek and Worthen), Shimer and Shrock, Index fossils N. Amer., 1944, p. 645, pl. 275, figs. 4–6.

Two incomplete pygidia in gray shale from the Upper Carboniferous at the "Willard Coal Mine, Carter County, Kentucky, south terminus of East Kentucky R. R.", appear to be referable to this species (no. 20).

Griffithides bufo Meek and Worthen

Plate 6, fig. 6; plate 7, fig.1.

Phillipsia (Griffithides) bufo Meek and Worthen, Proc. Acad. Nat. Sci. Phila., 1870, p. 52.

Giffithides bufo Meek and Worthen, Weller, U. S. Geol. Surv. Bull. 153, 1898, pp. 301–302 (gives full bibliography to 1887).

Giffithides bufo Meek and Worthen, Shimer and Shrock, Index fossils N. Amer., 1944, p. 647, pl. 275, fig. 9.

An excellently preserved entire test (no. 32), the cast of a good and somewhat larger test (no. 25), and a poorly preserved entire test of still larger size (no. 32), all from gray limestone of the Lower Carboniferous Keokuk group of Crawfordsville, Indiana. The smaller test and the cast are figured.

Family Odontopleuridae

Ceratocephala anchoralis (Miller)

Plate 7, fig.2.

Acidaspis anchoralis Miller, Cincinnati Quart. Jour. Sci., vol. 2, 1875, p. 349, figs. 23, 24.

Acidaspis anchoralis Miller, N. Am. Geol. Pal., 1889, p. 526, text. figs. 951, 952.

Ceratocephala anchoralis (Miller) Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 196.

Two cranidia in gray shale of the Upper Ordovician Maysville Formation of the Cincinnati region, Ohio, are probably both referable to this species, although one of them is labeled "*Acidaspis cincinnatiensis*".

The larger of these two cranidia (no. 109) has a very long and heavy neck spine, while the smaller one (no. 111) has a much shorter and more slender one. The figure of the type cranidium given by Miller has a neck spine that is intermediate in size between those of our two specimens. It would seem that if all three of these crandia are referable to *Ceratocephala anchoralis* there must have been much varation in the size of the neck spine in that species. Possibly the individuals with the heavier spines were males, those with more slender spines females.

It is possible that one or both of these cranidia are referable to one of the other two species of *Ceratocephala* which have been described from the Upper Ordovician beds of the Cincinnati region, *Ceratocephala ceralepta* Anthony and *C. cincinnatiensis* (Meek); but since these two species appear to have been based on pygidia alone and their cranidia seem not to be known, this question must be left open for the present. Both of these species were described before *C. anchoralis*, and the discovery of an entire test of either of them may demonstrate that the cranidium of *C. anchoralis* belongs with the pygidium of one of the other species.

Order Proparia

Family Encrinuridae

Encrinurus americanus Vogdes

Plate 7, figs. 3–4.

Encrinurus americanus Vogdes, Descr. new Crust. Clinton of Georgia, 1886, p. 1.

Encrinurus americanus Vogdes, Foerste, Bull. Sci. Lab. Denison Univ., vol. 2, 1887, p. 102.

Encrinurus americanus Vogdes, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 477.

The cotypes of this species, preserved in fine grained gray sandstone, are no. 12 in the Vogdes Collection. As their original description appeared without illustrations, in a private publication that is not available to most students and the species has not been figured since, the orginal description is reproduced here and both pygidia are figured. The original description, which appeared in a privately printed paper, entitled "Description of a new crustacean from the Clinton Group of Georgia, with remarks upon others", was published in New York City in 1886 (pp. 1–5, text-figs. 1–4). In addition to the description of *Encrinurus americanus* this paper contained discussions, with figures, of the trilobites *Calymene rostrata* Vogdes *(Calymenella rostrata)* and *Calymene clintoni* Vanuxem *(Calymene vogdesi* Foerste), both, like *Encrinurus americanus*, from Clintonian Middle Silurian beds in Georgia. The original description of *Encrinurus americanus* was as follows:

"Pygidium elongated-triangular in form, strongly arched in the anterior border and very convex, produced behind forming a muronate (mucronate) extension. Length 10 mm., greatest width 8 mm., or nearly ¾ as wide as long.

"Axis narrowly elongated, flattened on the surface and sharply pointed behind, marked by 20 or more axial rings; the first 13 extend entirely across, the others appearing only as notches on the sides, obscurely indicated in the specimens before us. The axis has a central row of nodes, which appear on the 1, 6, 9, and 12 ring (rings), and possibly on others.

"The lateral lobes are marked by six pairs of ribs, the anterior three of which are distinct and free at their outer extremities, the other three being united at their outer ends, the posterior pair being parallel to and appearing almost as a part of the axis. The ribs are abruptly directed backward, and distinctly separated from each other by rather deep grooves, they gradually decrease in size as they approach the termination of the pygidium, being rather flat on the surface. The first pair originate almost opposite the first axial ring, the second between the 2 and 3, the third between the 5 and 6, the fourth between the 7 and 8, the fifth pair run sub-parallel to the axis and the sixth pair are only separated from it by a shallow dorsal furrow.

"This species approaches *Encrinurus elegantulus*, Billings (Cat. Silurian Foss. Anticosti, p. 62), in general form, the axis of this species has 24 axial ring (rings) of which the first 8 or 9 extend entirely across it, the others being represented by elongated pits on each side, but it lacks the nodes. The lateral lobes of *Encrinurus elegantulus* are marked with five pair (pairs) of ribs, the first four being free at their extremities, the fifth pair being slightly curved outwards, and converging toward the axis they unite behind it, and continue as two short sharp spines. Between the fifth rib and the side of the axis there is a narrow smooth space with a faint groove on the inside, it extends round the apex of the axis and seems to be the rudiments of a sixth pair of ribs.

"The principal differences between these species lies in the character of the lateral lobes, *Encrinurus Americanus* having three free and three united ribs in the pygidium; whereas (in) *Encrinurus elegantulus* the first four are free and the other two unite at their extremities, the side ribs originate at the first axial ring, the second pair at the second, the third pair at the fourth, and the fourth pair at the sixth; whereas in the new species the third pair originate between the 5 and 6 axial ring, and the fourth pair between the 7 and 8. The minor differences with regard to the nodes on the axis may be due to the state of preservation.

"The pygidia of *Zethus verrucosus* and *Zethus bellatula* described and figured by Dr. Volborth (Russ. Mineral. Gesellsch. Verhandl., 1848, p. 4, pl. 1, figs. 3, 4, and 7), are in general form similar to those of *Encrinurus elegantulus*. They all have from 4 to 6 side ribs, the anterior ones being free, and the last two or three united at their extremities in rear of the axis. The axis in the Russian species has from 16 to 18 rings, the first 4 or 5 anterior ring (rings) only bearing side ribs, whereas the American species has from 20 to 24 rings, the first 8 to 13 rings extending across it, the side lobes extending down in one species at least to the 8 arial (axial) ring.

"The Russian species have a notched axis, with nodes along the smooth central part.

"*Geological Position*–Clinton Group, Taylor's Ridge, west of Catoosa Station, Catoosa Co., Georgia."

Family Calymenidae

Calymene vogdesi Foerste

Plate 7, figs. 5–7.

Calymene clintoni Vogdes (not Vanuxem), Proc. Acad. Nat. Sci. Phila. 1880, p. 178, figs. 3–4.

Calymene vogdesi Foerste, Bull. Sci. Lab. Denison Univ., vol. 2, 1887, p. 95, pl. 8, figs. 12–16.

Calymene vogdesi Foerste, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, pp. 169–170 (gives full bibliography to 1910).

Calymene vogdesi Foerste, Raymond, Bull. Mus. Comp. Zool., vol. 60, 1916, p. 27.

An incomplete cranidium and a free cheek, both in fine grained gray sandstone, and a pygidium in fine grained dark red sandstone, all from Clintonian, Middle Silurian, beds at Dug Gap, Walker County, Georgia, are no. 133 in the Vogdes Collection. Three other cranidia in fine grained gray sandstone of the same age from Taylor's Ridge, near Catoosa Station, Catoosa County, Georgia, are no. 132. These are evidently some (but not all) of the specimens which General Vogdes identified as *Calymene clintoni* (Vanuxem) in 1880 (Proc. Acad. Nat. Sci. Phila., pp. 177–178, text-figs. 3 and four) and in 1886 (Description of a new crustacean from the Clinton Group of Georgia, with remarks on others, p. 5, text-figs. 3 and 4) and which Foerste (Bull. Sci. Labs. Denison Univ., vol. 2, 1887, p. 96) referred to his species, *Calymene vogdesi.* The cranidium on which text-figures 3 of both of General Vogdes' papers were based is in the Vogdes collection and is reproduced here. Our single free cheek does not appear to be the one from which figures 4 of those two papers were made (General Vogdes stated that he had three free cheeks), and it is therefore figured here also. Our pygidium, which is probably that of a young individual, was not figured by General Vogdes, but is illustrated here. It was said by General Vogdes to have no ribs on the pleural lobes; but, although it is exfoliated, faint traces of such ribs can be seen and they were probably more distinct in unexfoliated shields of the same size. Foerste described the adult pygidium as having six ribs on the pleural lobes.

Calymene celebra Raymond

Calymene blumenbachii niagarensis Hall, Geol. Surv. Wisconsin, vol. 1, 1862, p. 432.

Calymene niagarensis Hall, 18th Rept. New York State Cab. Nat. Hist., 1865, p. 30 adv. sheets.

Calymene niagarensis Hall, 20th Rept. New York State Cab. Nat. Hist., 1868, p. 334; revised edition, 1870, p. 425.

Calymene niagarensis Hall, Weller, Bull. Chicago Acad. Sci., no. 4, pt. 2, 1907, p. 261, pl. 23, figs. 9, 19.

Calymene niagarensis Hall, Bassler (pars), U. S. Nat. Mus. Bull. 92, 1915, p. 168 (refers in part to true *Calymene niagarensis* Hall).

Calymene celebra Raymond, Bull. Mus. Comp. Zool., vol. 60, 1916, pp. 28-29, pl. 3, figs. 9, 10.

Calymene celebra Raymond, Shimer and Shrock, Index fossils N. Amer. 1944, p. 641, p. 272, figs. 6, 7.

Two entire tests (nos. 130 and 131) in gray Niagaran (Middle Silurian) dolomite from Preble County, Ohio, one enrolled test (no. 157) in yellowish dolomite of the Niagaran Racine Formation at Wauwatosa, Wisconsin, two entire tests (no. 127) in gray dolomite, probably of Niagaran age, from Illinois, an entire test, in gray dolomite (no. 163), labeled as having come from the Cincinnati Group at Cincinnati but probably from some Niagaran formation of the Mississippi Valley, and an entire test in reddish dolomite (no. 126), labeled as having come from a "Lower Silurian" formation but probably also from a Niagaran formation of the Mississippi Valley, all have the kind of wide pygidium which is characteristic of *Calymene niagarensis*, with only six segments in the axis and with only four short ribs on the pleural lobes, the outer halves of the lobes being unribbed.

Calymene platys Green

Calymene platys Green, Mon. trilobites N. Amer., 1832, p. 32.

Calymene platys Green, Hall, 15th Rept. New York State Cab. Nat. Hist., 1862, p. 82.

Calymene platys Green, Hall, Illustr. Devonian fossils, 1876, pl. 1, figs. 1-9.

Calymene platys Green, Hall and Clarke, Geol. Surv. New York, Palaeont., vol. 7, 1888, pp. 1-4, pl. 1, figs. 1-9, pl. 25, fig. 1.

Calymene platys Green, Shimer and Shrock, Index fossils, N. Amer. 1944, p. 641, pl. 272, figs. 8-10.

An incomplete cranidium, in black limestone, labeled as having come from the Middle Devonian Onondaga Formation of Genesee County, New York, would appear to be referable to this species (no. 134). It is much smaller than the cranidia of this species figured by Hall, but may be the head shield of a young individual.

Flexicalymene senaria (Conrad)

Calymene senaria Conrad, 5th Ann. Rep. Geol. Surv. New York, 1841, pp. 38, 49.

Calymene senaria Conrad, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 169 (gives full bibliography to 1913).

Flexicalymene senaria (Conrad), Whittington, Jour. Paleont., vol. 15, 1941, pp. 493-498, pl. 72, figs. 1-27, 31-34, 38-40, 42-47.

Flexicalymene senaria (Conrad), Shimer and Shrock, Index fossils of North America, 1944, p. 645, pl. 272, figs. 3–5.

A pygidium in black limestone of the Ordovician Trenton Group from Crab Island, Lake Champlain, has the furrowed ribs of the pleural lobes extending all the way to the rear edge of the shield, as is characteristic of this species (no. 163).

Flexicalymene meeki (Foerste)

Calymene senaria Meek, Geol. Surv. Ohio, Pal. 1, 1873, p. 173, pl. 14, figs. 14a–f.

Calymene meeki Foerste, Bull. Sci. Lab. Denison Univ., vol. 16, 1910, p. 84, pl. 3, fig. 18.

Calymene meeki Foerste, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 167 (gives full bibliography to 1913).

Flexicalymene meeki (Foerste), Shimer and Shrock, Index fossils N. Amer., 1944, p. 645, pl. 272, figs. 1, 2.

Apparently referable to this species are an enrolled test (no. 155), which has no orginal label but is almost certainly from some Upper Ordovician Maysvillian or some Richmondian formation of the Cincinnati region; a cephalon and attached thorax (no. 135), which are labeled as having been collected from Upper Silurian rocks in New York but are very probably also from one of the Maysvillian or Richmondian formations of the Cincinnati region; and four small enrolled tests (no. 138), which are labeled as having come from the Cincinnati region and are therefore likewise from some Maysvillian or Richmondian formation. All of them are excellently preserved.

Liocalymene clintoni (Vanuxem)

Hemicrypturus clintoni Vanuxem, Geol. New York, pt. 3, 1842, p. 79, Fig. 2.

Calymene clintoni (Vanuxem), Hall Palaeontology of New York, vol. 2, 1852, p. 298, pl. A66, figs. 5a–d.

Calpmene clintoni (Vanuxem), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 166 (gives full bibliography to 1909).

Liocalymene clintoni (Vanuxen), Raymond, Bull. Mus. Comp. Zool., vol. 60, 1916, p. 29.

Two small cranidia with very narrow brims, preserved in fine grained gray sandstone (presumably from some Clintonian, Middle Silurian, bed) in Catoosa County, Georgia, agree in form with this species (no. 128). They are smaller than the average adult cranidium of *C. clintoni* and they may be a southern variety of that species; but it is more probable that they are head shields of young individuals of *clintoni*, itself

These specimens were presumably collected by General Vogdes, himself, but he seems to have been in doubt as to their specific identity, for he labeled them merely "*Calymene* sp.?".

Calymenella rostrata (Vogdes)

Plate 7, figs. 8–10.

Calymene rostrata Vogdes, Amer. Jour. Sci., 3rd ser., vol. 18, 1879, p. 477.

Calymenella rostrata (Vogdes), Pompeckj, Neues Jahrb. Min., Geol., Pal., 1898, vol. 1 ,p. 243.

Calymenella rostrata (Vogdes), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 170 (gives full bibliography to 1910).

An almost entire cranidium, a small fragment of a cranidium, part of a small cranidium, an incomplete adult free cheek, a very small free cheek, and two adult pygidia, one exfoliated and one not, are labeled "*Calymene rostrata* Vogdes" by General Vogdes (nos. 129 and 136). These are presumably the cotypes of this species, from the Middle Silurian Clinton beds at Catoosa Station, Georgia, for the almost entire cranidium (no. 129A) and the exfoliated pygidium (no. 136A) appear to be the specimens on which figures 1 and 2 of General Vogdes second description of *Calymenella rostrata* was based (Proc. Acad. Nat. Sci. Phila., 1880, pp. 176–177, text-figs. 1 and 2). Whether all of these specimens are actually referable to this species is doubtful, but this cranidium certainly is, and the figured pygidium probably is, also. The fragment of a cranidium (no. 136B) is so incomplete that its certain identification is not possible, and the large free cheek (no 136C) is possibly referable to *Calymene vogdesi*. The small free cheek (no. 129C) is probably not even the free cheek of a *Calymenella*, but is rather that of a *Proetus*, as noted on an earlier page. The unexfoliated pygidium (no. 129B) differs somewhat in form and proportions from the exfoliated one, but seems to have the same number of axial segments (about eight) as the exfoliated shield and definitely has the same number of ribs on the pleural lobes–five, so it is probably a tail shield of *C. rostrata*.

An additional small pygidium, which is comparable in size to the smaller of the cranidia that are assigned above to *Calymene clintoni* and was placed with those cranidia by General Vogdes, is, however, probably the tail shield of a young *Calymene rostrata* (no. 128), as it agrees in form with the much larger, exfoliated, pygidium of that species discussed above.

Until entire tests of either *Calymene vogdesi* or *Calymenella rostrata* are discovered it will not be possible for us to be certain which of the calymenid pygidia found in the Clintonian beds of Georgia are referable to each of those species. The pygidium that is here assigned to *Calymene vogdesi* has the almost straight rear edge and subtriangular form of the pygidium assigned by Foerste to *C. vogdesi* (Bull. Sci. Labs. Denison Univ., vol. 2, 1887, pl. 8, fig. 16), but the unexfoliated pygidium assigned by General Vogdes to *Calymenella rostrata* has much the general appearance. However, the exfoliated pygidium assigned by General Vogdes to *Calymenella rostrata* has the rear edge more curved than it is in the small pygidium assigned to *Calymene vogdesi*, and the axis of the larger pygidium is narrower in porportion to its length than is that of the smaller pygidium of *C. vogdesi*. The larger *(C. rostrata)* pygidia are also more arched upward at the rear than is the smaller *(C. vogdesi)* pygidium, and in this respect they agree with the cranidia of *C. rostrata*, which are more convex in form than are those of *C. vogdesi*.

Family Homalonotidae

Trimerus delphinocephalus Green

Trimerus delphinocephalus Green, Mon. triobites N. Amer., 1832, p. 82, pl. 32, fig. 1.

Homalonotus delphinocephalus (Green), Murchison, Sil. System. 1839, p. 651.

Homalonotus delphinocephalus (Green), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 632-633 (gives full bibliography to 1910).

Trimerus delphinocephalus Green, Shimer and Shrock, Index fossils N. Amer. 1944, p. 654, pl. 272, fig. 33.

An entire test, preserved in brown weathered limestone presumably of Medial Silurian age and from an unknown locality (no. 153), and a pygidium with thorax attached, in black limestone, also of Medial Silurian age, from Lockport, New York.

Dipleura dekayi Green

Dipleura dekayi Green, Monograph trilobites N. Amer., p. 29, pl. 1, figs. 8, 9.

Homalonotus dekayi (Green), Vogdes, Occ. Pap. Calif. Acad. Sci., no. 4, 1893, p. 311 (gives bibliography to 1888).

Dipleura dekayi Green, Shimer and Shrock, Index fossils N. Amer. 1944, p. 643, pl. 272, figs. 26–31.

A cephalon and attached thorax, preserved in black limestone, labeled as having come from the Middle Devonian Hamilton Group of New York (no. 144).

Family Cheiruridae

Ceraurus pleurexanthemus Green

Plate 8, figs. 1–2

Ceraurus pleurexanthemus Green, Monthly Amer. Jour Geol., 1832, p. 560, pl. 4, fig. 10.

Ceraurus pleuerexanthemus Green, Raymond and Barton, Bull. Mus. Comp. Zool., vol. 54, 1913, pp. 528–533, pl. 1, fig. 1, pl. 2, figs. 1, 2, 7.

Ceraurus pleurexanthemus Green, Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, p. 203 (gives full bibliography to 1913).

Ceraurus pleurexanthemus Green, Wilson, Canadian Geol. Surv. Bull. no. 9, 1947, pp. 50, 51, pl. 9, figs. 3-5.

A young cephalon and attached thorax, preserved in black Middle Ordovician limestone (probably of the Trenton Formation) from New York (no. 137), and an adult cranidium and fragment of a young cranidium, also in black limestone and definitely from the Middle Ordovician Trenton Formation, of Trenton Falls, New York (no. 160).

The glabella of the young cephalon is less convex than that of the adult cranidium, and this makes the glabellar furrows of the young shield more noticable, although they are no longer and no more deeply impressed than they are in the adult one.

Sphaerexochus romingeri Hall

Sphaerexochus mirus Roemer, Die silurische Fauna des westlichen Tennessee, 1860, p. 81, pl. 5, fig. 20.

Sphaerexochus romingeri Hall, Geol. Surv. Wisconsin. vol. 1, 1867, p. 434.

Sphaerexochus romingeri Hall, Bassler, U. S. Nat. Mus. Bull. 92, vol. 2, 1915, p. 1167 (gives fully bibliography to 1910).

Sphaerexochus romingeri Hall, Shimer and Shrock, Index fossils N. Amer. 1944, p. 653, pl. 272, figs. 17-22.

Two young and three adult cranidia in light gray dolomite of the Middle Silurian (Niagaran) Racine Formation at Wauwatosa, Wisconsin (no. 162).

Family Dalmanitidae

Dalmanites limulurus (Green)

Asaphus limulurus Green, Mon. trilobites N. Amer. 1832, p. 48.

Dalmanites limulurus (Green), Billings, Geology of Canada, Geol. Surv. Canada, 1863, p. 320, text-fig. 340.

Dalmanites limulurus (Green), Bassler, U. S. Nat. Mus. Bull. 92, vol. 1, 1915, pp. 384-385 (gives full bibliography to 1913).

An entire test (no. 74) and a pygidium and attached thorax (no. 62), both in dark gray Middle Silurian (Niagaran) limestone from Lockport, New York.

Odontochile concinnus (Hall)

Dalmanites concinnus Hall, Illustrations of Devonian fossils, Crustacea, 1876, pl. 10, figs. 3-5.

Dalmanites (Hausmannia) concinnus Hall and Clarke, Pal. New York, vol. 7, 1888, p. 30, pl. 11A, figs. 9-11.

A single incomplete pygidium in light gray limestone, presumably of Onondagan (Medial Devonian) age, from Columbus, Ohio (no. 81).

Odontochile micrurus (Green)

Asaphus micrurus Green, Mon. trilobites N. Amer., 1832, p. 56, cast 19, pl., fig. 3.

Dalmania micrurus (Green), Hall, Pal. New York, vol 3, 1859, pp. 359–361, pl. 74, figs. 13–20.

Odontochile micrurus (Green), Shimer and Shrock, Index fossils N. Amer., 1944, p. 651, pl. 273, figs. 3, 11.

A pygidium in dark gray limestone, labeled "Upper Silurian, New York", but undoubtedly of Lower Devonian age (no. 60).

Anchiopsis anchiops (Green)

Plate. 8, fig. 3.

Calymene anchiops Green, Mon. trilobites N. Amer., 1832, p. 35, cast 7.

Dalmanites anchiops (Green), Vogdes, Occ. Pap. Calif. Acid. Sci., no. 4, 1893, p. 297 (gives bibliography to 1888).

Anchiopsis anchiops (Green), Delo, Jour. Paleont., vol. 9, 1935, p. 412.

Anchiopsis anchiops (Green), Shimer and Shrock, Index fossils N. Amer., 1944, p. 637, pl. 274, figs. 20–22.

Casts which appear to have been made from Green's holotype pygidium of this species are nos. 72 and 73 in the Vogdes Collection. Cast no. 72 is marked in pencil "16", and a paper label attached to it states that it is Green's cast no. 16, which is the cast of the holotype of *Dalmanites limulurus;* but this is an error. The original cast of the holotype of *anchiops* is Green's cast no. 7. As the cast of the holotype of *A. anchiops* seems not to have been figured, an illustration of cast no. 72 is presented here.

Corycephalus dentatus (Barrett)

Plate 8, fig. 4.

Dalmanites dentatus Barrett, Amer. Jour. Sci. 3rd ser., vol. 11, 1876 p. 200, pl.

Dalmanites dentata Barrett, Amer. Jour. Sci., 3rd ser., vol. 12, 1876, p. 70.

Dalmanites (Corycephalus) dentatus, Barrett, Hall and Clarke, Pal. New York, vol. 7, 1888, p. 58, pl. 11A, figs. 4–6.

Two cephala and a pygidium (no. 59) and three pygidia and a cranidium (no. 58), all in gray Lower Devonian limestone from Port Jervis, New York. The better preserved of the two cephala (no. 59) is figured here.

Coronura aspectans (Conrad)

Asaphus aspectans Conrad, 5th Ann. Rept. Pal. Dept. New York Geol. Surv., 1841, p. 49, text-fig. 9.

Dalmanites aspectans (Conrad), Hall, Illustrations of Devonian Fossils, Crustacea, 1876, pl. 13, figs. 6–8.

Dalmanites (Coronura) aspectans (Conrad), Hall and Clarke, Pal. New York, vol. 7, 1888, p. 33, pl. 13, figs. 1–11, 13.

Dalmanites aspectans (Conrad), Vogdes, Occ. Pap. Calif. Acad. Sci. no. 4, 1893, pp. 297–298 (gives full bibliography to 1888).

Coronura aspectans (Conrad), Shimer and Shrock, Index fossils N. Amer., 1944, p. 643, pl. 274, fig. 27.

Two pygidia in gray limestone of the Middle Devonian Onondaga Formation from Kelly Island, Lake Erie (nos. 71 and 76).

Calliops callicephalus (Hall)

Phacops callicephalus Hall, Pal. New York, vol. 1, 1847, p. 249, pl. 65, figs. 3a–i.

Dalmanites callicephalus (Hall), Vogdes, Occ. Pap. Calif. Acad. Sci., no. 4, 1893, p. 298 (gives full bibliography to 1855).

Calliops callicephalus (Hall), Delo, Jour. Paleont., vol. 9, 1935, p. 417, text-figs. 42, 43 (p. 414).

Calliops callicephala (Hall), Shimer and Shrock, Index fossils N. Amer. 1944, p. 639, pl. 273, figs. 20–23.

Calliops callicephalus (Hall), Wilson, Canadian Geol. Surv. Bull. no. 9, 1947, pp. 56, pl. 10, figs. 5, 6.

A single pygidium in black limestone, probably of the Ordovician Trenton Formation, from New York (no. 68).

Achatella carleyi (Meek)

Plate 8, fig. 5.

Dalmanites carleyi Meek, Amer. Jour. Sci., 3rd ser., vol. 3, 1872, p. 424.

Pterygometopus carleyi (Meek), Bassler, U. S. Nat. Mus. Bull. 92, 1915, p. 1066 (gives full bibliography to 1874).

A cephalon, complete except for the ends of the genal spines, in gray calcareous shale, presumably from the Upper Ordovician (Maysvillian) Fairmount Formation at Cincinnati, Ohio (no. 64).

Family Phacopidae

Phacops rana Green

Plate 9, fig. 1.

Calymene bufo rana Green, Mon. trilobites N. Amer., p. 42, casts 11, 12.

Phacops rana (Green), Hall, Descriptions of new species of fossils from the Upper Helderberg, Hamilton and Chemung groups (advance sheets of 15th Rept. New York State Cab. Nat. Hist.), 1861, p. 65.

Phacops rana (Green), Vogdes, Occ. Pap. Calif. Acad. Sci. no. 4, 1893, pp. 334–335 (gives full bibliography to 1888).

Phacops rana (Green), Shimer and Shrock, Index fossils N. Am., 1944, p. 651, pl. 274, figs. 2–5.

An entire test, two incomplete tests, and a cranidium, preserved in gray shale, and an entire test, enrolled and weathered to a buff color, all said to have been collected from the Middle Devonian Moscow Formation of the Hamilton Group of New York (no. 70), and two entire tests and parts of seven other tests, all from shale of the Moscow Formation type at London, Ontario (nos. 80 and 86). The specimens from London have had their under sides exposed by removal of the matrix so that the features of the lower side of the test can be observed, and the hypostomes and doublures can be seen in place in the two entire tests.

Phacops cacapona Hall

Plate 9, figs. 2–4.

Phacops cacapona Hall, Description of new species of fossils from the Upper Helderberg, Hamilton and Chemung groups (advance sheets of 15th Rept. New York State Cab. Nat. Hist.), 1861, p. 68.

Phacops cacapona Hall, Vogdes, Occ. Pap. Calif. Acad. Sci., no. 4, 1893, p. 333 (gives full bibliography to 1888).

An excellently preserved enrolled specimen of this large species, from Capon Springs, West Virginia, presumably from the Middle Devonian Hamilton Group (no. 82).

Phacops hudsonica Hall

Plate 9, fig. 5; plate 10, fig. 1.

Phacops hudsonica Hall, Pal. New York, vol. 3, 1859, p. 335, pl. 73, figs. 26–28

An excellently preserved enrolled entire test and a poorly preserved cranidium from the Lower Devonian of western Tennessee (no. 88) appear to be referable to this species. The cephalon agrees exactly with the holotype cephalon. The thorax has 11 segments. The ends of the pleura are rounded. The pygidium has about 7 segments in the axis and six ribs on the pleural lobes. These ribs extend to the edge of the shield.

Phacops cristata Hall

Phacops cristata Hall, Description of new species of fossils from the Upper Helderberg, Hamilton and Chemung groups (advance sheets of 15th Rept. New York State Cab. Nat. Hist.), 1861, p. 67.

Phacops cristata Hall, Vogdes Occ. Pap. Calif. Acad. Sci., no. 4, 1893, p. 333–334 (gives full bibliography to 1888).

Phacops cristata Hall, Shimer and Shrock, Index fossils N. Amer. 1944, p. 651, pl. 274, figs. 16, 17.

Two cranidia and a pygidium from the Devonian Schoharie Formation of New York (no. 84).

Phacops cristata pipa Hall

Phacops cristata pipa Hall and Clarke, Pal. New York, vol. 7, 1888, p. 18, pl. 8A, figs. 5–18.

An incomplete pygidium in gray limestone, probably of the Middle Devonian Onondaga Formation, from Columbus, Ohio, is probably referable to this subspecies (no. 81).

Eophacops catoosaensis, new species

Plate 10, figs. 2–4.

Three cranidia and a pygidium of a small species of *Eophacops*, all molds of the under side of the test and all preserved in fine grained sandstone of the Middle Silurian Clinton Group from beside the Chicamauga River, between Catoosa Station and Ringgold, Catoosa County, Georgia, are labeled by General Vogdes "*Phacops catoosaensis MSS*". They seem never to have been described by him, however, and are therefore described here.

Cranidium similar to that of the Middle Silurian Clinton species, *E. trisulcatus* (Hall), but with only 2 pairs of glabellar furrows, and those poorly developed. Neck furrow well developed. Free cheeks unknown.

Thorax unknown.

Pygidium with a narrow axis which tapers slowly and extends almost to the rear edge of the shield. Only one rib can be seen, faintly defined, on each of the pleural lobes of the only known pygidium, and only the faintest traces of two segments can be discerned on the axis.

Discussion–The cranidium of *E. catoosaensis* resembles that of *E. trisulcatus* (Hall) except that it has fewer glabellar furrows. The pygidium of *E. catoosaensis* resembles that of the Middle Silurian Niagaran species *E. handwerki* Weller, except that the axis of the Georgia species is narrower and longer.

Location of types–The holotype, the largest of the three cranidia, is no. 65a in the Vogdes Collection. The other two cranidia, paratypes, are nos

65b and c, and the paratype pygidium (the counterpart of which is also preserved), is 65d.

Formation and locality–Clinton Group, Middle Silurian, bank of Chicamauga River, at the Ringgold end of the bridge on the road from Catoosa Station to Ringgold, Catoosa Station, Georgia.

EUROPEAN SPECIES

Order Hypoparia

Family Harpedidae

Harpes venulosus Corda

Harpes venulosus Corda. Prodrom einer Mongraphie der böhmischen Trilobiten, 1847, p. 164.

Harpes venulosus Corda, Barrande, Systême Silurien du centre de la Bohême, vol.1, 1852, pp. 350–351, pl. 8, figs. 11–15, pl. 9, figs. 11–19.

A cephalon, in white limestone from Stage Ff2 (Silurian) at Konieprus, Bohemia (no. 169). A smaller cephalon, in similar limestone from Bohemia, and therefore probably from the same stage (no. 170).

Family Trinucleidae

Cryptolithus goldfussi Barrande

Trinucleus goldfussi Barrande, Nouveaux trilobites, supplement a la notice préliminaire sur le Systême Silurien et les trilobites de Bohême, 1846, p. 39

Trinucleus goldfussi Barrande, Systême Silurien du centre de la Bohême, vol. 1, 1852, pp. 628–631, pl. 30, figs. 29–40, pl, 35, figs. 30, 31.

Cryptolithus goldfussi (Barrande), Raymond, in Zittel-Eastman, Textbook of paleontology, 2nd edit., vol. 1, 1913, text-fig. 1361 (p. 711).

An almost complete cephalon and a fragment of a cephalon, in lilac-colored fine-grained sandstone of Stage Dd2 (Ordivician) at Veseta, Bohemia (no. 148).

Marrolithus ornatus (Sternberg)

Trilobites ornatus Sternberg, Verh. des vaterl. Mus., 1833, p. 53, pl. 2, figs. 2a, b .

Trinucleus ornatus (Sternberg), Burmeister, Organisation der Trilobiten, 1843, pl. 67.

Trinucleus ornatus (Sternberg), Barrande, Systême Silurien du centre de la Bohême, vol. 1, 1852, pp. 623–628, pl. 29, figs. 1–9, pl. 30, figs. 41–60.

Eight cephala in fine grained gray sandstone of Stage Dd1 (Ordovician) at Vosek, Bohemia (no. 150). Two cephala in fine grained gray sandstone, presumably of Stage D (Ordovician), from an unstated locality in Bohemia (no. 149).

Family Remopleuridae

Caphyra radians Barrande

Caphyra radians Barrande, Notice prèliminaire sur le Systême Silurien et les trilobites de Bohême, 1846, p. 32.

Remopleurides radians Barrande, Systême Silurien du centre de la Bohême, vol. 1, 1852, p. 359–361, pl. 43, figs 33–39.

A small cephalon in gray shale of Stage Dd5 (Ordovician) at Leskow, Bohemia (no. 167).

Order Opisthoparia

Family Olenidae

Protopeltura praecursor (Westergard)

Peltura praecursor Westergard, Lunds Univ. Arskrift, N. F., Afd. 2, Bd. 5, No. 3, 1909, p. 48.

Protopeltura praecursor (Westergard), Sveriges Geologiska Undersökning, Ser. Ca. No. 18, 1922, pp. 171–173, pl. 14, figs. 23–29, 30?, 31, pl. 15, fig. 1 (gives full bibliography to 1922).

Two cranidia and a thorax, unnumbered and preserved in fine grained black limestone which, although it is accompanied by no label except one which reads "Dikelocephalus?", is almost certainly from the Upper Cambrian of Norway or Sweden, are believed to be referable to this species, which occurs in the *Ctenopyge flagellifer* Subzone of the Olenus Beds of Scandinavia.

Aulacopleura konincki (Barrande)

Arethusa koninckii Barrande, Notice prèliminaire sur le systême Silurien et les trilobites de Bohême, 1846, p. 48.

Aulacopleura koninckii (Barrande), Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 84, pl. 5, fig. 48.

Aulacopleura angusticeps Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 85.

Arethusina konincki (Barrande), Systême Silurien du centre de la Bohême, vol. 1, 1852, pp. 495–497, pl. 15, figs. 1–21.

An excellent entire test and a cranidium in gray shale of Stage Ee2 (Silurian) from Lodenice, Bohemia (no. 168).

Family Asaphidae

Asaphus expansus (Linné)

Entomolithus paradoxus expansus Linné Syst. Nat., 12th ed., vol. 3, p. 160.

Entomostracites expansus (Linné,) Wahlenberg, Petrificata Telluris Svecanae, 1818, pp. 25–27.

Asaphus expansus (Linné), Dalman, Vet. Acad. Handl., 1826, p. 241, pl. 3, fig. 3.

Asaphus expansus (Linné), Angelin, Palaeontologia Scandinavica, 1878, pp. 52–53, pl. 28, fig. 1.

Asaphus expansus (Linné), Raymond, in Zittel-Eastman, Text-book of paleontology, 2nd edit., vol. 1, 1913, fig. 1384 (p. 719).

An excellent entire test from the Ordovician Orthoceras Limestone of Husbyfjöl, Ostrogothia, Sweden (No. 177), and an equally good enrolled test (no. 98) from the Ordovician of "Gothland" (probably Ostrogothia), Sweden. Also a cast (no. 75) of an entire test that is very possibly an example of this species, although it bears no label. There are, however, other European species of *Asaphus* that are very similar to *A. expansus*, and the details of the cast are not clear enough to permit of certain identification. The specimen form Husbyfjöl, Ostrogothia, is from Dalman's collection and must be a homeotype.

Nileus armadillo (Dalman)

Asaphus (Nileus) armadillo Dalman, Vet. Acad. Handl., 1826, p. 246, vol. 4, figs. 3a–e.

Nileus armadillo (Dalman), Angelin, Palaeontologia Scandinavica, 1878, p. 19, pl. 16, figs. 5a–c.

A good enrolled test from the Ordovician Orthoceras Limestone of Ostrogothia, Sweden (no. 107). This specimen is also from Dalman's collection, and is therefore presumably a homeotype.

Family Illaenidae

Wossekia katzeri (Barrande)

Illaenus katzeri Barrande, Système Silurien du centre de la Bohême, suppl. to vol. 1, 1872, pp. 72–73, pl. 5, figs. 28–37, pl. 6, figs. 1–4, pl. 14, fig. 36.

Wossekia katzeri (Barrande), Raymond, Bull. Mus. Comp. Zool., vol. 60, 1916, p. 12.

A good cranidium from Stage D. (Ordovician) of Bohemia (no. 94).

Warburg * has questioned the validity of the genus *Wossekia*. She thinks the species, *katzeri*, should perhaps be left in the genus, *Illaenus*.

Illaenus esmarki (Schlotheim)

Trilobites (Asaphus) esmarkii Schlotheim, Isis, 1826, p. 315.

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* Warburg, Elsa, The trilobites of the Leptaena Linestone in Dalarne with a discussion of the zoological position and the classification of the Trilobita, Bull. Geol. Inst. Univ. Upsala, vol. 17, 1925, pp. 99-100 (footnote).

Illaenus esmarkii (Schlotheim), Holm, Kongl. Svenska Vet. Akad. Handl., vol. 7, 1883, p. 55, pl. 3, figs. 1–10, pl. 6, fig. 8.

Illaenus esmarkii (Schlotheim), Holm, Mém. Acad. Imp. Sci. St.-Petersbourg, 7th ser., vol. 33, no. 8, 1886, pp. 47–54, pl. 1, figs. 1–6.

An entire test from the Ordovician Orthoceras Limestone of Husbyfjöl, Ostrogothia, Sweden (no. 106), a tophomeotype from Dalman's collection.

Family Scutellidae

Scutellum umbellifer (Beyrich)

Bronteus umbellifer Beyrich, Über einige böhmische Trilobiten, 1845, p. 35, figs. 12, 13.

Bronteus umbellifer (Beyrich), Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 879–882, pl. 44, figs. 13–24, pl. 48, figs 28–30 (gives full bibliography to 1847).

A pygidium in black Silurian limestone, presumably of Stage F, from Bohemia (no. 45).

Scutellum partschi (Barrande)

Plate 10, figs. 5, 6.

Bronteus partschi Barrande, Notice préliminaire sur le système Silurien et les trilobites de Bohême, 1846, p. 60.

Bronteus partschi Barrande, Système Silurien du centre de la Bohéme, vol. 1, 1852, pp. 870–873, pl. 46, figs. 19–31 (gives full bibliography to 1847).

A cranidium and a hypostome (no. 11), in black limestone of Stage Ec2 (Silurian) at Lochkow, Bohemia. As Barrande's figures of the cranidium and hypostome of this species do not agree exactly with our specimens and may be a little inaccurate, illustrations of our specimens are presented here.

Family Proetidae

Proetus concinnus (Dalman)

Calymene concinna Dalman, Vet. Acad. Handl., 1826, p. 231, pl. 1, figs. 5a–c.

Proetus concinnus (Dalman), Lovén, Vet. Acad. Förhandl, 1845, p. 49, pl. 1, figs. 2a, b.

Proetus concinnus (Dalman), Angelin, Palaeontologia Scandinavica, 1878, p. 21, pl 17, figs. 5–5b.

Forbesia concinna (Dalman), Anglein, Palaeontologia Scandinavica, 1878, p. 22, pl. 17, figs. 5–5b.

A single complete enrolled young test, which was part of a lot of 5 enrolled tests, the other four of which are believed to be young tests of *Cyphaspis elegantula* (all 5 were labled "*Proetus elegantulus*"), is believed to be a young shield of *P. concinnus*, as its surface is smooth and the long glabella has 3 pairs of furrows and reaches forward almost to the rim (no. 38). The specimen is from Silurian limestone on the island of Gothland, Sweden.

Proetus bohemicus Corda

Proetus bohemicus Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 75, pl. 4, fig. 45.

Proetus bohemicus Corda, Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 452-454, pl. 16, figs. 1–15 (gives full bibliography to 1847).

Proetus bohemicus Corda, Raymond, in Zittel-Eastman, Text-book of paleontology, 2nd edit., vol. 1, 1913, text-fig. 1389 (p. 721).

A cephalon in gray limestone, presumably of Stage F (Devonian), from an unrecorded locality in Bohemia (no. 79). Also a cranidium in red Lower Devonian linestone of Stage F2 (Hercynian) from Greifenstein, Hesse (no. 43).

Proetus orbitatus (Barrande)

Trilobites orbitatus Barrande, Notice préliminaire sur le système Silurien et les trilobites de Bohême, 1846, p. 78.

Proetus orbitatus Barrande, Système Silurien du centre de la Bohême, vol. 1. 1852, pp. 444–445, pl. 15, figs. 29–32, pl. 16, figs. 16, 17, pl. 27, fig. 22 (gives full bibliography to 1847).

Two cranidia, a free cheek, and nine pygidia, in red Lower Devonian limestone of Stage F2 (Hercynian) from Greifenstein, Hesse, appear to be referable to this species (nos. 43 and 47). Two other cranidia, a free cheek, and 5 pygidia, in gray limestone of the same formation at Bicken, Germany (no. 42), appear also to be referable to this species.

Proetus myops Barrande

Proetus myops Barrande, Notice préliminaire sur le système Silurien et les trilobites de Bohême, 1846, p. 74.

Proetus myops Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 422–443, pl. 15. figs. 20–22 (gives full bibliography to 1847.)

A free cheek in red Lower Devonian limestone of Stage F2 (Hercynian) from Greifenstein, Hesse (nos. 43), and a free cheek and pygidium in gray Lower Devonian limestone of the same formation at Bicken, Germany (nos. 42 and 47) seem to be referable to this species.

Proetus eremita Barrande

Proetus eremita Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, p. 462, pl. 17, figs. 9, 10.

A pygidium in gray Lower Devonian limestone of Stage F2 (Hercynian) from Bicken, Germany (no. 47).

Proetus venustus Barrande

Proetus venustus Barrande, Notice préliminaire sur le Système Silurien et les les trilobites de Bohême, 1846, p. 64.

Proetus lejurus Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 75.

Proetus venustus Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 467–468, pl. 17, figs. 1–6.

A small entire test, in gray limestone, probably of Stage E (Silurian) in Bohemia, bears no label or number, but agrees so exactly with Barrande's figures of this species that there can be little doubt about its identity or horizon and general locality.

Cyphaspis elegantula (Lovén)

Proetus elgantulus Lovén, Vet. Acad. Forhandl., 1845, p. 51, pl. 1 figs. 4a, b.

Goniopleura elegantula (Lovén), Angelin, Palaeontologia Scandinavica, 1878, p. 23, pl. 17, fig. 7.

Four enrolled young tests from the Silurian of Gothland, Sweden, have the tubercles, wide brim, and almost smooth pygidium of this species (no. 38).

Cyphaspis megalops (McCoy)

Harpes (?) megalops M'Coy, Synopsis of Silurian fossils of Ireland, 1846, pp. 54–55, pl. 4, fig. 5.

An entire test in gray limestone of the Silurian Wenlock Formation of Dudley, England (no. 158).

Dechenella verneuili (Barrande)

Phillipsia verneuili Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, p. 478.

Dechenella verneuili (Barrande), Kayser, Zeit. Deutsch. Geol. Ges., vol. 32, 1880, pp. 705–706, pl. 37, figs. 1–5.

A pygidium in gray limestone of the Eifel Formation (Devonian) of the Eifel, Germany, labeled as being this species (no. 22). It has only about 12 segments in the axis and about 8 ribs on the pleural lobes. This is fewer segments and fewer ribs than the average for this species; but Kayser's figures indicate that the number is less in some pygidia than in others. Kayser records the species from the Stringocephalus Limestone of the Eifel.

Family Odontopleuridae

Acidaspis crenata (Emmrich)

Odontopleura crenata Emmrich, Zur Naturgeschichte der Trilobiten, 1844, p. 17.

Ceraurus cerenatus (Emmrich), Lovén, Vet. Acad. Förhandl., 1845, p. 47, pl. 1, fig. 1.

Acidaspis crenatus (Emmrich), Angelin, Palaeontologia Scandinavica, 1878, p. 34, pl. 21, fig. 6.

Two cephala from the Silurian Gothland Limestone of the island of Gothland, Sweden (no. 110).

Order Proparia

Family Encrinuridae

Encrinurus variolaris (Bongniart)

Calymene? variolaris Brongniart, Histoire naturelle des crustacés fossiles, 1822, pp. 14, 15, pl. 1, figs. 3A-C.

Calymene variolaris Brongniart, Murchison, Silurian System, 1839, p. 655, pl. 14, fig. 1.

Cybele variolaris (Brongniart), Fletcher, Quart. Jour. Geol. Soc. London, vol. 6, 1850, pp. 404–405, pl. 32, figs. 6–10 (gives full bibliography to 1850).

Encrinurus variolaris (Brongniart), Murchison, Suluria, 3rd edit., 1859, text-fig. 64 (6), p. 261, pl. 18, fig. 9.

An enrolled test from the Silurian Wenlock Formation of Dudley, England (13). Also an unnumbered pygidium, labeled "Dudley, England?", which is probably referable to this species.

Encrinurus punctatus (Brünnich)

Entomostracites punctatus Wahlenberg, Petrificata telluris svecanae, 1818, pp. 32–33, pl. 2, fig. 1.

Cybele punctata (Whalenberg), Dalman, über die Palaeaden, 1828, p. 40, pl. 2, figs. 2a, b.

Calymene punctata (Wahlenberg), Murchison, Silurian System, 1839, pl. 23, figs. 8a, b.

Cybele punctata (Wahlenberg), Fletcher, Quart. Jour. Geol. Soc. London, vol. 6, 1850, pp. 403–404, pl. 32, figs. 1–5 (gives full bibliography to 1850).

Encrinurus punctatus (Wahlenberg), Salter, Cat. Cambrian and Silurian fossils in Geol. Mus. Univ. Cambridge, 1873, p. 131, text-fig. (p. 130)

Encrinurus punctatus (Wahlenberg), Raymond, in Zittel-Eastmen, Textbook of Paleontology, 2nd edit., vol. 1, 1913, text-fig. 1399 (p. 724).

A cranidium with thorax attached and a pygidium in gray Silurian limestone from the island of Gothland, Sweden (no. 14).

A pygidium (no. 15) preserved in fine-grained, red-weathering, buff sandstone, labeled as having come from Dudley, England, and therefore presumably of Silurian age, agrees with this species except that there is no medial spine on the rear end. The spine may have been removed by weathering, for the rear end of the shield is exposed. The rock in which this specimen is preserved is not that of the Wenlock Limestone of Dudley, and the locality indicated on the label may be wrong. The pygidium might well be that of the North American species, *E. ornatus* (Hall and Whitfield) which is very similar to *E. punctatus*, but lacks the spine on the end of the shield.

Encrinurus bohemicus (Barrande)

Cromus bohemicus Barrande, Systême Silurien du centre de la Bohême, vol. 1, 1852, p. 828, pl. 43, figs. 15–17.

Encrinurus bohemicus (Barrande), Raymond, in Zittel-Eastmen, Textbook of paleontology, 2nd edit., vol. 1, 1913, text-fig. 1400 (p. 724).

A pygidium in gray limestone of Stage Ee2 (Silurian) from Lochkow, Bohemia (no. 161).

Encrinurus beaumonti (Barrande)

Calymene? beaumonti Barrande, Notice préliminaire sur le Systême Silurien et les trolobites de Bohême, 1846, p. 52.

Amphion beaumonti (Barrande), Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 92.

Cromus beaumonti (Barrande), Barrande, Systême silurien du centre de la Bohême, vol. 1, 1852, pp. 826–828, pl. 43, figs. 6–14.

A cranidium in gray Silurian limestone, presumable of Stage E. from Bohemia (no. 159).

Family Calymenidae

Calymene declinata Corda

Calymene declinata Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 87.

Calymene declinata (Corda), Barrande, Systême silurien du centre de la Bohême, vol. 1, 1852, pp. 570–571, pl. 43, figs. 53–58.

An incomplete cranidium preserved in a fine grained black sandstone is believed to be referable to this species (no. 159). It is probably from the

Ordovician Stage D of Bohemia, since, although it bears no label, it was in a box with another specimen from Bohemia.

Calymene blumenbachi Brongniart

Calymene blumenbachii Brongniart, Histoire naturelle des crustacés fossiles, 1822, p. 11, pl. 1, figs, 1A–D.

Calymene blumenbachi Brongniart, Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852 pp. 566–567, pl. 19, fig. 10, pl. 43, figs. 46–48 (gives full bibliography to 1850).

Calymene blumenbachi Brongniart, Salter (pars), Monograph British trilobites, 1863, pp. 93–95, pl. 8, fig. 7–16, pl. 9, figs. 1, 2.

A good entire test from the Silurian Wenlock Limestone of Dudley, England (no. 125). Also two excellent adult, and two equally good young, enrolled entire tests from the Silurian of the island of Gothland, Sweden (no. 124).

Family Cheiruridae

Cheirurus sternbergi (Boeck)

Trilobites sternbergi Boeck, Notizer til Laeren om Trilobiterne, Magazin for Naturwidenskaberne, vol. 1, 1827, p. 1.

Cheirurus sternbergi (Boeck), Beyrich, über einige böhmischen Trilobiten, 1845, p. 15, fig. 4.

Cheirurus sternbergi (Boeck), Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 795–798, pl. 41, figs. 29–39 (gives full bibliography to 1847).

A cranidium and a pygidium in gray limestone of Stage Ff2 (Devonian) at Koneprusy, Bohemia (no. 166).

Sphaerexochus mirus Beyrich

Sphaerexochus mirus Beyrich, über einige böhmischen Trilobiten, 1845, p. 21.

Sphaerexochus mirus Beyrich, Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 808-810, pl. 42, figs. 16–23a (gives full bibliography to 1847).

An excellent cranidium and an equally good pygidium in gray limestone of Stage Ee2 (Silurian) at Listice, Bohemia (no. 165).

Family Dalmanitidae

Odontochile hausmanni (Brongniart)

Asaphus hausmanni Brongniart, Histoire naturelle des crustacés fossiles 1822, pp. 21–22, pl. 2, figs. 3A, B.

Odontochile applanata Corda, Prodrom einer Monographie der Böhmischen Trilobiten, 1847, p. 93.

Dalmania hausmanni (Brongniart), Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 538–540, pl. 23, fig. 20, pl. 24, figs. 1–12.

A good small entire, enrolled, test in black limestone presumably of Stage G (Devonian) from Trubin, Bohemia (no. 63), and a large pygidium in black limestone, also presumably of Stage G, from an unrecorded locality in Bohemia (no. 57).

Dalmanitina socialis (Barrande)

Phacops socialis Barrande, Notice préliminaire sur le Système Silurien et les trilobites de Bohême, 1846, p. 25.

Dalmania socialis (Barrande), Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 552–556, pl. 21, fig. 32, pl. 26, figs. 1–25, pl. 27, figs. 15–17 (gives full bibliography to 1847).

A cephalon, a thoracic segment and a pygidium, in gray sandstone, presumably of Stage D and of Ordovician age, from Bohemia (no. 78).

Chasmops macrourus (Angelin)

Phacops macroura Angelin, Palaeontologia Scandinavica, 1878, p. 9, pl. 7, figs. 3, 4.

Phacops (Chasmops) macroura Angelin, Schmidt, Mém. Acad. Imp. Sci. Saint-Pétersbourg, 7th ser., vol. 30, 1882, p. 114, pl. 3, figs. 10a, b, pl. 10, fig. 19.

An entire enrolled, test, labeled as having come from the "Upper Silurian of Bohemia", but presumably from the Ordovician of either Great Britain or Sweden (no. 61).

This species is usually attributed to Sjögren, but Angelin appears to have published the original description. When Angelin published his descriptions of this species and of *Chasmops bucculenta* he cited Sjögren as the author of both species; but he gave no bibliographic reference to any previous description of either species and indicated that both were new species. Apparently Sjögren had given him the specimens on which the two species were based, and had perhaps placed specific names on the labels accompanying them, but modern practice requires that, since Angelin published the first descriptions, both species are to be credited to him.

Family Phacopidae

Phacops fecundus major Barrande

Phacops fecundus major Barrande, Système Silurien du centre de la Bohême, vol. 1, 1852, pp. 514–518 (pars), pl. 21, figs. 10–21.

Six cephala in pink limestone, presumably of Stage F (Devonian), from an unrecorded locality in Bohemia (no. 69). A small cephalon and a fragment of a large cephalon, in black Lower Devonian limestone of Stage F2 (Hercynian) at Wildungen (Waldeck), Germany (no. 83), and a cranidium and pygidium, in red Lower Devonian limestone, also at Wildungen, Germany (no. 77.)

Phacops latifrons (Bronn)?

Calymene latifrons Bronn, Leonh. Zeitschr. Miner., 1825, p. 317, pl. 2, figs. 1–4.

Phacops latifroms (Bronn), Burmeister, Die Organisation der Trilobiten, 1843, pp. 105–107, pl. 2, figs. 4–6.

Phacops latifrons (Bronn), Salter, Monograph British trilobites, 1862, pp. 18–20, pl. 1, figs. 9–16 (gives bibliography to 1855).

Phacops latifrons (Bronn), Raymond, in Zittel-Eastman, Text-book of paleontology, 2nd edit., 1913, fig. 1410 (p. 726).

A cranidium and pygidium in Upper Devonian black slate from Birkenfeld, Germany, are labeled as being this species (no.83). Their preservation is so poor because of their being in slate that their identification is uncertain.

Phacops musheni Salter

Phacops musheni Salter, Monograph British Trilobites, 1862, pp. 23–24, pl. 2, figs. 7–12.

A cranidium in gray limestone of the Silurian Wenlock Formation at Dud ley, England (no. 85).

Reedops bronni (Barrande)

Phacops bronni Barrande, Notice préliminaire sur le Systême Silurien et les trilobites de Bohême, 1846, p. 84.

Phacops bronni Barrande, Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 106.

Phacops protractus Corda, Prodrom einer Monographie der böhmischen Trilobiten, 1847, p. 107.

Phacops bronni Barrande, Systême Silurien du centre de la Bohême, vol. 1, 1852, pp. 519–521, pl. 20, figs. 14–16.

Reedia bronni (Barrande), Wedekind, Abh. Preussischen Geologischen Landesanstalt, N. F., Heft 69, 1914, p. 35.

A good enrolled entire test in black limestone of "Stage Dd4" (Silurian) from Zahorcan, Bohemia (no. 87).

Phacopidella downingiae (Murchison)

Calymene downingiae Murchison, Silurian System, 1839, pl. 14, figs. 3a, b.

Phacops (Acaste) downingiae (Murchison), Salter, Monograph British Trilobites, 1862, pp. 24–26, pl. 2, figs. 17–36 (gives full bibliography to 1859).

Phacopidella downingiae (Murchison), Raymond, in Zittel-Eastman, Text-book of Paleontology, 2nd edit., vol. 1, 1913, text-fig. 1409 (p. 726).

Wedekind * placed this species in his genus *Reedia*, but Richter, and Richter †, because *Reedia* proved to be preoccupied, proposed the new name, *Reedops*.

An excellent cranidium in gray limestone of the Silurian Wenlock Formation at Dudley, England (no. 67). Also a fragment of a pygidium from the same formation and locality (no. 85.)

Phacopidella downingiae constricta Salter

Phacops downingae constrictus Salter, Monograph British Trilobites, 1862, pp. 27–28, pl. 2, figs. 13–16.

An entire, enrolled, test, the front of the glabella of which is so much less protruberant than is characteristic of the front of the glabella of *P. downingiae* that the specimen is believed to be referable to the variety, *constricta* (no. 67). The ribs on the pleural lobes of the pygidium are so poorly defined that they are almost invisible, and the pleural lobes appear, at first sight, to be smooth.

AUSTRALIAN SPECIES

Order Hypoparia

Harpes trinucleoides Etheridge and Mitchell

Harpes trinucleoides Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, vol. 42, 1917, pp. 496–497, pl. 27, figs. 2–5.

Two entire tests in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series at Bowning Creek, County Harden, New South Wales (nos. 173 and 174). Tophomeotypes.

Order Opisthoparia

Family Scutellidae

Scutellum bowningense (Etheridge and Mitchell)

Plate 10, fig. 7.

Bronteus bowingensis Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, vol. 42, 1917, p. 501, pl. 26, fig. 6.

An almost complete pygidium and a small part of the thorax, in brown shale of the Upper Trilobite Bed of the Upper Silurian Bowning Series at Bowning Creek, County Harden, New South Wales (no. 55). A homeotype

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* Wedekind, R., Paläontologische Beiträge zur Geologie des Kellerwaldes, Abhandlungen der Königlich Preussischen Geologischen Landesanstalt, Neue Folge, Heft. 69, 1914 p. 35.

† Richter, R., and E. Richter, Unterlagen zum Fossilium Catalogus, Trolobitae, III, Senckenbergiana, vol. 7, 1925, pp. 243-244.

and plesiotype. As this is a much better specimen than the one accompanying the original description of the species it is figured here.

Etheridge and Mitchell state that there are only 4 ribs on each side of the median ridge of the pygidium of this species, but their figure and our specimen show that there are 6 ribs on each side.

Scutellum jenkinsi (Etheridge and Mitchell)

Plate 10, fig. 8; plate 11, figs. 1-3.

Bronteus partschi de Koninck (not Barrande), Foss. Pal. Nouv.-Galles du Sud, 1876, pt. 1, p. 57.

Bronteus sp. Jenkins, Proc. Linnean Soc. New South Wales, vol. 3, 1879, p. 217, pl. 17, figs. 3, 4, 6, 8.

Bronteus jenkinsi Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 5, 1890, pp. 502-504, pl. 18, figs. 1-7.

An entire test (no. 52), two cranidia (nos. 21 and 54), and a pygidium (no. 46) in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series on Bowning Creek, County Harden, New South Wales All are tophomeotypes. As this species appears not to have been figured by photography, illustrations of it are presented here. It will be noted that the pygidium of the entire test that is here figured (plate 11, figure 2) is longer in proportion to its width than is the adult pygidium of which an illustration is presented (plate 11, figure 3). Etheridge and Mitchell have called attention to the fact that the pygidia of this species vary in this way. Possibly the differences are due to differences in sex.

Scutellum longispinifex (Mitchell)

Plate 11, fig. 4.

Bronteus longispinifex Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 2, 1887, pp. 435-437, pl. 16, figs. 1, 2.

A small cranidium in brown shale of the Upper Silurian Bowning Series at Bowning, New South Wales (no. 18). The species occurs in both the Middle Trilobite Bed and the Upper Trilobite Bed of the Bowning Series, and, as its label does not state from which bed it came, the exact horizon of our specimen is not known. As this species appears not to have been figured by photography and the figure of the cranidium published with the original description was not a very good one, an illustration of our specimen is included in the present paper. Our specimen is possibly a tophomeotype.

Family Proetidae

Proetus bowningensis Mitchell

Proetus bowningensis Mitchell, Proc. Linnean Soc. New South Wales, 2nd vol. 2, 1887, p. 439, pl. 16. figs. 4-6.

Proetus bowningensis Mitchell, Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 6, 1891, pp. 313–316, pl. 25, figs. 1, 1a–c.

The natural impression of an entire test, in brown shale of the Trilobite Beds of the Upper Silurian Bowning Series at Bowning, New South Wales (no. 175), and a cast of an entire test from the same beds and locality (no. 51). The natural impression is a homeotype, and the cast must have been sent to General Vogdes by Mitchell and must be a reproduction of a tophomeotype.

Proetus rattei Etheridge and Mitchell

Plate 11, fig. 5.

Proetus ascanius Ratte (not Barrande), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 1, 1886, p. 1066, pl. 15, figs. 1–4.

Proetus rattei Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 6, 1891, pp. 316-318, pl. figs. 2, 2a–d.

A complete test, in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series at Bowning, New South Wales (no. 23). A homeotype. As Etheridge and Mitchell's figures of this species do not show an entire specimen and this species has not been illustrated by photography, a figure of our specimen is presented here.

Cyphaspis yassensis Etheridge and Mitchell

Plate 12, figs. 1–2.

Cyphaspis yassensis Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 8, 1893, pp. 172–174, pl. 6, figs. 1, 1a–d.

A cranidium and a pygidium, in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series at Belle Vale, between Bowning and Yass, New South Wales (no. 172). Both are homeotypes. As the species has not been illustrated by photography these specimens are figured here.

Etheridge and Mitchell placed this species in the genus *Cyphaspis*. Although it has a smooth, not a granulated, test and agrees in other ways with *Proetus*, except that its glabella is very narrow, it is probably best looked upon as an aberrant form of *Cyphaspis*. Except that its cranidium and the axis of its pygidium are narrower, it resembles in a general way *Cyphaspis halli* Barrande, a smooth species found in the Silurian of Bohemia.

Family Odontopleuridae

Odontopleura bowningensis Etheridge and Mitchell

Odontopleura bowningensis Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 11, 1896, pp. 696–699, pl. 50, figs. 1–3, pl. 52, fig. 5.

The impression of an entire test (no. 114) and a pygidium (no. 117) in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series on Bowning Creek, County Harden, New South Wales. Tophomeotypes.

Odontopleura rattei Etheridge and Mitchell

Plate 12, fig. 3.

Acidaspis near *A. leonhardi*, Ratte (not Barrande), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 2, 1887, p. 99, pl. 2, figs. 2-4.

Odontopleura rattei Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 11, 1896, pp. 699-703, pl. 50, fig. 7, pl. 51, figs. 8, 9, pl. 52, figs. 1-4, pl. 53, figs. 1-3.

An entire test, in brown shale of the Upper Trilobite Bed of the Upper Silurian Bowning Series at Bowning Village, County Harden, New South Wales (no. 113). A tophomeotpye. As the species has not been illustrated by photography this specimen is figured here.

Odontopleura parvissima Etheridge and Mitchell

Acidaspis near *A. dormitzeri*, Ratte (not Corda), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 2, 1887, p. 96, pl. 2, figs. 1, 1 bis.

Odontopleura parvissima Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 11, 1896, pp. 703-705, pl. 50, figs. 4-6, pl. 52, fig. 8.

An entire test and a pygidium with part of the thorax attached, preserved in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series on Bowning Creek, County Harden. New South Wales (no. 123). Tophomeotypes.

Odontopleura jenkinsi Etheridge and Mitchell

Plate 12, fig. 4.

Acidaspis brightii Jenkins (not Murchison), Proc. Linnean Soc. New South Wales, vol. 3, 1879, p. 221, pl. 17, fig. 5.

Acidaspis prevosti Ratte (not Barrande), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 1, 1886, p. 1069, pl. 15, fig. 12 (not fig. 11).

Odontopleura jenkinsi Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 11, 1896, pp. 705-706, pl. 52, figs, 6, 7, pl. 53, figs. 4-7.

Odontopleura jenkinsi Etherdge and Mitchell, Chapman, Australasian fossils, 1914, text-fig. 110 B, p. 230.

An excellent thorax and attached pygidium (no. 171) and an excellent pygidium (no. 115), in brown shale of the Upper Trilobite Bed of the

Upper Silurian Bowning series, presumably from the Bowning railway station yard, Bowning Village, County Harden, New South Wales. Tophomeotypes.

As the theorax and pygidium of this species appear not to have been figured by photography, a photographic illustration of one of our specimens is presented here. The prominent tubercles on the pygidium, which are not well shown in Etheridge and Mitchell's figures can be seen in our picture, as can the double row of large tubercles on the pleural portions of the thorax that are characteristic of the species.

Ceratocephala vogdesi Etheridge and Mitchell

Acidaspis verneuili Ratte (not Barrande), or *A. vesiculosa* Ratte (not Beyrich), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 1, 1886, p. 1066, pl. 15, figs. 5–10.

Acidaspis prevosti Ratte (not Barrande), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 1, 1886, p. 1068, pl. 15, fig. 11 (not fig. 12).

Ceratocephala vogdesi Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 11, 1896, pp. 707–712, pl. 50, figs. 8, 9, pl. 51, figs. 1–7, pl. 53, fig. 9.

Two segments of a thorax, in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series near Bowning, County Harden, New South Wales (no. 119). A homeotype.

Ceratocephala longispina (Mitchell)

Plate 13, figs. 1–2.

Acidaspis near *A. mira*, Ratte (not Barrande), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 1, 1886, p. 1069, pl. 15, figs. 13, 14.

Acidaspis longispinis Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 3, 1888, p. 398, pl. 16, figs. 7–12.

Acidaspis longispina Mitchell, Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 11, 1896, pp. 715–718, pl. 53, fig. 10, pl. 54, figs. 1–5.

Two cranidia (nos. 108 and 116) and two pygidia (nos. 23 and 112), in brown shale of the Trilobite Beds of the Upper Silurian Bowning Series at Bowning Village, County Harden, New South Wales. Homeotypes. As the cranidium and pygidium of this species appear not to have been figured by photography the better of the two cranidia and pygidia in the Vogdes Collection are illustrated photographically here.

Order Proparia

Family Encrinuridae

Encrinurus mitchelli Foerste

?Cromus murchisoni De Koninck, Foss. Pal. Nov.-Galles du Sud, 1876, pt. 1, pl. 1, fig. 9, (not figs. 9a, b).

Encrinurus mitchelli Foerste, Bull. Sci. Lab. Denison Univ., vol. 3, 1888, pp. 124–126, figs. 2, 3, 20.

Encrinurus mitchelli Foerste, Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 40, 1915, pp. 657–661, pl. 54, figs. 1–5, pl. 55, figs. 1–3, pl. 56, figs. 2, 10, pl. 57, fig 9.

Encrinurus mitchelli Foerste, Süssmilch, An introduction to the geology of New South Wales, 1922, text-fig. 18 (1), pl. 49.

Five entire tests in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series at Bowning, County Harden, New South Wales (nos. 16, 48, 49, and 53). Homeotypes.

Encrinurus browningi Foerste

Encrinurus browningi Foerste, Bull. Sci. Lab. Denison Univ., vol. 3, 1888, pp. 122–124, pl. 13, fig. 7.

Encrinurus bowningensis Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 40, 1915, pp. 662–664, pl. 54, figs. 6–10, 12, 14, pl. 55, figs. 5, 6, 12, pl. 56, fig. 8.

An entire test (no. 17), a free cheek (no. 44), and two crandia and two pygidia (no. 56), all in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series at Bowning, County Harden, New South Wales. Homeotypes.

Foerste named this species *Encrinurus browningi*. Etheridge and Mitchell, believing that he had meant to write the specific name as *bowningensis* changed it accordingly. There is, however, no evidence that Foerste's name is a mere misspelling or misprint which would permit of a correction of it under the rules of zoological nomenclature, and it therefore seems to the writer that Foerste's name, less appropriate though it is, must be retained.

Family Cheiruridae

Staurocephalus murchisoni Barrande

Staurocephalus murchisoni Barrande, Système Silurien du centre de la Bohême 1st pt., vol. 1, 1852, pp. 812–814, pl. 43, figs. 28–32.

Staurocephalus murchisoni Barrande, Salter, Mon. Brit. Trilobites, pt. 1, 1864, pp. 84–85, pl. 7, figs. 13–20.

Staurocephalus near *murchisoni*, Ratte, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 2, 1887, p. 100, pl. 2, figs. 5–9.

Staurocephalus murchisoni Barrande, Van Ingen, School of Mines Quarterly, vol. 23, 1891, p. 35.

Staurocephalus murchisoni Barrande, Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 42, 1917, p. 495, pl. 27, figs. 6–11, 13.

An entire test and part of a cranidium and attached thorax (no. 118) in brown shale of the Lower Trilobite Bed of the Upper Silurian Bowning Series on Bowning Creek, County Harden, New South Wales.

This is one of the most widely distributed of the known species of trilobites, for it is found not only in Europe and Australia, but also in North America.

Family Dalmanitidae

Odontochile meridianus (Etheridge and Mitchell)

Phacops (Odontochile) caudatus McCoy (not Brünnich), Prod. Pal. Vict. Dec. 3, 1876, p. 13, pl. 22, figs. 1–7, pl. 23, figs. 7–10.

Hausmannia meridianus Etheridge and Mitchell (part), Proc. Linnean Soc. New South Wales, 2nd ser., vol. 10, 1895, pp. 504–509, pl. 38, figs. 1–8, pl. 4, fig. 1.

Hausmannia meridianus Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 44, 1919, pp. 443–446, pl. 15, figs. 3, 4, pl. 16, figs. 6, 7.

A pygidium (no. 89) and an entire test (no. 92), in brown shale of the Trilobite Beds of the Upper Silurian Bowning Series at Bowning, County Harden, New South Wales. Homeotypes.

Family Phacopidae

Phacops serratus Foerste

Plate 12, fig. 5.

Phacops serratus Foerste, Bull, Sci. Lab. Denison Univ., vol. 3. 1888, pp. 126–128, pl. 13, fig. 1.

Phacops serratus Foerste, Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 10, 1895, pp. 495-497, pl. 39, figs. 7, 8, pl. 40, figs, 7, 8, 11.

Phacops serratus Foerste, Chapman, Australasian fossils, 1914, text-fig. 111 E p. 230.

Phacops serratus Foerste, Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 44, 1919, pl. 15, fig. 6.

A thorax and attached pygidium in brown shale of the Upper Trilobite Bed of the Upper Silurian Bowning Series near the railway station at Bowning, County Harden, New South Wales (no. 90). A tophomeotype identified by Mitchell. As the published figures of this species are not very good, this specimen is figured here.

Phacops crossleii Etheridge and Mitchell

Plate 13, figs. 3–4.

Phacops crossleii Etheridge and Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 10, 1895, pp. 489–492, pl. 39, figs. 9–11.

Phacops crossleii Etheridge and Mitchell, Mitchell, Proc. Linnean Soc. New South Wales, 2nd ser., vol. 44, 1919, pl. 15, fig. 5.

An excellent cephalon and an equally good thorax and attached pygidium, both in brown shale of the Upper Trilobite Bed of the Upper Silurian Bowning Series at Bowning Village, County Harden, New South Wales (no. 91). Tophomeotypes. As the published figures of this species are not entirely adequate for its illustration, figures of our two specimens are presented here.

EXPLANATION OF PLATES

PLATE 1

Fig. 1. *Richardsonella unisulcata* Rasetti. Cranidium. X 3. Upper Cambrian pebble in Ordovician Lévis Conglomerate, Point Lévis, Quebec. San Diego Soc. Nat. Hist. Vogdes Coll., no 104A.

Fig. 2. *Loganellus macropleurus* Rasetti. Cranidium. X 3. Upper Cambrian pebble in Ordovician Lévis Conglomerate, Point Lévis, Quebec. San Diego Soc. Nat. Hist. Vogdes Coll., no. 104B.

Fig. 3. *Lloydia parva*, n. sp. Holotype pygidium. X2½. Upper Cambrian pebble in Ordovician Lévis Conglomerate, Point Lévis Conglomerate, Point Lévis. Quebec. San Diego Soc. Nat. Hist. Vogdes Coll., no. 104C.

Fig. 4. *Lloydia parva*, n. sp. Paratype pygidium. X 2½. Upper Cambrian pebble in Ordovician Lévis Conglomerate, Point Lévis, Quebec. San Diego Soc. Nat. Hist. Vogdes Coll., no. 104E.

Fig. 5. *Bathyurus extans* (Hall). Free cheek. X 2. Black River Formation, Middle Ordovician, Great Bend, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 122.

Fig. 6. *Bathyrus extans* (Hall). Cranidium. X 2. Black River Formation, Middle Ordovician, Great Bend, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 122.

Fig. 7. *Bathyurus extans* (Hall). Thorax and pygidium. X 2. Black River Formation, Middle Ordovician, Great Bend, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 122.

Fig. 8. *Ogygites canadensis* (Chapman). X 2. Collingwood Formation, Ordovician, Georgian Bay, Ontario. San Diego Soc. Nat. Hist. Vogdes Coll., no. 182.

Fig. 9. *Proetus parviusculus* Hall. Front view of enrolled test. X 6. Upper Ordovician of the Cincinnati region. San Diego Soc. Nat. Hist. Vogdes Coll. no. 24.

Fig. 10. *Proetus parviusculus* Hall. Rear view of enrolled test. X 6. Upper Ordovician of the Cincinnati region. San Diego Soc. Nat. Hist. Vogdes Coll., no. 24.

PLATE 2

Fig. 1. *Ogygites canadensis* (Chapman). Cephalon. X 1½. Collingwood Formation, Ordovician, Georgian Bay, Ontario. San Diego Soc. Nat. Hist. Vogdes Coll., no. 176.

Fig. 2. *Ogygites canadensis* (Chapman). X 2. Collingwood Formation, Ordovician, Georgian Bay, Ontario. San Diego Soc. Nat. Hist. Vogdes Coll. no. 184.

Fig. 3. *Isotelus gigas* DeKay. X1½. Trenton Formation, Middle Ordovician, Herkimer County, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 183.

Fig. 4. *Vogdesia vigilans* (Meek and Worthen). Young enrolled test. X 6. Lower Maquoketa Formation, Lower Silurian, Fayette County, Iowa. San Diego Soc. Nat. Hist. Vogdes Coll., no 120.

PLATE 3

Fig. 1. *Isotelus gigas* Dekay. X 1. Ordovician, Kentucky. San Diego Soc. Nat. Hist. Vogdes Coll., no 189.

Fig. 2. *Bumastus? vogdesi*, n. sp. Holotype pygidium. X 2. Clinton, Middl Silurian, Dug Gap, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 95.

Fig. 3. *Bumastus chicagoensis* (Weller). Pygidium. X 2. Racine Formation, Middle Silurian, Bridgeport, Illinois. San Diego Soc. Nat. Hist. Vogdes Coll., no 105.

Fig. 4. *Bumastus armatus* (Hall). Cephalon. X 1. Racine Formation, Middle Silurian. Bridgeport, Illinois. San Diego Soc. Nat. Hist. Vogdes Coll., no. 102A.

Fig. 5. *Bumastus armatus* (Hall). Cephalon. X 1. Racine Formation, Middle Silurian, Bridgeport, Illinois. San Diego Soc. Nat. Hist. Vogdes Coll., no. 102B.

Fig. 6. *Bumastus armatus* (Hall). Pygidium. X 1. Racine Formation, Middle Silurian, Bridgeport, Illinois. San Diego Soc. Nat. Hist. Vogdes Coll., no. 103.

Fig. 7. *Bumastus cuniculus* (Hall). Small cranidium. X 1. Racine Formation, Middle Silurian, Wauwatosa, Wisconsin. San Diego Soc. Nat. Hist. Vogdes Coll., no. 101A.

Fig. 8. *Proetus doris* Hall. Cast of test. X 1½. Goniatite Limestone, Waverly Group, Carboniferous, Rockford, Indiana. San Diego Soc. Nat. Hist. Vogdes Coll., no. 26.

Fig. 9. *Proetus doris* Hall. Cast of cotype pygidium. X 2. Goniatite Limestone, Waverly Group, Rockford, Indiana. San Diego Soc. Nat. Hist. Vogdes Coll., no. 26.

PLATE 4

Fig. 1. *Isotelus gigas* DeKay. Cross section of shield. X 1½. San Diego Soc. Nat. Hist. Vogdes Coll., no. 181.

Fig. 2. *Isotelus gigas* DeKay. Reproduction of description of cross section of shield shown in figure 1.

PLATE 5

Fig. 1. *Bumastus cuniculus* (Hall). Cephalon. X 2. Racine Formation, Middle Silurian, Wauwasota, Wisconsin. San Diego Soc. Nat. Hist. Vogdes Coll., no 101B.

Fig. 2. *Proetus*, sp. undet. Free Cheek X 5. Clinton Group, Middle Sil--urian, Catoosa Station, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 129C.

Fig. 3. *Proetus crassimarginatus* (Hall). Pygidium. X 2. Onondaga Formation, Kelly Island. Lake Erie. San Diego Soc. Nat. Hist. Vogdes Coll., no. 41.

Fig. 4. *Proetus haldemani* Hall. X 4. Hamilton Formation, Middle Devonian, Judd's Falls, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 39.

Fig. 5. *Proetus haldemani* Hall. X 4. Same specimen as is shown in figure 4.

Fig. 6. *Proetus bairdensis* Wheeler. X 2. Baird Formation, Middle Carboniferous, Baird, California. San Diego Soc. Nat. Hist. Vogdes Coll., no. 31.

Fig. 7. *Cyphaspis christyi* Hall. Enrolled test. X 2. Niagaran Group, Middle Silurian. San Diego Soc. Nat. Hist. Vogdes Coll., no. 156.

Fig. 8. *Cyphaspis christyi* Hall. X 2. Same specimen as is shown in figure 7.

Fig. 9. *Phillipsia insignis* Winchell. Pygidium. X 5. Burlington Formation. Lower Carboniferous, Curryville, Missouri. San Diego Soc. Nat. Hist. Vogdes Coll., no. 34A.

PLATE 6

Fig. 1. *Brachymetopus cuyahogae* (Claypole). Pygidium. X 4. Cuyahoga Formation, Lower Carboniferous, Akron, Ohio. San Diego Soc. Hist. Vogdes Coll., no. 66.

Fig. 2. *Phillipsia major* Shumard. Cranidium. X 3. Upper Carboniferous, Kansas City, Missouri. San Diego Soc. Nat. Hist. Vogdes Coll., no. 33A.

Fig. 3. *Phillipsia major* Shumard. Pygidium. X 3. Upper Carboniferous, Kansas City, Missouri. San Diego Soc. Nat. Hist. Vogdes Coll., no. 33B.

Fig. 4. *Phillipsia sampsoni* Vogdes. X 3. Chouteau Formation, Lower Carboniferous, Banks, Missouri. San Diego Soc. Nat. Hist. Vogdes Coll., no. 36.

Fig. 5. *Phillipsia stevensoni* Meek. Pygidium. X 3. Carboniferous, Monongalia County, West Virginia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 35.

Fig. 6. *Griffithides* bufo Meek and Worthen. X 2. Keokuk Group, Lower Carboniferous, Crawfordsville, Indiana. San Diego Soc. Nat. Hist. Vogdes Coll., no 32.

PLATE 7

Fig. 1. *Griffithides bufo* Meek and Worthen, Cast. X 2. Keokuk Group, Lower Carboniferous, Crawfordsville, Indiana. San Diego Soc. Nat. Vogdes Coll., no 25.

Fig. 2. *Ceratocephala anchoralis* (Miller). Cranidium. X 4. Maysville Formation, Upper Ordovician, Cincinnati region. San Diego Soc. Nat. Hist. Vogdes Coll., no. 111.

Fig. 3. *Encrinurus americanus* Vogdes. Cotype pygidium. X 3. Clinton Group, Middle Silurian, west of Catoosa Station, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 12A.

Fig. 4. *Encrinurus americanus* Vogdes. Cotype pygidium. X 3. Clinton Group, Middle Silurian, west of Catoosa Station, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 12B.

Fig. 5. *Calymene vogdesi* Foerste. Cranidium. X1½. Clinton Group, Middle Silurian, near Catoosa Station, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 132A.

Fig. 6. *Calymene vogdesi* Foerste. Free cheek. X1½. Clinton Group, Middle Silurian, Dug Gap, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 133A.

Fig. 7. *Calymene vogdesi* Foerste. Pygidium. X 4. Clinton Group, Middle Silurian, Dug Gap, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 133B.

Fig. 8. *Calymenella rostrata* (Vogdes). Cotype cranidium. X 3. Clinton Group, Middle Silurian, near Catoosa Station, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 129A.

Fig. 9. *Calymenella rostrata* (Vogdes). Cotype pygidium. X 3. Clinton Group, Middle Silurian, near Catoosa Station, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 129B.

Fig. 10. *Calymenella rostrata* (Vogdes). Cotype pygidium. X 3. Clinton Group, Middle Silurian, near Catoosa Station, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 136A.

Plate 8

Fig. 1. *Ceraurus pleurexanthemus* Green. X 2½. Trenton Formation, Middle Ordovician, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 137.

Fig. 2. *Ceraurus pleurexanthemus* Green. Cranidium. X 2½. Trenton Formation, Middle Ordovician, Trenton Falls, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 160.

Fig. 3. *Anchiopsis anchiops* (Green). One of Green's casts (no. 7) of the holotype pygidium. X 1. San Diego Soc. Nat. Hist. Vogdes Coll., no. 72.

Fig. 4. *Corycephalus dentatus* (Barrett). Cephalon. X 1. Lower Devonian, Port Jervis, New York. San Diego Soc. Nat. Hist. Vogdes Coll., no. 59.

Fig. 5. *Achatella carleyi* (Meek). Cephalon. X 4. Upper Ordovician, Cincinnati, Ohio. San Diego Soc. Nat. Hist. Vogdes Coll., no. 64.

Plate 9

Fig. 1. *Phacops rana* Green. X 2. Hamilton Group, Middle Devonian, London, Ontario. San Diego Soc. Hist. Vogdes Coll., no. 86.

Fig. 2. *Phacops cacapona* Hall. X 1½. Hamilton Group, Middle Devonian, Capon Springs, West Virginia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 82.

Fig. 3. *Phacops cacapona* Hall X1½. Same specimen as figure 2.

Fig. 4. *Phacops cacapona* Hall. X 1½. Same specimen as figures 2 and 3.

Fig. 5. *Phacops hudsonica* Hall. X 2. Lower Devonian, western Tennessee. San Diego Soc. Nat. Hist. Vogdes Coll., no. 88A.

PLATE 10

Fig. 1. *Phacops hudsonica* Hall. X 2. Lower Devonian, western Tennessee. San Diego Soc. Nat. Hist. Vogdes Coll., no. 88A.

Fig. 2. *Eophacops catoosaensis* n. sp. Holotype. Cranidium. X 5. Clinton Group, Middle Silurian, near Ringgold, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 65a.

Fig. 3. *Eophacops catoosaensis*, n. sp. Paratype cranidium. X 5. Clinton Group, Middle Silurian, near Ringgold. Georgia. San Diego Soc. Nat. Hist. Vogdes Coll.. no. 65b.

Fig. 4. *Eophacops catoosaensis*, n. sp. Paratype pygidium. X 5. Clinton Group, Middle Silurian, near Ringgold, Georgia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 65d.

Fig. 5. *Scutellum partschi* (Barrande). Cranidium. X 3. Stage Ec2, Silurian, Lochkow, Bohemia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 11A.

Fig. 6. *Scutellum partschi* (Barrande). Hypostome. X 3. Stage Ec2, Silurian, Lochkow, Bohemia. San Diego Soc. Nat. Hist. Vogdes Coll., no. 11B.

Fig. 7. *Scutellum bowningense* (Etheridge and Mitchell). Plesiotype pygidium. X 1½. Bowning Series, Upper Silurian, Bowning Creek, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 55.

Fig. 8. *Scutellum jenkinsi* (Etheridge and Mitchell). Cranidium. X 2. Bowning Series, Upper Silurian, Bowning Creek, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 21.

PLATE 11

Fig. 1. *Scutellum jenkinsi* (Etheridge and Mitchell). Cranidium. X 4. Bowning Series, Upper Silurian, Bowning Creek, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 54.

Fig. 2. *Scutellum jenkinsi* (Etheridge and Mitchell). Young test. X 2½. Bowning Series, Upper Silurian, Bowning Creek, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 52.

Fig. 3. *Scutellum jenkinsi* (Etheridge and Mitchell). Pygidium. X1½. Bowning Series, Upper Silurian, Bowning Creek, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 46.

Fig. 4. *Scutellum longispinifex* (Mitchell). Cranidium. X 3. Bowning Series, Upper Silurian, Bowning, New South Wales, San Diego Soc. Nat. Hist. Vogdes Coll., no. 18.

Fig. 5. *Proetus rattei* Etheridge and Mitchell. X 3. Bowning Series, Upper Silurian, Bowning, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 23.

PLATE 12

Fig. 1. *Cyphaspis yassensis* Etheridge and Mitchell. Cranidium. X 6. Bowning Series, Upper Silurian, Belle Vale, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 172A.

Fig. 2. *Cyphaspis yassensis* Etheridge and Mitchell. Pygidium. X 6. Bowning Series, Upper Silurian, Belle Vale, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 172B.

Fig. 3. *Odontopleura rattei* Etheridge and Mitchell. X 3. Bowning Series, Upper Silurian, Bowning Village, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 113.

Fig. 4. *Odontopleura jenkinsi* Etheridge and Mitchell. X 3. Bowning Series, Upper Silurian, Bowning Villiage, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 171.

Fig. 5. *Phacops serratus* Foerste. X 3. Bowning Series, Upper Silurian, Bowning, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 90.

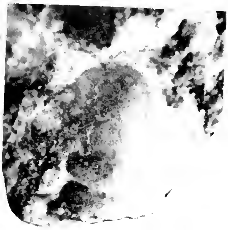
PLATE 13

Fig. 1. *Ceratocephala longispina* (Mitchell). Cranidium. X 2. Bowning Series, Upper Silurian, Bowning Village, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 108.

Fig. 2. *Ceratocephala longispina* (Mitchell). Pygidium. X 3. Bowning Village, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 112.

Fig. 3. *Phacops crossleii* Etheridge and Mitchell. Cephalon. X 3. Browning Series, Upper Silurian, Bowning Village, New South Wales. San Diego Soc. Nat. Hist. Vodges Coll., no. 91a.

Fig. 4. *Phacops crossleii* Etheridge and Mitchell. Thorax and pygidium. X 3. Bowning Series, Upper Silurian, Bowning Village, New South Wales. San Diego Soc. Nat. Hist. Vogdes Coll., no. 91b.



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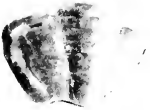

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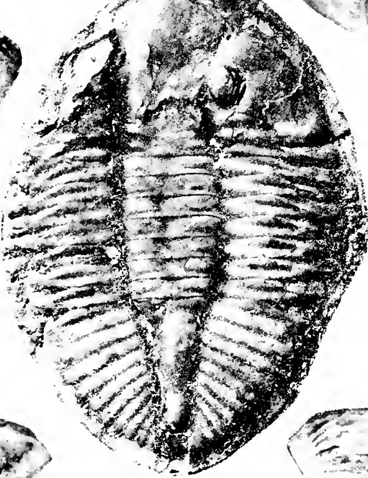

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Plate 1

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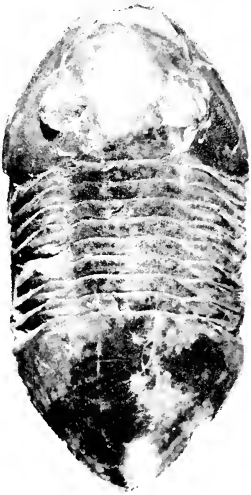

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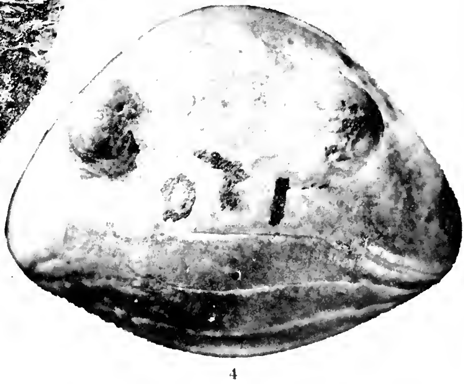

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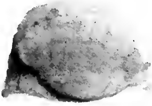
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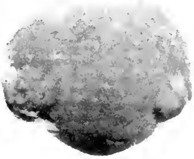
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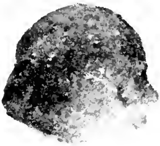
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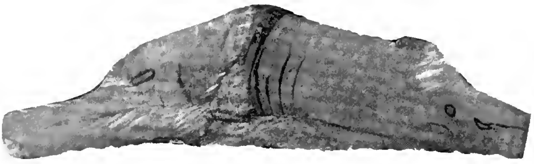

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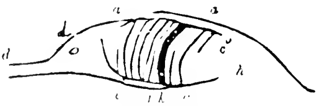
THE AUXILIARY IMPRESSIONS DERIVED FROM THE PYGIDIUM OF

ISOTELUS PLATYCEPHALUS, Stokes.

The general form of this part in the species is subtrigonal; the axis has an obtuse termination, and faintly marked with eight articulations. The dorsal shell, covering the entire pygidium, is finely punctate. Between the outer and the inner shell, there is a limited space, whichbecomes greater in the region bordered by the concaved limb, surrounding the outer margin of the pygidium.

The dorsal shell is only sligntly concave over the limb ; but the second covering of this part is much more so, owing to the large muscular space which lies between the two membraneous shells. The limb is marked on the second cover by a series of bands, they commence on the anterior lateral margin of the pygidium and along the inner and outer margins of the limb. The inner series consist of seven terraced stripes, connecting on the knee line and those which arise on the inner margin of the limb. The second, or outer series are entirely of a different character; they commence in the same manner as the first series, and are increased by additional stripes arising along the outer margin of the limb; but this series consist of irregular ribboned stripes, which are covered with an irregular lines of minute nodes.



We have made a transverse section of the pygidium of a young specimen, which shows some interesting points with regard to the internal structure. The specimen has a deep internal plate, shown at fig. h. connected with the lower membraneous shell of the dorsal surface by a median band represented at fig. k, and nine supporting arches—see fig. g, f, e. The central part of the internal plate is some what thickened, and connected with the ventral side of the trilobite. Unfortunately our specimen only exhibits a portion of this side.

The internal plate was probably connected with the second dorsal shell; such an attachment is indicated by its upward curvature. The dorsal furrows are shown at a a, and the limits of the limb, which surround the pygidium, at d d, in the above figure.

From Prof. Holmes Cabinet.

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Plate 4

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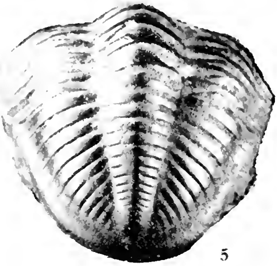

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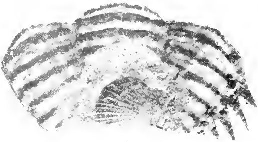
Plate 5



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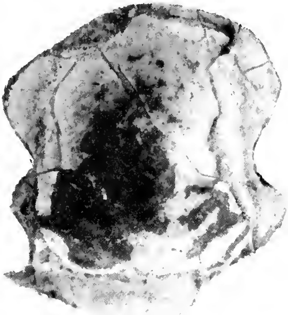

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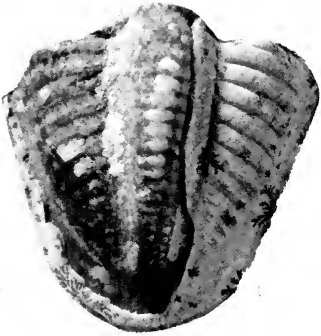

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Plate 6

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Plate 7

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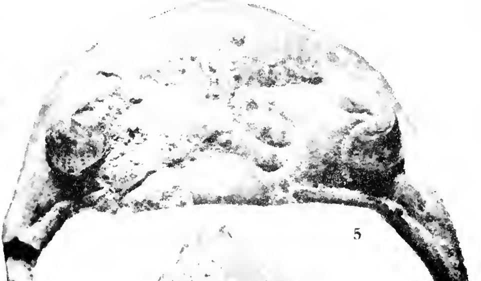

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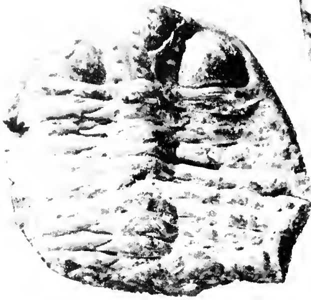

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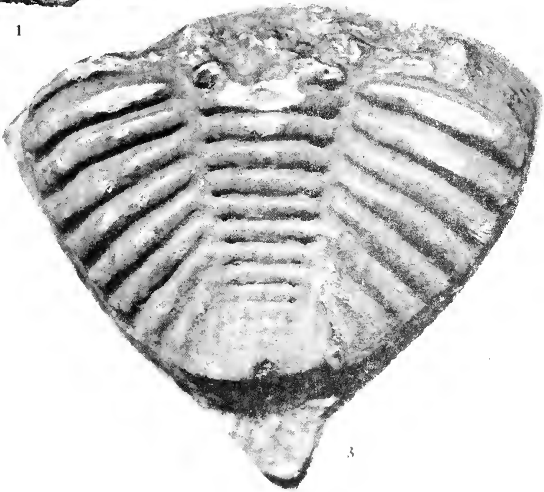

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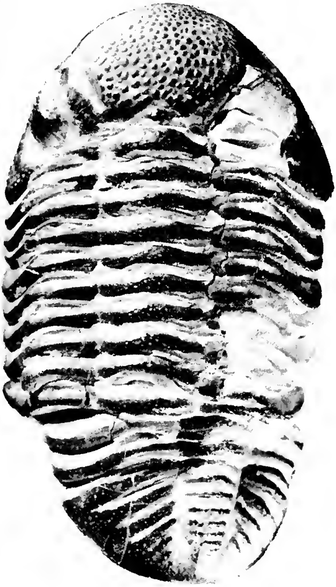
Plate 8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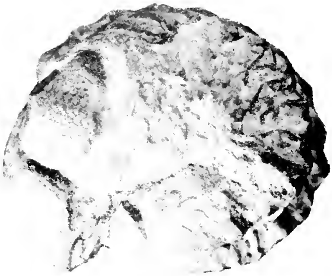
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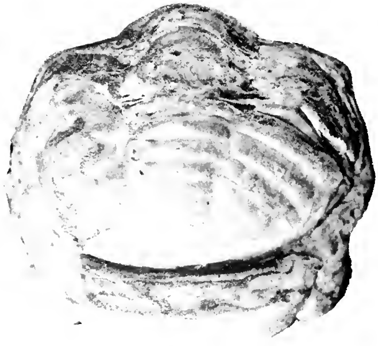
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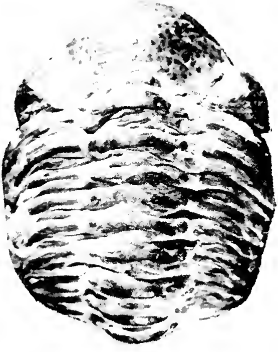
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Plate 9

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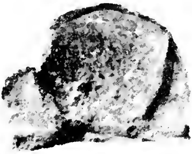

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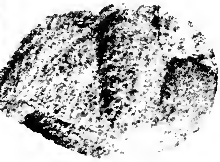

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Plate 10

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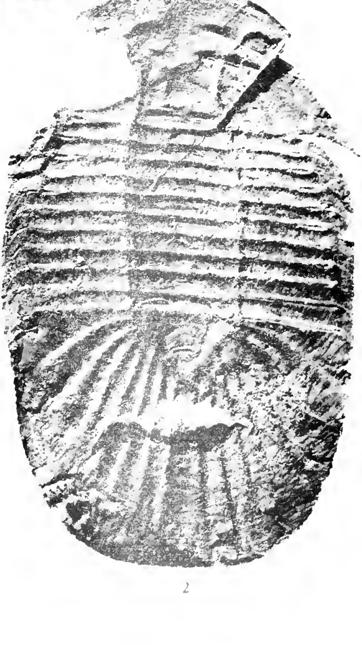

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Plate 11

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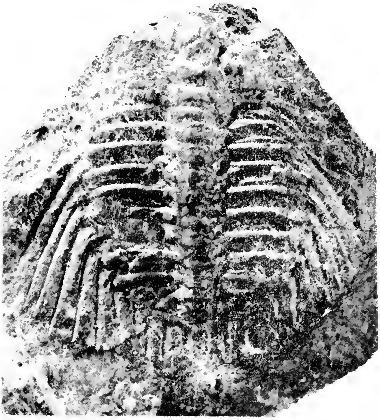

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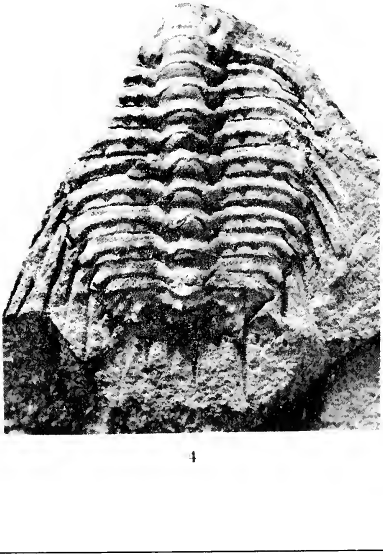

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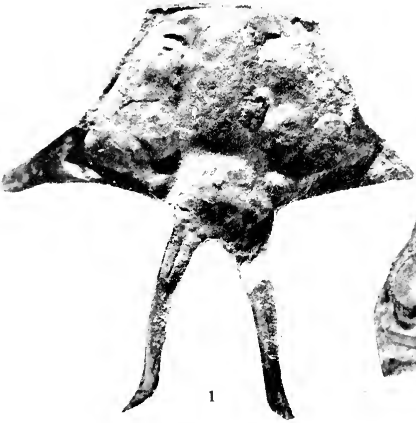
Plate 12



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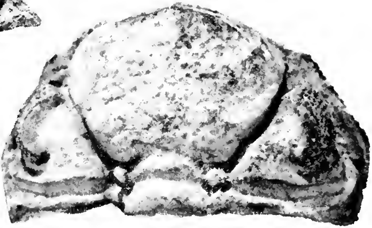

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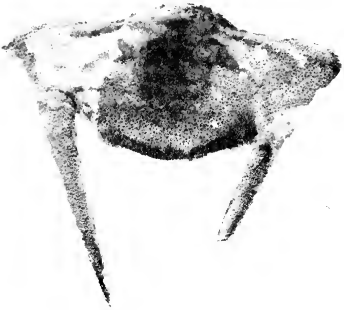

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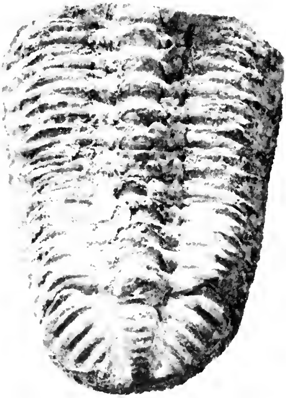

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Plate 13

TRANSACTIONS

OF THE

SAN DIEGO SOCIETY OF NATURAL HISTORY

VOLUME XI, No. 12, pp. 329-344, plates 24-25

TWO CALIFORNIAN MOUNTAIN SNAILS OF THE GENUS HELMINTHOGLYPTA—A PROBLEM IN THE RELATIONSHIP OF SPECIES

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Redlands, California

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TWO CALIFORNIAN MOUNTAIN SNAILS OF THE GENUS HELMINTHOGLYPTA—A PROBLEM IN THE RELATIONSHIP OF SPECIES

BY

S. Stillman Berry

Redlands, California

The field work, comparisons, and dissections which have been moulded into the present paper are portions of a much more extensive undertaking dating back a number of years. As there has never arisen an opportunity to carry out the additional field explorations implicit in rounding out the original plan, this fragment of the study as thus far accomplished has been selected for publication as more or less unitary and complete in itself, while in it are involved several questions the answers to which must be of concern to all students of the more fundamental problems of snail anatomy, the mechanics of speciation, and the evolution of a natural taxonomy in the group. As a groundwork for the consideration of these questions it first becomes necessary to investigate and discuss the anatomy of one of the established species which inhabits an isolated mountain top (Palomar) in southern California, and then with this in mind to delve into the characteristics of an hitherto unnamed species inhabiting a neighboring mountain (Hot Springs) which is isolated from the first by the interposition of the small but deep upper San Luis Rey Valley and a lower life zone.

1) Helminthoglypta lowei (Bartsch)

Pl. 24, figs. 1-3, text fig. 1.

1918. *Epiphragmophora cuyamacensis lowei* Bartsch,—Proc. U.S. Nat. Mus., 54: 523, pl. 83, figs. 1-3.

1939. *Helminthoglypta cuyamacensis lowei* Pilsbry, — Land Moll. N. Amer., 1 (1): 147, text fig. 74 (after Bartsch).

1940. *Helminthoglypta cuyamacensis lowei* Gregg,—Naut., 54 (1): 33.

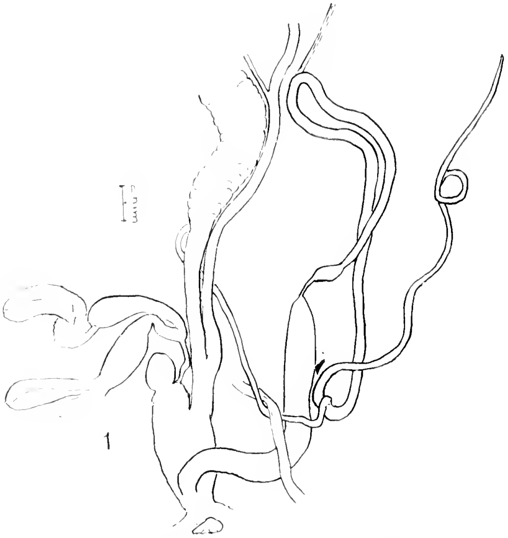
Material Studied:

1	Elev. 5,000 ft., Upper Pauma Cr., Palomar Mt.	H. N. Lowe	May 1919	topotype[1]
8	Observatory road, 3-4 mi. E. of Crestline, Palomar Mt.	E. P. & E. M. Chace		mostly juv.
11	Elev. 5,000 ft., near sawmill E. of Palomar P.O., S. ridge of Palomar Mt.	S. S. Berry & W. G. Craig	April 7, 1928	2 living adults

---

[1] Mr. Lowe informed the writer in 1929 that his exact type-locality was upper Pauma Creek, near the junction of Doane Creek, about three-fourths of a mile north of the highway of that time.

♂-system: The vas deferens is short, looping under the right ocular retractor, and forms a kink accompanied by a slight enlargement as it enters the epiphallus. The epiphallus is long and slender, rather evenly cylindrical until a point somewhat past the insertion of the retractor, but its final portion steadily diminishing in caliber except for a small but distinct oval expansion just before it enters the penis by way of a short and very narrowly restricted neck. The epiphallic caecum is very long and slender, longer than the penis, although not as long as the epiphallus. The large penis is elongate and sausage-shaped, abruptly expanding from the epiphallus at its proximal end and opening into the basal part of the atrium at its distal end; it is about as long as the combined atrium and vagina, but much shorter than either the epiphallus or its caecum; its inner tube is very thick-walled and folded into its very narrow lumen; the outer tube or sheath is closely applied and more or less adherent to the inner tube, very thin-walled, membranous, yet appearing in a small excised fragment of preparation 6548b as though composed of two or three layers. Retractor muscle slender and inserted quite high up (about at the distal third) on the epiphallus.



1

♀-system: The vagina is comparatively slender, quite straightly aligned, and rather shorter than the penis. The spermatotheca is small, with a long duct, and is provided with an exceedingly long convoluted

diverticulum of considerably greater diameter than is the duct at their point of junction and as great as or even slightly greater than that of the long common duct which does not effect juncture with the vagina until nearly or quite opposite the apex of the dart-sac. The atrium is large, saccular, thick-walled, nearly as long as the vagina, which enters it on one side well above the middle. The dart-sac is large, rotund, perched upon a pouch-like atrial sac or apical projection of the atrium a little larger than itself, and divided therefrom by a sharp constriction partly subtended in the specimen figured[1] by a small collar-like pad which appears to be continuous with the stalk-like common duct (a little longer than the dart-sac) of the two very large, moderately swollen, elongate-oval mucus-glands; the terminal appendices of the mucus-glands are not very extensive, but are fairly long, looped closely back on themselves, and furnished with copious enveloping membranous extensions.

Comments and Comparisons: Several of the anatomical features above described are remarkable among the species of the genus *Helminthoglypta* so far as these have been made known,— (1) the long saccular atrium, with (2) the vagina entering high on one side; (3) the extreme constriction of the epiphallus before it enters (4) the abruptly enlarged sausage-shaped penis; and (5) the small node-like inflation of the epiphallus just precedent to its final narrowing. Less peculiar, but also worth noting, are the extremely long redundant diverticulum, the large rotund dart-sac, the long mucus-glands, and the long epiphallic caecum. Many of these features are prevised in Pilsbry's hitherto rather enigmatic second figure of the reproductive complex in his original *H. cuyamacensis* (1939: 146, fig. 73), and it was certainly because of this that Gregg (1940: 33) so promptly identified the Pilsbryan snail with *H. lowei*. That a relationship is demonstrated can hardly be denied, but that this is tantamount to actual identity is not at all borne out by my dissections. The similarity is a general one only, and a comparison of my Fig. 1 with that of Pilsbry at once reveals important and, I believe, significant details to which it does not extend. On the ♂ side my preparation reveals (1) a more robust penis; and (2) an epiphallus which is extremely long proximad to the insertion of the retractor (about twice as long as shown in Pilsbry's figure). On the ♀ side we find (1) nothing like the long pre-atrium shown by Pilsbry; (2) the vagina entering the atrial sac about a quarter of the way down instead of immediately under the dart-sac; (3) the vagina much longer and (4) the mucus-glands much larger; (5) a much longer common duct of spermatotheca and diverticulum, consequent upon (6) its entrance into the vagina close to the atrium, and (7) the much higher juncture of the diverticulum relative to both spermatothecal duct and oviduct. It is of interest to note that both figures show the very peculiar distal dilatation of the epiphallus.

2) **Helminthoglypta thermimontis** new species

Pl. 24, figs. 4-9, Pl. 25, Text Figs. 2-4

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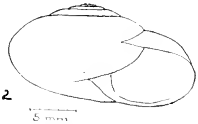
[1] This structure is much more obscure in 6548b.

Description: Shell of moderate size and thickness, with a thin whitish or reddish callus internally, low-conic in outline; whorls 5¼ to 5¾, convex, the suture distinct; last whorl produced anteriorly, moderately to quite strongly descending back of the lip. Aperture rounded-ovate, somewhat flattened above, in profile oblique. Peristome quite distinctly thickened and everted, the columellar flare sufficiently developed slightly to indent the widely funicular umbilicus. Umbilicus permeable to apex, contained on the average about 6½ times in the major diameter of the shell, but this figure varying from but 5½ times in one specimen to as much as 7 or 8 times in two of the smaller shells.



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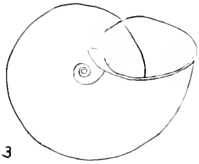


3

Spiral sculpture wanting. Initial half-whorl at first smooth and glassy, then with a few rather coarse concentric wrinkles and a few scattered, serially decurrent papillations superimposed; next succeeding turn very minutely wrinkly-papillose beneath a heavier, more scattered, but inconspicuous granulation which thereafter becomes stronger and is well developed over the main portion of the shell on both superior and inferior surfaces, the rounded papillae showing a somewhat inconstant tendency to arrangement in forward-slanting lines as far as the body-whorl, where they become coarser and more irregular, especially on the upper surface.

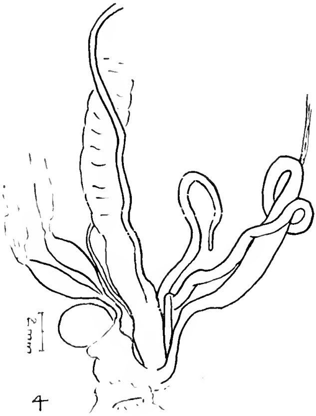
Periostracum of spire Sayal Brown to Snuff Brown, the base of the shell paling almost to Tawny Olive, the conspicuous supraperipheral band Chestnut-Brown, rather obscurely bordered on each side by a somewhat narrower pale area (Ridgway matchings).

Caliper Measurements:

		Max. Diam.	*Min. Diam.*	*Alt.*	*Diam. Umbilicus*	*Number Whorls*
		mm.	mm.	mm.	mm.	
	Paratype	27.3	22.7	15.1	4.3	5 3/4
	"	24.8	20.8	14.2	4.0	5 1/2
6548*b*	"	24.8	20.2	14.1	3.4	5 1/3
	"	24.6	20.4	14.3	4.0	5 2/3
	"	24.1	19.5	12.3	4.0	5 1/4
	"	23.8	19.8	13.7	3.9	5 1/3
	"	23.2	19.5	13.6	4.1	5 1/4
6547*a*	Paratype	23.2	19.2	14.0	3.5	5 2/3
	"	23.2	19.3	13.0	3.8	5 1/3
	Holotype	22.5	18.4	12.3	3.5	5 1/2
	Paratype	22.5	18.6	12.1	3.2	5 1/4
	"	21.8	18.3	13.2	2.6	5 1/2

♂-system: The vas deferens is short, looping tightly under the right ocular retractor to bind itself and the associated organs close to the base

of the vagina, and enters the epiphallus on the inner side of its curve by a hook-like kink. The epiphallus is quite evenly cylindrical, a little longer than the penis, bears a moderately long caecum (which is, however, a little shorter than the epiphallus itself), and insensibly enlarges into the penis. The penis too is long, club-shaped, attaining its maximum at about the proximal quarter, whence it tapers gradually to the slender stem-like exit; its inner tube is narrow and distinctly separate from the moderately thick-walled outer tube. The retractor muscle is very long, thin, flat, delicate, and inserted on the epiphallus but slightly proximad to its point of passage into the penis.



♀-*system*: The distal part of the oviduct is sharply narrowed, the lessening of its convolutions and *pari passu* its transition into the vagina being so gradual that it is not easy to decide upon any precise demarcation. The vagina is rather short, the distance distad to the emergence of the vas but about half as long as the penis. The spermatotheca is of moderate size, its duct slender, flattened, and quite long, almost equal in its greatest diameter to the long convoluted diverticulum which conjoins it with about the same diameter as the long common duct; the latter swells nearly opposite the top of the atrium to form a sharp node-like enlargement continuous with the rather abrupt basal expansion of the vagina. The atrium is a short, thick-walled, asymmetrical sac, most distended at the extreme base where both vagina and penis enter at one side; this sac is roughly rhomboid in form, and surmounted by a very large, oblique, rotund, heavy-walled dart-sac set off by a sharp basal constriction. The mucus-glands are large, elongate, moderately tumid, and provided with the usual convoluted membranous extensions apically; they open into a slender common duct perhaps half as long as the dart-sac.

Holotype: to be deposited in the collection of the San Diego Museum of Natural History. *Paratypes*: Cat. No. 6547 Berry Collection; others to be deposited in the collections of the United States National Museum, the Museum of Comparative Zoology of Harvard College, and the private collections of Allyn G. Smith, Dr. Wendell O. Gregg, and Emery P. Chace.

Type-Locality: Alt. 5000-5500 ft., gulch on southeast side of Hot Springs Mountain (see Pl. 25), Los Coyotes Indian Reservation, San Diego County, California; 11 mature and 7 immature living snails, 8 mature and 6 immature empty shells, S.S. Berry and Willis G. Craig coll., 5 April 1928; others taken in the immediate vicinity by Allyn G. Smith, 17 April 1919.

Comments and Comparisons: This fine snail at once suggests its mountain neighbor across the valley to the northwest, *H. lowei* (Bartsch) of the Palomar Range. In shell characters alone the two species are quite weakly differentiated, *H. thermimontis* being separable principally because of its wider umbilicus,[2] lesser number of whorls, and distinctly narrower and less inflated body-whorl. In fact were shells alone available to the student those of these two forms are so closely alike in sculpture and texture as well as in general form that he would be hard put to it to decide whether the two should be divided more than racially, it would take so little for connectent specimens to bridge the small gap between them.

The reproductive anatomy, on the contrary, tells a completely different story. The truly astonishing and unexpected situation revealed here is best brought out by a recapitulation in parallel columns of the more salient features of the two species.

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[2] This character does not seem important when comparison is made with Bartsch's fine figure of his holotype, but his specimen does not seem fully characteristic of its race in this particular, being more widely umbilicate than any topotype or other specimen from Palomar Mountain that I have seen.

	H. lowei	*H. thermimontis*
Epiphallus	Very long, about twice the length of the penis; a small dilatation followed by a sharp constriction distally.	Short, about equal in length to the penis; no distal dilatation or constriction.
Epiphallic caecum	Very slender and much longer than penis.	Shorter than penis.
Penis	Inner tube thick-walled, folded into its narrow lumen, and completely filling the thin-walled outer envelope. Entire organ large, sausage-shaped, sharply enlarged from epiphallus; base little constricted.	Inner tube slender, not filling the relatively thick-walled outer envelope. Entire organ club-shaped, gradually enlarging from epiphallus; base stalk-like.
Retractor penis	Attached high on epiphallus.	Attached near junction of epiphallus with penis.
Vagina	Narrow, of moderate length, entering high on atrium.	Stout, entering low on atrium close to penis.
Atrium	Very large, ovate; atrial sac small.	Short, with wide basal expansion; atrial sac large.
Dart-sac	Ovate-spherical, moderate in size, smaller than atrial sac.	Nearly spherical, very large, about as large as atrial sac.
Mucus-glands	Very large, elongate-ovate; common duct longer than dart-sac.	Moderately large, elongate; common duct shorter than dart-sac.

The only taxonomic divarication which has thus far been proposed within the genus *Helminthoglypta* is that of Pilsbry (1939: 68, 69, 170). On the foundation of a single character, the structure of the penis-wall, he divides the genus into two subgenera. In one subgenus, named by him *Charodotes*, this organ is solid, with its constituent layers of tissue closely adherent. In the typical subgenus, the outer layer is free so that the sac-like penis appears to be enclosed within an envelope. The actual significance of this difference in structure is not shown nor are any histological studies available which would help us in interpreting it. Furthermore, so far as it has been traced through the various species, the *tudiculata*, *californiensis*, *arrosa*, and *dupetithouarsii* groups appear to lie on one branch of the divarication and most of the *traskii* and *petricola* group of species on the other, whereupon some troublesome disassociations (from the standpoint of groupings based upon other structures) quickly become apparent. For example, *H. walkerana*, *H. ayresiana*, and *H. phlyctaena* do not find themselves closely grouped, but split. On this basis too, though perhaps properly, despite the close similarity of their rough, papillose shells, the *cuyamacensis*-series affords a world of trouble.

In the present instance, even though a careful histologic analysis of the tissues should show that the closely applied, adhering outer membrane of the penis in *H. lowei* is not quite Charodotean and not fundamentally different from the loose envelope in *H. thermimontis*, we are left with all the radical differences evinced in the rest of the anatomy still staring us in the face.

Thus, the most remarkable and surprising feature in all this is comparative, that two snails so closely similar in shell and locale should offer such radical contrast in internal organization. On the other hand the most unique single peculiarity to be noted in *H. thermimontis* probably lies in the curiously formed atrium and dart-sac. I know nothing elsewhere in the genus which is closely similar.

The specific name chosen is derived from the L. *thermae*, hot springs, and *mons*, mountain, and has reference to the current name of the eminence which at present provides its only known habitation.

Conclusion

Discovered in occupancy of precisely similar habitats, in the same Life Zone (Transition), well toward the summit of neighboring mountains, are two species of snails, so closely similar in all outward appearance that a certain amount of experienced meticulousness is required in their discrimination, yet so strikingly different in the anatomy of their reproductive systems that it seems fairly doubtful whether they could successfully mate, while according to the criterion adopted by the latest monographer of the genus, some might even place them in separate subgenera. The single character relied upon in the establishment of *Charodotes* Pilsbry 1939 runs athwart so many other features apparently of at least equal import that one cannot avoid a certain skepticism as to whether this group in fact forms a natural segregate or even indeed a useful one. Certainly as at present constituted it quite fails to do so. The structure of the penis-wall has never in any species been subjected to precise histologic investigation, for instance by imbedding and sectioning, yet it is so manifest that this structure undergoes wide variation in the respective species and groups that the assumption of an infallible morphologic dichotomy founded upon it may be premature and not fully to be borne out by more intensive study. One must increasingly wonder how far, if at all, it is safe to trust to a single character in basing a distinction as wide as a subgenus. And surely when such division runs across the grain of other known characters within the group it becomes still more needful to be wary.

I have here entered into perhaps redundant detail for the express purpose of bringing into sharper focus a yet deeper question of speciation and distribution which is of the utmost interest, and which now, as limned by the outline of these two species, is squarely within our view. What are their real relationships? Are they so closely allied to one another that we may refer to them as "geminate species," which, as their shell characters would indicate, have effected a comparatively recent divergence since their separation and isolation upon neighboring mountain tops? Or are their nearly identical shell characters the deceptive consequence of a convergent response to closely similar ecological influences, and their actual phylogenetic relationship consequently more remote as is so strongly indicated by the unexpected diversities evident in the reproductive anatomy? Although I must confess that the key to answering such far-reaching queries is one I have not yet come by, it seems to me that it must lie to a considerable degree implicit in the answer to yet another question—which characters in land-snails are correctly to be regarded as the more conservative and stable, and which as the more plastic, those of the hard shell with its more or less consistent sculptural detail, or those of the soft internal organs? The anatomical differences above described are so numerous, so great, and of so fundamental a character that it seems altogether incredible that they are not deeply significant; yet all the distributional and ecological data at hand seem rather to support the old-fashioned dictum that the shell is the more reliable key (within certain limits of course) to natural affinity. The large number of varyingly isolated species and races scattered about southern California, offering shells of such closely similar, occasionally almost invariant type that at times they could hardly be separated successfully if deliberately mixed together, coupled with a veritable eruption of anatomical variation, offers a most tempting field for future research, upon the outcome and interpretation of which our whole understanding of the phylogeny and inter-relationships of the members of this important and fascinating genus may one day turn.

Summary.

An hitherto undescribed land-snail, *Helminthoglypta thermimontis* n. sp., which inhabits the Transition Zone on Hot Springs Mountain, the highest peak in San Diego County, California, is intensively compared with an isolated neighboring species, *H. lowei* (Bartsch) which occupies corresponding habitats on neighboring Palomar Mountain, the two ranges being separated by the Upper Sonoran San Luis Rey Valley. Although the shells in the two species exhibit only very minor differentiation, the reproductive anatomy proves to be strongly divergent in practically all details. Attention is called to the bearing of the data set forth on the taxonomic value of the subgenus *Charodotes* Pilsbry 1939, and on the more fundamental question of the relative evolutionary plasticity of shell characters in land snails as against those of the internal organs.

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PLATE 24

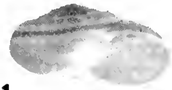
Figs. 1-3. *Helminthoglypta lowei* (Bartsch). Shell of specimen 6548c from Palomar Mountain, California; about natural size.

Figs. 4-6. *Helminthoglypta thermimontis* n. sp. Shell of holotype from Hot Springs Mountain, San Diego Co., California; about natural size.

Figs. 7-9. *Helminthoglypta thermimontis* n. sp. Shell of paratype 6547c from Hot Springs Mountain, San Diego Co., California; about natural size.

Fig. 10. *Helminthoglypta thermimontis* n. sp. Microphotograph of upper surface of latter portion of last whorl of holotype, showing papillose sculpture; x.

Fig. 11. *Helminthoglypta thermimontis* n. sp. Microphotograph of basal surface of latter portion of last whorl of holotype; same scale as preceding.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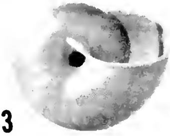
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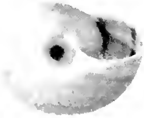
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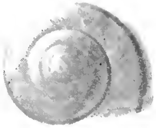
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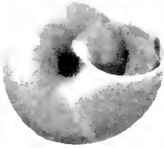
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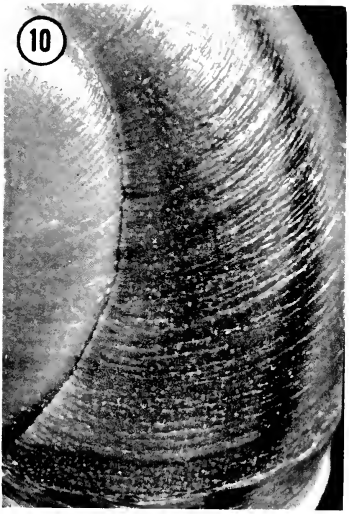
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PLATE 25

View looking up trail on southeast side of Hot Springs Mountain, San Diego Co., California; the type locality of *Helminthoglypta thermimontis* is among the trees on the right side of the small canyon shown in the center of the picture. (Photograph by S. S. Berry, 5 April, 1928.)

Explanation of Text Figures

Fig. 1. *Helminthoglypta lowei* (Bartsch). Camera sketch of anterior portion of ♂ ♀ system of specimen 6548a.

Figs. 2-3. *Helminthoglypta thermimontis* n. sp. Camera outlines of shell of holotype.

Fig. 4. *Helminthoglypta thermimontis* n. sp. Camera sketch of anterior portion of ♂ ♀ system of paratype 6547c; same scale as Fig. 1.

TRANSACTIONS

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MOLLUSKS FROM CLIPPERTON ISLAND (EASTERN PACIFIC)

with the

DESCRIPTION OF A NEW SPECIES OF GASTROPOD

BY

Leo George Hertlein and William K. Emerson

SAN DIEGO, CALIFORNIA
Printed for the Society
July 22, 1953

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LEO GEORGE HERTLEIN[2] and WILLIAM K. EMERSON[3]

INTRODUCTION

The marine faunas of Clipperton Island are of particular interest to zoogeographers because of the presence of Polynesian elements in an area situated on the boundary between the Panamic and Indo-Pacific Faunal Provinces. Through the courtesy of Dr. Edward L. Hamilton[4] the writers were privileged to examine a small but significant collection of mollusks representing most of the biological contents of two dredge hauls from 100-200 fathoms off the east slope of Clipperton Island. The material was collected in May, 1952, by the scientific personnel of Expedition "Shuttle" of the United States Navy Electronics Laboratory and represents the first deep water collection from that area. Five species of mollusks, two gastropods, one of which is described as new, three pelecypods, and two species of stony corals (not included in this paper) were represented in the dredged material. The acquisition of this material has prompted the writers to prepare the present report.

The authors wish to express their appreciation to Dr. J. W. Durham, Associate Professor, Department of Paleontology of the University of California, for helpful suggestions and for critical reading of the manuscript. Dr. G. D. Hanna, Curator of the Department of Paleontology, California Academy of Sciences, offered suggestions concerning the new species described in the present paper. Mr. J. R. Slevin, Curator of the Department of Herpetology of the same institution, called our attention to some of the references pertaining to Clipperton Island and furnished a photograph of the island. The conchological collection in the Department

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[1] Contribution from the Department of Paleontology, California Academy of Sciences, and the Museum of Paleontology, University of California.

[2] Associate Curator, Department of Paleontology, California Academy of Sciences.

[3] Museum of Paleontology, University of California.

[4] United States Navy Electronics Laboratory, Point Loma, San Diego, California.

of Geology at Stanford University was made available to us through the kindness of Dr. A. Myra Keen. Mr. Ted Dranga of Miami, Florida, furnished information concerning the occurrence of *Conus ebraeus* and sent specimens of *Bursa* useful to us during the present study. Mr. Elton L. Puffer, Department of Paleontology, University of California, aided us in verifying certain of the bibliographic references in the University library. Mrs. Carma R. Zimmerman, Librarian, and Mr. Allan R. Ottley, California Section Librarian, furnished references to articles concerning Clipperton Island in the California State Library at Sacramento, California. Mr. J. A. Gibbs, Jr., Seattle, Washington, gave information concerning the ship "Kinkora" which was wrecked on Clipperton Island. The photographs used to illustrate the specimens of mollusks on the plate were made by Frank L. Rogers.

General Remarks Concerning Clipperton Island

Clipperton Island is a coral atoll about two miles in diameter, surrounded by a fringing reef, which lies in Latitude 10°17′00″N., Long. 109°13′00″W., about 670 miles southwest of Acapulco, Mexico. The general cartographic features are shown on United States Hydrographic Office Chart No. 1680. It is cited in some of the early literature and charts under the names of "La Pasión" and "Médano" or "Los Médanos." Some authorities (Cubas, 1909: 76-77) have suggested that the island, or evidences of it, may have been sighted as early as 1527 by Captain Alvaro de Saavedra Cerón, captain of a Spanish armada sent across the Pacific to the East Indies by Hernando Cortés. Others consider it likely that the island was not discovered before the eighteenth century. It was definitely sighted by Clipperton in 1705. Morrell (1832:219) who anchored off the island in 1825 believed it to be of volcanic origin. He remarked on the presence of immense numbers of sea birds, a few land birds, and a few fur seals and sea elephants. A little coarse shrubbery, some coarse grass and a plant resembling sarsasparilla were recorded as occurring on the atoll. Later Belcher (1843:255-257) viewed it from the masthead but, like Clipperton, did not land there. Belcher remarked on the presence of two openings in the atoll, both on the weather side. It appears that the name Clipperton was first applied to this island by Captain Cook. Both Mexico and France have laid claim to this small islet; the latter has received the latest legal approval from an international tribunal to support her claim. The greater part of the atoll is composed of coral limestone which extends from about five to fifteen feet above sea level and varies in width from a few yards to one half mile.

On the southeastern edge, a single mass of rock (known as Clipperton Rock), an altered trachyte[5] (Teall, 1898; Elschner, 1913; Lacroix, 1931; Glasser, 1932) containing 54% of silicon dioxide, rises to a height of 62 feet (plate 26). This island furnishes nesting sites for a multitude of sea birds (Edwords, 1906; Gifford, 1913).

There have been differences of opinion as to the origin of this atoll. Pease (1865:201) believed that it showed evidences of elevation. He cited the journal of Lieutenant Griswold who landed on the island and who recorded that in places the walls of the high rock mass were encrusted with coral. Wharton (1898) inclined to the belief that the coral may have formed on the lip of a portion of a volcanic crater and that the highest portion of the island might be what remains of a volcanic plug. Others including W. M. Davis (1928), in one of the most comprehensive modern studies of coral reefs and atolls, considered Clipperton Island to be a "near-atoll" and probably a product of subsidence. A unique feature of the atoll is the considerable depth of the enclosed lagoon, reported to contain brackish water (Anon., 1938), which has been cited as ranging from one foot to fifty-five fathoms.

This lone atoll in the eastern Pacific is seldom visited. Its isolated position in the open sea results in a heavy surf which usually beats upon the shores. Abrupt changes in the weather may give rise to sudden squalls with attendant low visibility. This condition, together with lack of shelter and very poor anchorage, discourages the mariner from spending much time in that vicinity. The "Kinkora" was wrecked there in 1897 (Anon., 1897).

Guano and the phosphatic coral rock, some of the latter said by Elschner (1913:92) to contain 78 percent phosphate, led at times to commercial exploitation of these products which were shipped to the mainland. Workers were brought to the island at various times in connection with the concession to engage in this industry. Some of the experiences of the inhabitants have been described by Perrill (1937) and others (Anon., 1893).

Occasionally expeditions engaged in scientific research stopped briefly at Clipperton Island and collected a few natural history specimens. A few specimens from the island reached collectors through other sources.

One of the earliest collectors to secure a number of species of mollusks on the island was W. H. Ochsner, a member of the expedition of

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[5] Living specimens of *Delectopecten zacae*, dredged (Exped. "Shuttle") from 110-150 fathoms off the east slope, were attached to pebbles of trachyte.

the California Academy of Sciences to the Galapagos Islands in 1905-1906 (see Slevin, 1931:21-22). Eleven species and subspecies assembled by Ochsner were reported by Hertlein (1937). Dall (1910; 1911), Lowe (1933) and Bartsch & Rehder (1938) cited additional species from that locality. The species of *Conus* were recently included in a monograph by Hanna & Strong (1949) and the species of *Cypraea* by Ingram (1947; 1951).

In view of the few collections that have been made in this area, it seems reasonable to conclude that systematic collecting would greatly enlarge the known fauna.

Mollusks from Clipperton Island

A list of species of mollusks known to occur on Clipperton Island, compiled from collections and the literature, follows. Those not known to occur along the mainland of the western Americas are indicated by an asterisk (*).

Species and subspecies	Faunal Province	Source of Record
Pelecypoda		
"*Acar* species? (young)"	?	Bartsch & Rehder (1939:16)
Anomia peruviana d'Orbigny	Panamic[6]	Here recorded Exped. "Shuttle."
**Chama squamuligera subropicta* Bartsch & Rehder Very similar to *C. squamuligera* Pilsbry & Lowe, a Panamic species.	Clipperton Island type locality	Bartsch & Rehder (1939:16); also Exped. "Shuttle."
Ctena clippertonensis Bartsch & Rehder Similar to *C. clarionensis* Hertlein & Strong from Clarion Island, Mexico; also *C. bella* Conrad from the Hawaiian Islands, *fide* Bartsch & Rehder (1939:14).	Clipperton Island type locality. Also recorded from Maria Madre Island, Mexico, and Hannibal Bank, Panama, by Hertlein & Strong.	Bartsch & Rehder (1939:16)
Delectopecten zacae Hertlein	Panamic	Here recorded, Exped. "Shuttle."
Gastropoda		
**Bursa granularis* (Bolten) Röding[7] Synon.-*Ranella granifera* Lamarck.	Indo-Pacific	Morrison (1949:11) Also in Calif. Acad. Sci. coll.
**Clanculus* (*Panocochlea*) *clippertonensis*, n. sp.	Clipperton Island type locality	Here recorded, Exped. "Shuttle."

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[6] The Panamic faunal province is here construed as including tropical west American mollusks from west Mexico to northern Peru.

[7] *Tritonium jabick* (Bolten) Röding has line priority and may be the correct name for this species. Iredale (Rec. Australian Mus., Vol. 18, No. 4, June 29, 1931, p. 213) stated: . . . "*granifera* Lamarck, apparently equivalent to *granularis* Bolten and *jabick* Bolten, the latter having priority is here made the type of a new genus *Dulcerana*." On page 232, "*Dulcerana* gen. nov.: type *Ranella granifera* Lamarck." This appears to be distinct from *Bursa pustulosa jabick* Fischer, from West Africa.

Conus brunneus Wood	Panamic	Dall (1910:220)
Conus ebraeus Linnaeus	Panamic[5] and Indo-Pacific	Hertlein (1937:306); Hanna & Strong (1949: 312)
**Conus ebraeus vermiculatus* Lamarck	Indo-Pacific	Hertlein (1937:306)
Conus gradatus Mawe	Panamic	Hanna & Strong (1949:279)
Conus purpurascens regalitatus Dall	Panamic	Dall (1910:219)
Conus tiaratus Broderip	Panamic	Dall (1910:220, as *C. miliaris* Hwass); Bartsch & Rehder (1939:16, as *C. rooseveltí*). (See Hanna & Strong, 1949:272).
Cymatium vestitum Hinds *Cymatium vestitum insulare* Pilsbry occurs in the Hawaiian Islands. Both *C. vestitum* and its subspecies closely resemble the Indo-Pacific *C. pileare* Linnaeus.	Panamic	Hertlein (1937:307)
**Cypraea depressa* Gray	Indo-Pacific	Hertlein (1937:307, as *C. gillei* Jousseaume); Ingram (1947:72; 1951:149).
**Cypraea isabella* Lamarck	Indo-Pacific	Hertlein (1937:307); Ingram (1947:73; 1951:150).
Cypraea isabella mexicana Stearns	Panamic	Hertlein (1937:307); Ingram (1947:73; 1951:152).
**Cypraea scurra* Gmelin	Indo-Pacific	Hertlein (1937:307); Ingram (1947:77; 1951:157).
**Cypraea teres* Gmelin	Indo-Pacific	Hertlein (1937:307); Ingram (1947:81; 1951:162).
**Drupa ricinus* Linnaeus	Indo-Pacific	Hertlein (1937:308) Bartsch & Rehder (1939:16, as *Drupa "ricina"*).
**Hipponix fimbriatus* Bartsch & Rehder Very similar to *H. serratus* Carpenter, a Panamic species.	Clipperton Island type locality	Bartsch & Rehder (1939:16).
Hipponix pilosus Deshayes Synon.-*H. barbatus* Sowerby	Panamic and Indo-Pacific	Bartsch & Rehder (1939:16, as *H. barbata* Sowerby).
**Littorina schmitti* Bartsch & Rehder Related to *L. pintado* Wood from the Hawaiian Islands, *fide* Bartsch & Rehder (1939:10).	Clipperton Island type locality	Bartsch & Rehder (1939:16).

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[5] Mr. Ted Dranga (written communication, January 14, 1953) recently collected a live specimen of *Conus ebraeus* on the Pacific coast of Guanacaste Province, Costa Rica. It was taken "in a crevice on an extensive area of hard rock wave bench covered with short sea weed—just the sort of location that would have supported *ebraeus* in Hawaii. It was an area that is bared by the low tides, and the spot was not far from low water mark."

**Magilus robillardi* Lienard	Indo-Pacific	Bartsch & Rehder (1939:16).
**Mitra papalis* Linnaeus	Indo-Pacific	Hertlein (1937:308).
**Morula uva* Bolten (Röding) Synon.-*Ricinula morus* Lamarck; *Ricinula nodus* Lamarck; *Morula papillosa* Schumacher.	Indo-Pacific	Hertlein (1937:308, as *Drupa morus* Lamarck); Bartsch & Rehder (1939: 16, as *Morula nodus* Bory St. Vincent).
Nassarius catallus Dall	Panamic	Here recorded, Exped. "Shuttle."
**Nerita plicata* Linnaeus	Indo-Pacific	Bartsch & Rehder (1939:16)
**Opeas oparanum* Pfeiffer A land snail	Indo-Pacific	Bartsch & Rehder (1939:16)
Purpura nuttalli Conrad Almost certainly ballast	Californian	Collected by W. H. Ochsner. Label by I. S. Oldroyd states "ballast shell?"
Voluta ancilla Solander Almost certainly ballast	Patagonian	Lowe (1933:112)
**Voluta deshayesii* Reeve	Indo-Pacific	Dall (1911:112); Lowe (1933:112); Hertlein (1937:308)

The foregoing list is comprised of 31 species and subspecies of which one is a landsnail. In addition one genus (*Acar* sp.) occurs there, the species of which is unknown. Four species and subspecies are pelecypods and 27 are gastropods. Of the latter, one Californian species, *Purpura nuttalli* Conrad, almost certainly arrived on the island adventitiously by ballast in a ship or by other means and it appears quite probable that the same applies to *Voluta ancilla* Solander, a species known to occur in the Straits of Magellan and the neighboring region. This list obviously denotes but a small portion of the total molluscan fauna of the area, but its composition, based upon known occurrences, is extremely significant.

A number of the records of molluscan species cited from Clipperton Island are based upon shells lacking the live animal. However, in connection with this fact it is important to recall that a number of Indo-Pacific invertebrate species (mollusks and echinoids) have been taken alive in the eastern Pacific. Among these are *Quoyula madreporarum* (mainland; Marie Madre Island, Tres Marias Islands; Socorro Island, Revillagigedo Islands), *Conus ebraeus* (Costa Rica), *Conus tessullatus* Born (Synon.—*C. edaphus* Dall) (Clarion Island, Revillagigedo Islands), *Hipponix pilosus* Deshayes (Synon.—*H. barbatus* Sowerby) (mainland; Tres Marias Islands; Revillagigedo Islands; Galapagos Islands), the echinoids *Brissus latecarinatus* Leske (Gulf of California to Panama), *Metalia spatagus* Linnaeus (Gulf of California), *Echinometra oblonga* Blainville (Gulf of California; Clarion Island, Revillagigedo Islands; Galapagos Islands) and *Lovenia cordiformis* A. Agassiz (Santa Barbara, California, to Guayaquil, Ecuador; Hawaii).

Twelve species and subspecies (3 pelecypods and 9 gastropods), a little more than a third of the total number, are known to occur on the mainland of the tropical Americas. Of these, nine represent truly Panamic faunal elements, one is closely allied to a species described from Clarion island, and two gastropods, *Hipponix pilosus* and *Conus ebraeus* have been found living both on the mainland and in the Indo-Pacific region. One pelecypod and 16 gastropods have not been recorded from the mainland. Three of these gastropods have been recorded as occurring in the Galapagos Islands. Of the four species (1 pelecypod and 3 gastropods) known only from Clipperton Island, three have affinities with Panamic and one with Hawaiian forms. *Hipponix pilosus* is the only one of the Indo-Pacific mollusks from Clipperton Island which is known to occur as a fossil in the eastern Pacific. None of these species is known to be living in the Caribbean, but one species, *Cypraea isabella* or a subspecies of it, has been recorded as a fossil in the Miocene in that region. At least 10 of the 14 typically Indo-Pacific gastropods from Clipperton Island also occur in the Hawaiian Islands.

The vast expanse of uninterrupted abyssal marine water between the west American shores and the easternmost Polynesian Islands, the Eastern Pacific Barrier of Ekman (1935:105; 1953:72; Sverdrup, *et al.*, 1942: 860-861), is generally considered to be the prime obstacle to the distribution of littoral marine forms by transoceanic currents. It is an interesting fact, however, that the majority (approximately 60%) of the gastropods definitely known to comprise a portion of the Clipperton Island fauna are Indo-Pacific forms or have definite affinities with Indo-Pacific species.

The great preponderance of gastropods (25, not including 2 believed to have arrived as ballast) as compared to the pelecypods (4 and one genus, the species unknown), the comparatively large number of species of *Conus* (6), and *Cypraea* (5), as well as the decided Indo-Pacific affinity of the molluscan assemblage from this island, all are in harmony with the results of studies made by Hertlein (1937).

An analysis of the data afforded by the present list and those presented by Hertlein (1937) on the fauna of the other off shore islands (Cocos Id., Galapagos Ids., etc.), would seem to indicate that such groups as the Cypraeidae, Conidae, Bursidae and Cymatidae have exceptionally long pelagic larval stages which can tolerate current transport of considerable duration. Dispersal may also be accomplished by the attachment of the adult or larval phases to floating objects, to the feet of birds, to nekton, that is, pelagic swimming organisms such as fishes, mammals, etc., and as transport by man. It seems probable that most of the Indo-Pacific gastropod species reached Clipperton in a larval state by way of the Equatorial Counter Current. Whatever the agent of transport, it is significant to note the predominance of gastropods over the pelecypods, the latter with one exception, are all attaching types of Panamic faunal association. Obviously, this suggests that in the mollusks the larval stages of the gastropods afford the most successful means for dispersal of littoral forms across a great expanse of deep water. Hedley (1899:391-417) pointed out that distribution in Polynesian islands indicates that deep water is not a barrier to *Conus*, *Cypraea* and *Mitra*. Powell (1933:154-164) mentioned that triton shells pass through a free swimming stage in which the apical shell is allied to the type known as *Sinusigera*, a type of apex always associated with species of wide distribution. Iredale (1911: 319) noticed its presence in species of the Mitridae, Buccinidae, Nassariidae, Thaisidae, Pyrenidae, Coralliophilidae, Turridae, and Terebridae. Ostergaard (1950) found that forty of forty-one species (97 percent) of Hawaiian marine gastropods studied by him which attained the veliger stage were found to have a free swimming stage. The results of his work and that of others indicate that the greatest number of free swimming larvae occur in warm waters, the fewest in cold waters.

Inasmuch as the Equatorial Counter Current reaches the American coast, it is difficult to explain why more of the Indo-Pacific species have not been able to become established on the continental shelf. Only a very few of the Polynesian species appear in American coastal waters, the extreme eastern range for most of those species being the islands lying far off shore, namely, Cocos Island, Clipperton Island, the Tres Marias Islands, Revillagigedo Islands, and the Galapagos Islands. This restrictive distributional barrier is undoubtedly created by a number of complex factors interplaying upon each other, one of which perhaps is the competition of the established Panamic fauna.

Menard (1953:22) recently reported the discovery of a submarine escarpment trending between Christmas and Clipperton Islands, a distance of approximately 3300 miles. This topographic high is recorded to be 1000 feet in altitude and is bounded in its eastern limits by the Acapulco Trench. This submarine ridge is another factor to be taken into account in considering a possible migrational route for Indo-Pacific faunal elements to cross the mid-Pacific deep to Clipperton Island. The deep water of the Acapulco Trench apparently forms a barrier to the establishment of many of the Indo-Pacific species (especially shallow water forms) upon the continental shelf.

Questions connected with the processes of the formation of Clipperton Island, together with its isolated geographic location, the preponderance of Indo-Pacific mollusks there, continue to invest this easternmost atoll in the Pacific with a singular attraction, intriguing to students of natural history.

Clanculus (Panocochlea) clippertonensis Hertlein & Emerson, new species

Plate 27, Figures 19, 20, 22

Description: Shell rather small and consisting of about 5 depressed turbinate whorls, the sutures deeply channeled; nucleus smooth, followed by about one and one half similar grayish whorls; the succeeding whorl gradually becomes somewhat flattened, colored red and developing a carinate shoulder posterior to which there are 3 or 4 fine spiral threads; on the succeeding whorls there are 4 coarse, nodose, spiral ribs which are nearly equally spaced and between these major ribs there are 3 or 4 fine spiral threads which become coarser on the later whorls, on the last whorl a nodose median riblet occurs in the interspace between the third and fourth rib and below the latter a weak nodose spiral rib occurs below the periphery, this is followed by 2 or 3 smooth, nearly obsolete spiral threads on the base; the base is broadly rounded, smooth and imperforate; whorls crossed by fine oblique lines of growth; aperture obliquely rounded, columella curved, a well developed node is present near the base, and below this a very small node is present on the base of the aperture, the interior of the outer lip is smooth; exterior of shell above the periphery red, the nodes white, base pinkish-cream and aperture of a pearly cream color. Dimensions: height, 8.6 mm., of aperture 5.9 mm., maximum diameter 10.5 mm.

Holotype: No. 33341, Univ. Calif. Mus. Paleo. Coll. from Loc. A-8635 (U.C.M.P.), east slope of Clipperton Island, Lat. 10°17.5′00″N., Long. 109°11.5′00″W., dredged in 100-200 fathoms by Expedition "Shuttle," U. S. Navy Electronics Laboratory, Point Loma, California, May 14, 1952.

This species bears a general resemblance to *Clanculus* (*Panocochlea*) *rubidus* Dall,[9] originally described from the Gulf of Panama, in 259 fathoms. The species here described as new differs from *C.* (*P.*) *rubidus* in that the major spiral ribs are nearly equally spaced whereas in Dall's species, the third rib is separated by a wide interspace from the two rather closely spaced posterior ribs. The outline of the outer lip of the aperture of the new species is evenly rounded in comparison to that of *C.* (*P.*) *rubidus* in which the outline reflects the depressed interspaces which also bear more numerous spiral threads. The node at the base of the columella on the species here described from Clipperton Island is much smaller than the large callus mass shown in the figure of Dall's species. Furthermore, another very small node occurs on the interior of the base of the aperture, but no such node is mentioned on the Panamanian shell.

The subgenus *Panocochlea* Dall, type *Clanculus* (*Panocochlea*) *rubidus* Dall, lacks the umbilical opening and denticulate aperture typical of the genus *Clanculus* Montfort. The type (by original designation) of *Clanculus* is *Clanculus pharaonicus* Linnaeus originally described as *Trochus pharaonicus.*

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[9] *Clanculus* (*Panocochlea*) *rubidus* Dall, Bull. Mus. Comp. Zool., Vol. 43, No. 6, p. 346, pl. 8, figs. 3, 4, October, 1908. "U.S.S. 'Albatross,' station 3396, Gulf of Panama, in 259 fathoms, mud, bottom temperature 47°.4 F. U.S.N. Mus. 122, 954."

Hoffstetter (Bol. Inst. Cienc. Nat. (Quito), Año 1, No. 1, June, 1952, p. 48) recorded the occurrence of "*Clanculus* cf. *rubidus* Dall" as a subfossil from Salinas, Ecuador.

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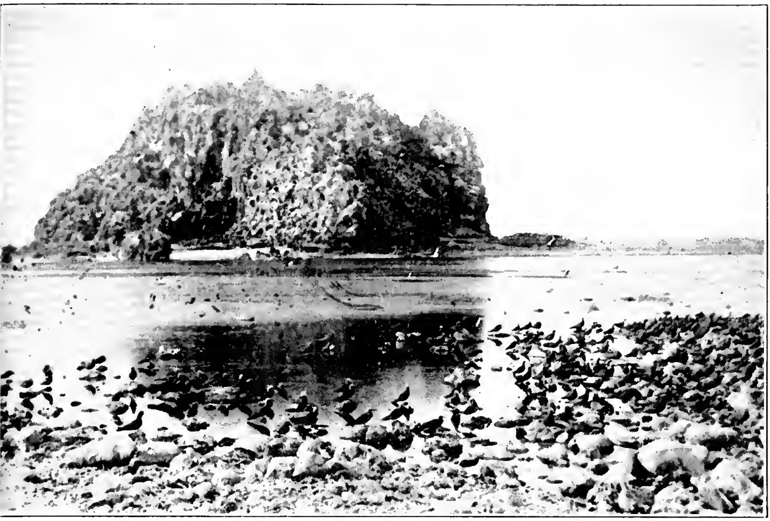


View of Clipperton Rock, a cavernous mass of altered trachyte, looking northwest from coral reef across an arm of the lagoon. The birds in the foreground are noddy terns. Photograph taken by Rollo H. Beck, August 10, 1905.

The original negative from which this picture was made remained undeveloped for over a year until after the Expedition of the California Academy of Sciences to the Galapagos Islands returned to San Francisco on November 29, 1906.

Explanation of the Plate

PLATE 27

Fig. 1. *Cypraea isabella mexicana* Stearns. Hypotype No. 9878, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length 40.4 mm., width 22 mm. Dorsal view.

Fig. 2. *Cypraea isabella* Linnaeus. Hypotype No. 9879, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length 35.4 mm., width 18.2 mm.

Fig. 3. *Nassarius catallus* Dall. Hypotype No. 33343, Univ. Calif. Mus. Paleo. Invert. Type Coll. Length 13.4 mm., maximum diameter 8.5 mm. Inspection of a series of specimens of this species reveals considerable variation in the sculpture. See Figs. 4, 9, 13. The present specimen has fine axial sculpture in comparison to that shown in Figs. 9 and 13.

Fig. 4. *Nassarius catallus* Dall. Hypotype No. 33344, Univ. Calif. Mus. Paleo. Invert. Type Coll. Length 16.5 mm., maximum diameter 11.1 mm.

Fig. 5. *Cypraea scurra* Gmelin. Hypotype No. 9880, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length 47.2 mm., width 24.2 mm. Dorsal view.

Fig. 6. *Cypraea scurra* Gmelin. Ventral view of specimen shown in Fig. 5.

Fig. 7. *Delectopecten zacae* Hertlein. Hypotype, right valve, No. 33347, Univ. Calif. Mus. Paleo. Invert. Type Coll. Length 16 mm., height 16.5 mm.

Fig. 8. *Cypraea teres* Gmelin. Hypotype No. 9881, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length (somewhat worn) 28.2 mm., width 16.3 mm.

Fig. 9. *Nassarius catallus* Dall. Hypotype No. 33345, Univ. Calif. Mus. Paleo. Invert. Type Coll. Length 14.4 mm., maximum diameter 9.2 mm. This specimen, somewhat eroded, has coarse axial sculpture in comparison to that shown in Figs. 3 and 4.

Fig. 10. *Delectopecten zacae* Hertlein. Hypotype, right valve, No. 33348, Univ. Calif. Mus. Paleo. Invert. Type Coll. Length 18.3 mm., height 19.6 mm. Individuals of this species show variation in the development of radial threads on the right valves. Axial sculpture is nearly lacking on the medial portion of the present specimen in comparison to that shown in Fig. 7.

Fig. 11. *Cypraea teres* Gmelin. Ventral view of specimen shown in Fig. 8.

Fig. 12. *Cymatium vestitum* Hinds. Hypotype No. 9883, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length 55 mm., maximum diameter 29.5 mm.

Fig. 13. *Nassarius catallus* Dall. Hypotype No. 33346, Univ. Calif. Mus. Paleo. Invert. Type Coll. Length 15.4 mm., diameter 10.3 mm.

Fig. 14. *Cypraea teres* Gmelin. Hypotype No. 9882, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length (worn) 36.1 mm., diameter 20.9 mm. Dorsal view.

Fig. 15. *Cypraea teres* Gmelin. Ventral view of specimen shown in Fig. 14.

Fig. 16. *Delectopecten zacae* Hertlein. Hypotype, left valve, No. 33348, Univ. Calif. Mus. Paleo. Invert. Type Coll. Length 18.3 mm., height 19.6 mm.

Fig. 17. *Drupa ricinus* Linnaeus. Hypotype No. 9885, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length 20 mm., maximum width 16.8 mm.

Fig. 18. *Bursa granularis* Bolten (Röding). Hypotype No. 9884, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length 54.2 mm., diameter 35 mm.

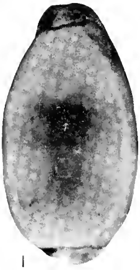
Fig. 19. *Clanculus* (*Panocochlea*) *clippertonensis* Hertlein & Emerson, new species. Holotype No. 33341, Univ. Calif. Mus. Paleo. Invert. Type Coll. Height 8.6 mm., maximum diameter 10.5 mm.

Fig. 20. *Clanculus* (*Panocochlea*) *clippertonensis* Hertlein & Emerson, new species. Basal view of specimen shown in Figs. 19 and 22.

Fig. 21. *Conus ebraeus* Linnaeus. Hypotype No. 9886, Calif. Acad. Sci. Dept. Paleo. Type Coll. Length (slightly worn) 19.5 mm., maximum diameter 9.8 mm.

Fig. 22. *Clanculus* (*Panocochlea*) *clippertonensis* Hertlein & Emerson, new species. Apertural view of specimen shown in Figs. 19 and 20.

Specimens shown in Figures 3, 4, 7, 9, 10, 13, 16, 19, 20, 22, were dredged in 110-200 fathoms off the east end of Clipperton Island by the scientific personnel of Expedition "Shuttle," U. S. Navy Electronics Laboratory, Point Loma, San Diego, California. All the other specimens illustrated on this plate, except those shown in figures 1, 2 and 18 from the Henry Hemphill Collection (C.A.S.) were collected by W. H. Ochsner on Clipperton Island during the Expedition of the California Academy of Sciences to the Galapagos Islands, 1905-1906.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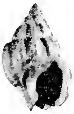
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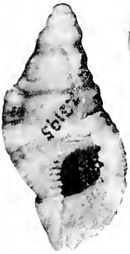
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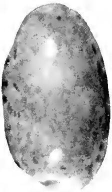
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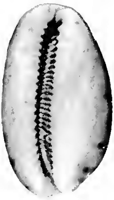
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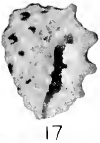
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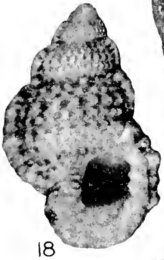
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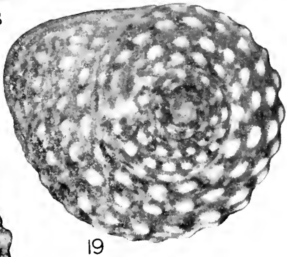
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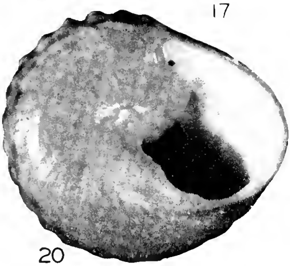
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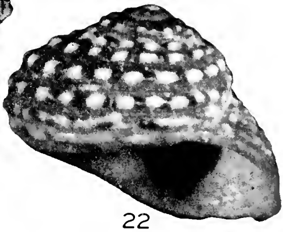
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THE AMPHIBIANS AND REPTILES FROM RANCHO LA BREA

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THE AMPHIBIANS AND REPTILES FROM RANCHO LA BREA*

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INTRODUCTION

Data and records of Pleistocene reptiles and amphibians from the West coast of the United States are rare. A study was therefore made of the herpetological material from Rancho La Brea in the Los Angeles County Museum and the Museum of Paleontology, University of California.

Stock (1949) has recently reviewed the literature on Rancho La Brea and the reader is referred to that paper for any additional information on Rancho La Brea not presented herein.

ACKNOWLEDGMENTS

The writer wishes to thank Dr. Hildegarde Howard of the Los Angeles County Museum and Dr. Charles L. Camp, Museum of Paleontology, University of California, Berkeley, for the loan of Rancho La Brea herpetological material. The writer wishes also to thank Drs. Raymond B. Cowles, George A. Bartholomew, Daniel I. Axelrod, and Laurence M. Klauber for their criticisms and suggestions.

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PART I. RANCHO LA BREA

LOCATION

Rancho La Brea is in the Wilshire district of the city of Los Angeles, Los Angeles County, California. The pits, when found, occupied a grass-filled open area near the base of the wide bajada descending from the nearby Santa Monica Mountains. The pits are now part of Hancock Park, maintained by the Los Angeles County Museum.

AGE

Geological evidence (Eaton, 1928; Grant and Sheppard, 1939; and Woodring, Bramlette, and Kew, 1946) and paleontological evidence (Stock, 1929, 1949; Merriam, 1906, 1911, 1912, 1914; A. H. Miller, 1929, 1937, 1947; and L. Miller, 1910, 1911, 1912, 1925) suggest that the pits at Rancho La Brea are probably very late Pleistocene; just how late requires further investigation by more modern techniques. Many of the characteristic animals found at Rancho La Brea are similar to or identical with types described elsewhere from Pleistocene horizons. Many representatives of living species are also known from the asphalt. It is not known if there has been continuous deposition in the pits from Late Pleistocene into Recent. It seems possible that the various pits may have been exposed to the surface periodically for varying lengths of time from late Pleistocene to Recent. This view is supported by the reptilian fauna to be discussed below.

The presence of the skull of *Camelops* in a cave in west-central Utah and remains of ground sloths, *Nothrotherium*, in the dry caves of Nevada, Arizona and New Mexico suggest that those species, which have also been found in Rancho La Brea, were living in North America in relatively recent times. Radiocarbon dating (Arnold and Libby, 1951) of the dung of *Nothrotherium* found in the Gypsum Cave, Nevada, gives an age range of from 8,000 to 10,000 years for this material.

The presence of human remains and a few extinct species of birds, with no extinct mammals in pit 10, suggests that this pit is an important link between the Pleistocene and the Recent (Merriam, 1914; Howard and Miller, 1939).

MATERIAL

Herpetological material from Rancho La Brea has been found in Pits A, B, 3, Y, 81, and 101, and in University of California Museum of Paleontology localities 2051 and 2052. Some material in the Los Angeles County Museum is labeled "Rancho La Brea" with no other data. The approximate positions of the majority of these localities may be seen in Fig. 1.

Herpetological material from the early excavations is rare or lacking. In these sites, the larger bird and mammal bones were saved, but the residue, probably containing many amphibian and reptile bones, was discarded. Recently, Dr. W. D. Pierce of the Los Angeles Museum, assisted by Drs. E. E. Hadley and G. A. Kanakoff, made extensive re-examinations of the material from Pits A and B, primarily in search of entomological material. Dr. Pierce has developed a special xylene technique for separating the oil and tar from the smaller organic material. The writer is indebted to him for saving and separating the herpetological material. Dr. Pierce has also washed out the brain cases of some of the Saber-toothed Cats from earlier excavations and has found herpetological remains in them.

The fragility of small amphibian and reptilian fossils, even those from Rancho La Brea, cannot be over-emphasized.

METHODS

All the herpetological material taken from the tar pits has been compared with recent skeletons and checked with descriptions in the literature. In some cases the differences would not be of major osteological character but are those of minor shapes, processes, contours, and proportions. In some cases specific identification was impossible, but in most, the species could be determined.

LIST OF SPECIES

The following is a list of species of Amphibians and Reptiles identified from Rancho La Brea which will be discussed in the following section:

AMPHIBIANS

Bufo nestor	Nestor Toad
Bufo boreas	Western Toad
Hyla sp.	Tree Frog
Rana aurora	Red-legged Frog

LIZARDS

Sceloporus magister	Desert Scaly Lizard
Sceloporus occidentalis	Western Fence Lizard
Uta stansburiana	Side-blotched Lizard
Phrynosoma coronatum	California Horned Lizard
Elgaria multicarinata	Alligator Lizard
Xantusia vigilis	Yucca Night Lizard
Cnemidophorus tigris	Whip-tailed Lizard
Eumeces skiltonianus	Western Blue-tailed Skink

SNAKES

Coluber (*Sensu latu*)	Racer
Pituophis catenifer	Gopher Snake
Lampropeltis getulus	Western King Snake
Crotalus viridis	Western Rattlesnake

TURTLES

Clemmys marmorata	Pacific Pond Turtle

PART II. SPECIES ACCOUNTS

Bufo nestor Camp

Camp (1917) described *Bufo nestor* from Rancho La Brea distinguishing it primarily on the basis of cranial elements. Limb and girdle measurements are not useful in distinguishing *B. nestor* from *B. b. halophilus*. The parasphenoids are, however, useful in distinguishing the two species. No cranial bones, such as those used by Camp in his description, have come to light since his description of *B. nestor*.

Bufo nestor was found in U. C. locality 2051 and is known only from fossil material.

Camp placed *B. nestor* in the *boreas-canorus* group of western toads characterized by not having cranial crests and with the presence of narrow fronto-parietals. Its habits and habitat were probably similar to *B. boreas*. It probably still should be regarded as a distinct species, not intergrading with *B. boreas*, as no intermediates (at least in parasphenoid measurements) can be found. The species is extinct.

Bufo boreas halophilus Baird and Girard

Camp (1917) established the first record of a Pleistocene *Bufo boreas halophilus* from Rancho La Brea. Since then, some 19 "Riker Mounts" of toad bones, all from Pit A, have been available for examination. None of this toad material is different from skeletons of living *B. b. halophilus*. No material of *Scaphiopus* has, as yet, been found in the asphalt. Two fragments of vertebrae of a toad from Pit B are here referred to *B. boreas*.

Camp (1917) gives an account of the comparison of *B. nestor* with Rancho La Brea *B. b. halophilus*, and recent *B. b. boreas* and *B. b. halophilus*, as well as presenting measurements of all of these forms. None of this material will be presented herein other than to add what material has come to light since Camp's work. The following is a summary of the material from Pit A.

A series of 24 parasphenoids, 15 pterygoids, 5 ectopterygoids, and 17 lower jaws (whole) are the only skull material available for examination. The measurements of the parasphenoids fall within the range given by Camp (1917) though they average somewhat smaller than the average given by Camp. Average measurements of specimens from Pit A are as follows: total length, 10.5; total width, 14.5; greatest width of anterior arm, 2.1; and greatest width of wing, 2.2 mm. The ratio of the width of the wing to the total length is 23.8. The lengths and widths of four of the pterygoids are: 9.9-9.5, 9.4-7.0, 9.2-7.1, 8.4-5.5 mm. Lengths and widths of three of the ectopterygoids are: 11.6-7.0, 10.8-6.7, and 12.5-7.5 mm. Lengths of the lower jaw are from 15.1 to 23.3 mm. There are no teeth in the lower jaw.

A total of 41 humeri of amphibians are here all referred to *Bufo*. The humeri of *Rana*, *Bufo*, or *Scaphiopus* are indistinguishable. Of 30 available amphibian radio-ulna bones, 28 are referred to *B. boreas*, and the other two are identified as belonging to the species following.

By means of size and shape, 49 tibia-fibula have been identified as *B. boreas*. The minimum and maximum of all specimens were 10.3 and 30.0 mm. long. The tibia-fibula of a good-sized recent *Rana aurora draytoni* measures 50.6 mm. in length.

Twenty-seven tarsals and astragali, 1 epicoracoid, 7 clavicles, 17 right and 11 left coracoids, 20 left and 19 right scapulas are all referred to *B. boreas*. The coracoids are much shorter than in *Rana* and the median process is not as wide as is that of *Rana*.

The following measurements have been made of amphibian femurs from Rancho La Brea: Largest fossil, 31.6 mm. long; large middle size, 26.2 mm.; small middle size, 20.2 mm.; small, 10.5 mm. as compared with a recent *Rana a. draytoni* which measured 49.4 mm. long. They thus all agree with *B. b. halophilus* and with the measurements given by Camp (1917).

Many miscellaneous tarsal and carpal bones as well as 20 ilia, 3 coccyx, and 10 ischia are all referred to *B. boreas* on the basis of size and shape, though actually the tarsal and carpal bones cannot be distinguished from *Rana* or *Scaphiopus*. The ischia of this species can be distinguished from *Rana* and *Scaphiopus* by its dorsal extension.

On size and shape 14 sacral, 119 thoracic, and 10 atlas vertebrae are referred to *B. b. halophilus*. It is difficult to distinguish differences between *Rana* and *Bufo* atlases, but the thoracic vertebrae of *Bufo* do not have the high neural spine, or the posterior extension of the neural spine, as in *Rana*.

The two species of *Bufo* here discussed are apparently not related to the Pliocene forms of Kansas (Taylor, 1941, 1942).

The material of *Bufo boreas* from Rancho La Brea was referred by Camp (1917) to *B. b. halophilus* (?). No major differences in the subspecies of *Bufo boreas* are evident, though the Rancho La Brea material may well be of *B. b. halophilus* due to the widespread geographical range of the subspecies today. Pleistocene *B. boreas* may not have yet differentiated into the subspecies known today. Only a large series of skeletons of living and fossil *B. boreas* and its subspecies will give the answer to this problem.

Bufo b. halophilus is found in the area of Los Angeles today and has a wide range extending from northern California through the San Joaquin Valley and south into northwestern Baja California, while the other subspecies, *B. b. boreas*, extends northward to Alaska and eastward to Montana, Wyoming and Colorado.

Hyla sp.

A small radio-ulna and a small tibia-fibula from Pit A are here referred to *Hyla* sp. The tibia-fibula measures 7 mm. in length as compared with 10.3 and 30 mm. as the minimum and maximum for fossil *B. boreas*. The radio-ulna is small (see Fig. 2), the distal end expands widely and the proximal end is weakly bifurcated. Comparative measurements are given below in relation to *Rana aurora*. There are no apparent differences between the bones of *Hyla regilla* and *H. arenicolor*.

It is probable that in the spring, *Hyla* would congregate about the small temporary pools undoubtedly in the Rancho La Brea area and perhaps mistake one of the asphalt pits for a pool. The small fragile bones would probably not preserve well, or they may have been overlooked in collecting.

Rana aurora Baird and Girard

One radio-ulna from Pit A, with the distal ends of the bone not widely separated as in *Bufo* and with the shape of the anterior end thin as compared with *Bufo*, is here referred to *Rana aurora*. It is indistinguishable from present-day skeletons of *R. a. draytoni*. Comparative measurements are as follows:

	Length mm.	Width mm. Anterior	Posterior
Rana aurora—Fossil	14.9	4.5	6.0
Rana a. draytoni—Recent	17.0	6.0	7.1
Bufo boreas—Fossil	16.0	4.3	4.8
Bufo boreas—Fossil	15.6	4.0	5.1
Hyla sp.—Fossil	6.6+	2.5	3.4+

Drawings of the radio-ulnas of these three species are given in Fig. 2, A, B, and C.

One large, isolated vertebra from Pit B is here referred to *Rana aurora* primarily on the basis of the shape of the neural spine.

Today *Rana a. draytoni* occurs in the Santa Monica Mountains approximately two miles north of Rancho La Brea. This subspecies ranges from northwestern California, through the Sierra Nevada and Coast Ranges south into northwestern Baja California.

Sceloporus magister Hallowell

Material from Rancho La Brea localities Pit A and "no data," consisting of 14 dentaries, 7 maxilla, 1 quadrate, 4 frontals, 1 occipital, and 10 parietals are here referred to *S. magister*.

The *Sceloporus magister* quadrate from Rancho La Brea has a dorsolateral thin margin and a deep depression posteriorly whereas *S. orcutti* is shallow posteriorly. The dentary can be distinguished from that of *S. occidentalis* by its larger lize and by the presence of a well developed flat area on the lateral side of the dentary just lateral to the teeth. The occipital may be separated from that of *S. occidentalis* only on the basis of size and minor details of the processes.

Sceloporus magister is not found in the Los Angeles city area today. It is present primarily on the fringes of the desert. The cause of its disappearance from the coastal area is not known. A possible increase in aridity of the area should not have affected a desert-margin species. Possible interspecific competition with *S. occidentalis* might be a cause of its elimination from the area. What effect the increasing human population in the area had on the distribution of the lizard is unknown.

Sceloporus occidentalis Baird and Girard

Material of *S. occidentalis*, taken from Rancho La Brea localities A, 101, Y, 81, and "no data," include 40 dentaries, 24 maxilla, 8 parietals, 15 frontals, 2 occipitals, 3 scapulas, 1 femur and several miscellaneous bones such as parts of pelvic and pectoral girdles, vertebrae, sacra, and hyoids.

The parietals of *S. occidentalis* are quadrangular. The frontals do not expand anteriorly and are usually found to have a median process. The dentaries are larger than in *Uta* and smaller than in *S. magister* or *S. orcutti.* The posterior teeth on the dentary and maxilla are trifid, the anterior teeth are not. There is no flat area just lateral to the teeth on the dentary. The lower end of the dentary extends posteriorly more than the upper does. This species differs from *Sceloporus graciosus* in details, especially as to the parietals and frontals.

The material from Pits A and 81 may be referred to the subspecies *S. o. biseriatus*, living in the area today, to emphasize the close similarity of the fossil and living specimens. The two dentaries and the two maxillae from Pit 101 and the one dentary from Pit Y differ sufficiently so that they are identified as *S. occidentalis* only. The most anterior mental foramen in the dentary from Pit Y is elongate rather than round.

Remains of this species are the most abundant lizard material found in the Rancho La Brea diggings to date and it is also the most abundant lizard in the Los Angeles area today.

Uta stansburiana Baird and Girard

Rancho La Brea material from Pits A, 81, and "no data" consisting of 18 dentaries, 18 maxillae, 17 parietals, 10 frontals, 9 scapulae and numerous girdle and limb elements can be referred to *Uta stansburiana.* Usually the bones of *Uta* can be distinguished by their small size, however, characters do exist that differentiate between this and other genera.

The frontal bone is expanded anteriorly and the posterior portion is extremely thin in the central area. In both fossil and recent specimens the parietal is very thin in the anterior central area and is often broken through. The teeth are usually not trifid. The teeth of *Uta* are small and numerous. The dentary is pointed anteriorly, at least more so than *Sceloporus occidentalis.*

This lizard's remains are very abundant in the Rancho La Brea material and it is also a common species in the area today.

Phrynosoma coronatum (Blainville)

The osteology of the genus *Phrynosoma* has been discussed by Bryant (1911) and recently by Reeve (1952). Fortunately the Rancho La Brea material consists of two posterior temporal spines from Pit A which, by their character, places them with *Phrynosoma coronatum.* According to Reeve (1952) two subspecies, *P. c. frontale* and *P. c. blainvilli,* occur in the Los Angeles area today. A comparison of measurements of these two subspecies and the one Rancho La Brea specimen given below suggests that the fossil form had not as yet differentiated into the two subspecies. No definite conclusions can be reached, however, based on only one specimen.

Species	Width of base mm.	Distance between tips of spines mm.	Height of spines mm.		Number
			Posterior	Anterior	
Fossil—La Brea	6.0	4.4	6.1	4.4	1
P. c. frontale	6.1	4.5	5.9	3.6	5
P. c. blainvilli	6.8	5.5	6.3	4.2	10
P. p. platyrhinos	4.5	3.7	2.6	2.4	1

Elgaria multicarinata (Blainville)

From Rancho La Brea localities Pit A and "no data," 7 maxillae, 12 dentaries, 5 parietals, 4 frontals, 15 occipitals, 3 pterygoids, 7 angulare and articular bones of the lower jaw, and 1 quadrate are referred to *Elgaria multicarinata.*

Tihen's recent (1949) revision of the genera formerly assigned to *Gerrhonotus* makes identification of this form simple and the reader is referred to his paper for discussion of the osteology. The frontal and parietal are particularly diagnostic and can be easily referred to *E. multicarinata.* The pterygoids have teeth on them and the teeth of the maxillae and dentary are conical. The bones of *E. multicarinata* are larger than any of the *Elgaria coeruleus* group, and perhaps on size alone (mean length and width of all Rancho La Brea dentaries 11.6 and 3.1 mm.), may be referred to the subspecies *E. m. webbi.*

Xantusia vigilis Baird

Portions of 2 maxillae and 3 fragments of dentaries from Rancho La Brea Pit 101 are here referred to *Xantusia vigilis.* The general shape of the maxilla of both the fossil and of recent *X. vigilis* is triangular with a wide, flat anterior surface. The maxillae of *X. henshawi* and *X. riversiana* are quadrangular and have no wide, flat anterior surface. The teeth on the maxilla and dentary bones of *Xantusia* are trifid.

Xantusia vigilis does not occur in the area of the tar pits today. It is found in the Mohave and Colorado Desert region just outside the barriers formed by the San Gabriel, San Bernardino, and San Jacinto Mountains. It is not known what could have caused its extinction from the Los Angeles area. It is not known if changes in the human population of the area has caused its elimination from the Los Angeles area. It is possible that the specimens in Pit 101 represent an isolated race or form, diverging from the main *vigilis* stock, with subsequent extinction of this form in the area for unknown reasons. Additional material is needed from Rancho La Brea before the taxonomic status (on the subspecific level) can be determined.

Pit 101 is one that suggests a relatively older age than Pit A. Herpetologically this is emphasized by the *Xantusia* and one specimen of a *Cnemidophorus* (see below) from this pit. The *Sceloporus* and *Eumeces* from this pit are less like recent specimens.

Cnemidophorus tigris Baird and Girard

Rancho La Brea localities Pit A, 101, and "no data," contain 2 dentaries, 1 maxilla, and 6 frontals that are referred to *Cnemidophorus tigris*.

Maxillary and dentary bones with bifid teeth are easily referred to this genus. The shape and size of the bones, especially the frontal, are also diagnostic (DuBois, 1943). The material is referred to this species on similarity of size and shape. The only other Teiid in the area today is *Cnemidophorus hyperythrus*, from which *C. tigris* can be distinguished by size and general shape of the bones.

The one dentary from Pit 101, when compared with recent *C. tigris*, differs in that the dentary is more robust, larger, and wider. The teeth appear taller. The junction of the fork of the bifurcation of the teeth is more pronounced, especially below the fork. The distance between the two posterior mental foramen is greater than in recent specimens (2.3 mm. compared with an average of 1.6 mm. for recent *C. tigris*). It appears to be an extra large specimen of *C. tigris*. This large size might be explained on the basis of a warmer climate, hence larger individuals, according to Bergmann's rule as modified by Cowles (1945) for cold-blooded vertebrates. It might also be explained on the chance that an unusually large specimen was trapped in the pits. Even though differences are apparent, they do not seem to be significant enough to warrant separating this as a distinct species or subspecies.

Cnemidophorus tigris is found in the Los Angeles area today and is common in the Arroyo Seco, Tujunga, and San Gabriel washes as well as in the Santa Monica Mountains.

Eumeces skiltonianus (Baird and Girard)

Rancho La Brea material from Pits A, 3, Y, 101, and "no data," consists of 11 dentaries, 1 maxilla, and 8 parietals. All are referred to *Eumeces skiltonianus*. The osteology of this genus is presented by Taylor (1935) and is discussed by him in regard to two Pliocene forms (1941). The specimens from the asphalt all agree with the characters of this genus as presented by Taylor (1935, 1941) and with skeletons of recent *E. skiltonianus* and *E. gilberti*. *E. skiltonianus* can be separated from the closely related *E. gilberti* only on the basis of size, *gilberti* being the larger. There are no major osteological differences between the two species, but there are small differences of details of shape of the various bones. The material from Pits 101, Y, and 3 (the latter being washed out of the cranium of a saber-tooth tiger from this pit) seem to be less like recent *E. skiltonianus* than the material from Pit A or "no data."

Eumeces skiltonianus is found living in the area of the tar pits today, whereas *E. gilberti* lives only on the top of the San Gabriel Mountains and in the San Bernardino Mountains.

Coluber sp. (sensu latu)

One partly damaged lower jaw of a snake from Pit 81 is here referred to the genus *Coluber* by reason of the fact that the Meckel foramen is almost closed laterally. The two genera, *Coluber* and *Masticophis* (of Ortenburger, 1928), can be distinguished by the shapes of the nasals, frontals, parietals, and postfrontals; however none of these bones were found in the asphalt. Generic (*sensu strictu*) and specific determination of this snake must await additional material.

Pituophis catenifer (Blainville)

All of the colubrid vertebrae found in the tar pits, with one exception mentioned below, can be referred to *Pituophis catenifer.* The gopher snake material was found in Pit A (96 vertebrae, 3 premaxillae), Pit B (26 vertebrae), U.C. 2051 (1 vertebra), U.C. 2052 (1 vertebra), and Rancho La Brea "no data" (1 vertebra).

These vertebrae are identified as *P. catenifer* on the basis of size and measurements. *Pituophis* lacks the strong subcentrum keel and the heavy top ridge of the neural spine as found in *Lampropeltis. Pituophis* has small hook-like processes on the anterior ends of the zygosphene which are generally lacking in *Lampropeltis. Lampropeltis* characteristically has rounded anterior corners of the zygosphene. *Pituophis* vertebrae can be distinguished from *Thamnophis* by the absence of the hypapophysis present in that genus. From other genera it differs in size.

Measurements of La Brea, McKittrick, and recent skeletons of *Pituophis catenifer* are presented in another paper (Brattstrom, 1953). Three premaxillae from Pit A are referred to *P. catenifer* on the basis of size and shape. They are not similar to any of the other colubrid premaxillae seen, but they differ from recent *P. catenifer* in small details. The vertebrae appear more like *P. c. annectens* than *P. c. affinis, P. c. deserticola* or *P. c. catenifer.*

Lampropeltis getulus californiae (Blainville)

On the basis of a strongly developed sub-centrum keel and in the presence of rounded anterior corners of the zygosphene, one vertebra bearing no other data than "Rancho La Brea" is identified as *Lampropeltis getulus.* It is distinguished from *Lampropeltis zonata* on size and is referred to this subspecies on the basis of geographic distribution.

Crotalus viridis Rafinesque

Crotalus material is available from Pits A, B, 81, U.C. 2052, and "no data." Previously Gilmore (1938) mentioned that due to lack of material all fossil Crotalids should be referred to *Crotalus* sp. Since 1950 the writer has been engaged in a study of the comparative osteology of the Crotalidae including the species and subspecies of *Crotalus.* All of the species of *Crotalus* can be distinguished by means of osteological characters. It is therefore possible to refer most of the fossil material, including Rancho La Brea specimens, to recent or fossil species on the basis of size, shape, and comparative measurements. The differences in vertebrae of the various species is sometimes very diagnostic, but some species show great variability. As additional studies of the comparative osteology of the rattlesnakes are in progress, a final analysis will be presented later.

Fifteen vertebrae, 1 pterygoid with 8 teeth, and a questionable presphenoid from Pit 81 can all be identified as *Crotalus viridis*. The material from Rancho La Brea with no data are also of this species. From Pit A there are 7 ribs or fragments of ribs, 3 presphenoids, 1 fragment of a lower jaw and many vertebrae. The presphenoids are variable among snakes and these are only tentatively referred here to *C. viridis*. The ribs are all small, the measurements being similar to present day *C. viridis helleri*. The *Crotalus* vertebrae from Rancho La Brea can be identified as *C. viridis* on the basis of relative proportions of the parts and on the shape and size of the zygosphene, centrum and zygapophyses. A summary of measurements of La Brea, McKittrick and recent skeletons are presented elsewhere (Brattstrom, 1953). The La Brea specimens resemble skeletons of *C. v. oreganus* and *C. v. helleri* more than any of the other subspecies of *C. viridis*. The rattlesnakes from the La Brea pits were larger than average for this species. This is suggested by the material from U.C. 2052 and a few vertebrae from Pits A and B. If Bergmann's rule (as modified by Cowles, 1945) is applicable, the large size of some of these rattlesnakes may indicate a warmer climate.

Crotalus viridis helleri and the very closely allied *C. v. oreganus* occur today from British Columbia to Baja California (the break between the two races being essentially in Santa Barbara County, California). *C. v. helleri* is found today in the Santa Monica Mountains just north of Rancho La Brea.

Clemmys marmorata (Baird and Girard)

Material from Rancho La Brea localities Pit A and "no data" consists of 3 femora, 5 innomonate bones, 2 scapulas, 1 humerus, 1 tibia, 1 fibula, 34 pieces of plastron and carapace, and 41 pieces of marginal dermal scutes. Some turtle material from Pits 3 and 5 is listed in the Los Angeles County Museum catalogue, but has not been found and is apparently lost.

When Hay (1903) described the two western fossil forms, *Clemmys saxea* (Pliocene) and *Clemmys hesperia* (Miocene), from the John Day country of Oregon, he had no skeletons of the recent *C. marmorata* available. The material from Rancho La Brea is easily identifiable with *C. marmorata* and does not differ from it except possibly in size, as seen in Figure 4. *Clemmys saxea*, the Pliocene species, can be separated from *C. marmorata* by the elongate pygal (Fig. 4). *Clemmys hesperia*, the Miocene form, can likewise be distinguished from *C. marmorata* on the shape of the hyoplastron. The hyoplastron of *C. marmorata* is straight laterally whereas in *hesperia* it is curved inward. Whether *C. hesperia* and *saxea* differ is not known as the available material of each fossil does not contain the diagnostic bones of the other species (Hay, 1903, 1908).

Clemmys marmorata is found today in areas of permanent water from Washington to 31° N. Latitude in Baja California. It occurs today, though rarely, in the Los Angeles area in places of permanent water such as the San Gabriel Mountains, the Arroyo Seco and Los Angeles Rivers (prior to the cementing of the beds of these rivers) and Malibu Creek in the extreme eastern Santa Monica Mountains. It does not occur today in that part of the Santa Monica Mountains just north of Rancho La Brea.

PART III. CLIMATE, ECOLOGY, AND ZOOGEOGRAPHY

FLORA

Plants are usually good indicators of past climates, but unfortunately the material from Rancho La Brea is rather scarce and of the material available only the more obvious species have been determined. The plant material from Pit A has not as yet been studied. It is at present in the process of being separated from the asphalt (Templeton, personal communication). So far the following plants have been identified from Rancho La Brea:

Pinus muricata	Bishop Pine
Pinus sabiniana	Digger Pine
Cupressus sp.	Cypress
Quercus agrifolia	Coast Live Oak
Arctostaphylos sp.	Manzanita
Xanthium calvum	Cockle Burr
Sambucus glauca	Blue Elderberry
Celtis mississippiensis var. *reticulata*	Western Hackberry

The *Cupressus* sp. and the *Pinus muricata* come from relatively older pits in association with the Mastodon and Imperial Mammoth, whereas the other species are from various pits. Beside the two pines mentioned above, another fossil pine, *P. linguiformis* Mason, resembles the Rancho La Brea material (Mason, 1932 and personal communication). The taxonomic status of the *Cupressus* is still in doubt (Mason, 1927) and Mason has suggested (personal communication) that, ". . . all the described species for the state of California might possibly be reduced to just two, a northern species and a southern. Cones alone are not adequate to distinguish these entities, the characters of the bark also being important."

The plants of the older pits would indicate a humid flora, drying slightly to a more arid association of Juniper, *Quercus* and *Arctostaphylos* characteristic of Upper Sonoran Life Zone, with perhaps subsequent drying to today's present level of aridness.

FAUNA

A summary of the ecology of the mammalian faunas is given by Stock (1949) and a summary of the avifauna is presented by Miller and De May (1942). Pierce (1946, 1947, 1948) has been studying the invertebrate fauna of the asphalt. In general, the bird, mammal, and invertebrate faunas suggest a moist climate warming and drying to the condition found today.

AMPHIBIANS AND REPTILES

Table 1 gives a summary of the number of individuals of the various species of reptiles and amphibians from the various pits of Rancho La Brea. The relative number of individuals is also presented in Figure 4. The number of individuals was estimated by counting the highest number of any one bone available for that species (or in the case of paired bones, counting and dividing by two) to give the approximate number of individuals thus far found in the diggings of Rancho La Brea. The number of reptiles and amphibians is small compared to that of the birds and mammals. This is probably due to their small size and to the methods employed in collecting.

It may be seen that most of the material comes from Pit A. This is probably due to the fact that this material was carefully handled and separated from the tar by Dr. Pierce, and hence more of the smaller material was saved. The *Eumeces* from Pit 3 was washed out of the skull of a saber-tooth tiger. Camp has suggested (personal communication) that U.C. locality 2052 is relatively recent. On the basis of herpetological material it is suggested that pits 101, 81, 3, Y, and U.C. 2051 are relatively older than Pits A, B, and 2052. Pit B may be slightly older than A. There is no herpetological material from Pit 9, which contained the *Pinus muricata* and the Imperial Elephant material. Little attention has been paid to the comparative study of the faunas of the various pits, though there are obvious differences. Relative ages for some pits are suggested in some cases (Howard and Miller, 1939), but no analysis by pits has been given in the literature.

Conspicuous by their absence in the asphalt are such forms as the spadefoot toads, *Scaphiopus*, and the garter snakes, *Thamnophis*. Perhaps some of the indistinguishable bones of the amphibian material are of *Scaphiopus*, but its identity in the asphalt must wait until diagnostic material is available. *Thamnophis* should have been found in the asphalt if it had been in the area, as the presence of water would suggest. The vertebrae of this genus are very characteristic with a wide hypapophysis on each centrum. Many of the smaller forms (Salamanders, *Hypsiglena*, *Tantilla*, etc.) would without doubt have been lost or broken in the movements of the asphalt, or these may have been lost in the diggings that had not been handled with such care as is being done by Pierce. Certain forms not found in the tar pits may be due to their absence from the area during the deposition of the pits.

Only one species, *Bufo nestor*, is extinct.

RELATION TO OTHER PLEISTOCENE LOCALITIES IN CALIFORNIA

On the basis of herpetological data, Rancho La Brea contains material that appears to be equal in age, at least in part, to the McKittrick asphalt, but with deposition possibly continuing into Recent times. As judged from conclusions reached on the basis of avian and mammalian faunas (Stock, Merriam, Miller), Rancho La Brea is definitely younger than either Hawver or Potter Creek Caves. Herpetological material tends to support this view, though there appears to be less of a change in the herpetofauna than has taken place in the mammalian and avian fauna. A summary of the other California Pleistocene herpetological material is presented elsewhere (Brattstrom, 1953).

ZOOGEOGRAPHY

There appears to have been no conspicuous local change in the zoogeography of the reptiles and amphibians of the Late Pleistocene as indicated by the forms found in the asphalt of Rancho La Brea. Most of the forms in the pits can still be found in the immediate vicinity today or in adjacent regions of Los Angeles County such as the Santa Monica, San Gabriel, or Palos Verdes Mountains (Bogert, 1930; Hill, 1948). Only one form, *Bufo nestor*, is extinct. The single species of turtle, *Clemmys marmorata*, is still found in the adjacent areas of Los Angeles County wherever there are permanent streams. Two species, *Xantusia vigilis* and *Sceloporus magister*, occur typically at the edge of the desert today. The factors that caused the disappearance of these species from the area, or whether they were populations separated from the main stock, is unknown. The apparent decrease in rainfall would not affect these two as it would the turtle, nor would it be expected that a small increase or decrease in temperature would affect them both. Strictly Lower Sonoran desert species (*Dipsosaurus*, *Callisaurus*, etc.) have apparently not been in the Los Angeles basin during the time of the tar pits. Other forms might have been kept from entering the asphalt by having different ecological habitats than that which was present at Rancho La Brea (*Lampropeltis zonata*, *Sceloporus graciosus*, *Anniella pulchra*, etc.). Other material, of very small size, is probably present but, as yet, undiscovered.

CLIMATE AND ECOLOGY

It is difficult to suggest paleoclimatic conditions based on the present day ecology of the same or similar forms and their associated faunas and floras, but this is the only means available in most cases.

As a means of estimating the paleoclimate of the time of deposition of the animals in the asphalt, a summary of the optimum body temperatures for existent relatives is given below (Data from Stebbins, 1951; Mullally, m.s.; Cowles and Bogert, 1944; Cole, 1943; Zweifel, personal communication).

Species	Optimum body temperature	Mean or Median
Bufo boreas	16.7-22.2°C	19.5°C
	22-24.5	23.2
Sceloporus magister	34-37	35.5
Sceloporus occidentalis	36.6	36.6
Uta stansburiana	35-38	36.5
Phrynosoma coronatum	34.9	34.9
Elgaria multicarinata	27.4	27.4
Xantusia vigilis	29	29.0

Total 242.6

Mean 30.32°C. (86.6°F.)

This is not to infer that the temperatures during the Late Pleistocene were as high as indicated by these data, as these forms can alter their body temperatures by behavior, so that they may maintain their optimum metabolic rates under seemingly unfavorable air temperatures. These animals can, of course, operate for a time at temperatures below their optimum, but not much above the optimum, as these temperatures of reptiles and amphibians are usually just a few degrees below their lethal temperature (Cowles and Bogert, 1944).

Most of the present day reptiles and amphibians represented in the asphalt are characteristic of the Upper Sonoran Life Zone. A few of the species range into coastal Lower Sonoran and/or Dry Transition Life Zones. A few species (*Crotalus viridis, Elgaria multicarinata*) range into higher zones and are probably not good indicators of past climate. Most of the forms are typically open valley, ground-dwellers, (*Bufo boreas, Pituophis, Coluber, Lampropeltis, Uta, Phrynosoma* and *Cnemidophorus*), while some (*Rana aurora, Crotalus viridis, Elgaria,* and *Eumeces*) prefer rocky areas. A few (*Bufo boreas, Xantusia vigilis*) are nocturnal today, *Pituophis, Crotalus viridis,* and *Lampropeltis* are both diurnal and crepuscular, and the remainder are diurnal. A moist situation, with permanent streams or pools, is suggested by the presence of the *Bufo, Hyla, Rana, Eumeces,* and *Clemmys.* The *Rana* (Grinnell and Camp, 1917; Stebbins, 1951) and the *Clemmys* (Storer, 1930; Seeliger, 1945; Carr, 1952) are restricted today in southern California to areas of permanent water.

Notes on the ecology of *Eumeces skiltonianus* according to Rogers and Fitch (1947) suggest that:

"Although it seems to be adaptable to widely different habitats and climates, it appears to favor moderately humid climate. It is apt to be concentrated in localized colonies where there is an abundance of ground cover in the form of dead wood or flat rocks and a good growth of herbaceous vegetation. The localities where *skiltonianus* has been found in the greatest abundance are mostly in or near open woods of blue oak, garry oak, or coast live oak and bay (*Umbellularia*)."

The presence of this lizard in the pits would suggest a more humid climate than in the area today. This is also supported, especially in the case of the older pits, by the presence of the *Cupressus* and *Pinus muricata.*

This evidence would also suggest a pushing northward of the species as a result of increasing aridity of the southern part of its range. This suggestion is supported by the restricted range in the Cape region of Baja California of *Eumeces lagunensis,* which is very similar to *E. skiltonianus,* and which has, by some authors, been considered as a subspecies of *skiltonianus* even though intergradation does not occur (see Rogers and Fitch, 1947, for a discussion).

As based on the ecology of the reptiles and amphibians found in the asphalt and by the inclusion of data derived from the flora and other faunas, the ecological conditions surrounding the asphalt pits was probably greater than at present, as indicated by the plants, aquatic amphibians and reptiles, and aquatic beetles and bugs. Undoubtedly small permanent streams or pools were present in the area. The temperature was probably the same as today or a little warmer.

There was probably a local diminution of rainfall from a time in which Cypress and Pine were locally found through a time of open, interior and warmer, Juniper-Oak association, which finally gave over to an Oak-woodland Savanna and Coastal Sage-scrub association. The topography was probably, from all geological evidence, the same as today.

CONCLUSIONS

Previous to this study, *Bufo nestor*, *B. boreas* and *Clemmys* sp. were the only herpetological species that had been identified as coming from the asphalt of Rancho La Brea. As a result of this study, 17 forms, representing approximately 135 individuals, have been identified.

There is no evidence to prove that there has not been continuous or partial deposition in the pits since their formation. The fact that the pits may be of different ages, ranging from Late Pleistocene to Recent, is suggested by the fauna and flora of the various pits.

Bufo nestor is the only extinct amphibian found. Most of the forms studied are identical with living species found in the area today.

Two reptiles, *Xantusia vigilis* and *Sceloporus magister*, are found only on the periphery of the desert today and not in the vicinity of the city of Los Angeles. The reason for the elimination of these two forms from the area is unknown.

An aquatic turtle, *Clemmys marmorata*, is absent in the immediate Los Angeles area today except in areas of permanent water. This would suggest a local diminution of yearly rainfall. This view is supported by the presence of amphibian (*Rana*) and botanical material.

A summary of the ecology of the birds, mammals, amphibians, reptiles, and insects suggests an Upper Sonoran Life Zone. From the discussion of the plants and with a possible differentiation of time of deposition of the various pits, it is suggested that from Late Pleistocene to Recent there was a local transition from a moist climate of *Pinus* and *Cupressus* through a stage of decreasing rainfall and a vegetation of *Quercus agrifolia* and *Juniperus californica*, to the present-day climate and vegetation of Oakwoodland Savanna and Coastal Sage-scrub with subsequent changes in the fauna.

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TABLE 1

Summary of the approximate number of individuals of reptiles and amphibians from the various pits in Rancho La Brea.

SPECIES	A	B	101	81	3	Y	2051	2052	No data	Total
AMPHIBIANS										
Bufo nestor (extinct)							15			15
Bufo boreas	25	1						15		41
Hyla sp.	1									1
Rana aurora	1	1								2
SNAKES										
Pituophis catenifer	3	1					1	1	1	7
Coluber (*sensu latu*)				1						1
Lampropeltis getulus									1	1
Crotalus viridis	2	2		1				1	1	7
LIZARDS										
Sceloporus magister	6								1	7
Sceloporus occidentalis	14		2	4		1			2	23
Uta stansburiana	11			1					1	13
Phrynosoma coronatum	1									1
Cnemidophorus tigris	6		1						1	8
Elgaria multicarinata	6								1	7
Eumeces skiltonianus	3		1		1	1			1	7
Xantusia vigilis			1							1
TURTLES										
Clemmys marmorata	2								1	3

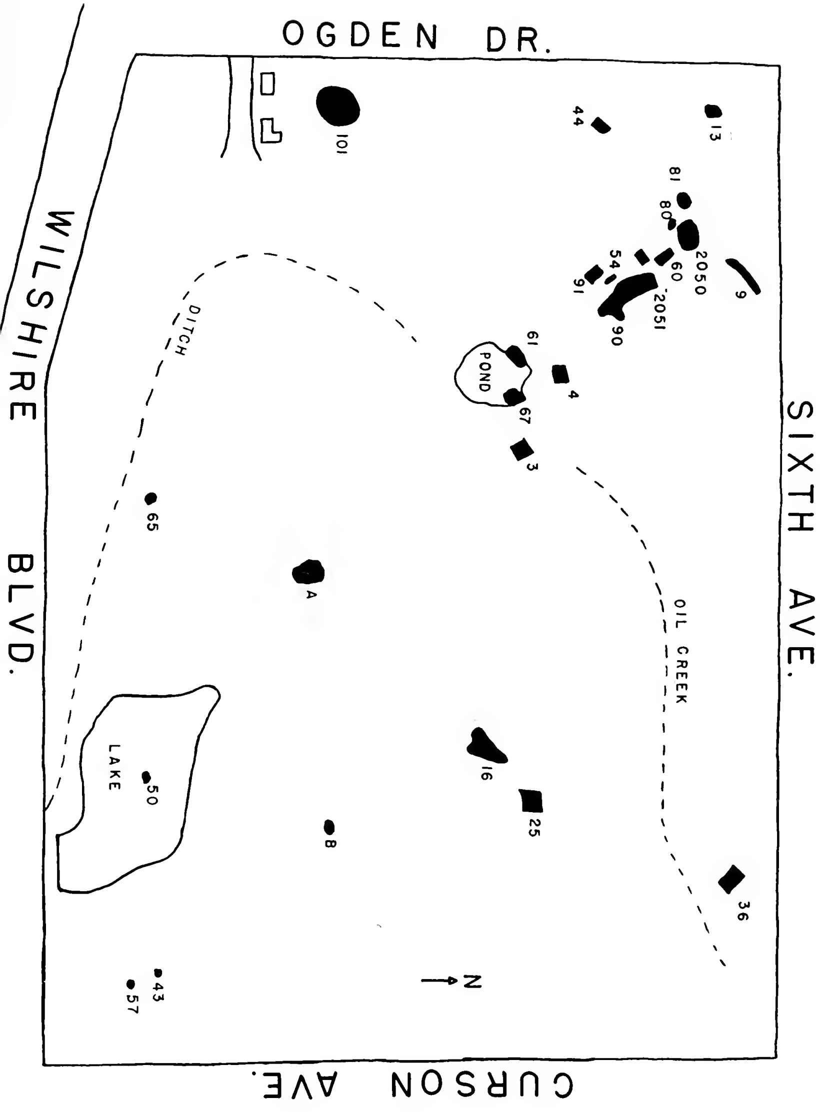

Figure 1. Map of Rancho La Brea showing locality sites of major excavations.

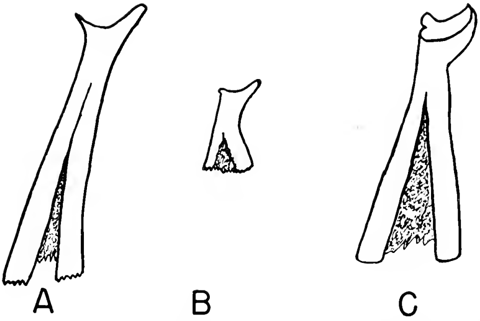

Figure 2. Amphibian radio-ulna bones from Rancho La Brea. A. *Rana aurora*, B. *Hyla* sp., and C. *Bufo boreas*.

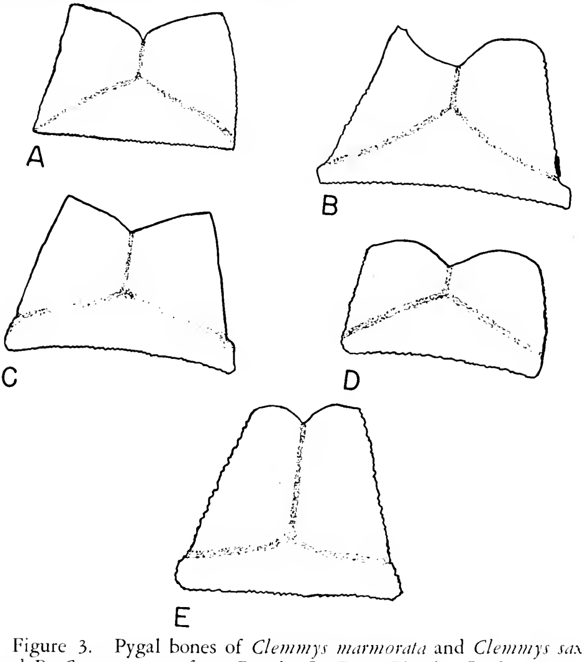

Figure 3. Pygal bones of *Clemmys marmorata* and *Clemmys saxea*. A and B. *C. marmorata* from Rancho La Brea, Pit. A. C. *C. marmorata* from Rancho La Brea with no pit data. D. Recent *C. marmorata* from San Gabriel River, Los Angeles County, California. E. *Clemmys saxea*, Type, Pliocene of Oregon (Redrawn from Hay, 1908, pg. 294).

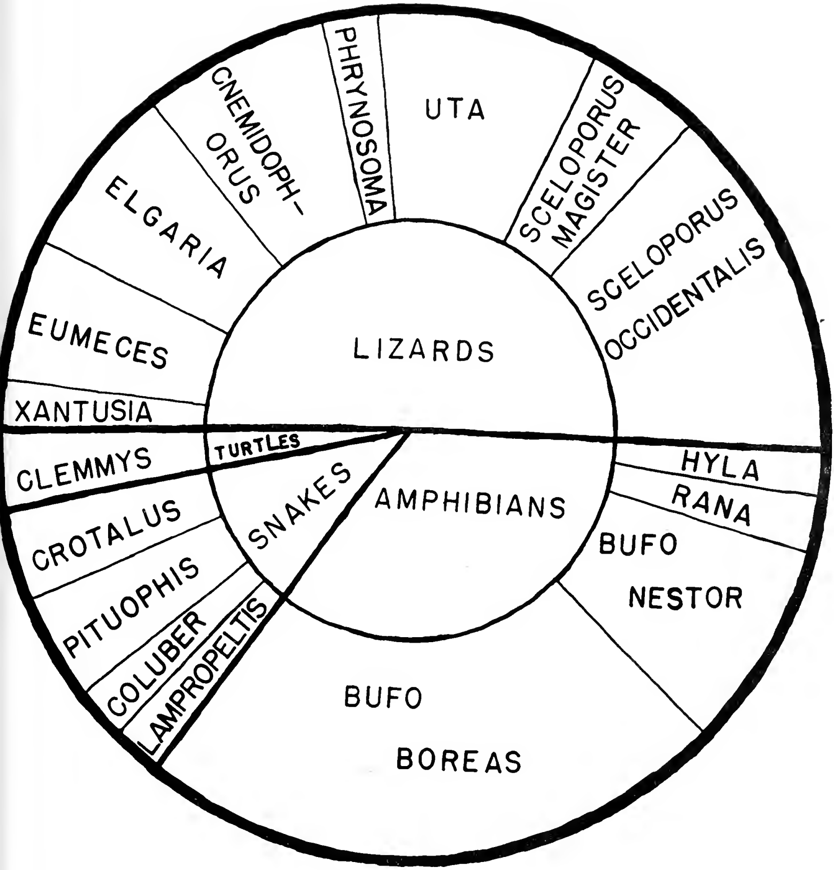

Figure 4. Chart showing the relative abundance of the species of amphibians and reptiles thus far found in Rancho La Brea.

TRANSACTIONS

OF THE

SAN DIEGO SOCIETY OF NATURAL HISTORY

VOLUME XI, No. 15, pp. 393-404, Fig. 1-4

WEST AMERICAN RAZOR-CLAMS OF THE GENUS ENSIS

BY

S. STILLMAN BERRY

Redlands, California

SAN DIEGO, CALIFORNIA
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WEST AMERICAN RAZOR-CLAMS OF THE GENUS ENSIS

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Prior to the present study but a single species of the genus *Ensis* Schumacher (family *Solenidae*) has been recognized in the Recent fauna on the western coast of North America, although the related genus *Solen* is quite generously represented. That there are two species actually present and confused both in our collections and in the literature is the burden of the ensuing communication.

Grateful acknowledgement is due to the collectors variously mentioned in the following pages for the gift of helpful material, and especially to Dr. Harald A. Rehder and his associates at the United States National Museum and to Dr. Joshua L. Baily, Jr., of the San Diego Society of Natural History, as well as to Dr. A. Myra Keen of the Department of Paleontology, Stanford University, for making available to my study the essential material in the collections under their care. I am indebted to Mr. Edgar R. Fisher of Redlands for making the photographs used in the plate.

1. Ensis californicus Dall 1899

1899. *Ensis californicus* Dall,—Proc. U. S. Nat. Mus., 22: 108 (except the Californian record); 110.

1936. *Ensis californicus* Jordan,—Contr. Geol. Dept. Stanford Univ., 1 (4): 112 (rec. from Pleist. of Magdalena Bay).

1950. *Ensis californicus* Hertlein and Strong,—Zoologica, N.Y., 35 (4): 227 (except the Californian record).

Holotype: U. S. Nat. Mus. Cat. No. 158891.

Type-Locality: 14 fathoms, off San Pedro Martir Id., Sonora, Mexico; U. S. F. C. Str. "Albatross," Sta. 3013.

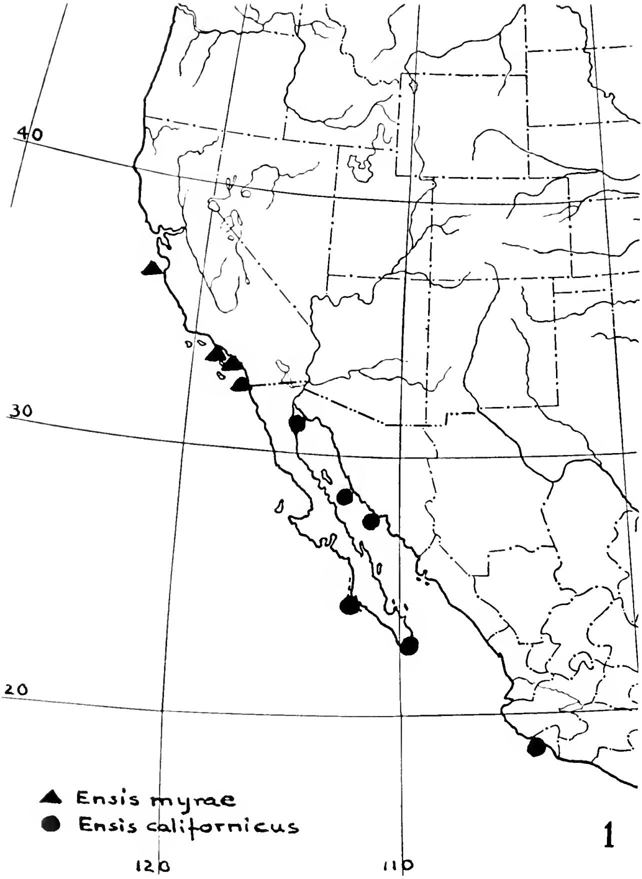

Fig. 1. Map showing the presently known distribution and range of the two west American species of *Ensis*.*

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* The Santa Barbara record was established too late for inclusion in the map.

Material Examined:

No. Speci-mens	*Depth*	*Locality*	*Collector or Source*	*Mus. No.*	*Remarks*
5		Santa Maria Bay, Baja Calif.	H. N. Lowe	SDM 22549	imper-fect
1		Cape San Lucas, Baja Calif.	Stearns Coll. ex Verrill	USNM 74854	
frag-ments	5½ fms.	off Cape San Lucas, Baja Calif.	"Albatross" Sta. 2835	USNM 158892	
1		La Paz, Baja Calif.	Belding	USNM 34064	
12	shore	San Felipe, Baja Calif.	H. N. Lowe 1933	SDM 22577	
1 v.	beach drift	San Felipe, Baja Calif.	Ralph Hav-ickhorst 1952	Berry 18355	
2 v.	beach	Miramar, Sonora	Mary E. Long, Jan. 1951	Berry 19680	
1	14 fms.	off San Pedro Martir Id., Sonora	"Albatross" Sta. 3013	USNM 158891	holotype

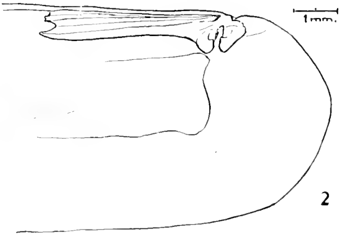

Fig. 2. *Ensis californicus* Dall. Anterior portion of a left valve from San Felipe, Baja California (No. 18355) in camera outline, showing the hinge-plate.

Additional (probably valid) *Published Records*: *Pleist.*—N. of village of Magdalena Bay, Baja California (Jordan). *Recent*—30 fathoms, off Manzanillo, Colima (Hertlein and Strong).

Commentary: This slender, exceedingly graceful, highly polished little species is one of the most attractive west American representatives of the *Solenidae*. It has been much misunderstood and frequently misidentified, partly no doubt because it is far from common in collections, and partly because of the lack of any correct representation of it in the literature. So far as I can discover the true species is here illustrated for the first time. The finest series of the shells that I have seen is that from

San Felipe, collected by the late H. N. Lowe, and now in the San Diego Museum of Natural History, where it has been reposing under the name *Ensis mexicanus* Dall; the latter properly a *Solen.* More detailed interpretations and comparisons will be found in the commentary upon the following species.

1892. *Solen ensis* var. *minor* Dall (*not* of Conrad) in Williamson,—Proc. U. S. Nat. Mus., 15: 184 (recorded from Long Beach, Calif.).

1899. *Ensis californicus* Dall,—Proc. U. S. Nat. Mus., 22: 108 (*pars*,—the Californian record only).

1907. *Ensis californicus* Kelsey,—Trans. S. D. Soc. Nat. Hist., 1 (2): 39 (rec. from vicin. San Diego, Calif.).

1924. *Ensis californicus* Oldroyd,—Stanford Univ. Publ. Geol. Sci., 1 (1): 189 (*pars*,—the Californian record only); pl. 49, fig. 6 (*not* of Dall).

? 1937. *Ensis californicus* Willett,—Trans. S. D. Soc. Nat. Hist., 8 (30): 391 (rec. from Upper Pleist. of Baldwin Hills).

1945. *Ensis californicus* Burch,—Minutes Conch. Club So. Calif. (43): 27.

1948. *Ensis californicus* Smith and Gordon,—Proc. Cal. Ac. Sci., 26 (8): 176 (Monterey Bay records).

1950. *Ensis californicus* Hertlein and Strong,—Zoologica, N.Y., 35 (4): 227 (*pars*,—the Californian record).

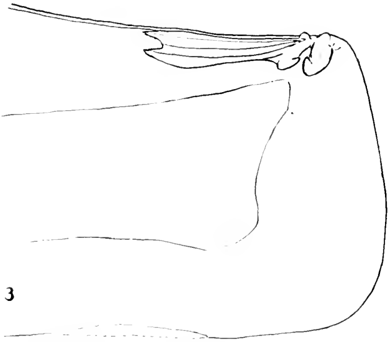

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Fig. 3. *Ensis myrae* n. sp. Anterior portion of left valve of an immature paratype (No. 1256) having nearly the same length as the shell illustrated in Fig. 2; camera outline in same scale.

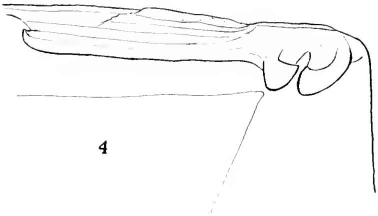

Fig. 4. *Ensis myrae* n. sp. Hinge-plate of left valve of holotype in camera outline; same scale as Figs. 2 and 3.

Description: Shell of moderate size and slenderness, rather strongly falciform; valves narrowing slightly and rather sharply and squarely truncate in front, more rounded and narrowing a little more steadily and decidedly posteriorly. Hinge-plate strongly anterior in position, small and comparatively short; right major cardinal compressed, squarish in profile, strongly projecting; right posterior cardinal slender, short (appreciably less than one-tenth the length of the shell), laminar, terminating in a short free flange; left major cardinals strongly unciform and considerably heavier than that in the right valve; inner left posterior cardinal generally similar to its mate of the right valve, the weaker outer cardinal closely adnate to the shell margin. Exterior of shell mostly with a somewhat silky sheen due to the numerous fine growth-striae underlying the thin shining Sayal Brown to Mikado Brown periostracum; in adult shells the periostracum is usually rubbed away in a blade-shaped swath extending from the beaks to the posterior margin, this area being white except for some ruddy or purplish coloring, especially along the edges of the area and in the incremental rest-marks, where the Deep Rose Pink or Vinaceous tinting of the interior may shine through.

Comparative Measurements:

Species	*Specimen*	*Cat. No.*	*Max. Long. mm.*	*Alt.*		*Diam. mm.*
				mm.	*% of length*	
californicus	valve, Miramar	19680	58.2+	6.9	11.8	—
"	" San Felipe	18355	54.8	5.8	10.6	—
myrae	holotype	SU7852	81.3	11.9	14.6	5.8
"	paratype		74.8	11.7	15.6	6.2
"	"	1256	56.+	7.8	14.0	3.8

Holotype: Stanford University Paleo. Type Coll. No. 7582.

Paratypes: No. 8533 Stanford Univ. Paleo. Coll. (Oldroyd, No. 359): Nos. 1256, 18370, and 18371 Berry Collection; No. 1151 W. O.

Gregg Collection; others to be deposited in the collections of the San Diego Museum of Natural History, the Los Angeles Museum, Museum of Comparative Zoology, and the United States National Museum.

Type-Locality: San Pedro Bay, California; mainly cast up by storms in the vicinity of Terminal Island; Mr. and Mrs. T. S. Oldroyd, Dr. R. H. Tremper, Mrs. M. Burton Williamson, and Mrs. W. H. Eshnaur, collectors.

Additional Specimens Examined:

Number Specimens	*Depth*	*Locality*	*Collector*	*Repository*	*Remarks*
1	8-10 fms.	off Monterey, Calif.	W. H. Dall	USNM 158893	fragment
1		Santa Barbara, Calif.		L.A. Mus.	
3 (+ 4 v.)		Long Beach, Calif.	Mrs. M. B. Williamson	L.A. Mus.	
16		Long Beach, Calif.	H. N. Lowe	SDM 22550	
4		Point Loma, Calif.	Mary G. Beckwith	SDM 4847	juv.

Additional Published Records (all as *E. californicus* but probably valid for *E. myrae*): California—15 fathoms, off Pacific Grove, Monterey Co. (Smith and Gordon); 25 fathoms, off Redondo, Los Angeles Co. (Burch); Newport Bay, Orange Co. (Burch); vicinity of San Diego, San Diego Co. (Kelsey).

Commentary: This has been a familiar species to Californian malacologists for many years, but has gone unrecognized through its incorrect identification with the more southern and tropical *E. californicus* Dall, a confusion the more strange since any direct comparison at once reveals the two as amply distinct. The error actually originated with Dall himself when in his first publication of *E. californicus* (1899: 108) he included in its attributed range a locality as far north as Monterey Bay. A further natural bias toward the confusion arose from the name selected, since this, although perfectly apropos to any species described from the Gulf of California is resorted to more commonly by taxonomists when reference is intended to the State of that name. Happily Dall did not specify any Californian paratypes, otherwise he would neatly have pointed up the danger inevitably inherent in the unfortunate and increasingly prevalent present practice by some authors of denominating paratypes of a new species from a locality or horizon different from that of the holotype. Now whatever the lack of discrimination prevailing in the literature of these two species, *E. myrae* is readily distinguishable from *E. californicus* by 1) its much greater size and robustness; 2) its definitely stronger arcuation; 3) its generally subdued polish, the conspicuous and close growth-striae giving it a somewhat silky lustre; 4) the squared-off rather than rounded truncation of the anterior end; 5) the nearly terminal rather than subterminal position of the relatively stronger hinge-plate, with the posterior cardinals markedly shorter; and 6) a pallial line running appreciably nearer the margin. All of these appear to be reasonably good and dependable solenid characters. Superficially *E. myrae* does not appear greatly dissimilar to the somewhat larger European *E. ensis* (Linne), but there are numerous differences in detail, particularly in the hinge. An excellent and very characteristic figure of the exterior of one of the shells of the type-lot has been published by Oldroyd (1924: pl. 49, fig. 6).

So far as I have been able to learn all specimens collected from San Diego north belong unquestionably to *E. myrae*, all the West Mexican examples from as far up the coast as Magdalena Bay to *californicus*. From the long outer shore of Baja California between these two widely sundered localities no species of the genus have as yet been seen, so it is not known in what precise area the two species meet or overlap, or whether they are separated by some hiatus in distribution. However this may be, their disentanglement resolves a somewhat anomalous minor distributional problem, the supposed penetration of a characteristically West Mexican and therefore tropical species as far north as the cool-temperate waters of Monterey Bay. The data here offered do indeed indicate that *E. californicus* is sufficiently thermal in its preferences to be placed without reserve in the tropical fauna, while *E. myrae* is as definitely warm to cool temperate. This conclusion becomes of potential consequence in assisting to a correct interpretation of any fossil faunule in which either of these two species may prove to be represented. Up to the time of writing I have been able to find but two references to the occurrence of any species of *Ensis* in the Californian and Mexican Pleistocene (Jordan, 1936: 112, and Willett, 1937: 391). As the fauna elucidated by Willett is a temperate one but with a strong warm-water element involved, it would be of much interest to re-examine his material and establish its true identity.

I can further find nothing on record concerning the natural history of *E. myrae* save a brief but suggestive comment by Burch (1945: 27) which I think is worth quoting in full; "Our experience has been to find this species exceedingly rare. We have dredged great numbers with the 25 fathom gravel off Redondo Beach but by the very nature of the bottom and the dredgings it was a very low ratio of recovered complete specimens. The species is quite fragile. We have sets in our collection labelled as from San Pedro Bay and from Terminal Island, collected by Mrs. W. H. Eshnaur and others in the years before the dredging of Deadman's Island, etc."

This fine species is here dedicated to Dr. A. Myra Keen of Stanford University in deserved recognition of the major contributions she is steadily making to our knowledge of west American pelecypods.

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[The genus *Ensis* is described on pp. 47, 143.]

SMITH, A. G., and GORDON, M., JR.
1948. The marine mollusks and brachiopods of Monterey Bay, California, and vicinity. Proceedings California Academy Sciences, ser. 4, 26 (8): 147-245, text figs. 1-4, pls. 3-4, 15 Dec. 1948.

WILLETT, G.
1937. An Upper Pleistocene fauna from the Baldwin Hills, Los Angeles County, California. Transactions San Diego Society Natural History, 8 (30): 379-406, pls. 25-26, 15 Dec. 1937.

WILLIAMSON, MRS. M. B.
1892. An annotated list of the shells of San Pedro Bay and vicinity. Proceedings United States National Museum, 15: 179-219, pls. 19-23, 1892.

TRANSACTIONS

OF THE

SAN DIEGO SOCIETY OF NATURAL HISTORY

Volume XI, No. 16, pp. 405-428,
Plates 28-29, Figs. 1-10

NOTICES OF NEW WEST AMERICAN MARINE MOLLUSCA

By
S. Stillman Berry
Redlands, California

SAN DIEGO, CALIFORNIA
Printed for the Society
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COMMITTEE ON PUBLICATION

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NOTICES OF NEW WEST AMERICAN MARINE MOLLUSCA

BY

S. Stillman Berry

Redlands, California

Any long continued regional study of a fauna is likely to result in the gradual accumulation of currently unidentifiable specimens, some of which eventually demand publication as new. It is in the effort to clear away a few such odds and ends and to make possible intelligible reference to some of them in other work now impending that the ensuing paper has evolved. The eleven molluscan species to be described include several which have long been known but have been quite as long rather thoroughly misunderstood, among them a most interesting new mussel (*Volsella*), a *Diplodonta*, and a fine new *Nassarius*. Of special interest among the remaining species, all of which are gastropods, are an exquisite off-shore *Ocenebra*, a beautiful olive-shell (*Agaronia*) from the tropical fauna, a splendid species of the striking turrid genus *Knefastia*, and two minute but hardly less remarkable tectibranchs, each of these last constituting the type of a new genus.

In addition to the various collectors mentioned in connection with the specimens so generously furnished me by them, my very appreciative thanks are likewise due to Dr. Harald A. Rehder and his associates of the Division of Mollusks, United States National Museum, to Dr. A. Myra Keen, Department of Paleontology, Stanford University, and to Col. Arthur F. Fischer and Dr. Joshua L. Baily, Jr. of the San Diego Museum of Natural History for affording me every possible facility in the study and in some instances the utilization of relevant comparative material to be found in the collections under their care. Further grateful expression of obligation is due to Dr. G. D. Harris and Dr. Katherine V. W. Palmer of the Paleontological Research Institution, Ithaca, and especially to my good friend Mr. Edgar R. Fisher of Redlands for making the photographs used in the accompanying plates.

1. **Volsella sacculifer** new species

Pl. 28, figs. 1, 2, Text-fig. 1.

Description: Shell of but moderate size for the genus, in outline broadly almond-shaped; highest at about the mid-point, thin, smooth, moderately inflated; hinge-line nearly straight to very slightly arcuate. Valves well rounded behind, more or less distinctly swollen ventrally in the byssal region and produced abruptly into a small obtuse lobe-like flare or pocket just under the umbones, the rounded angle of this pocket forming the anterior end of the shell; postero-dorsal area subalate, its angle obtuse. Hinge toothless except for a short, sharply conical, posteriorly directed process set off by a notch at the anterior insertion of the ligament. Periostracum light to deep brown (near Buckthorn Brown to Mummy Brown), smooth, polished, under the more or less dehiscent traces of some fairly considerable posterior shagginess.

Measurements:	Max. long. mm.	Max. alt. mm.	Diam. mm.
Chace Coll. 1789	61.7	38.2	24.5
Paratype 20654	40.1	23.2	17.6
Paratype USNM	39.1	22.8	17.6
Holotype	38.0	20.0	15.8

Holotype: To be deposited in the collection of Stanford University, No. 7853.

Paratypes: Cat. No. 20654 Berry Collection, together with a small series in the Oldroyd Collection in the Department of Paleontology, Stanford University, besides one to be deposited in the collection of the United States National Museum.

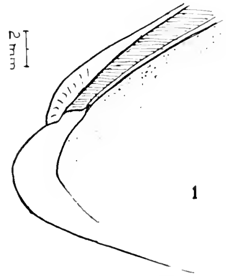

Fig. 1. *Volsella sacculifer* n. sp. Camera sketch of anterior portion of right valve of paratype 20654 to show anterior pouting and its relationship to umbo and hinge.

Type-Locality: San Pedro Harbor, California (Los Angeles County Museum collectors and others).

Additional Locality: Long Beach, California; one large complete specimen washed in from deep water; Emery P. Chace no. 1789.

Commentary: This species has been known and neglected for a number of years. It does not appear to be very common, but occasional specimens are to be seen in local collections, almost invariably having been collected in San Pedro Harbor or its near vicinity, and usually masquerading under the name of the very different *V. fornicata* (Carpenter). The byssal swelling varies greatly in strength in different individuals (it is rather weak in the shell which happened to be selected as the holotype), but the anterior pouting is both a constant and characteristic feature which enables this species to be distinguished at a glance from any other presently known west American member of the genus. It is probably not an animal of littoral habit, but a dweller in somewhat moderate depths offshore, since almost all the specimens seen were taken at the time of the major dredging operations in San Pedro Bay and few if any of them appear to have been picked up alive. It is not probable that the species is anywhere either abundant enough or sufficiently available to be of importance as food, yet in its proper habitat it may occur more numerously than we at present know. The Long Beach example in the Chace Collection is far larger than any other examined and retains more of the pristine shagginess.[1]

The specific name is derived from the L. *sacculus*, pouch, + *-fer*, bearer, and has reference to the peculiar sub-umbonal pouting.

2. **Diplodonta impolita** new species

Pl. 28, figs. 3, 4. Text-fig. 2.

Description: Shell of medium size, thin, crude, dull and more or less chalky in texture, subrotund, a trifle longer than high, tumid, equivalve, distinctly oblique, the anterior end shorter but more narrowly rounded and projecting than the posterior. Surface pale brown, roughened by the coarse growth-striae which are lower and more distant on the earlier portion, but abruptly both more acute and more crowded during the subsequent half of development. Beaks narrow, bent strongly forward, quite angular and pointed for a *Diplodonta*, the area in front somewhat excavated. Hinge plate and teeth small; posterior right cardinal strongly divided by a sharp groove throughout its length, each segment strongly and rather acutely cusped on its inner side; anterior right cardinal smaller, simple, arising close under the valve margin and projecting but little below the supporting plate, its cusp either rounded or obtusely angular; anterior left cardinal simple, elongate, very oblique; posterior left cardinal duplex, little projecting ventrally, nearly vertical in align-

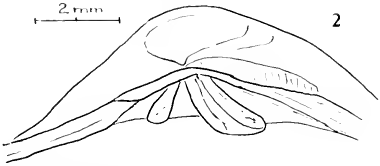

Fig. 2. *Diplodonta impolita* n. sp. Interior view of umbonal region of right valve; holotype; camera outline.

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[1] During the printing of this paper and thus unfortunately too late to make it the type-series, a suite of three superb examples of this species were kindly sent to me by Dr. Howard R. Hill of the Los Angeles County Museum (Berry Coll. 18367). These were dredged alive in 25 fathoms, off Santa Catalina Id., California, in June 1927 by the late George Willett. The largest measures: long. 74.8, alt. 40.4, diam. 33.6 mm.

ment; hinge plate short, continuing, especially in front, as a low ridge running along the slopes of the valve close to the somewhat beveled and even slightly excavated margin; ligamental plate narrowly angled or ridged on its inner aspect, anterior adductor-scar subpyriform, concave or indented on the inner margin; posterior scar more ovate and without emargination. Periostracum thin, light brown, largely worn away in adult.

Measurements: Largest paratype, long. 26.0, alt. 25.0, diam. (depth) 8.8 mm.; holotype, long. 23.0, alt. 21.2, diam. 8.6 mm.

Holotype: To be deposited in the type collection of the Department of Paleontology, Stanford University, No. 7854.

Paratypes: Cat. No. 3658 Berry Collection; others to be deposited in the collections of the San Diego Society of Natural History, the United States National Museum, and the Museum of Comparative Zoology of Harvard College.

Type-Locality: 15 fathoms, off Forrester Id., Alaska; dredged by George Willett, July-Aug., 1916.

Commentary: This is the species which Willett (1918: 68) reported from Forrester Island as *D. orbella* (Gould). He noted that it is "much less globose than California specimens," and indeed upon closer study it appears clearly distinct from them specifically, differing not only in the very much narrower, more pointed, and less projecting umbones, but also in the earthy texture, the heavier incremental striae, the relatively minute hinge-plate, the smaller, more obtuse, and less projecting cardinals, and other more minor features. It may bear some relationship to *D. aleutica* Dall (1901: 820), but this I have not seen. It would seem a distinctly less globose and more elongate species than either *D. impolita* or *D. orbellus*.[2] I suspect that nearly or quite all of the more northern published records under Gould's name will prove referable to the present species.

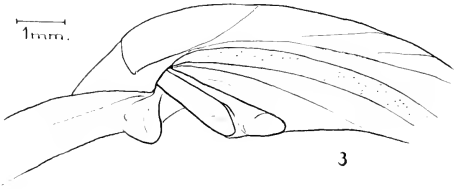

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Fig. 3. *Diplodonta orbellus* (Gould). Interior view of umbonal region of right valve of specimen from San Pedro, California; no. 160, Berry Coll.; camera outline.

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[2] As the Latin *orbis* is masculine in gender, its diminutive should logically be spelled *orbellus*, for which Gould's use of *orbella* might be regarded as a *lapsus calami*. We could do with either a sharper or a more inclusive definition of what properly constitutes *lapsus calami* within the purview of the International Code.

Unfortunately all of the mature shells are incomplete and represent the same valve, the right.

The specific name is the L. *impolitus*, unpolished, and refers to the crude, inelegant appearance of the outer surface of the shell.

3. **Lacuna succinea** new species

Text-fig. 4.

Description: Shell small, thin, narrowly acutely conic, umbilicate; spire attenuate, produced. Whorls about 6.3, rapidly descending and enlarging, moderately convex above the strongly corded peripheral carina which nearly always remains visible just above the rather deep suture almost from its inception; nepionic whorls at first whitish, smooth, polished, eventually becoming slightly roughened by the increasingly strong incremental lines and the faint beginnings of spiral sculpture; later whorls corneous, translucent, strongly and copiously spirally striate; base concavely flattened. Aperture large, sub-pyriform or semi-lunar, acute posteriorly, broadly rounded in front; lip thin, very sharp, effuse anteriorly, very slightly everted near its junction with the parietal wall just below the carina, whilst in front continuing smoothly past the columella into the threaded keel which bounds the very open, crescentic, trimly reamed umbilical groove; columella narrow, solid, calloused, whitish, for the most part nearly straight, its attenuate lower third curving into the aperture.

Color of shell usually a nearly uniform Deep Olive-Buff to Wood Brown without definite markings or mottlings, the umbilical keel a little darker, but the larger shells occasionally showing on the body-whorl a few dim brownish oblique lines, especially visible near the carina as it approaches the lip.

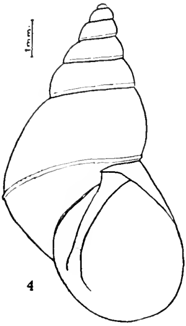

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Fig. 4. *Lacuna succinea* n. sp. Camera outline of holotype.

Measurements: Holotype, alt. 8.9, max. diam. 5.5, alt. aperture 4.7, diam. aperture 2.6, max. diam. umbilical chink from carina to inner face of columella 0.8, max. inner diam. of chink 0.4 mm.

Holotype: Cat. No. 11983 Berry Collection.

Paratypes: Cat. No. 12886 Berry Collection; others to be deposited in the collections of the San Diego Museum of Natural History, Stanford University, and the United States National Museum.

Type-Locality: San Pedro, California; Emery P. and Elsie M. Chace.

Material Examined:

Number Specimens	*Locality*	*Collector*	*Date*	*Where Deposited*
2	Avalon, Santa Catalina Id., Calif.	S. S. Berry	1903	Berry Coll. 1424
2	Arch Beach, Orange Co.,Calif.	H. Grace Eaton	——	" " 9181
6	San Diego, Calif.	F. W. Kelsey	——	" " 1484
1	San Pedro, Calif.	E. P. & E. M. Chace	——	" " 11983 Holotype
10	" "	"	——	" Paratypes
10	" "	"	——	Chace Coll. Paratypes
2	" "	"	——	San Diego Mus. Paratypes
1	" "	"	——	Stanford Coll. Paratypes
2	" "	"	——	U.S.N.M. Paratypes

Remarks: The determination of this pretty and altogether distinct little species has bothered me for some time. It clearly has nothing to do with the boreal group of *L. solidula* Lovén and its allies, although I have several times seen it under the name *solidula* in collections. I have also seen it labeled *aurantiaca* Carpenter (1864: 656) despite that having been succinctly described as "keel obsolete, resembling the chinked *Phasianellae*" and hence evidently something quite different from the present species. A third name which I have seen applied to it is *carinata* Gould (1848: 75), but that is a northern species and has a much more robust shell (Gould called it "ovato-globosa") and the extensive material I have seen does not lead me to the conviction that the two are in any way closely related. To my reading Carpenter's diagnosis of his *L. compacta* (1864a: 429) is more suggestive of *succinea* than any of the three species aforementioned. However, his use of the word "compact," his failure to mention the characteristically drawn-out spire, and his description of the columella as "vix lacunata," together with the fact that *compacta* was a segregate from his variable Neah Bay series, whence he described a total of no less than five species and varieties of this genus, afford good evidence that he could not have been considering this southern species.

The color matching I have given is from a shell taken with the animal. Empty beach shells are often quite a clean bright amber in hue, hence the specific name, which is the *L. succineus*,—of amber.

4. **Turritella orthosymmetra** new species

Plate 28, fig. 5.

Diagnosis: Shell of moderate size, rather thin; spire compactly coiled, elongate-conic, with straight smooth slopes; apical angle narrowly acute, showing no marked change with advancing growth; suture distinct, very narrowly channeled. Sculpture of early post-embryonic whorls comprising a strong peripheral keel slightly below the middle, a weaker one a little below the upper suture, and very soon a third immediately above the lower suture, which last increases in strength until on the final whorl it forms a sharp carina which bounds the concavely flattened base; a smaller secondary rib also develops between the uppermost major rib and the suture, while on all the later whorls a fine somewhat wavy spiral threading covers all the surface between the major spirals and also extends over the base, the number of threads on the base varying from about 12 to 20 in addition to a few weak intercalaries. Aperture asymmetrically quadrate, slightly widest anteriorly, strongly angled and somewhat pinched where intersected by the basal keel; outer lip thin, sharp, usually more or less broken away; columella narrow, arcuate, slightly twisted, the basal lip very weakly everted where it adjoins it, sometimes appearing to form the bare rudiment of a canal; columellar callus rounding out over the base somewhat in advance of the lip.

Color of shells always considerably obscured and dulled by a grayish deposit or bloom, but apparently fairly near Clay Color, more or less clouded with Army Brown and related tones.

Measurements: Holotype, alt. 30.0+, max. basal diam. 8.5, alt. aperture 5.0, diam. aperture 5.0 mm.

Holotype: Cat. No. 11,979 Berry Collection.

Paratypes: Cat. No. 502 Berry Collection, others to be deposited in the collections of Stanford University, United States National Museum, and San Diego Museum of Natural History.

Type-Locality: Off Pebbly Beach, Santa Catalina Id., California; dredged in 50 fathoms by J. H. Paine and S. S. Berry, 31 Aug.-1 Sept. 1903.

Remarks: This beautiful *Turritella* has been known to collectors for a long time, but I can not find that any valid name has ever been applied to it. It has probably most frequently been labeled *T. jewettii* Carpenter (1866: 276), but the description of that enigmatic and perhaps indeterminable fossil species is no very close fit for the shells of this living race, especially the description of the base as "parum angulata," and I believe we are well advised to follow Merriam (1941: 123) in regarding *jewettii* either as a variant of *cooperi* Carpenter, or still better as a mere *species inquirenda* until its true identity is one day definitely established. Although apparently, from its plan of sculpture, allied to *cooperi* (Carpenter 1864: 612, 655), the present species is sharply distinguished by its less attenuate, evenly geometric, flat-sided, tightly coiled spire, acute basal keel, quadrate angled aperture, and definite spiral sculpture on the base. In form it is much more like *T. pedroensis* "Applin" Merriam (1941: 121, pl. 35, figs. 1-9), but is smaller and the shell is much less heavily sculptured. The species was a common one at the type-locality and Paine at one time had quite a number of the shells. I have seen few of them from other dredgings.

The specific name is derived from the Gr. *orthos*, correctly, and *symmetros*, symmetrical, and is descriptive of the trimly aligned spire.

5. **Ocenebra crispatissima** new species

Pl. 28, fig. 6.

Description: Shell rather small, thin, somewhat broadly fusiform, with a large, rounded body-whorl; spire short, turreted, acutely conical. Whorls (counting suturally) about seven (apex missing in holotype); larval shell small, high, straight-sided, sharply carinately tabulate and inward sloping above, nearly smooth, with about one and a quarter whorls; succeeding whorls more narrowly and flatly tabulate, abruptly bearing a small spiral cord on the shoulder, a slightly weaker one a little below it, and soon with traces of a third still weaker one appearing now and then in the suture, these cords at first smooth but soon becoming roughened by the appearance of fine incremental lirations, following which additional spiral cords gradually appear, the original two cords nevertheless maintaining their primacy throughout, until back of the aperture there may be as many as 14 or 15 cords of varying strength separated by considerably narrower, deeply squarish interspaces, beyond which anteriorly a few more similar spirals gradually fade away on the canal; simultaneously the incremental threads have likewise been rapidly increasing both in strength and number until on the last whorl they form a close, erect, crispate, laminate imbrication over-riding both the axial ridges, on the summit of which, most especially on the shoulder spiral, it attains its greatest and almost spinose emphasis. Aperture about three-tenths as long as the shell, ovate-pyriform, acute posteriorly; axial threads corresponding to the outer laminations continuous and closely crowded around the inner lip to separate it from the columellar wall and render the peritreme complete, eventually terminating on the roof of the canal; outer wall of aperture dentate with about five teeth, including one small tubercle situated a little above the middle, a second one so weak as to be hardly more than a trace, then two somewhat stronger ones, and finally a very heavy tubercle at the entrance of the canal. Canal a little longer than the aperture, narrow, nearly straight, gently recurved, and covered for all but the anterior third of its length.

Color cream-white outwardly, the interior polished and warmly flesh-tinted.

Operculum shortly pyriform, the columellar border weakly concave; striae low, rounded, rather heavy, not very crowded.

Measurements of holotype: Alt. 20.9, max. diam. 11.1, alt. aperture 6.1, length canal 7.8 mm.

Holotype: To be deposited in the type-collection of the Department of Paleontology, Stanford University, No. 7855.

Paratype: An immature shell with perfect apex, Cat. No. 18972 Berry Collection.

Type-Locality: 33 fathoms, off Isthmus Cove, Santa Catalina Id., California; "Zaca" Sta. 23, Stanford-Crocker Expedition (Dr. George S. Myers), 16 Sept. 1938.

Additional Material: A single adult shell from 15 fathoms, Avalon Harbor, Santa Catalina Id., California (Berry Coll. 8945).

Commentary: For an *Ocenebra* this is a shell of unusual refinement and beauty, quite as lovely as some of the northern "trophons" and indeed recalling them in nearly every way except the more robust body-whorl. In its own genus nothing appears to demand particular comparison with it. It probably belongs in the group with *O. barbarensis* (Gabb) and *O. squamulifera* Carpenter, from both of which it differs in the smaller size, thin shell, relatively low spire, long and very narrow canal, very sharp sculpturing, and complete lack of any brown coloring.

The specific name is the superlative of the L. *crispatus*, curled or crimped, and has reference to the incremental lamination.

6. **Nassarius (Schizopyga) rhinetes** new species

Plate 28, fig. 7.

Diagnosis: Shell quite large, thin, high-conic, with an acute apex, the slope of the spire distinctly arcuate; whorls about 8, the later ones quite inflated, with rounded profile and only the weakest suggestion of a very narrow shouldering; suture distinctly impressed and deep. Sculpture, subsequent to the abraded apical whorls, developed first as about 14 rather strong, nearly straight axial ridges, soon becoming somewhat retractively slanting, relatively finer and more crowded, and on the last whorl weakly arcuate or hypo-sigmoid, here increasing in number to about 30; spiral sculpture appearing soon after the axial; on the spire about 6, on the fully exposed last whorl about 12 cords, not all of them of equal strength, the first cord anterior to the suture being distinctly more slender and the second cord more emphasized than succeeding ones, while the 10th and 11th cords just posterior to the columellar fossa are again somewhat emphasized, while the 12th cord, which runs along the posterior wall of the fossa itself, is little more than a strong thread; cords 1 to 10 form distinctly squarish interspaces with the axial ribs, with the intersections rather sharply tuberculate; tubercles slightly emphasized at the shoulder along cord 2, and reduced along cord 11, while cord 12 and the 5 crowded ribs of the wall of the canal anterior to the fossa are non-tuberculate. Aperture ample, about 51% of the total altitude, ovate-pyriform, truncate in front; outer lip thin, its inner surface marked by slender shallow spiral grooves corresponding in position to the cords of the exterior; inner lip strongly concave in profile, covered by a thin, smooth, whitish callus which extends well in front of the aperture, but barely passes the sutural line and is not very sharply bounded; columella strongly twisted and incurved, weakly biplicate near its termination; canal open, deep, its outer margin reflexed against the rather narrow sharply excavated fossa. Color of shell whitish, unbanded, but with traces of a thin, axially laminated, semi-dehiscent, pale yellowish brown periostracum between the costae.

Measurements: Holotype—alt. 32.5, max. diam. 18.9, alt. aperture 16.6, diam. aperture (opening only) 8.8, diam. aperture to edge of callus, 11.2 mm.

Holotype: Cat. No. 1182 Berry Collection.

Paratypes: Cat. No. 1163 Berry Collection.

Type-Locality: Dredged in 40 fathoms, off Moss Landing, Monterey Bay, California; mud bottom; S. S. Berry, June 1906.

Remarks: This beautiful species has been held in MS. for some time. It has long been known to Californian students as one of the strange congeries of forms which has passed under the name *Nassa californiana* (Conrad), the present type-material having been reported under this name by myself (1907: 40) shortly after its collection. And to avoid misunderstanding, it should be admitted at once that if Conrad's name can properly be associated with any living species, the subject in hand is the likeliest candidate for selection. Unfortunately the original description of *californiana* is at once so brief and so generalized as to be nearly worthless, while the almost equally inadequate figure shows only two whorls, the spire represented by a restoration in outline. While the figure is about the same size as adult Recent shells and the reconstituted spire is rather startlingly close to the contours they exhibit, there exist otherwise what appear to me as quite troublesome discrepancies. There is shown no trace whatever of any parietal callus, no internal lirations, the sculpture is indicated as quite closely cancellate rather than ribbed, and while its delineation makes it appear nearly as much like an injury as a normal structure, the fossa is in profile both considerably more open and more "profound." Fortunately at least one fossil form has been reported and figured, which, in spite of the indefinite status of Conrad's type-horizon, is probably fairly near it in the time-scale, and is likewise more or less in accord with it in the characters just noted. This is the *Nassa californiana* recorded by Arnold (1908: pl. 36, fig. 6) from the Pliocene south-west of Capitola in Santa Cruz County, which I am accordingly inclined to accept as reasonably identified, enabling us to fix, far better than any other published evidence, Conrad's enigmatic name. Arnold gives no description, but the clean-cut photographic figure represents the shell of a species obviously of the same intimate group as the living one, but differing in its decidedly wider outline, more finely cancellate sculpture, the wide *smooth* fossa, and at least the appearance of a rather remarkable excavation of the columella, the importance of which is difficult to estimate without examination of actual specimens.

Of other living species *N. perpinguis* (Hinds) seems about the closest but is much smaller, spiral cords are appreciably more numerous on the later whorls, and there are so many other differences of detail that only through the utmost carelessness could the two species readily be confused.

The specific name chosen is from the Gr. *rhinetes*, one who rasps or files, and refers to the rasp-like sculpturing of the shell.

7. **Agaronia murrha** new species

Pl. 29, fig. 1. Text-fig. 5.

Description: Shell of moderate size, rather heavy at maturity, ovate-fusiform, widest near middle, the spire tapering rapidly and on the lip side somewhat convexly to the minutely mammillate apex; anterior extremity truncate. Whorls 5 or a trifle more, rapidly increasing, the body-whorl convex and including about 90% of the total length of the shell. Suture sharp and strongly but not very deeply channeled. Aperture ample, sharply angled posteriorly, about three-fourths as high as the shell; outer lip sharp until maturity when it becomes reinforced inwardly by a whitish callus which becomes quite heavy approaching the suture; outer anterior lobe subangular, slightly surpassing the columella; canal open, moderately wide; parietal wall covered by a sharply delimited white callus which is thickened above the suture posteriorly and thence extends in most specimens completely across the whorls to the suture above so that the spire is completely calloused; anteriorly the callus passes over the columella to the canal. Columella with a single strong fold at the canal which is bounded by a rather sharp and deep channel; behind this appears a rather complex system of low folds,—first, two or three outer ones parallel to the callus-margin, second, entering against these at a low angle and supplanting them toward the aperture are three or four more slender costae, and third, an apertural series of low less sharply ascending folds which are of rather irregular development and strength; fasciole hardly elevated. Surface smooth except for extremely weak traces of a microscopic spiral striation and the growth lines, the latter becoming stronger in nearing the aperture; parietal callus and fasciole microscopically wrinkly-punctate.

Color of exterior of adolescent or mature shells everywhere a slightly grayish porcelain-white, the outer wall of the interior deep brownish except for the calloused margin of the lip which is white; very young shells light brownish gray with an indistinct yellowish zone below the suture, a rather sharp white band on the anterior part of the body-whorl, and a brown-bordered white zone marking the fasciole.

Measurements of largest paratype, alt. 38.5 mm., max. diam. 16.6, alt. aperture 31.8 mm., no. whorls 5; of holotype, alt. 36.3, max. diam. 15.4, alt. aperture 29.3 mm., no. whorls 5+.

Holotype: San Diego Museum of Natural History.

Paratypes: Cat. No. 16431 Berry Collection; others to be deposited in the collections of the United States National Museum, the Department of Paleontology of Stanford University, the Museum of Comparative Zoology of Harvard College, and the private collection of Dr. Joshua L. Baily, Jr.

Type-Locality: Corinto, Nicaragua (Herbert N. Lowe, 1931).

Commentary: In critically reviewing the available West American specimens of *Agaronia* with a view to correlating their distribution, it shortly became apparent that two quite different forms are involved whereas only a single species, the widespread *A. testacea* (Lamarck), has been hitherto recognized from the region. Since an exhaustive search of available literature has revealed no lost name which can be revived for the rarer form, a name is here supplied for it and tentatively given specific rank. It differs from *A. testacea* in detail at almost all points, but adults may perhaps be most easily separated by 1) the low spire, slightly convex on the apertural side; 2) the long aperture; 3) the constricted and relatively shallow sutural channel; 4) the more evenly ovate outline; 5) the extension of the parietal callus across the whorl to the suture with a consequent smoothly calloused spire; 6) the relatively large and more mammillate nepionic shell; 7) the closely wrinkled inner lip, with its folds oblique to the thin major plaits; and 8) the barely raised fasciole. To these might be added the opaque whitish-porcelain coloring of the exterior and the inside margin of the outer lip, besides the warm deep brown of the interior without any trace of the usual bluish-gray of *A. testacea*, except that it must be borne in mind that the *Olividae* are a family in which extreme colored variants are of the commonest occurrence and these differences, conspicuous though they are, may turn out to be more

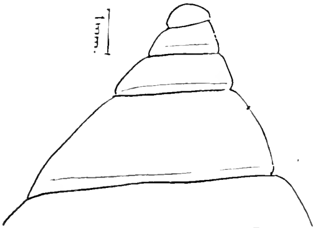

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Fig. 5. *Agaronia murrha* n. sp. Camera outline of apex of paratype 16431a.

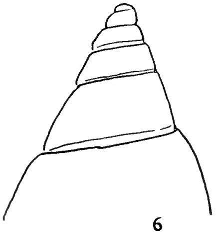

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Fig. 6. *Agaronia testacea* (Lamarck). Camera outline of apex of shell from Cholla Cove, Sonora; no. 15122a, Berry Coll.; same scale as Fig. 5.

characteristic of the particular colony whence the type-series was taken than of the species as a whole, although some describable difference in the respective color ranges of the two species is quite certainly to be anticipated. Until then such characters as those provided by the calloused spire and the nepionic shell should provide more certain criteria for separation than mere color, but this can be better told when larger series become available for comparison. Although the present species apparently lacks the lively coloring exhibited by *A. testacea* in its best forms and is not known to approach it in size, it is nevertheless attractive in a modest way.[3]

The specific name chosen is the L. *murrha*, porcelain.

8. **Antiplanes (Rectiplanes) willetti** new species

Pl. 29, fig. 2.

Description: Shell elongate fusiform, with tall, sharply conic spire; whorls 8, convex, each appressed closely against the whorl above, the suture distinct; nepionic whorls two, mammillate, their inflation insufficient to alter appreciably the symmetrical outline of the apex, polished, the first smooth, the second developing a few weak traces of spiral sculpture on its concluding portion, which develops into a system of about 10 fine spiral threads on the next succeeding whorl, and increases to about 20 gradually stronger but still very weak threads on the penultimate whorl and many more on the body-whorl, where they continue to the canal, those in the fasciolar area being excessively fine, crowded, and numerous; axial sculpture absent except for the numerous growth lines of rather uneven strength. Aperture elongate-pyriform, about 40% of the height of the shell; outer lip thin, sharp, strongly arcuately produced; inner lip and columella smooth, arcuate; canal open, short, slightly recurved; anal sulcus wide and deep, passing smoothly into the produced segment of the lip; fasciole not sharply delimited, marked mainly by the fineness of the sculpture.

Measurements: Holotype—alt. 18.4, maj. diam. 6.6, alt. aperture 7.0, diam. aperture 2.2 mm. Paratype—alt. 17.8, maj. diam. 6.7, alt. aperture 6.3, diam. aperture 2.0 mm.

Holotype: Cat. No. 11,977 Berry Collection.

Paratypes: Cat. No. 3843 Berry Collection, and the collection of the San Diego Museum of Natural History, No. 22856.

Type-Locality: 50 fathoms, off Forrester Island, S.W. Alaska; dredged by George Willett, July 1917.

Remarks: This very attractive little species has been previously recognized under the name *Crassispira rotula* (Willett 1919: 21). The latter species was originally described from fossil material under the name

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[3] Too late for consideration except in a footnote, there was called to my attention a large series of a small dark *Agaronia* in the San Diego Museum taken in 1931 by H. N. Lowe at San Juan del Sur, Nicaragua. These shells are mostly of purplish-gray coloring with a deep brown (rarely light yellowish-brown) apex and fasciole, and appear to represent a dark phase of the species here described.

Pleurotoma (*Spirotropsis*[1]) *smithi* Arnold (1903: 216, pl. 6. fig. 13), but the specific name having been preoccupied in *Pleurotoma* more than once, it was later renamed *rotula* by Dall (1921: 71). To this the northern living species is admittedly quite close, but differs from it according to the material seen 1) in being much smaller, with fewer whorls and a shorter canal; 2) in the distinct spiral sculpture, which in the fossil is either entirely absent as described by Arnold, or represented by some nearly obsolete traces on the anterior part of the body-whorl as shown in one of my Hilltop Quarry specimens; and, perhaps most importantly of all, 3) by the very much smaller and less bulbous nepionic shell. I have found *A. rotula*, or what I at present interpret as that species, only twice at Hilltop Quarry, so it would seem of relatively infrequent occurrence there, although the specimens are beautifully preserved. The holotype of *rotula* came from Arnold's supposed "Pliocene" of Dead Man's Island, now generally considered as the equivalent of the lower Pleistocene at Timm's Point. The nepionic shell in the fossils I have seen is similar in general form and structure to that of *willetti*, but is greatly larger and somewhat more inflated, rendering the apex distinctly obtuse. *A. rotula* is one of the extraordinary melange of species placed by Grant and Gale (1931: 553-4) in the synonymy of *perversa* (Gabb), but I am wholly at a loss to comprehend how anyone with both this and *perversa* in hand could possibly confound them, their characterization being sufficiently ample quite aside from the mere direction of coil, a prejudice against which as a taxonomic anchor appears to have blinded these authors to everything else.

The species is dedicated to its discoverer, the late George Willett, of the Los Angeles Museum.

9. **Knefastia princeps** new species

Pl. 29, fig. 3. Text-fig. 7.

Description: Shell moderately large, elongate, fusiform; larval shell decollated in holotype but persisting whorls 8½, turreted, strongly convex, sloping above to a high, subangulate shoulder; a flattened fold-like ridge strongly appressed against the suture is subtended by a shallow spiral furrow in the rather wide anal fasciole, the latter sculptured otherwise mainly by the very strong and coarse incremental striae and a few weak traces of low spirals; body of whorl marked by from 7 to 8 massive axial ribs (there are 7 on the last whorl) which are slightly knobbed on the shoulder, and 4 low but strong spiral ridges which over-ride both the axial ribs and their interspaces, the two central ridges being a trifle more widely separated than either is from its outer neighbor; base with about 13 or 14 gradually weakening spirals; the axial ribs pass onto the base but become obsolescent in the region of the canal. Aperture unarmored, about 45% the length of the shell, elongate-pyriform, acute posteriorly; outer lip sharp-edged, hardly crenulated by the spiral ridges, its margin convex in front of the strong open anal notch which nearly subtends the

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[1] Apparently an inadvertence for *Spirotropis* Sars 1878.

end of the suture. Canal open and fairly long. Columellar wall somewhat erose parietally, covered with a moderate wash of shining enamel.

Periostracum shining, the spire and main portion of body-whorl lustrous Antique Brown, paling anteriorly and on the nodes to Raw Umber, the spiral ridges sharply paler and the anterior portion of the shell as well, even to Chamois at the extreme portion and on the spirals, with one or two darker bands under the periphery. Interior polished and bright, near Cinnamon to Pinkish Cinnamon.

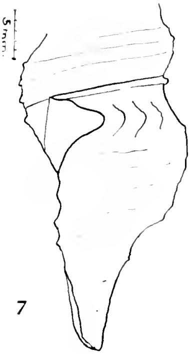


Fig. 7. *Knefastia princeps* n. sp. Camera sketch to show profile outline of lip.

Operculum a little smaller than the aperture, acute in front, more blunt posteriorly, with a shallow furrow running parallel to the inner margin.

Measurements of holotype: Alt. 60.3+, max. diam. 19.9, alt. aperture 28.0, max. diam. aperture ca. 9.2 mm.

Holotype: Cat. No. 13949 Berry Collection.

Type-Locality: 20 fathoms; pebble, mud and shell bottom; 2 miles N. of Cedros Village, Cedros Id., Baja California; Kenyon-Williams Mexican Expedition, Sta. 17B, 14 May 1946.

Commentary: This magnificent species, one of the finest in a generally striking genus, appears nearest to *K. dalli* Bartsch (1944: 28) among described forms, differing in its larger size, more slender form, the relatively longer and attenuate canal, the slender and well-spaced spiral cords, the very much fewer and less nodulous axial ribs, the more open sinus, and the warmer and brighter coloring, especially of the interior. The single example taken was dredged up alive.

The specific name is the L. *princeps*, the first in rank or most distinguished.

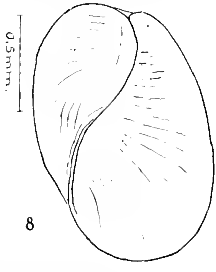
10. WOODBRIDGEA new genus

Diagnosis: Shell minute, thin, transclucent, inflated, obliquely bulliform; whorls nearly embracing, rather narrowly planate above, rapidly expanding to the greatly inflated body-whorl; aperture wide, ear-shaped, strongly and obliquely expanded in front; columella unarmed; surface strongly spirally striate.

Type: the following species.

Woodbridgea williamsi new species
Text-fig. 8.

Description: Shell minute, very thin, subvitreous, whitish, translucent; somewhat suggesting a lop-sided *Haminoea* in form; whorls closely embracing and very rapidly expanding from the minute, planate, barely exposed apex to the greatly expanded body-whorl. Aperture ample, ear-shaped, strongly oblique to the shell-axis, narrow and sub-acute posteriorly, widely produced in front; outer lip thin, sharp, forming a shallow but distinct sinus posteriorly, whence it descends slantingly to its insertion; inner lip weakly calloused, sigmoid, the columellar portion nearly straight, slender, in front very narrowly flattened or possibly even sulcate between the rather solid appearing pillar and the thin margin of the lip, the precise formation being difficult to see and interpret clearly in so tiny and transparent a shell. Surface covered with numerous conspicuous sharp spiral striations fanning out from the aperture in two series, those above the periphery trending parallel to the suture and those below the periphery descending very much more rapidly, especially just in front of the columella.



8

Fig. 8. *Woodbridgea williamsi* n.g. & sp. Camera sketch of holotype; spiral sculpture merely indicated.

Measurements of the unique holotype: Alt. 1.33, max. diam. 0.96, alt. aperture 1.22, max. diam. aperture 0.71 mm.

Holotype: Cat. No. 13907 Berry Collection.

Type-Locality: 25 fathoms, fine brown sand and mud, ¾ mile off Cedros Village, Cedros Id., Baja California; one example, Kenyon-Williams Mexican Expedition, Sta. 17A, 14 May 1946.

Commentary: I know nothing sufficiently similar to this minute but very beautiful little sea-snail to render fruitful any precise comparisons. Until something can become known of the animal its nearer affinities can be hardly more than surmised, but from the form and texture of the shell one can scarcely doubt that its general relationships are tectibranch. In some respects the *Scaphandridae* are suggested, in others the *Diaphanidae* or the *Philinidae*.

Both the species and its genus are dedicated to its assiduous collector, Mr. M. Woodbridge Williams of Inverness, California.

11. MICRAENIGMA new genus

Diagnosis: Shell minute, white, translucent, almost exactly like a very minute *Bulla* in form, but imperforate both apically and basally, and unique in that the columella is provided with a strong downward-slanting tooth-like plate.

Type: the following species.

The name is derived from the Gr. *mikros*, small, + *ainigma*, difficulty or riddle, and refers to the development of the large columellar tooth, anomalous in the group.

Micraenigma oxystoma new species

Text figs. 9, 10.

Description: Shell minute, milky white, moderately translucent, evenly ovoid, bulliform, widest near middle, about 63% as wide as long; whorls embracing, but merely flattened at summit without the formation of an apical pit, imperforate basally; aperture elongate-ear-shaped, widest in front, narrowing posteriorly where it appreciably exceeds the spire; outer lip simple, sharp, thin, evenly curved; parietal wall less strongly

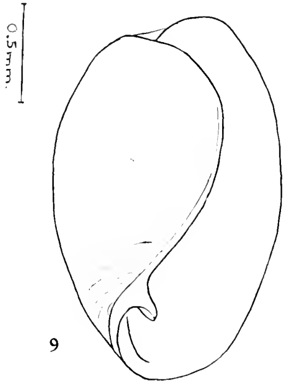


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Fig. 9. *Micraenigma oxystoma* n.g. & sp. Camera outline of holotype.

convex than the outer, covered with a restricted light callus, and curving back rather sharply into the short straight pillar-like columella, which bears a heavy and very long, downward and slightly backward slanting, triangular, plate-like, somewhat penetrating and ascending tooth, which is narrow and sharply conic in front view with a slight twist. Surface smooth except for the very fine microscopic incremental striation, some traces of a very delicate axial striation (perhaps only an emphasis of the first) on the upper moiety of the whorl, and four or five fine spiral striae on the otherwise ill-defined columellar fasciole.

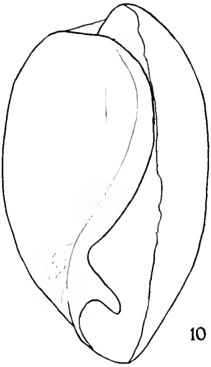
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Fig. 10. *Micraenigma oxystoma* n.g. & sp. Camera outline of holotype, looking obliquely into the aperture to show the full length of the columellar tooth; same scale as Fig. 9.

Measurements of holotype: Alt. 1.78, max. diam. 1.13, max. diam. aperture 0.51, max. long. tooth (upper side) 0.28 mm.

Holotype: Cat. No. 13907 Berry Collection.

Type-Locality: 25 fathoms, fine brown sand and mud, ¾ mile off Cedros Village, Cedros Id., Baja California; one example, Kenyon-Williams Mexican Expedition, Sta. 17A, 14 May 1946.

Commentary: To judge from the texture, form, and general appearance of the shell there seems little doubt that we have in this pleasant little species another tectibranch, yet, so far as I can discover, the heavy basal tooth is a feature unique in the entire order, although in some groups (such as the *Retusidae*, to which family perhaps *Micraenigma* may be tentatively referred until the animal is known) a low columellar fold may at times appear which from its position would seem clearly homologous with the tooth.

The specific name chosen is derived from the Gr. *oxystomos*, fanged, and appropriately refers to the apertural tooth.

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EXPLANATION OF PLATES

PLATE 28

Fig. 1. *Volsella sacculifer* n. sp. Exterior view of right valve of holotype, San Pedro Harbor, California; x ca. 1 2/3.

Fig. 2. *Volsella sacculifer* n. sp. Interior view of left valve of holotype; same scale.

Fig. 3. *Diplodonta impolita* n. sp. Exterior view of right valve, the holotype, from 15 fms., off Forrester Id., Alaska; x ca. 1¾.

Fig. 4. *Diplodonta impolita* n. sp. Interior view of same valve; same scale.

Fig. 5. *Turritella orthosymmetra* n. sp. Holotype, from 50 fms., off Pebbly Beach, Santa Catalina Id., California; x 2.1.

Fig. 6. *Ocenebra crispatissima* n. sp. Holotype, from 33 fms., off Isthmus Cove, Santa Catalina Id., California; x 2.9.

Fig. 7. *Nassarius rhinetes* n. sp. Holotype, from 40 fms., off Moss Landing, Monterey Bay, California; x ca. 1 2/3.

PLATE 29

Fig. 1. *Agaronia murrha* n. sp. Holotype, Corinto, Nicarague; x ca. 1.6.

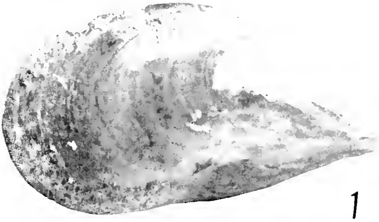
Fig. 2. *Antiplanes* (*Rectiplanes*) *willetti* n. sp. Holotype, from 50 fms., off Forrester Id., Alaska; x 2¾.

Fig. 3. *Knefastia princeps* n. sp. Holotype, from 20 fms., off Cedros Id., Baja California; x ca. 1.1.

Fig. 4. *Ensis californicus* Dall. Exterior view of left valve, Miramar, Sonora; x 1.

Fig. 5. *Ensis myrae* n. sp. Exterior view of left valve of holotype, San Pedro, California; same scale as preceding.

Fig. 6. *Ensis myrae* n. sp. Interior of right valve of same; same scale.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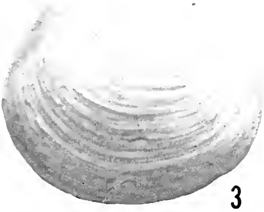
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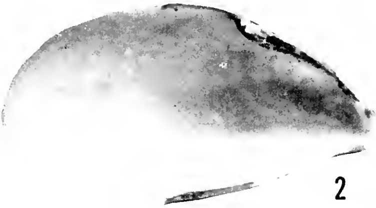
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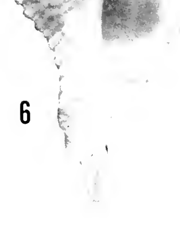
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TRANSACTIONS

OF THE

SAN DIEGO SOCIETY OF NATURAL HISTORY

Volume XI, No. 17, pp. 429-444, map

A PLEISTOCENE INVERTEBRATE FAUNA FROM THE SOUTHWEST CORNER OF SAN DIEGO COUNTY, CALIFORNIA[1]

BY

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SAN DIEGO, CALIFORNIA
PRINTED FOR THE SOCIETY
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[1] Contribution from the Museum of Paleontology, University of California, Berkeley, California.

INTRODUCTION

The purpose of this paper is to enumerate the mega-invertebrate fauna collected from a Pleistocene terrace deposit situated in the extreme southwest corner of San Diego County, California. Paleoecologic interpretations of the fauna are undertaken and an attempt is made to correlate this terrace with local terrace deposits. The study is based on a collected fauna totaling 91 identified species and subspecies.

Acknowledgments. The writers are indebted to Messrs. Ralph O. Fox and James W. Emerson for aid in field collecting and to Drs. J. Wyatt Durham, L. G. Hertlein, W. P. Woodring, and Mr. James W. Valentine for offering helpful suggestions and pertinent data pertaining to Pacific Coast Pleistocene problems. Mr. Owen J. Poe prepared the illustration.

REVIEW OF LITERATURE

Though the Pleistocene terrace fossils from the San Diego area have been recorded and discussed by a number of writers, including Dall (1878), Arnold (1903), Berry (1922), Stephens (1929), Webb (1937), and Hertlein and Grant (1939, 1944), the locality herein reported upon is specifically mentioned only by Stephens. In a paper pertaining to the fossiliferous Pleistocene deposits of the San Diego area, Stephens (1929: 250) briefly described this locality and listed the most conspicuous faunal elements. His description and remarks follow:

> "International Boundary Monument No. 258 stands on a mesa a few yards from its edge, which is at the Pacific Ocean. This mesa is a terrace about seventy feet in altitude at the beach and about one hundred and fifty feet where it abuts against the hills to the eastward. It is about half a mile in width. Northward, it is bounded a quarter of a mile from the international boundary by the Tijuana River bottom. The sand beach on the ocean side of the terrace is a hundred yards in width. The bank at the edge of the terrace is a steep, soil-covered slope carrying a considerable growth of brush. The soil covers the edges of the more or less consolidated strata of sand and clay underlying the terrace and rock exposures are very few. Seventy-five yards north of Monument No. 258, a small ravine cuts through the talus and exposes a fossiliferous stratum about forty feet below the upper edge of the slope. The stratum is about a foot thick and contains an abundance of fragments of large bivalves. These fragments are so thoroughly broken that few can be recognized specifically. By sifting, a number of small univalves were obtained, mostly small species. The material underlying the fossiliferous stratum appears to be a soft sandstone. That

over it is sand and clay, poorly consolidated except a hard stratum near the top of the slope. The species most abundant here are: Alectrion [=*Nassarius*] *perpinguis*, *Alectrion fossatus*, *Columbella* [=*Mitrella*] *carinata*, *Conus californicus*, *Crepidula adunca*, *Dentalium neohexagonum*, *Olivella boetica*, *Tellina meropsis*, *Turbonilla* sp.," (S. D. S. N. H. Loc. no. 118, and =U.C.M.P. Loc. no. A-9003 of this report).

In addition to the species recorded above Stephens (1929:251) listed *Glycymeris septentrionalis* [=*G.* (?) *profunda* Dall, 1897], *Kellia laperousii*, *Odostomia* sp., *Olivella pedroana*, and *Tellina bodegensis* from outcrops in a ravine about 200 yards north of the international boundary and approximately a quarter of a mile from the ocean, (S. D. S. N. H. loc. 119 and, probably, the same as U. C. M. P. loc. A-9005).[2] On the basis of similar lithology and altitude of the beds, he concluded that localities 118 and 119 represent outcrops of the same stratum which ". . . underlies much of the terrace, possibly as far as it extends . . .," (Stephens, 1929:250). For the purposes of this report, Stephens' localities were re-examined and a reconnaissance of the area concerned was undertaken.

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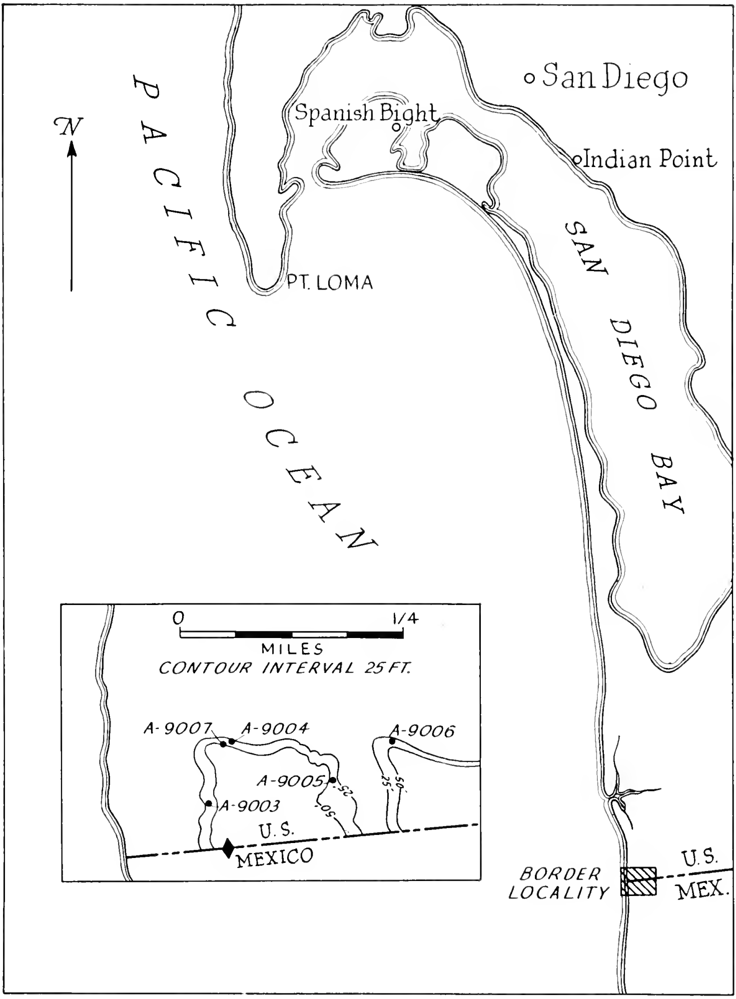
[2] Hereafter locality citations refer to those of the Museum of Paleontology of the University of California, Berkeley, unless otherwise stated.



Index map of area showing location of Border, Spanish Bight and Indian Point localities.

DESCRIPTION OF AREA

General Aspects. In the extreme southwest corner of San Diego County, California, a low terrace forms a bank facing the ocean for a short distance north of the United States-Mexican Boundary (see map). Though the terrace extends south for some distance along the Baja California coast, the erosional action of the Tijuana River has all but destroyed that part which extends immediately north of the border. On the American side, the terrace attains a maximum elevation of 53 feet, gaining very slightly in altitude as it runs from the beach front to the foot of higher Pliocene terraces to the east. Hereafter, for expediency, this deposit is referred to as the "Border locality."

A fossiliferous stratum outcrops in several small gullies along the truncated west face of the terrace (loc. A-9003) and is well exposed along the northwest river-cut face of the terrace (loc. A-9004). Approximately one-fourth of a mile east of the ocean front a small ravine runs north through the terrace from the Mexican side of the border. A highly fossiliferous exposure occurs in a road cut leading to International Monument No. 258 along the west face of this ravine (loc. A-9005). The stratum also outcrops for a short distance immediately east of the ravine in the north face of the terrace (loc. A-9006). Beyond this point the face of the terrace is obscured by vegetation and soil creep. A second sparsely "fossiliferous" stratum caps the westernmost portion of the terrace (loc. A-9007). Inasmuch as mollusks in this deposit may represent scattered kitchen midden remnants, this assemblage is not included in subsequent discussions relating to the fauna of the Border locality.

Stratigraphic Aspects. The principal fossiliferous stratum is essentially horizontal. It immediately overlies a grey weathering, micaceous, sandy siltstone of probable Pliocene age.[3] The contact is best exposed in small gullies along the seaward face of the terrace (loc. A-9003). Here the Pliocene (?) siltstones show evidence of channeling and contain specimens of the burrowing bivalve, *Zirfaea pilsbryi, in situ.* At locality A-9004, the basal sand is overlain by 30 feet of poorly consolidated sediments. These beds appear to be unfossiliferous throughout and range from a massive, poorly sorted, gravelly sand to thinly bedded, very fine grained sands. The sands are capped by 1 to 2 feet of red weathering, sandy soil containing occasional kitchen midden (?) mollusks, (loc. A-9007).

The highly fossiliferous basal bed ranges in thickness from 1 to 12 inches. It is composed of grey, fine grained sands containing occasional cobbles and boulders. The sands are predominately well-sorted and unconsolidated except for local calcareous cemented pockets.

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[3] For a discussion of the evidence for Pliocene dating for these sediments see page 438.

RELATION TO OTHER TERRACES

For the purposes of this paper only the principal terrace deposits in the San Diego region are considered. Ellis in Ellis and Lee (1919:26, pl. 6) described five marine terraces from the San Diego Bay region, namely: Tijuana terrace, 20 to 50 ft.; Nestor terrace, 25 to 100 ft.; Chula Vista terrace, 100 to 130 ft.; Avondale terrace, 200 to 250 ft.; and Otay terrace, 430 to 525 ft. Hertlein and Grant (1944:20) in discussing the younger terraces of the San Diego Quadrangle record the presence of still other smaller, though poorly developed and preserved, intermediate terrace deposits in addition to those named by Ellis. Hanna (1926:194) proposed the name La Jolla terrace for the prominent, lowermost terrace that ranges from 25 to 200 feet and extends from La Jolla to Pacific Beach; he concluded that it corresponds, at least in part, with the Chula Vista terrace of Ellis. Gale in Grant and Gale (1931: 39,49) considered the La Jolla terrace to be a northern extension of the Nestor terrace. Webb (1937) described a rock-cliff, tide-pool fauna from the lowermost terrace, ranging from 25 to 100 feet in elevation, on the west side of Point Loma, a peninsula extending into the Pacific Ocean to form a protecting promontory to the northwestern portion of San Diego Bay (see map). He assigned a late Pleistocene age to the Point Loma terrace on physiographic and faunistic evidence.

Ellis (1919:pls. 3,6) assigned the terrace deposit containing the fauna enumerated in this paper to the Nestor which he believed to be correlative with the "San Pedro formation." Though no fossils were recorded from this locality by Ellis, "Quarternary fossils" are reported by him from the Nestor deposits occurring north of the Tijuana River near Oneonta (south San Diego) at an elevation of about 50 feet.

In proposing the name, Bay Point formation, for late Pleistocene terrace deposits in the San Diego area, Hertlein and Grant (1939:72) specifically included exposures occurring at Bay Point in Mission Bay (type locality), Spanish Bight and Indian Point in San Diego Bay, and Pacific Beach; correlation, at least in part, with the Palos Verdes formation in the Los Angeles region was suggested.

Available physiographic evidence does not permit precise correlation of the Border terrace remnant with other terrace deposits in the region. Its relationship to the Bay Point formation is uncertain at present.

DEPOSITIONAL ENVIRONMENT

Suggested Environment. The composition of the Border locality fauna, enumerated in the check list on page 439, indicates relatively shallow water conditions, possibly a protected coast facies. This inner neritic interpretation is corroborated by depositional evidence, the fossiliferous sediments being composed of sands containing gravel, cobbles, and broken shell fragments. With the exception of a few deeper water elements (*Fusitriton, Barbarofusus, Glycymeris, Dentalium,* etc.),[4] a similar Recent

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[4] In the vicinity of San Diego *Fusitriton oregonensis* is recorded from deep water (Burch, 1945, no. 54,5) and "dredged" (Kelsey, 1907:48); and *Dentalium neohexagonum* from 5 to 15 fms. (Burch, 1945: no. 46,9). Off Redondo Beach, Calif., *Glycymeris profunda* is recorded from 25 fathoms (Willett, 1945:110).

fauna is recorded from Mission Bay, San Diego,[5] where a number of diversified ecologic niches, including sand spits and rocky bottom, are present in a shallow water embayment which is protected from severe wave and current action. However, the absence of diagnostic tidal flat dwellers such as *Melampus* and *Cerithidea* from the fauna precludes definite assignment to a protected bay facies. It is probable that the Pleistocene Point Loma island[6] constituted a protecting barrier against southerly directed currents for the coastal region immediately to the south, including the present localities.

A protected coast facies need not be postulated for the fauna as representatives of it, with very few exceptions, are known to be living today off Redondo Beach, California, in waters ranging from 10 to 50 fathoms; most of the species are recorded in 10 to 25 fathoms from bottoms composed of fine to coarse sands and gravels.[7] The fauna may not conclusively be referred to depths greater than the eulittoral zone and the shallower limits of the sublittoral zone as only a small part of the fauna consists of deeper water species. The deeper water faunal element is composed of very few individual specimens all of which are badly worn or fragmented indicating probable transport.

Climatic inferences. An analysis of the geographical ranges of extant representatives of the fauna indicates that all are living today in the latitude of San Diego with the exception of one species which is recorded from the San Pedro area. Thus temperate marine conditions are suggested with water temperatures at the time of deposition being essentially the same as today.[8]

Ecologic requirements. Ecologic evaluations of Pleistocene invertebrate faunas can be drawn through comparisons with present distribution of component species. On the basis of ecologic data available for 84 percent of the fauna, two primary substrate requirements must be satisfied. First, a few gastropods and most of the pelecypods occur only in sandy bottoms. Secondly, rock areas are required to support a majority of the gastropods. Ecologic niches in which rocks may be found in association with sand occur in Mission Bay and inner Newport Bay, California, as well as subtidally along the outer, southern California coast, and would suggest that the fossil fauna lived in an environment similar to one of these.

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[5] Morrison, R. L., (1943: no. 19, 5-6); Wilson, E. N., (1943: no. 19, 6-8).

[6] Stephens, F., (1929:245).

[7] Burch, Tom, (1942: no. 17, 5-11).

[8] The mean annual surface temperature for San Diego is 16.7°C.

FAUNAL COMPARISONS

Schenck and Keen (1937) have proposed an index method for comparing molluscan faunas. By this method, the medians of latitudinal mid-points of present geographic ranges are compiled for extant constituents of the fossil assemblages. With these findings it is possible to evaluate temperature requirements of a fossil fauna by reference to present day average ocean temperatures for the calculated latitudinal median. By comparing this average temperature with that prevailing at the actual latitude of the fossil locality, precise differences in water temperatures have been postulated. Inasmuch as the reliability and limitations of this comparative system have been discussed by Schenck (1945:11), Woodring *et al.* (1946:103), and Newell (1948:165), these problems are not treated here. Notwithstanding the inherent difficulties involved in an analysis of this type, it would appear that such evaluations may provide a useful method for comparing Pleistocene faunas provided that the assemblages are based upon adequate, accurately identified samples and represent comparable bathymetric and ecologic facies.

For the purpose of faunal comparisons, medians of mid-points for the best known Pleistocene faunas of the San Diego region are tabulated in table 1. From these data it must be inferred that the faunas, taken as a whole, indicate a latitudinal occurrence in the region to the north of Point Conception, 34° 26′ N. latitude and, consequently, average water temperatures definitely cooler than those of the San Diego region today. These findings are not in harmony with interpretations based upon primarily qualitative evaluations of the same faunas. None of the warm water indicators such as *Chione gnidia*, *Cardium procerum*, *Dosinia ponderosa*, and *Turritella gonostoma*, appear in the Border or Point Loma (Webb, 1937) faunas. Since these species occur in other late Pleistocene deposits in the San Diego area, previous workers have postulated, on the basis of present geographic ranges of the species,[9] that warmer water conditions than those now prevailing existed during deposition of those sediments. Thus an extension of marine surface water isotherms of several hundred miles northward is indicated (Grant and Gale, 1931:49; Hertlein and Grant, 1944:71). It is also difficult to explain the identical medians of mid-points for the faunas of the Point Loma terrace and the Border locality as the two deposits represent diverse ecologic types, the former being a typical rock-cliff and tide-pool facies and the latter being a probable protected coast, rock and sand facies. Hertlein and Grant (1944:68) interpreted the absence of southern indicators and the totally modern aspect of the Point Loma fauna as indicative of a younger age than the Bay Point faunas. Conversely, Woodring, *et al.*, (1946:106)

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[9] Present northern limits of distribution based upon living material and mean annual surface temperatures are:

Chione gnidia	Cedros Island	(17.0°C.)
Dosinia ponderosa	Scammon Lagoon	(18.3°C.)
Cardium procerum	Scammon Lagoon	(18.3°C.)
Turritella gonostoma	Scammon Lagoon	(18.3°C.)

attribute the absence of southern species to facies differences and presume the deposits to be of the same age.

Warm water species which characterize the late Pleistocene Bay Point and Palos Verdes faunas are absent from the Border fauna. Therefore, it can be postulated that water temperatures during the deposition of the Border terrace were possibly as cold as those of San Diego at present. Results of the median of mid-points analysis corroborate this assumption and suggest even colder water temperatures. However, the evidence at hand is not entirely conclusive. This apparent lowered water temperature requirement may represent a local facies difference, possibly the influence of upwelling, which is not reflected by the faunas of the Bay Point formation complex, and may, or may not, indicate an isothermal shift of temporal magnitude.

In the final analysis, physiographic reality rather than faunal interpretation appears to be the more promising tool for determining contemporaneity of the terrace remnants in this area.

TABLE 1

Upper Pleistocene Deposits of the San Diego Region
With Medians of Mid-points of Mega-Invertebrate Faunas

Locality	Latitude	Formation	Median of Mid-point[10]	No. of Species Utilized	Authority for Fauna
"Border Locality"	32° 32′	Bay Point?	35° 06′	86	This paper
Point Loma	32° 40′	Bay Point?	35° 06′	81	Webb, 1937
Spanish Bight	32° 42′	Bay Point	35° 48′	74	Arnold, 1903
Pacific Beach	32° 48′	Bay Point	34° 24′	53	Arnold, 1903

AGE

Previous mention is made in this paper of the superposition of the Border locality terrace deposits over apparent Pliocene sediments. Hertlein and Grant (1944:59) record the occurrence of Pliocene mollusks, including *Patinopecten healeyi*, from a well just north of the Mexican Boundary and from the bottom of Matadero Canyon which is situated four-tenths of a mile west of the United States-Mexican Boundary Monument No. 256. The writers collected Pliocene fossils, including *Patinopecten healeyi*, from a bed of fine grained sandstone outcropping in the mouth of a ravine one-half mile east of loc. A-9006.

If the deposit is correctly assigned to the Nestor terrace, an unquestioned post-San Diego age is indicated on the basis of physiographic data since the Nestor bevels the Pliocene San Diego formation.

The fauna, totaling 91 identified invertebrate species, is composed of extant species with one exception, a fragment of a nassarid gastropod which may be referred to *Nassarius delosi* (Woodring). This species was

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[10] Geographic range data and mid-points were compiled from Keen (1937) with the exception of "extra-limital species."

originally described from the Palos Verdes sands and is not known from earlier Pleistocene deposits or from Recent faunas. Woodring (*in literis*) reports the presence of this species in the late Pleistocene faunas of Pacific Beach and Spanish Bight, San Diego. The lone specimen obtained shows evidence of transport and may have been re-worked from previously deposited sediments.

The data, both faunistic and physiographic, indicate a late Pleistocene age for the deposit. Though faunal evidence points to a possible younger age than the "so-called" Palos Verdes sands equivalents in the San Diego area, this evidence is not conclusive and the deposit may only be referred to the late Pleistocene on the basis of the available data.

ALPHABETICAL CHECK LIST OF FOSSILS

The nomenclature used in the check list of the fauna generally follows that of Keen (1937). Though no screening was undertaken to obtain minute organisms, a fauna was collected from the primary fossiliferous bed totaling 88 species of mollusks (48 gastropods, 2 scaphopods, and 38 pelecypods), 1 echinoid, and 2 barnacles. From the soil capping the terrace (loc. A-9007) a total of 7 species of mollusks (1 gastropod and 6 pelecypods possibly of kitchen midden origin) were collected; only three species are common to both beds.

	Locality Nos.				
GASTROPODA	A-9004	A-9005	A-9006	A-9003	A-9007
Acanthina spirata (Blainville, 1832)	X	X			
Aletes squamigerus Carpenter, 1856		X			
Amphissa versicolor Dall, 1871	X				
Astraea undosa (Wood, 1828)	X	X			
Barbarofusus aff. B. barbarensis arnoldi (Cossmann, 1903)	X				
Bursa californica Hinds, 1843		X			
Calliostoma ligatum Gould, 1852 = *C. costatum* Martyn, 1784	X				
Calliostoma decarinatum (Perry, 1811) = *C. canaliculatum* (Martyn, 1784)	X				
Calliostoma tricolor Gabb, 1865		X			
Clathrodrilla incisa ophioderma (Dall, 1908)	X				
Conus californicus Hinds, 1844	X	X	X	X	
Crepidula adunca Sowerby, 1825	X	X	X		
Crepidula lingulata Gould, 1846	X	X	X	X	
Crepidula nivea C. B. Adams, 1852	X				
Crepidula norrisianum Williamson, 1905		X			
Crepidula onyx Sowerby, 1824	X	X	X		
Cytharella hexagona (Gabb, 1865)			X		
Diodora aspera (Eschscholtz, 1833)	X	X		X	
Diodora inaequalis (Sowerby, 1835)	X				
Epitonium indianorum (Carpenter, 1864)	X				
Fartulum cf. *F. hemphilli* Bartsch, 1920		X			
Fusitriton oregonensis (Redfield, 1846)	X				
Halistylus subpupoideus (Tryon, 1887)	X	X	X		
Homalopoma carpenteri (Pilsbry, 1888)	X				
Jaton festiva (Hinds, 1844)		X			

	Locality Nos.				
	A-9004	A-9005	A-9006	A-9003	A-9007
Kellettia kelletti (Forbes, 1850)	X	X			
Littorina scutulata Gould, 1849		X			
Maxwellia gemma (Sowerby, 1879)		X			
Megasurcula carpenteriana (Gabb, 1865)	X				
Megatebennus bimaculata (Dall, 1871)	X				
Megathura crenulata (Sowerby, 1825)	X				
Mitra idae Melvill, 1893				X	
Mitrella carinata (Hinds, 1844)	X	X	X		
Mitrella carinata gausapata (Gould, 1851)		X	X		
Nassarius delosi (Woodring, 1946)	X				
Nassarius fossatus (Gould, 1849)	X	X	X		
Nassarius mendicus cooperi (Forbes, 1850)	X	X	X	X	
Nassarius perpinguis (Hinds, 1844)	X	X	X	X	
Norrisia norrisi (Sowerby, 1838)	X				
Ocenebra interfossa Carpenter, 1864		X			
Ocenebra lurida aspera (Baird, 1863)	X		X		
Olivella biplicata (Sowerby, 1825)	X	X	X		
Olivella pedroana "Conrad" of Woodring, 1946	X	X	X		
Polinices lewisi (Gould, 1847)		X	X	?	
Pusula californica (Gray, 1863)		X			
Seila montereyensis Bartsch, 1907	X				
Tegula aureotincta (Forbes, 1850)					X
Triphora cf. T. pedroana (Bartsch, 1920)			X		
Zonaria spadicea (Swainson, 1823)	X				
SCAPHOPODA					
Dentalium neohexagonum Pilsbry and Sharp, 1897	X	X	X	X	
Dentalium pretiosum Sowerby, 1860	X	X		X	
PELECYPODA					
Aequipecten aequisulcatus Carpenter, 1864	X				X
Aloidis luteola Carpenter, 1864	X	X	X		
Anomia peruviana d'Orbigny, 1846		X			
Apolymetis biangulata (Carpenter, 1855)		X			
Botula californiensis (Philippi, 1847)	X				
Chama pellucida Broderip, 1835	X	X	X		
Chione californiensis (Broderip, 1835)					X
Crassinella branneri (Arnold, 1903)	X	X			
Cryptomya californica (Conrad, 1837)	X	X	X	X	
Cumingia californica Conrad, 1837	X	X		X	
Donax gouldi Dall, 1921	X	X			
Gari californica (Conrad, 1849)		X			
Glans carpenteri (Lamy, 1922)	X				
Glycymeris (?) *profunda* Dall, 1879[11]	X	X	X	X	
Leptopecten latiauratus monotimeris (Conrad, 1837)	X	X	?	?	
Lucina nuttalli Conrad, 1837		X	X	X	
Lucinisca californica (Conrad, 1837)	X	X			
Macoma nasuta (Conrad, 1837)	X	X		X	
Mactra californica Conrad, 1837		X			
Mytilus californianus Conrad, 1837					X
Nuculana taphria (Dall, 1896)		X	X		
Pandora punctata Conrad, 1837	X	X			
Petricola carditoides (Conrad, 1837)	X	X			
Platydon cancellatus Conrad, 1837	X	X			

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[11] Specimens compare favorably with Arnold's (1903) figure of *G. septentrionalis* (= ? *G. corteziana* Dall, 1918), but are dissimilar with Willett's (1944) figures of *G. corteziana*.

	Locality Nos. A-9004	 A-9005	 A-9006	 A-9003	 A-9007
Pododesmus macroschisma (Deshayes, 1839)	X	X		X	
Protothaca fluctifraga (Sowerby, 1853)					X
Protothaca staminea (Conrad, 1837)				X	
Saxidomus nuttalli (Conrad, 1837)		X	X	X	
Schizothaerus nuttalli (Conrad, 1837)	X	X		?	
Semele decisa (Conrad, 1837)	X	X	X	X	X
Semele pulchra (Sowerby, 1832)	X	X			
Spisula catilliformis (Conrad, 1867)			X		
Spisula falcata Gould, 1850		X	X		
Taras orbellus (Gould, 1852)		X			
Tellina bodegensis Hinds, 1844	X	X		X	
Tellina meropsis Dall, 1900		X	X		
Tivela stultorum (Mawe, 1823)			X		X
Trachycardium quadragenarium (Conrad, 1837)	X	X		X	
Transennella tantilla (Gould, 1853)	X				
Volsella fornicata (Carpenter, 1864)	X	X		X	
Yoldia cooperi Gabb, 1865	X	X			
Zirfaea pilsbryi Lowe, 1931	X	X	?	X	
ECHINOIDEA					
Dendraster excentricus (Eschscholtz, 1831)	X	X	X		
CIRRIPEDIA					
Balanus cf. B. nubilus Darwin, 1854	X	X			
Balanus cf. B. tintinnabulum californicus Pilsbry, 1916		X	X		

FOSSIL LOCALITIES

Collecting localities were located on the U.S.G.S. San Ysidro, California quadrangle (1:31680), edition of 1943. All localities are in the NE¼ of Sect. 7, T.19S., R.2W.; the localities are plotted on the index map, page 433.

A-9003. (32° 32′ 5.7″ N. - 117° 07′ 19.5″ W.). Small gulley in terrace, 250 feet along shore line north of U.S.-Mexico border. From 1-5 inch stratum immediately overlying channeled Pliocene (?) sediments. Same locality as S.D.S.N.H. 118 (Stephens, 1929). Rock type: soft, poorly sorted sands with occasional cobbles and boulders. Elevation: 35 feet. Collected by R. O. Fox, J. W. Emerson, and the authors.

A-9004. (32° 32′ 12.2″ N. - 117° 07′ 18.6″ W.). North face of terrace, 700 feet north of International Boundary Monument No. 258. From 1-3 inch stratum overlying Pliocene (?) sandy siltstone. Rock type: grey, unconsolidated, fine grained sand. Elevation: 20-25 feet. Collected by R. O. Fox, J. W. Emerson, and W. K. Emerson.

A-9005. (32° 32′ 10.6″ N. - 117° 07′ 11.5″ W.). Northeast face of terrace, 600 feet east of locality A-9004. From highly fossiliferous, 6-12 inch stratum exposed in cut along road to International Boundary Monument No. 258. Apparently same locality as S.D.S.N.H. 119 (Stephens, 1929). Rock type: grey, well-sorted, fine grained sand. Elevation: about 30 feet. Collected by R. O. Fox, J. W. Emerson, and the authors.

A-9006. (32° 32′ 9.4″ N. - 117° 07′ 6.3″ W.). North face of terrace immediately east of 250 foot wide, north trending ravine and 1,750 feet inland from ocean. From 4-8 inch stratum underlying a boulder conglomerate. Rock type: poorly sorted sand with occasional cobbles. Collected by R. O. Fox, J. W. Emerson, and W. K. Emerson.

A-9007. Same as locality A-9004 only 25 feet higher stratigraphically. From irregular 2 foot stratum capping terrace. Rock type: red weathering, poorly sorted sand. Elevation: 50 feet. Collected by J. W. Emerson and the authors.

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INDEX

Transactions of the San Diego Society of Natural History, Volume XI
Titles of papers and new systematic names are in **heavy-faced** type

ERRATA, VOLUME XI

p. 210, line 7 Merrian = Merriam
p. 224, line 22 Subsp. = subsp.
p. 225, line 18 Subsp. = subsp.
p. 235, line 7 (*Rosa minuifoldia*) = (*Rosa minutifolia*)
p. 236, line 11 *peralius* = *paralius*
p. 239, line 30 *Adenostroma* = *Adenostoma*
p. 270, line 13 hs. = has
p. 276, line 35 stevensoni = *stevensoni*
p. 296, line 18 (*Brongniart*) = (Brongniart)
p. 302, line 10 *Jenkins* = Jenkins
p. 311, line 20 bufo = *bufo*
p. 385, line 38 N.N.Bramlette = M.N.Bramlette
p. 440, line 3 *Kellettia kelletti* = *Kelletia kelletii*
p. 440, line 16 *Norrisia norrissi* = *Norrisia norrisii*
Article no. 11, plates 1-13 = plates no. 11-23