





Mammals

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PROCEEDINGS

OF THE

GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

ZOOLOGICAL SOCIETY

"

OF LONDON.

1921, pp. 1-446,

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OF THE
GENERAL MEETINGS FOR SCIENTIFIC BUSINESS
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PROCEEDINGS

OF THE

GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.



PAPERS.

1. The Comparative Anatomy of the Tongues of the Mammalia. II. Family 1. Simiidae. By CHARLES F. SONNTAG, M.D., Ch.B., F.Z.S., Anatomist to the Society.

[Received October 14, 1920: Read February 8, 1921.]

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Introduction.

Many papers dealing with the anatomy of the Anthropoid Apes contain details of the macroscopic appearances of the tongues. Most of the authors, however, have limited their accounts to the description of one or more salient features, such as the number and arrangement of the vallate papillæ. More attention, too, has been paid to the large Anthropoids than to

the Gibbons. I have referred to nearly thirty papers, and in no case did I find a complete account of any of the Simian tongues. Even Deniker's paper on the tongue of the Gorilla, which is the best, is incomplete, for it deals mainly with the tongue in the fœtus and says little about its condition in the adult.

For the purpose of the present communication I have examined both fresh and preserved specimens in the Society's Prosectorium and in the Museum of the Royal College of Surgeons, the specimens from the latter being indicated by the words Mus. R.C.S. Of all the tongues examined only the measurements of fresh specimens are given, for the dimensions of preserved ones are worthless. I am indebted to Professor Arthur Keith for permission to examine some of the tongues described in this and future papers.

Genus ANTHROPOPITHECUS.

THE CHIMPANZEE (*A. troglodytes*).

Of the three tongues examined one was fresh, one had been preserved in the Society's Prosectorium, and one (No. J. 359.1) was preserved in the Museum of the Royal College of Surgeons. These are described respectively as specimens one, two, and three. The fresh specimen was a male from Landana, S.W. Africa.

Several writers have stated that Traill first described the tongue of the Chimpanzee in 1821, but Traill's paper is entitled "The Description of an Orang-Outan" (206). He certainly described an arrangement of the vallate papillæ which closely resembles that of the Chimpanzee, but he expressly mentions the tongue as being that of an Orang*.

My fresh specimen has the following measurements:—Total length 9.1 cm.; length from the apex to the antero-median vallate papilla 6.1 cm.; length from that papilla to the epiglottis 3 cm.; width between the lingual attachments of the anterior faucial pillars 4.5 cm.; width of the apex 3 cm.; thickness in the region of the antero-median vallate papilla 3.5 cm.; thickness of the apex .3 cm.

The tongue is long and comparatively narrow, and its width does not decrease greatly from base to apex. Cunningham (118) is the only author who points out that its elongated form is due to the shape of the mouth. He also shows how the tongues of the Chimpanzee and Gibbons differ more from that of Man in the disproportion between length and breadth than does the tongue of the Orang-Outan.

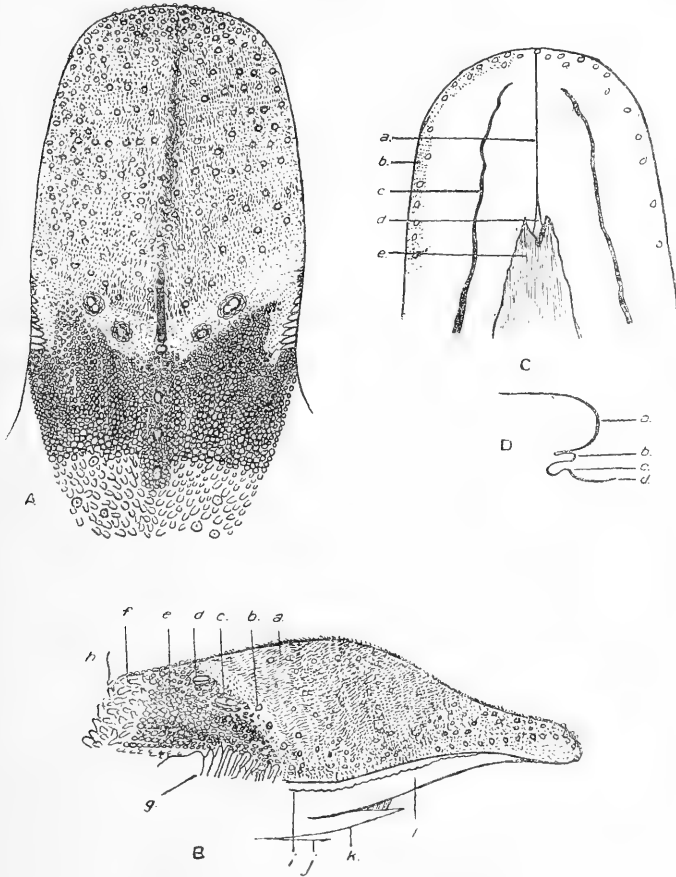
The antero-median vallate papilla stands a short distance behind the summit of an elevation whence the dorsum slopes towards base and apex, but the declivity is greater in the latter direction (text-fig. 1 B, *d*). In this connection the Chimpanzee

* Flower states that Traill really described a Chimpanzee from the Gaboon.

is pre-eminent among the Anthropoids, but the degree of slope varies in different individuals.

The *Apex and Lateral Borders* exhibit characters which are common to many of the Anthropoids. The *apex* is blunt and may or may not possess a median notch ; the notch only occurred

Text-figure 1.



The tongue of *Anthropopithecus troglodytes*.

A. dorsum ; B. lateral view ; C. inferior surface ; D. vertical section of the side of the tongue. Descriptions in text.

in my fresh specimen. It is roughened by conical papillæ and tuberculated by large prominent fungiform papillæ. Their size varies in different tongues, but they are always numerous ; some are smooth, glistening, and hemispherical, others are granular

and hemispherical, and others may possess a central boss (text-fig. 2 A, *l, m, n*). All the conical papillæ have their points directed backwards. The *lateral borders* are full and rounded (text-fig. 1 D, *a*); they are beset with both conical and fungiform papillæ, and the lateral organs are situated at their posterior extremities (text-fig. 1 B, *g*).

Medial Sulci.—Medial sulci may be present on the dorsal and inferior surfaces. In my fresh specimen (text-fig. 1 A) the *median dorsal sulcus* extends from the apical notch to a point 4 mm. in front of the antero-median vallate papilla. It is irregular and invaded by both conical and fungiform papillæ; posteriorly it is deep and lodges fungiform papillæ alone. On the base of the tongue the median row of vallate papillæ is situated on a depressed band of mucosa which is bounded by large papillæ and lymphoid nodules.

In my second specimen there is, instead of a median sulcus, a row of prominent fungiform papillæ, and the only representative of the fissure is a small pit, lodging a fungiform papilla, lying immediately in front of the antero-median vallate papilla.

In my third specimen (No. J. 359.1, Mus. R.C.S.) there is neither a median sulcus nor a median row of fungiform papillæ, but there is a pit in front of the antero-median vallate papilla.

The small pit described above must not be mistaken for the *foramen cæcum of Morgagni* which is absent in the Chimpanzee.

The *median ventral sulcus* will be described later.

Transverse ridges and sulci are absent.

The Papillæ.

Papillæ are present on the entire dorsum, apex, lateral borders, and a bounding zone on the inferior surface. This *general distribution* is so common among the Anthropoids that it can be regarded as the rule. The only exceptions are the Orang-Outan and the Siamang Gibbon, which have areas on the base which are devoid of papillæ. I am unable to say whether these smooth areas exist in all Siamangs, but they are not present in all Orangs.

The Circumvallate Papillæ (text-fig. 1 B, *c & d*).

The vallate papillæ vary in number and arrangement in different individuals, but the relation between the species of Chimpanzee and the papillary pattern has not been stated by authors. The following types have been described:—

T-form: Flower (28); Dwight (123); Symington (202); Huxley and Hunter.

Y-form: Gratiolet and Alix (131); Bischoff (7); Münch [1].

V-form: Cavauna (109); Ehlers (23).

Cruciate form: Mayer (162).

Linear type: Humphry (142).

The numbers of vallate papillæ vary from three, as recorded by Wyman (215), to fifteen mentioned by Humphry (142).

In my three specimens the arrangements are as follows:—

Specimen No. 1.—There are eight papillæ arranged in the Y-form (text-figs. 1 A & 2 B). Each lateral limb has an outer compound and an inner simple papilla, and the mesial antero-posterior row consists of four simple elements.

The papillary bodies of the compound papillæ are oval on plan; the inner papillæ of the lateral rows are circular; the antero-median papilla is circular, and the other three papillæ are oval on plan. All the papillæ are conical on elevation (text-figs. 2 A, *r*, & 1 B, *c*), the narrow ends of the cones being attached to the bottom of the fossæ. The surfaces are all granulated, possibly by secondary papillæ. The vallums are lobulated, and the fossæ are more or less patulous (text-fig. 2, *p*, *g*, *t*).

Specimen No. 2.—There are eight papillæ arranged in the Y-form, and all of them are simple (text-fig. 2 B). The left lateral row has three papillæ, the right lateral limb has two, and the mesial antero-posterior limb has three. All the papillæ of the lateral limbs are circular and prominent, and the vallums and fossæ are well marked. They are surrounded by papillose ridges passing inwards from the corresponding lateral organs. The median row of papillæ consists of oval elements well recessed beneath their vallums. The most posterior papilla is difficult to see unless the pedunculated papillæ of the base of the tongue are withdrawn from over it.

In *Specimen No. 3* the arrangement of the vallate papillæ is uncommon. There are eight papillæ in the Y-form (text-fig. 2 B), but the two lateral limbs lie closely side by side, and the vertical limb has one papilla. The left lateral limb has four papillæ and the right one has three.

The Fungiform Papillæ (text-figs. 1 B, *b*, & 2 A, *m*, *n*, *o*).

Fungiform papillæ are numerous and cover the dorsum, apex, lateral borders, and a bounding zone on the inferior surface. They have the usual arrangement in clusters behind the apex, transverse rows farther back, and oblique chains in front of the vallate papillæ. On the lateral borders they are arranged vertically, and on the inferior surface they are in straight lines passing from without inwards.

They invade the median dorsal sulcus, and may replace it altogether. In one of my specimens there is a well-marked median row of prominent fungiform papillæ in place of the median sulcus.

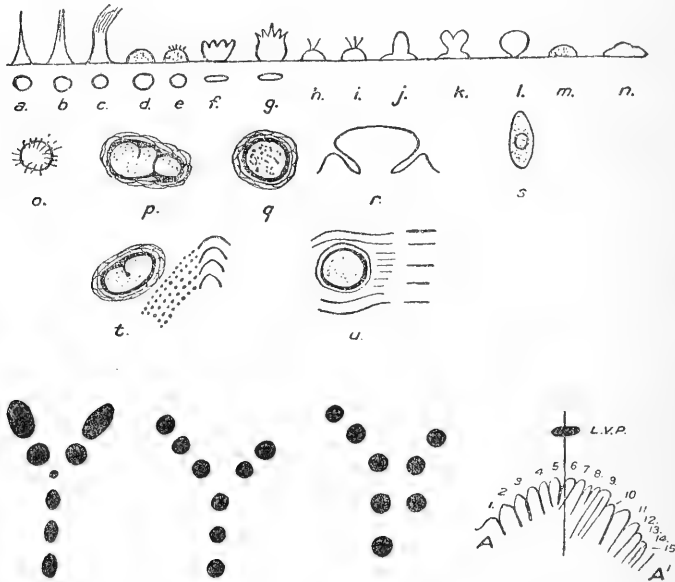
In one of my specimens there are more fungiform papillæ than those presented to the naked eye, for the lens shows how filiform papillæ entirely conceal many fungiforms.

At the base of the tongue (text-fig. 1 A) there are many long *pedunculated papillæ* which belong to both fungiform and conical groups. It is only possible, however, to settle by microscopic examination to which of them any particular papilla can be referred. They vary in degree of development in different

tongues, and I agree with Humphry (142) that some of them may be a quarter of an inch long.

These pedunculated papillæ are smaller and fewer than in the Gorilla, and larger and more numerous than in the Gibbons. They are absent altogether in the Orang-Outan. Their surfaces are smooth or granular. The different forms of papillæ are shown in text-fig. 2 A, *m-o*.

Text-figure 2.



The papillæ and lateral organs of *Anthropopithecus troglodytes*.

a-l, conical papillæ; *m-o*, fungiform papillæ; *p-u*, circumvallate papillæ; AA', lateral organ; the three figures on the left side of the bottom row are vallate patterns, described in the text as 2 B.

The Conical Papillæ (text-fig. 1 B, *a, e, & f*).

The conical papillæ have the same form of arrangement as the fungiforms, and they are seen to the best advantage when the tongue is allowed to dry, for they then stand up on the surface. All their points are directed backwards.

They increase in *size* from before backwards, and from without inwards, the largest ones on the anterior part of the dorsum being in and around the median sulcus. They overlap the fungiform papillæ and conceal some of them entirely. In one of my specimens they stand on ridges like those on the finger-tips.

They belong to both cylindrical and filiform groups. The *filiform varieties* have one or more points. When there is only one the papilla is tapering, and circular on section. When

there are more than one point the body may be cylindrical, or flat and thin (text-fig. 2 A, *a-g*). The *cylindrical types* are interspersed among the others. They have a granular surface, and some of them are very rough. In the latter case, however, it is difficult to be precise as to their character; they may have lost long points as the result of handling (text-fig. 2 A, *h, i*).

The relative proportions of the filiform and cylindrical types differ in different tongues. Either type may be in excess, and they may in some cases be evenly distributed, but it is usual to find one form predominating.

The different forms are shown highly magnified in text-fig. 2 A, nos. *a-l*.

Lymphoid Tissue.

The base of the tongue contains much lymphoid tissue which gives the surface a lobulated appearance, and there is a great contrast between it and the rough anterior surface when the tongue is viewed from the side (text-fig. 1 B). The degree of contrast depends greatly on the number of filiform papillæ on the anterior two-thirds of the dorsum; when these are very numerous the roughness is greater and the contrast more marked.

The lymphoid nodules vary in size, and the large ones have small central pits, but it is only possible to tell by microscopic examination whether any one orifice has ducts of glands connected to it or not. Few of the pitted follicles lie anterior to the most posterior vallate papilla.

The Lateral Organs (text-figs. 1 B, *g*, & 2, AA').

Boulart and Pilliet [2] have stated that the lateral organs of the Anthropoid Apes are well developed, and mention that the Chimpanzee has twelve ridges in its organs, but they do not say whether both organs have the same number of fissures and ridges. Dwight (123) showed that each organ is convex internally. I agree with Dwight, but not with Boulart and Pilliet. All my specimens have organs convex inwardly, but there is great variability in the number of fissures and ridges as the following figures show:—

Specimen 1 (text-fig. 2, AA').

Right organ :	<i>Length</i> 1.55 cm.	<i>Ridges</i> 15.	<i>Sulci</i> 16.
Left organ :	<i>Length</i> 1.6 cm.	<i>Ridges</i> 14.	<i>Sulci</i> 15.

Specimen 2.

Right organ :	<i>Length</i> 1.4 cm.	<i>Ridges</i> 7.	<i>Sulci</i> 8.
Left organ :	<i>Length</i> 1.7 cm.	<i>Ridges</i> 9.	<i>Sulci</i> 10.

Specimen 3.

Right organ :	—	<i>Ridges</i> 10.	<i>Sulci</i> 11.
Left organ :	—	<i>Ridges</i> 9.	<i>Sulci</i> 10.

Each organ begins anteriorly as a number of sulci on the infero-lateral aspect of the tongue, but the pieces of the tongue

between them are not raised above the general surface. Behind these the ridges appear and increase both in length and prominence till a point is reached almost level with the outermost vallate papilla of the corresponding lateral row. After that they diminish in size, but increase in prominence till the posterior limit of the organ is reached. Many ridges are simple, but a few are divided by small secondary sulci.

Ridges pass across the dorsum from the upper ends of the ridges of the lateral organs. These either encircle the vallate papillæ or pass backwards on their outer side.

The Inferior Surface (text-fig. 1 C & 1 B, *l*).

The inferior surface presents for examination a mesial sulcus, two plicæ fimbriatæ, the papillary border, frenum and sublingual fold, or frenal lamella, so called by Pocock (text-fig. 1 B, *k*, & 1 C, *e*).

The *mesial sulcus* (text-fig. 1 C, *a*) extends backwards from the posterior border of the papillary zone to the attachment of the frenum. It is not occupied by any crest as in the Gorilla.

The *plicæ fimbriatæ* (text-fig. 1 C, *c*) are, it is acknowledged, remnants of the sublingua of the Prosimiæ, and in one of my specimens the two plicæ and intervening piece of mucous membrane have the appearance of an under tongue.

The plicæ are two longitudinal folds, almost touching in front, running backwards and outwards from near the apex to a point well behind the middle of the tongue, but in one of my specimens they are nearly parallel to one another. They lie on the lateral aspects of the inferior surface between the mesial sulcus and the edges of the tongue. Each one has undulating and crenated edges, and increases in width from before backwards.

When a vertical section of the tongue is made about its centre (text-fig. 1 D) one sees the mucosa of the floor of the mouth (*d*) reflected to form the frenal lamella (*e*). From the upper surface of the latter it is reflected on to the plica (*b*), and thence to the under surface of the tongue (*a*). The mucosa between the plica fimbriatæ and the sublingual fold is thrown into many small folds.

The Sublingual Fold (text-fig. 1 C, *e*).

The sublingual fold, or frenal lamella (Pocock), lodges Wharton's Ducts. It is triangular in shape with the base behind. The apex is bifid and the two ducts open on the points which are very sharp; the edges are undulating and crenated. Its mucosa is continuous with that of the floor of the mouth below and the frenum linguæ above.

Some have said that the sublingual fold corresponds to the sublingua of the Prosimiæ, but most anatomists are agreed that the plicæ fimbriatæ represent it, so the tongue of the Chimpanzee, which possesses both, is sufficient to disprove the statements of the former group of observers.

The Papillary Border (text-fig. 1 C, b).

The narrow papillary border has fungiform and conical papillæ, the latter belonging to the filiform and cylindrical groups. They are arranged in lines passing from without inwards. The fungiform papillæ are small and most numerous beneath the apex of the tongue.

The Frenum Linguae (text-fig. 1 C, d).

The frenum is short and thick. It runs from the upper surface of the sublingual fold to the under surface of the tongue from the posterior end of the median ventral sulcus backwards.

No *lytta* is present in the interior of the tongue.

When the apex is examined histologically, no *Apical Gland of Nuhn* is seen. In this connection it agrees with the Gorilla and Gibbons, and differs from Man and the Orang-Outan.

There is only a narrow groove between the base of the tongue and the epiglottis (text-fig. 1 B, h).

Genus GORILLA.

THE GORILLA (*G. gorilla*).

The literature containing details of the structure of the tongue of the Gorilla is not so large as that dealing with the tongue of the Chimpanzee, but the papers are more complete. Ehlers (23), Bischoff (7), and Duvernoy (22) have written accounts of the adult tongue, and Deniker (17) has described the fetal tongue very fully, but he has said little about the adult form. Boulard and Pilliet [2] have not mentioned the Gorilla in their study of the lateral organs of the Mammalia. The specimen which I examined (No. J. 358.1, Mus. R.C.S.) exhibits features which have not been mentioned by these authors, or are different from the conditions described by them.

The tongue has not such a great disproportion between its length and width as that of the Chimpanzee. It is comparatively broad, and in this connection I agree with Bischoff (7), and differ from Duvernoy (22) who said it is narrow. The whole organ appears rectangular. It slopes gently from the vallate papillary region to the apex, and more steeply from the vallate region to the epiglottis; it differs, therefore, from the tongue of the Chimpanzee.

The *apex* is square-cut, has no mesial notch, and bears conical and fungiform papillæ which are thickly clustered; the latter are not so prominent as in the Chimpanzee, but are more marked than in the Orang-Outan.

The *lateral borders* have large and medium-sized fungiform and conical papillæ arranged in vertical lines, and they are fissured by numerous sulci prolonged on to them from the dorsum. At their posterior extremities one sees the outer ends of the fissures and laminae of the lateral organs. In this respect the tongue agrees with that of the Orang-Outan, and differs from those of

the Chimpanzee and Gibbons, in which most of the lateral organs lie on the lateral borders of the tongue.

Mesial Sulci.—Mesial sulci are present on the dorsal and inferior surfaces. The *dorsal sulcus* lies in the centre of the anterior two-thirds; it is wide and shallow, and contains many conical and few fungiform papillæ. Just in front of the antero-median vallate papilla there is a small pit containing both conical and fungiform papillæ, but this must be regarded as a part of the mesial sulcus. It must not be mistaken for a *foramen cæcum*, which does not exist in the Gorilla. There is no median sulcus on the base of the tongue.

The *median ventral sulcus* (text-fig. 3 B, c) begins in front at the posterior edge of the papillary zone and runs back, widening as it goes, till it terminates in a triangular pit into which the frenum passes. It lodges a median fold of mucous membrane termed the *plica mediana* or *mesial crest* (text-fig. 3 B, d).

Transverse Ridges and Sulci.—Several transverse ridges and sulci are present on the anterior two-thirds of the dorsum. They are undulating and irregular in direction, and some of them cut the lateral borders of the tongue and run inwards on the bounding papillary zone of the inferior surface. The sulci are narrow and the ridges are covered with papillæ.

In the interior of the tongue there are neither *lytta* nor *Apical Gland of Nuhn*.

The Papillæ.

Papillæ are present on the entire dorsum, apex, lateral borders, and a bounding zone on the inferior surface. The last is better developed than in the Chimpanzee and Orang-Outan.

The Circumvallate Papillæ (text-figs. 3 A & 3 D, a, b).

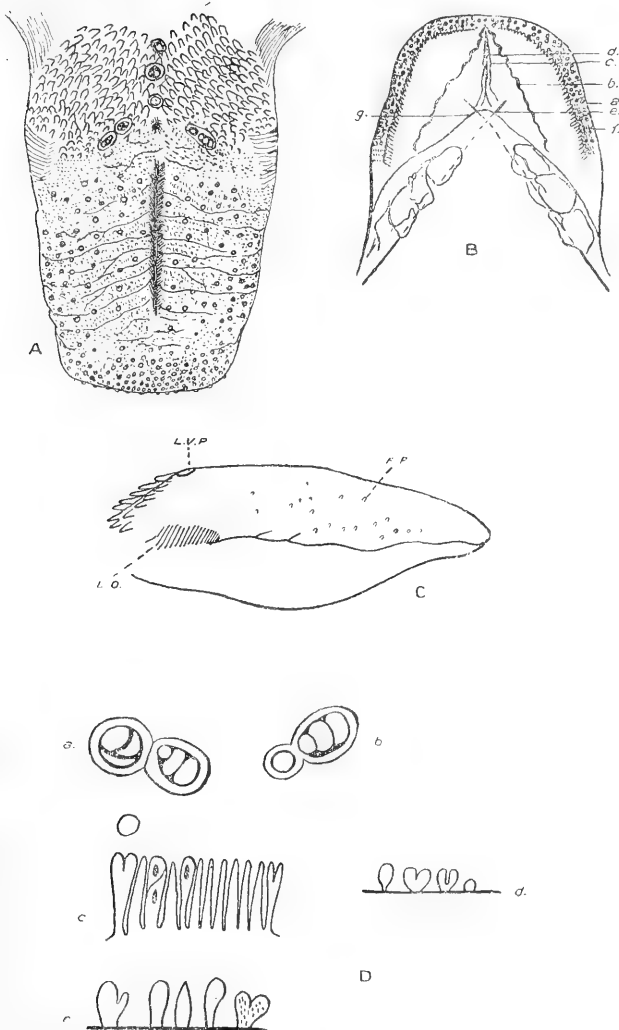
In my specimen there are seven vallate papillæ arranged in the form of a Y, and the notable feature is that most of them are compound. Each lateral limb has two papillæ and the median one has three.

The two papillæ of the right limb are compound (text-fig. 3 D, a) and lie very close together, for their vallums are only separated from one another by a narrow fissure. Both fossæ and vallums are prominent and the papillary elements are recessed below the vallums. The papillary bodies are granulated, possibly as the result of secondary processes.

The outer papilla of the left lateral limb (text-fig. 3 D, b) is compound and the inner one is simple. The fossæ are patulous and the two vallums are in continuity. It seems as if the inner papilla is an element which has been separated off from the outer compound papilla. In the case of the compound papilla the elements are recessed below the vallum, but the simple papilla is more prominent. The surfaces of the elements are granular.

The outer papillæ of the lateral limbs are level with the

Text-figure 3.



The tongue of *Gorilla gorilla*.

A. dorsum ; B. inferior surface ; C. lateral view ; D. *a*, *b*, *d*, *e*, papillæ ; D. *c*, lateral organ showing the lateral vallate papilla above its posterior lamina.

posterior extremities of the lateral organs as in the Orang-Outan (text-figs. 3 A & 3 D, *e*). In the Chimpanzee and Gibbons, on the other hand, they are level with the central rows and sulci of the lateral organs.

The median row of vallate papillæ has three elements. The anterior and posterior ones are simple, but the middle one is compound.

The following numbers and arrangements have been recorded:—

1. Five papillæ in V-formation—Ehlers (23).
2. Five papillæ in V-formation in the fœtus—Deniker (17).
3. Six papillæ in V-formation—Duvernoy (22).
4. Seven papillæ in V-formation—Bischoff (7).
5. Eight papillæ in V-formation—Duvernoy (22).

My specimen, therefore, differs in the type of arrangement of its vallate papillæ from that described by other authors.

The Conical Papillæ.

The conical papillæ have the same forms and arrangements as in the Chimpanzee, but they are not so large in the anterior two-thirds of the dorsum. Behind the vallate region, however, the large pedunculated papillæ are larger and much more numerous than in the Chimpanzee. These latter papillæ are tapering or club-shaped, and many of them have small secondary processes as described and figured by Bischoff (7). Their points are directed backwards, and some of them overlap the most posterior vallate papilla (text-fig. 3 D, *e*).

The Fungiform Papillæ.

The fungiform papillæ are not so large or so numerous as in the Chimpanzee, but they exceed those of the Orang-Outan both in size and numbers. They are in clusters behind the apex, in transverse rows farther back, and in oblique chains in front of the vallate papillæ. They are most numerous behind the apex and close to the lateral borders of the tongue, and diminish in numbers towards the mesial sulcus. There are, however, no fungiform papillæ overhung by filiform types.

When the tongue is viewed laterally (text-fig. 3 C, *FP*) one sees how prominent many of the fungiform papillæ are, and some of them appear almost pedunculated. In this connection the Gorilla differs from all the other Anthropoids.

On the sides of the tongue the fungiform papillæ are in vertical chains, and they are in rows passing from without inwards on the inferior surface (text-fig. 3 C, *FP*).

The Lateral Organs (text-fig. 3 C, *LO*, & 3 D, *c*).

The lateral organs of the Gorilla have been omitted from Boulart and Pilliet's paper. They are situated on the edges of the dorsum of the tongue, beginning posteriorly on a level with

the external vallate papillæ of the lateral rows, and extending forwards to a point level with the posterior extremity of the mesial sulcus. The numbers of ridges and elevations are as follows:—

Right organ :	<i>Length</i> 1.3 cm.	<i>Ridges</i> 11.	<i>Sulci</i> 12.
Left organ :	<i>Length</i> 1.35 cm.	<i>Ridges</i> 12.	<i>Sulci</i> 13.

In his study of the tongue of the fœtal Gorilla, Deniker (17) has shown that the lateral organs are better developed than in the adult.

The ridges and sulci just cut the lateral borders of the tongue. They are long, narrow, and tapering; some are twisted and some have secondary fissures.

The Inferior Surface (text-fig. 3 B).

The inferior surface presents for examination a papillary border, a frenum, a sublingual fold, two plicæ fimbriatæ, a mesial crest, and a mesial sulcus which has already been described. It has, therefore, the same structures as the tongue of the Chimpanzee, with the mesial crest in addition.

The *papillary border* maintains the same width across the under surface of the apex, but it widens out from before backwards along the lateral borders. It bears conical and fungiform papillæ whose method of disposition is of the usual type (text-fig. 3 B, *a*).

The most notable feature is a row of closely-set club-shaped conical papillæ bounding the zone internally (text-fig. 3 B, *f*). They increase in size from before backwards, and they lie flat against the surface of the tongue. Some are entire and others are subdivided into lobules as shown in text-fig. 3 D, *d*. In no other Anthropoid tongue is there a uniform row of these papillæ.

The *mesial crest*, or *plica mediana*, is a fold of mucous membrane occupying the ventral mesial sulcus (text-fig. 3 B, *d*). It runs along the anterior border of the frenum, and thins out and disappears on the dorsal surface of the sublingual fold. Deniker (17) considers that it is a remnant of the sublingua of the Prosimiæ.

The *plicæ fimbriatæ* (text-fig. 3 B, *b*) are united anteriorly at the posterior border of the papillary zone on the inferior surface. When they are traced backwards they diverge and become wider and more prominent. They have undulating free margins, and are pale in colour. The mucosa between them is pale and the remainder is pink in preserved specimens, so the plicæ and intervening part together look like a sublingua. A vertical section of the tongue of the Gorilla resembles that of the Chimpanzee (text-fig. 1 D).

The *frenal lamella*, or sublingual fold, is triangular in shape and has a rounded entire apex (text-fig. 3 B, *g*). Wharton's Ducts open on its dorsal surface, and the bristles shown in text-fig. 3 B, *e*, pass into them.

Bischoff (7) denied the existence of a *frenum*, but Ehlers (23) and Deniker (17) saw one. In my specimen it runs from the dorsal surface of the sublingual fold to a triangular depression on the inferior surface of the tongue (text-fig. 3 B).

Genus SIMIA.

THE ORANG-OUTAN (*S. satyrus*).

The tongue of the Orang-Outan resembles that of Man in its relative proportions of length and width and certain of its structural peculiarities. I examined three preserved specimens in the Museum of the Royal College of Surgeons, and the following description refers to No. J.421.3. It is designated as specimen No. 1 here.

The *apex* is rounded, has no mesial notch, and possesses conical and fungiform papillæ, but both forms are small.

The *lateral borders* are massive, and have both conical and fungiform papillæ distributed in the usual manner. Only the outer ends of the laminae and sulci of the lateral organs cut the lateral borders of the tongue.

The dorsum has no median or transverse sulci.

The Papillæ.

Papillæ cover most of the dorsum, apex, lateral borders, and a bounding zone on the inferior surface.

The Circumvallate Papillæ.

The following numbers and arrangements of the vallate papillæ have been recorded:—

1. Ten papillæ in V-formation—Flower (28), Boulart and Pilliet [2].
2. Eight papillæ in V-formation—Münc [1].
3. Seven papillæ in V-formation—Sandifort (271).
4. Three papillæ on each limb of a V—Fiek (235).
5. Eight papillæ in the T-form—Traill (206)*.

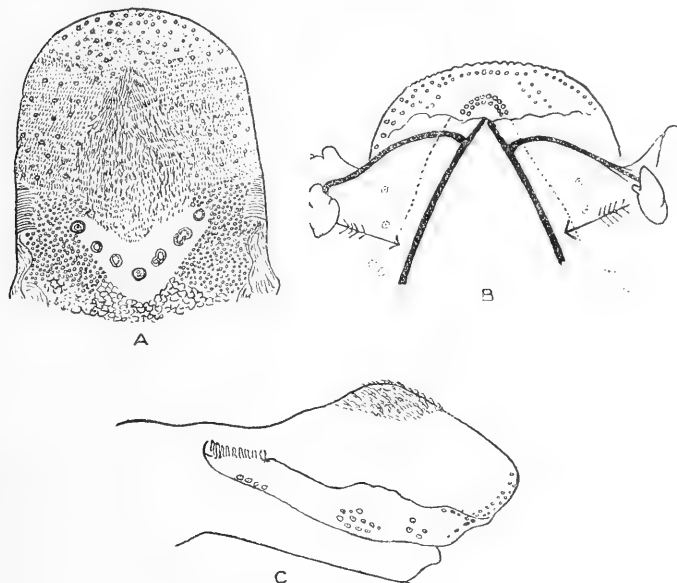
I observed the following numbers and arrangements of the papillæ:—

Specimen No. 1. (text-fig. 4 A).—The papillæ are arranged in the V-form, but the angle embraced by the two limbs is more acute than in Man. There is an apical papilla and three papillæ on each limb, the whole series standing on a raised smooth band of tongue. The papillæ of the left limb are all simple, and the most external one has a small umbilicus (text-fig. 4 A). The most external papilla of the right limb is simple, and the middle and inner papillæ are compound. The apical papilla is compound. All the papillary bodies are round or oval on plan and conical on elevation, with the free broad end of the cone overlapping the vallum. The fossæ are well marked.

* See footnote on page 2.

Specimen No. 2.—The papillæ which are twelve in number, are arranged in the form of a V, but they do not stand on a raised band of tongue as in specimen number one. Several of them are compound.

Text-figure 4.

The tongue of *Simia satyrus*.

A. dorsum; B. ventral surface. The mucosa has been dissected back to show Wharton's Ducts; the arrows point to the actual positions of the sublingual glands, and the dotted lines indicate the positions of the plicæ fimbriatæ.

The Fungiform Papillæ.

The fungiform papillæ are very small. They have the same arrangement in clusters and rows as occurs in the Chimpanzee and Gorilla. In the centre of the dorsum they are concealed by long filiform papillæ. On the inferior surface of the tongue they are larger than on the dorsum, and they are disposed in lines passing from without inwards. A double row forms a prominent arch round the anterior extremity of the frenum (text-fig. 4 B).

The Conical Papillæ.

The conical papillæ are marked features on the anterior two-thirds of the dorsum (text-fig. 4), but they are more pronounced in some individuals than in others. They have the same arrangement in clusters, transverse rows, and oblique chains as in the other Anthropoids, and they increase in size from before backwards and without inwards. They are very long on an area in

the centre of the anterior two-thirds of the dorsum, but, as their points face in all directions, they appear tangled and without any definite method of arrangement. In that central area, again, fungiform papillæ are concealed by the conical forms. There is, therefore, a similarity to the condition already described in the Chimpanzee, and shown in text-fig. 1 A, but the papillæ are more diffused in the latter.

The papillæ belong to the filiform and cylindrical types, but the former predominate, thereby giving the dorsum its shaggy appearance.

The base of the tongue is devoid of the long conical papillæ which are present in the other Anthropoids, and it resembles that of Man in this respect.

On the sides of the tongue they are in vertical chains, and on the inferior surface they are in lines passing from without inwards.

In all situations, except on the central area of the dorsum described above, the points are directed backwards.

The Lateral Organs.

Boulart and Pilliet [2] state that the lateral organs have each twelve laminae, but I found that the numbers of fissures and ridges differ on the two sides as follows:—

Right organ :	Length 1.6 cm.	Ridges 14.	Sulci 15.
Left organ :	Length 1.6 cm.	Ridges 12.	Sulci 13.

The ridges run obliquely from below upwards, and they diminish in size both forwards and backwards, but the organs are continued by simple folds of the mucosa.

The lateral organs end posteriorly on a level with the most external vallate papillæ. The greater part of each lies on the dorsum as in the Gorilla, but some of the anterior laminae and sulci project considerably on to the lateral borders of the tongue.

Lymphoid and Glandular Tissue.

The Orang-Outan agrees with Man and differs from all other Anthropoids in the possession of the *Apical Gland of Nuhn*. Mucous and serous glands occur as usual on the base of the tongue, but there are no large follicles with central pits as in Man and the Chimpanzee.

On the inferior surface there are several small pits surrounded by a raised zone (text-fig. 4 B), but histological examination alone will reveal their true nature. I have been unable to study these as my specimens have been preserved too long in formalin for satisfactory histological work.

The *frenum lingue* is well-marked, as in Man, the *plicæ fimbriatæ* are of no greater development, and the *frenal lamella* is as in the human tongue; it is not a triangular process as

in the other Anthropoids, but simply a fold over Wharton's Ducts.

The tongue of the Orang-Outan, therefore, resembles that of Man in the following particulars:—

1. Its general proportions.
2. Its rounded apex.
3. The V-type of vallate papillæ.
4. The absence of long conical papillæ on the base.
5. The frenum linguæ.
6. The small proportions of the fimbriate plicæ.
7. The nature of the sublingual fold.
8. It has an Apical Gland of Nuhn or Blandin.

In all these particulars it differs from the Chimpanzee and Gorilla, so it must be placed next to that of Man in a classification of tongues.

SYMPHATANGUS.

THE SIAMANG (*S. syndactylus*).

(Specimen No. J. 357.3, Mus. R.C.S.)

The tongue is long and narrow, and the distance between the antero-median vallate papilla and the epiglottis is long (text-fig. 5).

The *apex* is rounded and devoid of a notch. It bears conical and fungiform papillæ which have the usual disposition.

The *lateral borders* are full and rounded. They bear conical papillæ with backwardly-directed points, prominent fungiform papillæ, and the chief parts of the lateral organs. This condition is present in all Gibbons, but the fungiform papillæ vary in size and prominence in different species.

Mesial and transverse sulci are absent on the anterior two-thirds of the dorsum. Both are present on the base of the tongue, but these may have been induced by the preserving fluid.

The mesial ventral sulcus begins at the posterior border of the papillary zone, and runs backwards to open into a triangular depression into which the frenum passes.

The Papillæ.

Papillæ are present on the apex, lateral borders, the entire anterior two-thirds of the dorsum, the sides of the posterior third of the dorsum, and the bounding zone on the inferior surface.

On the posterior third of the dorsum there is a large central area devoid of papillæ (text-fig. 5). It stretches forwards anterior to the median row of vallate papillæ, and sends out limbs on which the lateral papillæ stand. It extends right back to the epiglottis, and is ridged and furrowed at its posterior part. Anteriorly it is bounded by small conical papillæ, and large

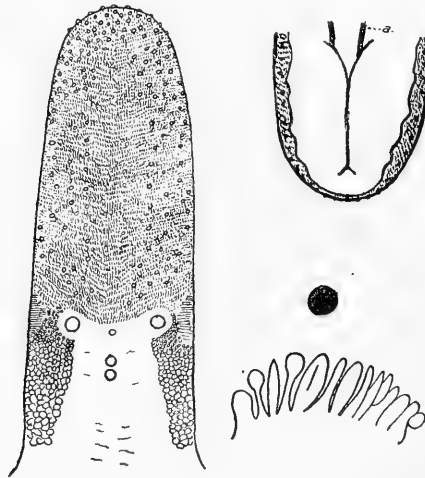
conical papillæ occupy the spaces between its lateral borders and the edges of the tongue.

The Orang-Outan is the only other Anthropoid which has a bare area (text fig. 4 A), but it is V-shaped and smaller in size.

The Circumvallate Papillæ.

Five vallate papillæ are arranged in the form of a Y; of these, three form a mesial row, and there is a right lateral and a left lateral papilla. All the papillæ are circular on plan and conical on elevation, and the fossæ are well-marked. But the vallums are not demarcated off from the smooth area on which the papillæ stand. All have smooth bodies, and the right and left lateral ones are umbilicated.

Text-figure 5.



The tongue of *Symphatagus syndactylus*, showing the dorsum, inferior surface, and right lateral organ with lateral vallate papilla.

The Fungiform Papillæ.

The fungiform papillæ are present over the anterior two-thirds of the dorsum except for a zone along the mid-line. They have the usual distribution in clusters and rows, and are never very large nor concealed by conical papillæ. On the lateral borders and inferior surface they are arranged in lines running vertically or from without inwards.

The Conical Papillæ.

They have the usual form of distribution in clusters and ridges, and their characters are visible to the naked eye right forward to the apex. Most of them are filiform with the points directed backwards, or backwards and inwards.

The conical papillæ on the base increase in size from before backwards, but they never attain the degree of development which is exhibited on the tongues of the Chimpanzee or Gorilla. They belong to the cylindrical type, and many of the large ones at the base have long hair-like processes. These basal papillæ are arranged in two groups—one on each side of the non-papillary area.

No *foramen cæcum*, *lytta*, or *plicæ fimbriatæ* are present.

The Lateral Organs (text-fig. 5).

The two lateral organs, which are convex inwardly, have the following measurements, etc.:—

Right organ :	<i>Length</i> 1.3 cm.	<i>Ridges</i> 11.	<i>Sulci</i> 12.
Left organ :	<i>Length</i> 1.3 cm.	<i>Ridges</i> 12.	<i>Sulci</i> 13.

The organs are situated chiefly on the sides of the tongue, but the inner extremities of their laminae and sulci extend on to the dorsum. Anteriorly and posteriorly they are continued by simple folds of mucous membrane. These characters are common to all the Gibbons and the Chimpanzee.

The lateral vallate papillæ are level with the laminae and ridges of the posterior halves of the organs, but they are not so far back as in the Gorilla or Orang-Outan, and not so far forwards as in the Chimpanzee and many other Gibbons.

There are no *lymphoid nodules* with central pits on the base of the tongue.

The *frenum* is short, and runs from the floor of the mouth to a triangular depression on the inferior surface of the tongue.

The Siamang is the only Gibbon which has no bifid triangular *sublingual fold* through which Wharton's Ducts pass. The latter open on *carunculæ sublinguales*, as in the Orang-Outan, but it was not at all clear if these were overlapped by *plicæ* in the specimen which I examined.

In the presence of the bare area on the base of the dorsal surface and in the characters of the openings of Wharton's Ducts, the tongue of the Siamang agrees with that of the Orang-Outan, and differs from the tongues of all the other Simiidae.

Genus HYLOBATES.

THE SLENDER GIBBON (*H. agilis*).

I have not had the opportunity of examining the tongue of *H. agilis*, but Flower (28) points out that it has the following characters:—

1. The tongue narrows slightly from base to apex.
2. The apex is obtusely rounded.
3. The vallate papillæ are small, irregularly placed, and adopt the V-formation.
4. Fungiform papillæ are large and evenly distributed

5. Conical papillæ short and thick on the anterior part of the dorsum.

6. Conical papillæ at the base of the tongue large, soft, and pointed.

7. Lateral organs distinct.

8. Sublingual fold bifid.

THE HOOLOCK GIBBON (*H. hoolock*).

(Specimen No. J. 357.2, Mus. R.C.S.)

The tongue is short, compact, and rough, and tapers from base to apex (text-fig. 6).

The *apex* is rounded and has no mesial notch. It bears conical and fungiform papillæ, but the latter are small and inconspicuous. The *lateral borders* are the same as in *S. syndactylus*, but are shorter.

The Papillæ.

The papillæ have the usual general distribution, but there is no smooth non-papillary area at the base as in *S. syndactylus*.

The Circumvallate Papillæ.

There are four vallate papillæ arranged in the Y-form. Two are mesial, and there is a right and a left lateral papilla (text-fig. 6).

The right and left lateral papillæ are level with the central laminae and sulci of the lateral organs. They are circular on plan and conical on elevation, the narrow ends being attached to the bottoms of the fossæ. The fossæ are plain, and the vallums are lobulated and surrounded by conical papillæ.

The two mesial papillæ (text-figs. 6 & 9, 19) are close together. The anterior one is circular and the posterior one is oval on plan, and both are conical on elevation with the broad ends free. Both lie within a depression surrounded by a prominent lobulated ridge of mucosa, and the space between them and the latter is crowded with small cylindrical conical papillæ. The fossæ are not very prominent. All around the common rampart there are conical papillæ.

The Fungiform Papillæ.

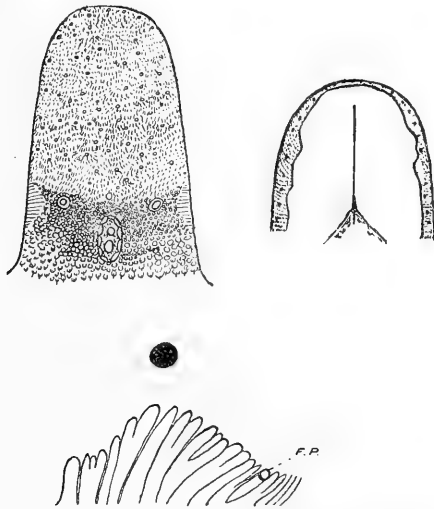
The fungiform papillæ are *disposed* over the whole of the anterior two-thirds of the dorsum. As many of them are concealed by the conical papillæ, it is necessary to employ a lens to detect them all. The largest ones on the *dorsum* are immediately in front of the vallate papillæ, but all the others are small. There are few on the *lateral borders* of the tongue. On the papillary zone of the *inferior surface* they are larger than anywhere else. They occupy most of the zone beneath the apex, but farther back they are arranged in an irregular double row, on which some of the papillæ are hemispherical and others are

pedunculated. Some run into the lateral organs (text-fig. 6, *FP*).

The Conical Papillæ.

On the anterior two-thirds of the *dorsum* the conical papillæ are strong and coarse, and give the tongue a rough appearance. Their disposition in clusters and rows is not very clearly marked, but is maintained. Several groups are arranged in an undulating manner, and the points of the papillæ point backwards, backwards and outwards, or backwards and inwards (text-fig. 6). They conceal several of the fungiform papillæ.

Text-figure 6.



The tongue of *Hylobates hoolock*, showing the dorsum, inferior surface, and right lateral organ.

Behind the *vallate papillæ* the tongue is covered with cylindrical conical forms. On the area lying between the lateral vallate papillæ and the level of the posterior pole of the rampart common to the two mesial vallate papillæ they are small, but behind that level they are large, and many have strong single processes (text-fig. 9, 5). There are some small cylindrical forms anterior to the vallate papillæ.

The characters and disposition of the conical papillæ on the sides and inferior surface are the same as in all other Anthropoids.

The Lateral Organs (text-fig. 6).

Right organ: Length 1.2 cm. Ridges 12. Sulci 13.
Left organ: Length 1.25 cm. Ridges 10. Sulci 11.

Both organs are convex inwardly and lie on the lateral borders, with the inner extremities of their ridges and sulci on the dorsum. In the specimen (No. J. 357.2, Mus. R.C.S.) which I examined more of the left organ is on the dorsum, but that may be produced by mechanical distortion. Most of the ridges are subdivided, and fungiform papillæ invade the anterior ones on both organs. Simple folds of the mucosa lie anterior to each organ, and the lateral vallate papillæ are level with the central laminae and sulci.

The following structures are absent :—

1. Large lymphoid nodules with central pits.
2. Lytta.
3. Plicæ fimbriatæ.
4. Apical gland of Nuhn.
5. Foramen cæcum.

The *frenum* is of moderate length.

The *ventral mesial sulcus* is narrow, deep, and lodges an antero-posterior crest. It runs back from the posterior border of the papillary zone to the triangular depression into which the frenum passes.

The *bifid sublingual fold* is not present in the specimen in the Museum of the Royal College of Surgeons, and the frenum passes straight from the triangular pit on the inferior surface of the tongue to the mucous membrane of the floor of the mouth.

THE BORNEAN GIBBON (*H. muelleri*).

The specimen described below was obtained from a female Gibbon from Borneo which died in the Society's Menagerie.

Measurements.—Total length 6.5 cm.; length from the apex to the central vallate papilla 5.25 cm.; length from the central vallate papilla to the epiglottis 1.25 cm.; width between the attachments of the anterior faucial pillars to the edges of the tongue 2.8 cm.; width of the apex 1.4 cm.; thickness at the central vallate papilla 1.2 cm.; thickness of the apex .6 cm.

The tongue is, therefore, long and narrow, and it is pigmented.

Pigmentation.—The dorsum in front of the vallate papillæ is bluish black in colour, and the glistening bluish-black fungiform papillæ appear prominently on it, as their colour is darker than the rest of the dorsum. The dorsum behind the vallate papillæ is not pigmented, is white, and the lateral organs lie at its antero-lateral aspects.

The inferior surface has a central unpigmented area shaped like the head of a spear, whose apex reaches the posterior border of the papillary bounding zone. From the posterior extremity of the hastate central area a narrow clear band runs on each side to the lateral organ, and thus brings the clear areas of dorsum

and inferior surfaces into continuity. The rest of the inferior surface is bluish black in colour.

Apex.—The obtuse apex has a fine central notch. It bears fine conical papillæ on the dorsum and lateral borders, and both conical and fungiform papillæ on the inferior surface. The conical papillæ are of the cylindrical and filiform types, and the latter have their points directed backwards. The numbers of points differ greatly.

Median sulci.—Median longitudinal sulci are present on both dorsum and inferior surfaces. The median dorsal sulcus runs back from the apex for a distance of 1.4 cm. The median inferior sulcus begins at a point .5 cm. posterior to the apex for 1.5 cm., becoming wider as it goes, till it opens into a triangular area to which the frenum is attached. It is shut off from the apex by the papillary border.

Lateral borders.—The lateral borders have fungiform and conical papillæ. The latter are both cylindrical and filiform with their points directed backwards.

The inferior surface.—The inferior surface is surrounded by a papillary border which is rough to the touch; it varies in width from .2 cm. at the apex to .5 cm. at the lateral organs, so it becomes wider when it is traced backwards. It bears both fungiform and conical papillæ. The former are arranged in two rows, of which the inner one consists of closely-set elements, but the outer papillæ are more discrete. There is, however, no disposition according to size, for both rows have different sizes of members. The conical papillæ are cylindrical and filiform with their points directed backwards.

Internal to the papillary border the mucous membrane is smooth and, with the exception of the mesial sulcus, furrowless.

Plicæ fimbriatæ, lytta, foramen cæcum, and the *Apical gland of Nuhn* are absent.

The Papillæ.

Papillæ cover the entire dorsum, the apex, lateral borders, and a bounding zone of the inferior surface.

The Circumvallate Papillæ.

There are three vallate papillæ arranged in the form of a triangle whose apex is in the mid-line posteriorly, and the vertical angle included is obtuse. The lateral papillæ, which are simple, are .7 cm. distant from the compound apical papilla and 1.3 cm. from one another.

The apical papilla is very prominent, is oval in shape with the long axis antero-posterior, and measures .6 cm. by .3 cm. Its fossa is narrow and irregular, and lodges two elements (text-figs. 7 & 9, 17). These have smooth glistening bodies, and the anterior one has a small central depression. The entire series of elements is dumb-bell-shaped and the vallum sends small lobules

into its hollows. The vallum is finely lobulated. Perhaps this papilla has been formed by fusion of elements similar to those in the mesial limb of *H. hooleck* (text-fig. 9, 19).

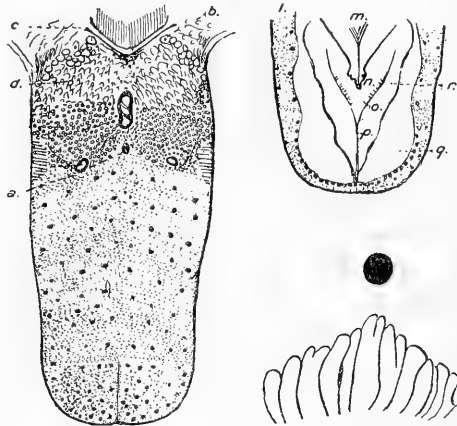
The two simple lateral papillæ are ovoid, and the papillary bodies and vallums are granular (text-fig. 7).

All the papillæ are conical on elevation, the broad ends of the cones projecting beyond the vallums (text-fig. 9, 17).

The Conical Papillæ (text-fig. 9, 1-13).

The conical papillæ have the usual arrangement in clusters and rows of varying degrees of obliquity, and belong to the cylindrical and filiform series. The latter have one or more points, all of which are directed backwards. Those shown in text-fig. 9, nos. 1-5, have shafts circular on section, but the papillæ (text-fig. 9, 6-8) are flat.

Text-figure 7.



The tongue of *Hyllobates muelleri*.

a, central fungiform papilla; *b*, *d*, conical papillæ; *c*, epiglottis; *l*, papillary bounding zone of inferior surface; *m*, part of frenum; *u*, frenal lamella; *o*, *p*, mesial ventral sulcus; *q*, pigmented area; *r*, unpigmented area.

At the base of the tongue there are large conical papillæ whose points are directed backwards and inwards. Their surfaces are granular, and they may have prominent secondary papillæ. They are not so well developed as in the Gorilla and Chimpanzee, but their secondary processes are larger than in either of these animals. They are shown in text-fig. 9, 9-13.

The Fungiform Papillæ (text-fig. 9, 14-16).

There is little to note about the fungiform papillæ. They have the same type of arrangement as in the other Anthropoids, and

they are evenly distributed. They are most numerous behind the apex on the dorsum and inferior surface.

The Lateral Organs.

The lateral organs, as in the Chimpanzee, lie on the sides of the tongue, with the upper ends of their fissures and ridges projecting on to the dorsum (text-fig. 7). Each organ is convex inwards, and has both plain and subdivided ridges. The two organs are compared as follows:—

Right organ :	Length .9 cm.	Ridges 12.	Sulci 13.
Left organ :	Length .9 cm.	Ridges 11.	Sulci 12.

The middle ridges and sulci of the lateral organs are level with the lateral vallate papillæ.

Lymphoid Tissue.

Small and large lymphoid nodules are present on the base of the tongue, and some of the large ones have central pits which are, however, larger than in the Chimpanzee.

The Frenum.

The frenum is short and thick. It runs from the upper surface of the sublingual fold to be inserted into a triangular depression on the under surface of the tongue and from its under surface to the floor of the mouth.

The Sublingual Fold.

The sublingual fold is triangular, and has a bifid apex and crenated edges.

THE WHITE-HANDED GIBBON (*H. lar*).

I examined two preserved specimens (Nos. J. 357.1 & J. 357.2) in the Museum of the Royal College of Surgeons. The former is oval in shape and the latter is conical, but the differences in form are possibly due to varying degrees of muscular contracture. They both differ also in the character of their papillæ and lateral organs. Unless differences are specifically stated here, the characters described are common to both.

The *apex* is similar to that of *S. syndactylus*.

The *lateral borders* are full and rounded. They possess both conical and fungiform papillæ, and the latter are very prominent; some are hemispherical and others are pedunculated. At their posterior extremities the lateral organs are situated.

No *mesial sulci* are present on any part of the dorsum.

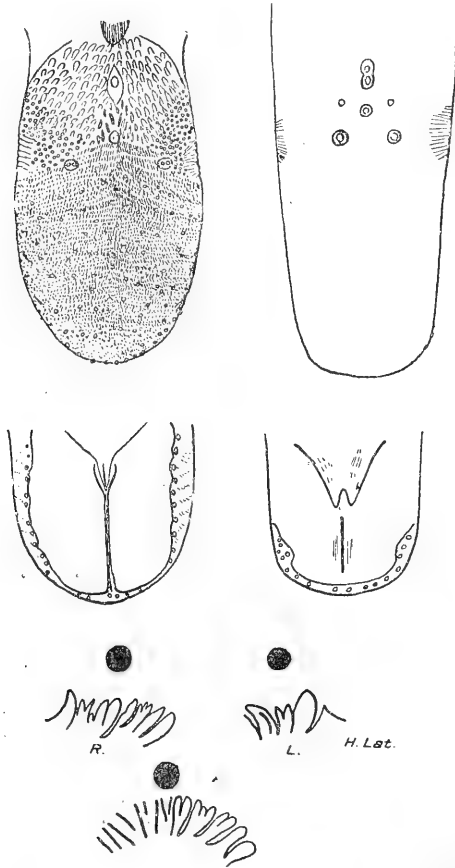
The Papillæ.

The papillæ have the same distribution as in *H. muelleri* and *H. hoolock*, and there is no smooth area on the base of the tongue as in *S. syndactylus*.

The Circumvallate Papillæ.

In specimen No. J. 357.1 there are four papillæ arranged in the Y-formation. These are so disposed that there is a right lateral papilla, a left lateral papilla, and two mesial papillæ—anterior and posterior. All are small in size.

Text-figure 8.

The tongue of *Hylobates lar*.

Two forms are shown, with dorsum (upper row) and inferior surface (middle row).

The figures R and L are lateral organs of the figure on the right hand, and the unmarked lateral organ belongs to the left one.

The lateral papillæ are oval and subdivided into two by fissures, and the vallums and fossæ are not very obvious.

The mesial papillæ are small, the vallum of the anterior papilla consists of two crescentic ridges, and the vallum of the posterior papilla is large and fusiform.

The Fungiform Papillæ.

The fungiform papillæ have the usual disposition in rows and clusters. They tuberculate the apex. There are few on the lateral borders, but they are numerous and prominent on the anterior part of the papillary zone of the inferior surface. They vary in prominence in different tongues, and the degree in which they are concealed by conical papillæ also varies. There is a prominent cluster immediately in front of the vallate papillæ, and some invade the vallate Y and are hard to distinguish from them.

The Conical Papillæ.

Most of the conical papillæ are of the filiform type, and have the usual type of arrangement on the dorsum, lateral borders, and inferior surface. Their points are directed backwards, or backwards and inwards, and they increase in size from before backwards and without inwards. They conceal the anterior fissures and ridges of the lateral organs.

At the sides of, and posterior to, the vallate papillary Y they become large and oval or round, with the apices directed backwards and inwards, and the round ones have each a long central spine.

The Lateral Organs.

Specimen 1 (text-fig. 8, R. & L.).

Right organ: Length	·8 cm.	Ridges	5.	Sulci	6.
Left organ: Length	·8 cm.	Ridges	4.	Sulci	5.

Specimen 2 (text-fig. 8).

Right organ: Length	1·2 cm.	Ridges	10.	Sulci	11.
Left organ: Length	1·25 cm.	Ridges	10.	Sulci	11.

The lateral organs differ in character in the two specimens. In specimen 1 there are six or five sulci appearing as slits running obliquely forwards and upwards, and the intervening laminae are coarse, short, and not greatly raised above the level of the surface of the tongue. In the second specimen the organs have the appearance usual in all the other Gibbons.

The following structures are absent:—

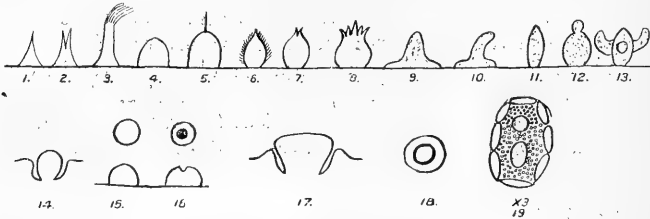
1. Lymphoid nodules with central pits.
2. Lytta.
3. Foramen cæcum.
4. Plicæ fimbriatæ.

The *sublingual fold* is triangular in shape with a bifid apex. From its upper surface the short *frenum* passes to the inferior

surface of the tongue and from its under surface to the floor of the mouth.

The *ventral mesial sulcus* begins anteriorly at the posterior border of the papillary zone. It is narrow and deep, and lodges a small median crest.

Text-figure 9.



Papillæ of the Gibbons.

1-13, conical papillæ; 14-16, fungiform papillæ; 19, vallate papillæ of *H. hoolock*.

SUMMARY AND CONCLUSIONS.

1. Apical notches and mesial dorsal sulci are more frequently absent than present, and are of no particular value for comparative purposes.

2. The lateral borders have the same characters as regards papillæ in all forms. In the Chimpanzee and Gibbons they lodge the greater part of the lateral organs, but in the Gorilla and Orang they only lodge a small part.

3. The vallate papillæ are usually fewer than in Man (7-12). In the Orang they are in V-formation, but they usually assume the Y-type in others. Compound papillæ are common.

4. Filiform papillæ are the predominating type of the conical group on the anterior two-thirds of the dorsum.

5. The long conical papillæ on the base are largest in the Gorilla, smaller in the Chimpanzee, smallest in the Gibbons, and absent in the Orang.

6. Only the Orang and Siamang have smooth non-papillary areas on the base.

7. Plicæ fimbriatæ are absent in the Gibbons.

8. Median ventral crests occur in the Gorilla and some Gibbons.

9. The Orang and Siamang have no triangular sublingual fold, but all the other Simiæ possess one. In the Gorilla the apex is entire, but in all the rest it is bifid.

10. Only Man and the Orang have the Apical Gland of Nuhn.

11. The tongue of the Orang resembles that of Man more closely than any other one does, and the tongue of the Bornean Gibbon resembles, in many ways, those of the Cercopithecues, which will be described in my next paper.

BIBLIOGRAPHY.

The numbers included in round brackets correspond with those in Professor Arthur Keith's "Introduction to the Study of the Anthropoid Apes" (Natural Science, vol. ix. 1896, Rep. 1897). Those included in square brackets refer to the following papers not mentioned by Professor Keith:—

1. MÜNCH.—Morphol. Arbeiten, Bd. 6, pp. 605–690. 1896.
2. BOULART & PILLIET.—Journ. de l'Anat. et de la Physiologie, Paris, 1885, p. 337.

[I was unable to see the characters of the part of the frenum running between the inferior surface of the frenal lamella and the floor of the mouth in the specimens in which I have not specifically described this part.]

2. Note on the Capture (in London) of a rare Parasitic Fly, *Hammomyia (Hylephila) unilineata* Zett. By Lt.-Col. S. MONCKTON COPEMAN, F.R.S., M.D., F.R.C.P., F.Z.S.

[Received October 14, 1920 : Read February 8, 1921.]

(Text-figure 1.)

The exceptional rarity of this fly, of which I have had the pleasure of presenting to the British Museum (Natural History) the only specimens in our national collection, affords reason for a record of its capture in considerable numbers in London (Primrose Hill) during the past two years, for some discussion of its nomenclature, and for a brief account of its seasonal prevalence and habits so far as they are at present known.

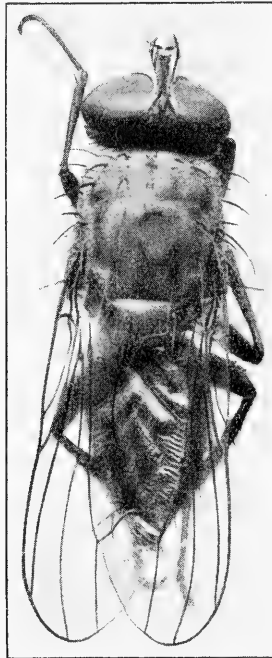
In a previous communication I have set out some facts as to a flourishing colony of a burrowing bee (*Andrena fulva*) on a localized area on the south-western slopes of Primrose Hill, which has been kept under observation over a period of six years, during the latter half of which period the number of individual burrows has, for reasons which were explained in my previous paper, increased to a considerable extent. It was while watching the operations of the bees on an outlying portion of this colony, on May 16, 1919, that, for the first time, I observed and obtained specimens (two in number) of a fly which, from its actions, which I studied carefully for some time, is apparently a parasite of the burrowing bee.

On the morning (about 10 A.M.) of this day, which was bright, without obvious breeze, I was lying motionless on the grass watching the bees leaving and returning to a collection of burrows on a small patch of bare earth, when my attention was attracted by a homeward-bound bee, which, on approaching its burrow, dived stright down into it, instead of, as usual, hovering around for several seconds before doing so. As it approached, I noticed that it was followed by a couple of flies, of a species unknown to me, which appeared for the moment to be as astonished as I was at its precipitate retreat into its burrow. After what looked like a fight with one another for a few moments over the surface of the ground, one of them followed the bee down into the hole, reappearing almost immediately, and then again descending into the burrow, this time backwards. Meanwhile, the second fly remained on guard outside. When the first fly at length emerged head foremost, both of the flies were eventually trapped in a match-box, a net not being available at the time. But unfortunately one of them managed to escape before they could be taken home and killed. The remaining specimen was despatched at once to Major E. E. Austen, D.S.O., at the British Museum (Natural History), with a request for its identification, as the species was unknown to me. Under the circumstances, it may

be of interest to quote from Major Austen's reply, of May 17th, 1919, as follows:—

“The fly enclosed with your letter is a most interesting thing, and I am more than sorry that I have been unable to name it for you The species of the genus *Miltogramma* (fam. Tachinidæ) and its nearest allies behave exactly as you described, and on more than one occasion I have watched one of these flies stalking

Text-figure 1.



Hammonyia (Hylephila) unilineata Zett., ♀.

(The mark in the centre of the thorax is due to the fly having been pinned before the photograph was taken.)

Magnified $\times 10$.

a solitary bee as a stoat does a rabbit—moving when the bee moved, stopping when the bee stopped, and so on. Judge of my surprise, therefore, when, on opening the box, I found an insect such as, to the best of my belief, in nearly thirty years' experience of Diptera, I have never seen before! The species undoubtedly belongs to the *Anthomyiidae*—not to the Tachinidæ,—but is aberrant in more than one respect. It is not represented either in our own collection or in the series presented by the late

Mr. Verrall (the result of some fifty years' collecting). My colleague, who works at Diptera, does not know it, and I have spent some hours . . . trying to work it out with books etc., but without success. It is a most surprising thing, especially in view of the locality. I hope that you will be able to secure more specimens, and of both sexes."

Mr. Austen, at first, was of the opinion that the sex, not only of this particular fly, but also of each of a number of similar specimens that I was subsequently able to send him, was *male*, but when, later on, at the suggestion of Mr. Collin, who had learnt of my find through Professor Poulton (to whom I had given some specimens for the Hope Collection at Oxford), one of the flies was dissected, leading to the discovery of a perfect egg, it became obvious that the flies that had been captured must be females. And it is a curious and interesting fact that among about fifty specimens of this fly which have been caught (all in the same locality) up to the end of their seasonal prevalence in the early part of June of the present year (1920) not a single individual of the male sex has been secured. I learned, however, from Mr. Collin that he now possesses three specimens of the male insect—two taken by the Rev. A. E. Eaton at Seaton (Devon) and the third taken by himself at Long Sutton in Hampshire, all in May 1919, curiously enough the same year and month in which the first specimens (females) were found by myself on Primrose Hill. Mr. Collin further informed me that he possesses female specimens from the following localities:—"Newmarket, Shoeburyness, and Dunsford (all June captures); Cuckmere (Sussex) taken in May; and a specimen taken by Col. Yerbury at Charlton in April.

The difficulty as to the sex of my first captures arose from the masculine character of the approximation of the eyes, which is the cause of the very narrow "frons," which, however, appears to be peculiar to, and distinctive of, the female in this group of Anthomyids—a feature which is well shown in the photograph, and which, so far as I am aware, has not previously been illustrated.

NOMENCLATURE.—As stated above, Major Austen and his colleague in the Diptera department of the British Museum (Natural History) were unable, at first, to identify this fly, but on calling there on May 28th, 1919, with some further captures, Major Austen informed me that Dr. P. H. Grimshaw of the Royal Scottish Museum, who had recently paid him a visit, had stated, when the specimens were shown to him, that he recognised the fly, identifying it as *Chortophila buccata* Fallén, although the species was not (as Major Austen understood him) included in the Scottish collection.

Shortly afterwards Professor Poulton arranged with Major Austen that Mr. Collin should be afforded opportunity of examining the specimens I had presented to the Museum, for the reason that, as Mr. Collin informed me, his uncle, the late Mr. Verrall, had suggested that a fly, apparently identical

with mine, should be known as *Hammomyia unilineata* Zett. rather than *H. (Chortophila) buccata* Fallén.

Subsequently Mr. Collin wrote to me that he possessed several continental specimens of *H. buccata* Fln., including a pair so named by Zetterstedt himself, and that he was of opinion that these were abundantly distinct from the British species, which is undoubtedly *Hammomyia (Hylephila) unilineata* Zett. Furthermore, he kindly directed attention to the fact that in describing *unilineata* Zetterstedt wrote "Feminæ ad nidis Andrænarum inventæ, in quarum larvis larvæ hujus speciei Ariciæ verisimiliter parasitæ vivunt observante D. Professore Wahlberg." Apparently, therefore, *buccata* Fallén requires confirmation so far as our British fauna is concerned, as Mr. Collin is convinced that he has never seen a British specimen of the true *buccata*.

SEASONAL PREVALENCE.—As stated above, my first specimens of this fly were captured on Primrose Hill on 15th May, 1919. On the same circumscribed area of ground I caught ten more specimens on May 19th, ten on May 20th, and seven on May 21st. Then, after an absence from town of several days, a further seven flies were caught on May 27th and three on May 29th—at which date I had again to leave home for about a fortnight. Just before my return the fine weather gave place to rain, accompanied by a considerable fall in temperature, with the result that, subsequently, neither bees nor flies were to be found, notwithstanding careful search on several successive days.

It may be mentioned that, in 1919, *Andrena* bees were first seen on May 6th, a warm and sunny day, when a number of males, which always emerge before the females, were flying about; while females were not found, with the exception of one or two solitary specimens, until several days later. So that, as might be expected in view of what is known as to the parasitism of the fly in question, it is obvious that the seasonal prevalence of the female of both fly and bee tallies closely.

In consequence, doubtless, of the abnormal meteorological conditions during the present year (1920), both bees and flies appeared at an earlier date than in 1919, the first flies, three in number, having been obtained on May 11th. Careful search was made for male specimens of the fly, but again without success. By the end of May both bees and flies had disappeared.

It will be noted that, with some exceptions, the specimens of the fly in Mr. Collin's collection were captured in the month of May—the month during the latter half of which, as my observations on Primrose Hill, extending over a period of several years, have shown, the female of the bee *Andrena fulva* is more particularly prevalent.

3. The Bases of Classification of the Theriodontia.

By D. M. S. WATSON, F.Z.S., University College, London.

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(Text-figures 1-29.)

Among the first series of reptiles from the Karroo system of South Africa sent home by Andrew Geddes Bain were a few poor fragments of animals with a heterodont carnivorous dentition. Later collections from the same rocks included more satisfactory remains of these animals, which were described by Owen, who recognised their mammalian appearance and despite his ante-evolutionary views even suggested that they were mammalian ancestors. Prof. Seeley's visit to South Africa marked a turning-point in our knowledge of these reptiles, because he showed that their remains were found in rocks of widely different ages, and that the latest assemblage—*Diademodon*, *Cynognathus*, and *Trirachodon*—were more mammal-like in their dentition than were their earlier forerunners. He showed also that they possessed a mammal-like secondary palate, but failed to arrive at a satisfactory interpretation of that region in the less complete remains of the earlier forms known to him. Neither Owen, Seeley, nor Lydekker was able to draw up any useful classification of these reptiles on account of the paucity of material, and the first definite step in so doing was made by Broom, when in 1904 he showed that *Scylacosaurus sclateri*, a form from the lowest zone of the Beaufort beds, differed from the "Cynodonts" of the highest zone of that formation in lacking any trace of a secondary palate.

Subsequent work by Broom added many new generic types to those included with *Scylacosaurus* in that primitive division of the carnivorous Therapsids whose members lacked a secondary palate and had uncusped molar teeth. This division Broom made into an order and called Therocephalia.

No further important additions were made to our knowledge of the skull of any of these reptiles till, in 1911, the writer gave a very detailed account of the skull of *Diademodon* and Broom a more general description of the skull in all the Cynodonts. The first important addition to our knowledge of the earlier Theriodonts was the description by the present author of the posterior half of a skull from the *Cistecephalus*-zone, which agreed with *Gorgonops* in having a broad parietal region, the parietal bone being excluded from the margin of the temporal fossa. In the same paper some of the more salient features of the palate of *Gorgonops* were described, and it was indicated that the form showed the beginnings of the Cynodont secondary palate, the skull known as *Arctognathus curvimola* showing an intermediate condition. Whilst I was writing this paper in

London, Broom in South Africa was describing two very complete Gorgonopsid skulls, one associated with the anterior part of a skeleton. Of these skulls Broom gave a good description, bringing out the whole structure of the face and parietal region, but not giving us so satisfactory an account of the palate and occiput. Broom, sometimes in conjunction with Haughton, subsequently added many new and often strange forms to the Gorgonopsidæ—on the whole, emphasizing rather their resemblance to the Deinocephalia and Dicynodontia and even Pelycosauria than those which they show to the "Cynodontia." In 1914 I was able to show that known Gorgonopsids could be arranged as a morphological series giving a gradual passage in the structures of the occiput, and of the basicranial and otic regions between *Dimetrodon* a Pelycosaur and *Diademodon* a "Cynodont." In the same paper I described the palate of the "Cynodont" *Bauria*, showing that it differed much from the Cynognathids and resembled the non-Gorgonopsid Theriodonts with a primitive palate more than the Gorgonopsids. In consequence, purely as a temporary measure, I revived the order Theriodontia and divided it into four sub-orders—the Therocephalia, the Gorgonopsia, the Bauridæ, and the Cynodontia. Since that paper was written, Haughton has published descriptions of certain new forms and made important new additions to our knowledge of the brain-case of the earlier Theriodonts. In his most recent paper he uses provisionally my 1914 classification, emphasizing its insufficiency.

In revising a paper on the relative ages of the Palæozoic and Triassic reptile-bearing rocks, which has occupied me at intervals for some years, I was forced to deal with the problems presented by the fauna of the copper-bearing Permian sandstones of the Orenburg district of the Urals. One of the most noteworthy forms from this locality is *Rhopalodon*, an animal whose skull, which alone is certainly known, presents many resemblances to the Gorgonopsids. The necessity of discussing the systematic position of this form led me to an examination of all the Theriodont material available, with the results which are set out below.

It is convenient to begin with a description of the material at my disposal, then to discuss the morphological results which arise from it, and, finally, consider the evolution of the group and the relationship of *Deuterosaurus* to it.

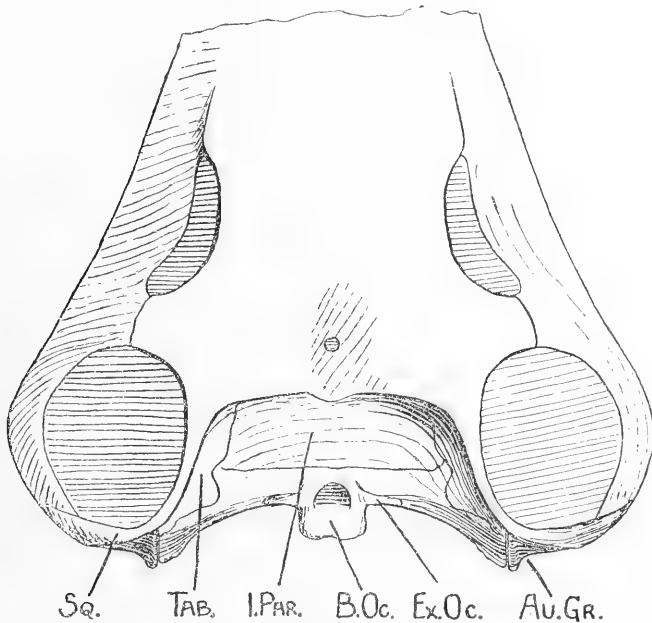
ARCTOPS WILLISTONI Watson, Proc. Zool. Soc. 1914, p. 1026.

Type and only known material: a skull lacking the anterior part of the snout, the quadrates and quadrate rami of the pterygoids, otherwise complete and practically undistorted. From Howse Post, near Fort Beaufort, S. Africa, not improbably ENDOTRHODON zone.

I described and figured the occiput and basicranial region in the original description.

Arctops has a depressed and very massive skull, the snout, when broken off about 5 cm. in advance of the orbit, being rectilinear in section, bounded by a straight dorsal surface which passes somewhat abruptly into straight, nearly vertical, lateral surfaces. The orbit is small, placed high in the skull, and nearly laterally directed; its upper margin is continued forward by a ridge separating the dorsal surface from the lachrymal region, which is excavated into a shallow depression. The interorbital region is very wide, forming a flat surface bounded laterally by shallow bays over the orbits.

Text-figure 1.

*Arctops willistoni* Watson. Type-skull.Dorsal aspect. $\times \frac{3}{2}$.

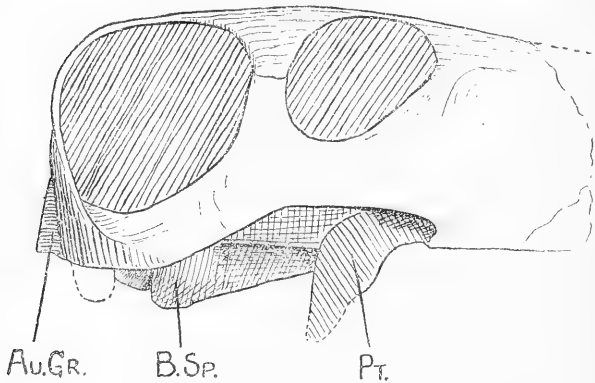
B.Oc., basioccipital; I.PAR., interparietal; SQ., squamosal; TAB., tabular.

The parietal region, also flat, is even wider than the interorbital surface; it separates the very small temporal fossæ which face more largely laterally than dorsally. The occipital surface is very wide and is separated from the parietal by a sharp corner. The squamosal is small, consisting mainly of a vertically standing plate passing directly outward from the end of the massive paroccipital process. The posterior surface of the bone at this articulation is produced backwards into a ridge which forms the

inner wall of the auditory groove. Sutures over the outer surface are not clearly recognisable.

I have already described the basicranial region, but would again call attention to the flat, laterally directed, plate-like basi-ptyergoid processes. The narrow ridged girder formed by the parasphenoid and pterygoids extends forward to the front of the orbit, where it suddenly passes into the wide posterior end of the palate. The pterygoids pass outward to form thick downwardly directed flanges, not very deep when compared with later forms, but of great antero-posterior extent. The middle region of the posterior part of the palate forms a slightly raised area separating two concavities, whose surface lies mainly on the ectopterygoids, large square bones which only take a small part in the great flanges. The middle part of the palate forms a shallow groove

Text-figure 2.



Arctops willistonii Watson. Type-skull.

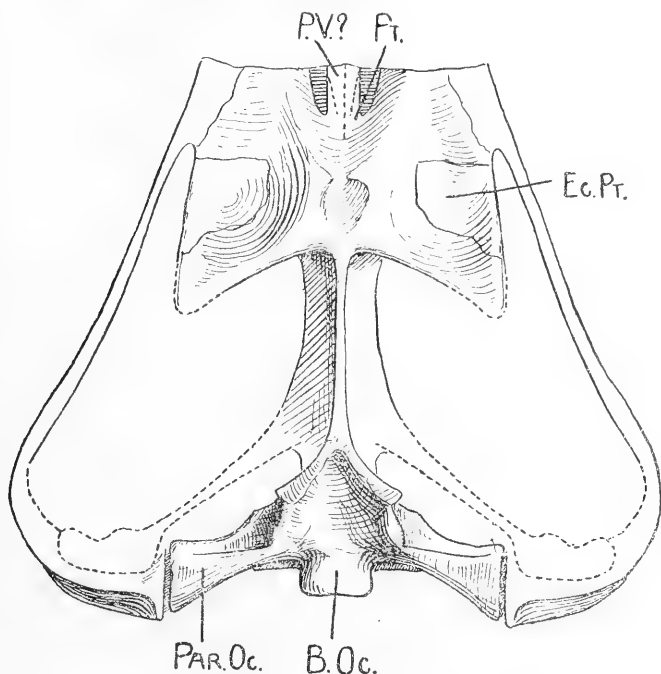
Right lateral aspect. $\times \frac{2}{3}$.

B.Sp., basisphenoid; Pt., pterygoid.

beginning at the extreme posterior end and running forwards to the posterior nares. At about the level of the anterior end of the ectopterygoid, this groove is overhung by a pair of small processes rising from the pterygoids. Further forward the floor of this groove is cut into by the narrow slits which represent the posterior ends of the posterior nares. These are separated by a narrow bar of considerable vertical depth. The structure of this bar is not quite certainly determinable, but on the curved fracture which forms its present front termination it is certain that its upper surface consists of a pair of ridges separated by a parallel-sided cleft not more than a millimetre wide and nearly a centimetre deep. From this slit a suture seems to be continued on to the palate. Further back two lateral ridges are

added to the original pair, the gaps between them being also apparently continued as sutures on to the palate. Thus the posterior part of the bar separating the internal nares seems to be built up of two pairs of bones, of which the outer terminates not far in front of the posterior ends of the nares. It is probable that the inner pair are prevomers and the outer the anterior ends of the pterygoids, which hence form a part of the border of the posterior nares.

Text-figure 3.

*Arctops willistoni* Watson. Type-skull.Palatal aspect. $\times \frac{3}{2}$.

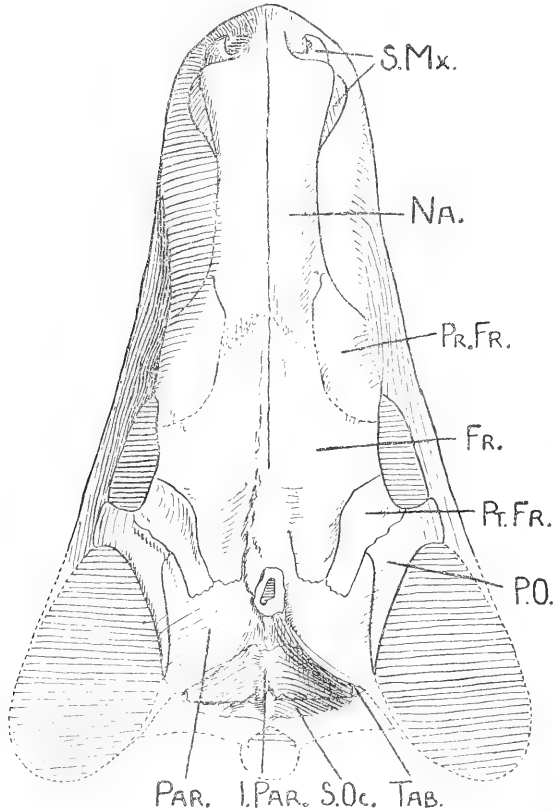
Ec.Pt., ectopterygoid; PAR.Oc., paroccipital; Pt., anterior end of pterygoid;
P.V.?, prevomer, posterior end of internarial bar. Parts in broken lines
restored without evidence.

GORGONOPS TORVUS Owen, Cat. S. Afr. Rept. 1876.

Type: a skull with the zygomatic arches broken away, the basis cranii only represented by a fractured surface passing horizontally through the basisphenoid. The paroccipital processes only represented by the impression on the matrix of the anterior face of that of the right side, the posterior part of the palate represented only by the impression of its dorsal surface.

Otherwise the skull is complete and, on the whole, extremely well preserved. It is represented by beautiful and most accurate lithographic drawings in Owen's Catalogue. From Mildenhals, Fort Beaufort. Another more complete, but less well-preserved, skull from the *Endothiodon*-zone of Beaufort West is in the American Museum of Natural History.

Text-figure 4.

*Gorgonops torvus* Owen. Type-skull.

Dorsal aspect. $\times \frac{3}{2}$. Parts in broken line restored without evidence.

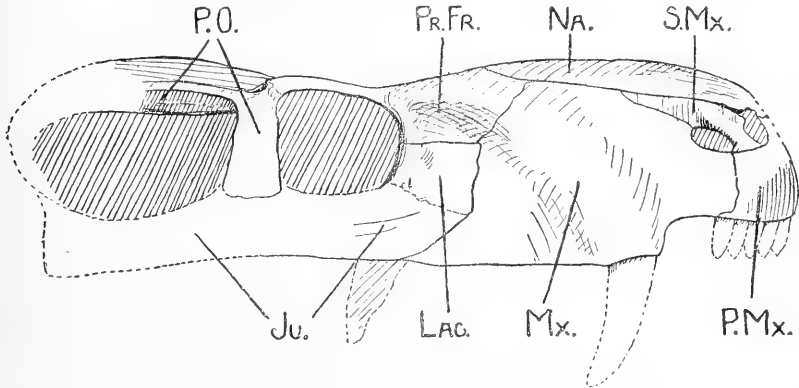
FR., frontal; I.PAR., interparietal; PR.FR., prefrontal; P.O., postorbital;
Pt.FR., postfrontal; S.Mx., septomaxilla; S.Oc., supraoccipital.

The skull of *Gorgonops* has a flat dorsal surface, which passes through a chamfered corner into the nearly vertical sides of the snout. The orbit is large, directed almost entirely laterally and of considerable depth. Immediately in front of it the snout is

nearly square in section, the lachrymal region being excavated into shallow hollows overhung by a thickening of the prefrontal, which forms the lateral border of the flat dorsal surface. Further forward the snout becomes deeper, the nearly flat lateral surface passing by a rounded corner into the dorsal surface. There is a long broad swelling on the maxilla over the root of the canine.

The interorbital and parietal regions are both very broad, the latter passing smoothly into the broad occipital surface. The part of the occiput preserved consists mainly of the very broad interparietal, whose sutures with the tabulars are shown. The supraoccipital has only a very shallow exposure below the interparietal. A peculiar feature of this skull is the irregular shape of the pineal foramen and the fact that that opening is raised on a little column standing up above the general level of the parietal region.

Text-figure 5.

*Gorgonops torvus* Owen. Type-specimen.

Right lateral aspect. $\times \frac{2}{3}$. Parts in broken lines restored without evidence.

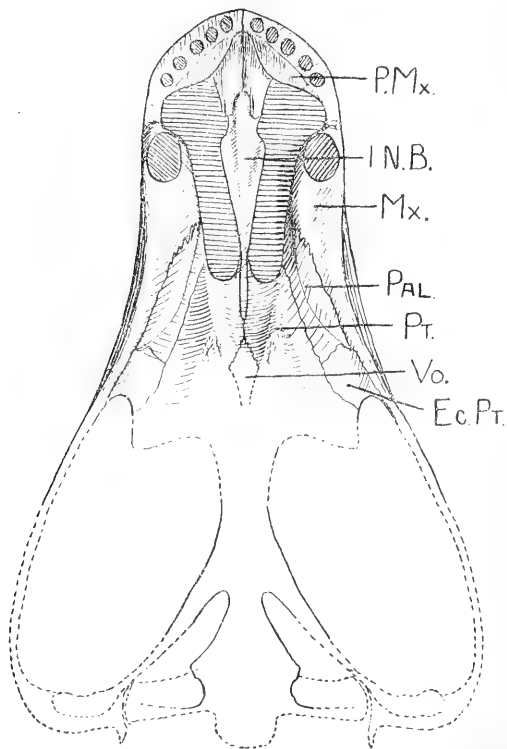
Ju., jugal; LAC., lachrymal; Mx., maxilla; P.Mx., premaxilla.

The general structure of the dorsal and lateral surfaces will be best understood from text-figs. 4 & 5. The cruciform shape of the pair of frontals is noticeable.

The structure of the external nostril is very well shown in the specimen. The dentigerous part of the premaxilla is deep, and articulates directly with the anterior end of the maxilla, which overlaps on to it. The dorsal surface of the two bones is the lower margin of the nostril and forms the emplacement of the septomaxilla. Behind the nostril the maxilla rises to a long suture with the facial part of the septomaxilla; behind this bone it reaches the nasal. The nasals form a slightly covered roof to the olfactory chamber and reach forward almost to the end of the nose, where they terminate in a nearly straight margin, from the middle of which arises the narrow process which articulates with

the facial processes of the premaxilla. The facial part of the septomaxilla articulates with the lower margin of the nasal, but the two bones separate before the nasal terminates, so as to leave that bone overhanging the nostril like the eaves of a roof. After its separation from the nasal the septomaxilla passes downwards and gives off a process from its anterior border, which passes inwards towards the middle line, following the curve of the

Text-figure 6.



Gorgonops torvus Owen. Type-specimen.

Palatal aspect. $\times \frac{2}{3}$. Unshaded areas surrounded by continuous lines present but mutilated, broken lines parts restored without evidence.

P.V.?, internarial bar, ? prevomers; P.A.L., palatine; V.o., "vomer."

anterior border of the nasal. The lower part of the septomaxilla is a rounded column, swelling out to a base which rests on the premaxilla.

I have already (1912) given an account of the general features of the palate of *Gorgonops*, but, as further study of the specimen in the light of other material has enabled me to make out some

interesting features not previously recorded, I give here a more detailed description. The premaxilla has a narrow dentigerous surface, with five sockets for the roots of the incisors; above the border the bone thickens, forming a deep wall, from whose admedian half the palatine process arises; this is at first a flat expansion, but soon becomes a rounded, backwardly directed tubercle, separated from its fellow and resting in a groove on the lower surface of the "prevomer." The internarial bar is a narrow rod which anteriorly is comparatively wide. Anteriorly its palatal surface bears a median ridge which separates two channels bounded by other lower ridges, which form the lateral borders of the bone. Further back the lower surface of the bar becomes flat, and the whole of the posterior part is only represented by a broken surface, which probably originally supported a deep median ridge.

The internal nares are very large openings bounded by the premaxilla in front, where they are very wide, and contracted posteriorly by the thickening of the maxillæ necessitated by the large sockets for the canines. The maxillæ form their outer borders for some distance and are then excluded by the palatines. Finally, the posterior border is formed by the semi-circular margin of a bone whose nature has to be discussed. Between the internal nares and the pterygo-parasphenoidal bar the palate forms a large area of complicated shape. The height above the lower margin of the premaxilla at which the palatal processes start, and the deep step in the lower border of the maxilla just in front of the canine make the ventral surface of the internarial bar lie much dorsal to the lower edges of the maxillæ in the cheek-region. Thus at the back of the nares the palate is very much vaulted. Behind the canine the palatal exposure of the maxilla, which bears no trace of cheek-teeth, is very broad and its admesial surface forms a deep vertical plate. This surface when followed caudally passes into a similar face carried by the palatine, which stands almost vertically, tightly attached to the maxilla by an obvious and deeply interdigitated suture, and with its lower edge forming with that bone a broad flat face in the area where cheek-teeth would naturally be expected. These teeth must have been functionally replaced by a hard gum, possibly cornified so as to form a crushing plate.

The wide groove formed by the palate at the posterior end of the internal nares is rapidly divided into three, each groove of the lateral pair is deep and narrow and cylindrical; it shallows rapidly when traced backwards, finally becoming flat when it reaches the ectopterygoid. The bottom of the lateral groove has a suture running the whole of its length, which is completely exposed on the right side, but concealed by matrix except for its anterior end on the left side of the type-skull. This suture, which seems to be truly a suture and not a crack, unites the palatine with the pterygoid, which bone hence forms the posterior margin of the posterior nares,

The middle groove of this part of the palate becomes narrower as it is traced backward, but remains deep. Its hinder end is separated from the lateral grooves by triangular raised areas, which are roughened, but seem not to bear teeth.

The internarial bar is continued back into this part of the palate as a narrow slip separated from the pterygoids by a pair of open and very obvious sutures. These sutures rapidly approach and fuse, being continued backwards by an obvious median suture for about 5 mm. This open suture, with a visible strip of matrix in it, then suddenly ends and is with certainty not continued backward in the middle line. It is, however, apparently replaced by a pair of much less obvious sutures, between an overlapping median bone and the pterygoids, which pass outward to the margins of the median groove and seem then to be continued backward by still less obvious sutures running along these borders. Further back the wide, essentially flat palate gives origin to the descending flanges. The ectopterygoids are separated by obvious sutures and are comparatively small bones not taking any large part in the flange.

The palate of *Gorgonops* thus seems to show large pterygoids reaching forward to the posterior nares and widely separating the palatines, which are small bones simply continuing the ectopterygoids forward. In that part of the palate which lies in front of the transverse flanges the pterygoids do meet each other for a very small distance in the middle of their length, but posteriorly are separated by a median vomer and anteriorly by the posterior end of the internarial bar which is clasped between their distal ends. There is no evidence to show whether or not these two median bones are really separated, but as the anterior passes dorsal to the pterygoids, whilst the other overlaps their ventral surface, there is great probability that they do not represent parts of the same element.

SCYMNIGNATHUS WHAITSI Broom, Proc. Zool. Soc. 1912, p. 861.

Type: a figured skull, nearly complete, but considerably crushed and showing little of the structure. Other imperfect skulls and other bones.

The individual of which, under the name of *Scymnognathus whaitsi*, I described the lower jaw (1912) and the brain-case and occiput (1914), does not belong to this species, and is described in this paper as a new genus and species. There are in the British Museum three specimens of *S. whaitsi*:—R. 4053 collected by the Rev. J. H. Whaits, as a very large number of small fragments which, fitted together, form a skull from the front of the orbits backwards with the pro-atlas and atlas in position, the anterior end of the snout and a mass of separate fragments representing the major part of the face; of these a small bit of the posterior part of the palate is of great morphological interest. The back of the skull built up from these remains is quite undistorted and has been very completely developed, now showing

the whole lateral surface of the brain-case, the structure of the zygomatic arches and roof of the skull and occiput with great perfection. It is in many ways the best Gorgonopsid skull known.

R. 4052. A skull retaining a well-preserved and only slightly sheared snout, with a much crushed posterior part, permitting the definite identification of R. 4053.

49369. A snout, somewhat distorted and not very well preserved which has been cut into slabs. It agrees well with the corresponding part of R. 4052.

All the material of *Scymnognathus whaitsi* comes from the *Endothiodon*-zone of Beaufort West. The skull, as a whole, is remarkable for the marked distinction between the relatively narrow snout and palate and the wide postorbital region. Owing to this shape, the orbits look as much forward as outward. The temporal fossæ are very large and face more upwards than outwards. The parietal region is, in consequence, narrow and the occiput deeply cupped, owing to the backward swing of the squamosals from their union with the postorbitals.

The snout is much more rounded than in *Gorgonops* or *Arctops*, although towards the orbits it is still somewhat "square-cut." The external nares closely resemble those of *Gorgonops*, and there is the same step between the lower edges of the premaxilla and maxilla.

The structure of the dorsal and lateral surfaces of the skull are obvious from text-figs. 7 & 8, but it is necessary to give some account of the brain-case and palate.

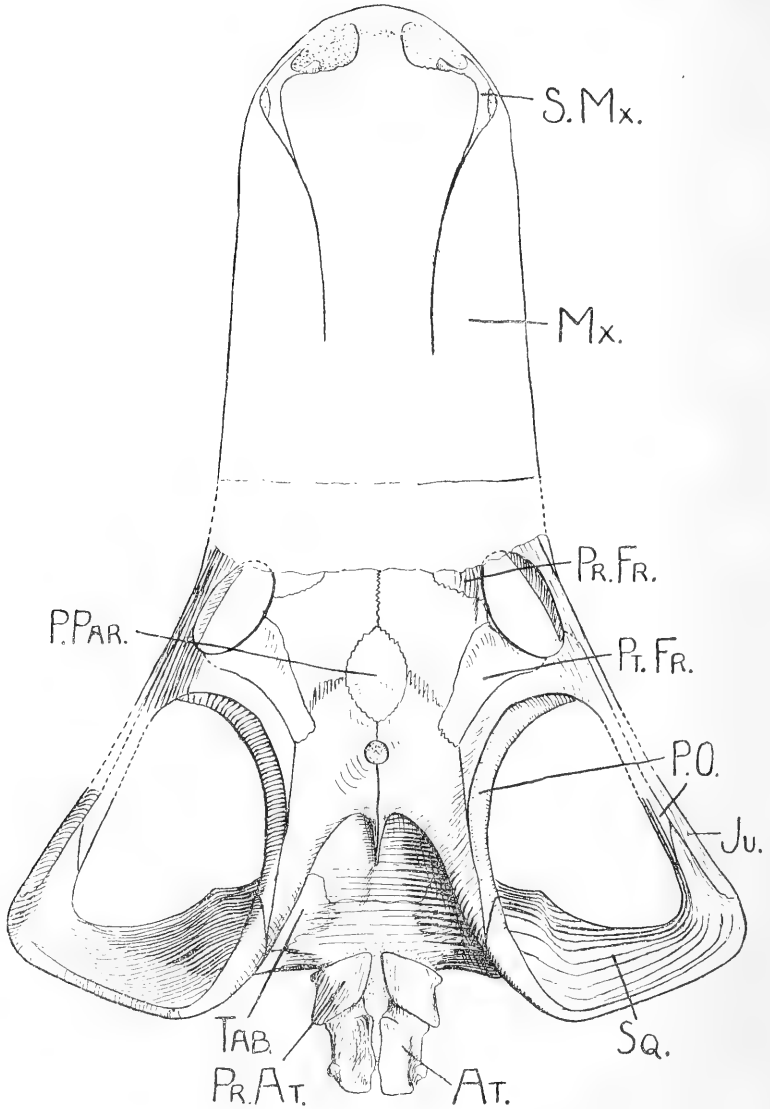
The basioccipital is fused with the exoccipital and paroccipital, and its suture with the basisphenoid has been destroyed by a fracture. It is a long narrow bone, terminating behind in a single condyle, which is probably partly exoccipital. This condyle, as seen in section, is much wider than it is high, the dorsal surface being excavated by the lower part of the foramen magnum. The posterior part of the basioccipital is thus thin.

The exoccipitals are of the ordinary Gorgonopsid or Pelycosaur pattern, but their upper surfaces are concealed by the overlapping elements of the proAtlas. Further forward the lower surface of the basioccipital and of the paroccipital fused with it project down as a short, powerful, obscurely bilobed process, whose outer part supports the fenestra ovalis; with this process the powerful tuber basisphenoidalis articulates dorsally, though ventrally the two projections are separated by a gap.

The paroccipital and pro-otic are fused, not only with each other, but also with the basioccipital; the suture between the pro-otic and the basisphenoid remains open.

The paroccipital process is extremely massive, passing out from the side of the basioccipital on the lower surface of the skull to its broad abutment on the squamosal. The anterior and lower faces of this process are excavated by a groove which leads inward to the large irregular opening, which is the fenestra ovalis. The

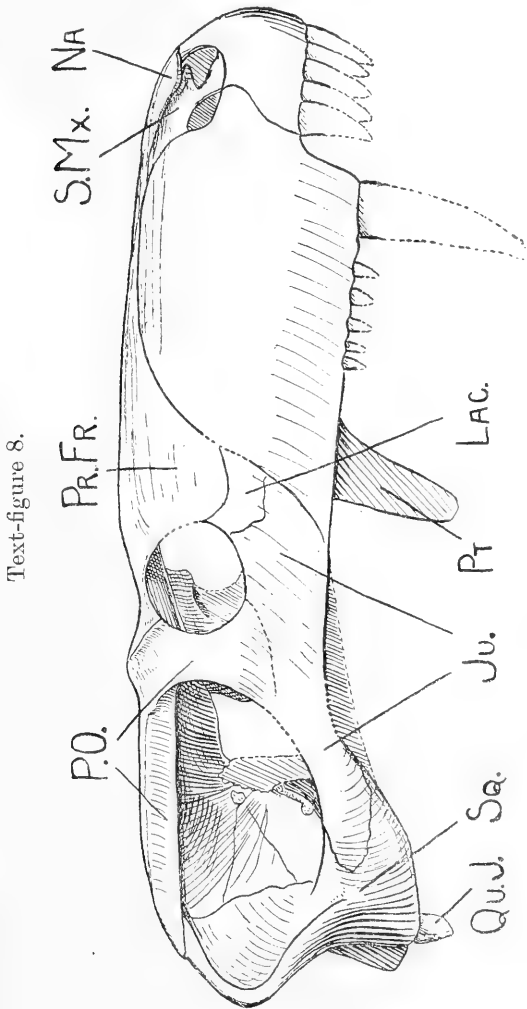
Text-figure 7.



Scymnognathus whaitsi Broom. Back from R. 4053. Snout from R. 4052.
B.M.N.H. Dorsal aspect. $\times \frac{5}{9}$.

AT., atlantal neural arch; JU., Jugal; P.PAR., preparietal; PR.AT., pro-atlas.

paroccipital process is bounded above by the small oval post-temporal fossa, which lies at the level of the floor of the foramen magnum.



Scymnognathus whititsi Broom. Back to front of orbit from R. 4053. Snout from 4052.

Right lateral aspect of skull. $\times \frac{1}{5}$.

NA., nasal; Qu.J., quadratojugal.

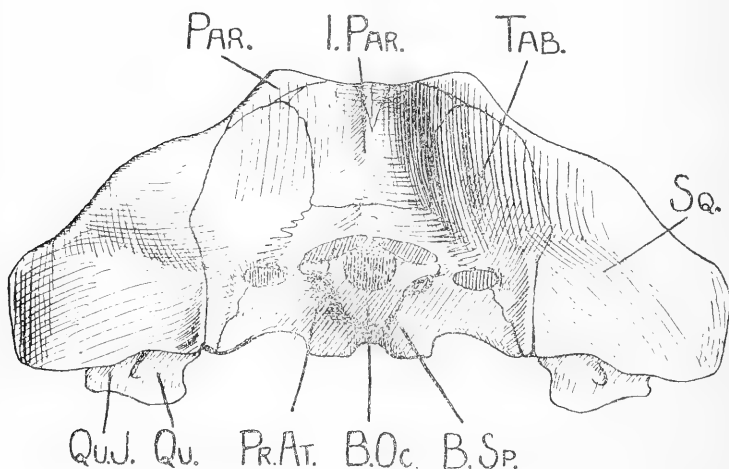
In the pro-otic on its front face, above, and in front of the fenestra lies the outer opening of the foramen for the facial nerve. This opens downwards and has below it a little hollow for the geniculate ganglion.

Immediately above and a little in front of the facial is another much larger foramen opening directly forward; its outer margin

is carried by a spout-like projection from the pro-otic, its inner border is basisphenoid. That bone immediately in advance of the foramen has a deep depressed groove. There can be no doubt that this foramen is for the fifth nerve, the cavity before it having housed the Gasserian ganglion. Above and in front of this foramen the pro-otic is continued forward, having a suture with the basisphenoid, until its anterior margin or that of the indistinguishably fused supraoccipital is cut into by a notch, which is very nearly converted into a foramen by the basisphenoid. This foramen must be venous; it is in part the homologue of one which is almost constantly represented in Therapsids.

The supraoccipital is as always spread out into a wide plate, but from the anterior part of this expansion a special thickening

Text-figure 9.



Scymnognathus whaitsi Broom. R. 4053. B.M.N.H.

Occipital aspect of skull, with the anterior ends of the proatlas attached. $\times \frac{1}{2}$.

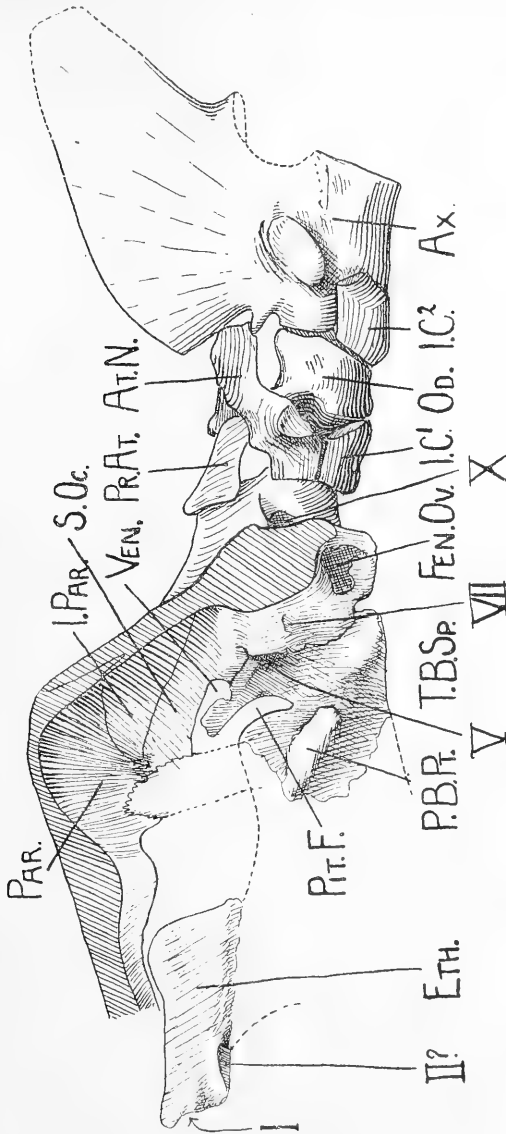
PAR., parietal; QU., quadrate; T.B.SP., tuber basi-sphenoidalis.

is carried forward, forming the roof and part of the side-wall of the brain-case. It is this thickening whose margin forms the dorsal border of the venous notch. With the sides of the upper part of the supraoccipital in the region of this thickening the interparietal articulates, stretching far forward in contact with the parietal above and the supraoccipital below, and widely exposed in the outside view of the brain-case.

The basisphenoid is a remarkable bone, which in the specimen is broken off in front. As far as it is preserved, however, it consists of a body which is articulated with the front of the basioccipital largely through the intermediary of the two

massive downward projections, which are its tubera. Above this articulation the bone becomes narrower where it is attached to the

Text-figure 10.



Scymnognathus whaitsi Broom. Axis from R. Atlas and skull from R. 4053. $\times \frac{2}{3}$.
 Left lateral aspect of the brain-case as seen when the left side of the skull is removed by a parasagittal cut just medial of the post-temporal fossa, with the atlas and axis in position.
 Reference letters as before, with:—A. I. N., atlantal neural arch; A. X., axis; E. P. R., epipterygoid; E. T. H., "ethmoid." = orbito-sphenoid; F. E. N. O. V., fenestra ovalis; I. C., 1st and 2nd intercentra; O. D., odontoid; V., VII., X., X₁ foramina for the exit of those nerves.

pro-otic. Its lateral face here bears the groove for the Gasserian ganglion, above which the bone again widens to the continuation
 PROC. ZOOL. SOC.—1921, No. IV. 4

of its suture with the pro-otic. Above and in front of the termination of this suture the basisphenoid is still continued upward as a slender process, whose upper margin is the lower border of the great venous notch and whose lower margin meets its fellow in an open median suture below the brain, immediately in advance of the hypophysis. The rostral part of the basisphenoid is a vertically placed plate arising from the body of the bone and separated from the upper parts, just described, by a deep narrow notch, the open side of the pituitary fossa. From its sides arises the thick flat expansions, which are the basi-ptyergoid processes. These incline downwards at the back at an angle of about 45° , and whilst their dorsal surface is sharply separated from the vertical face of the medial lamina, which lies above them, their ventral faces pass smoothly down to form a blunt ridge on the lower surface of this part of the basisphenoid.

The parietal is composed of a plate of bone lying on the roof of the skull with an almost plane dorsal surface. Its postero-lateral corner is drawn out into a long process, which passes backwards to touch the extreme tip of the squamosal. The posterior edge of the whole bone is in contact with the interparietal towards the middle line and with the tabular laterally. By far the greater part of the outer margin of the parietal is in contact with the postorbital, which completely excludes it from participation in the margin of the temporal fossa. From the lower surface of the parietal a powerful ridge is developed, which marks the side-wall of the brain-case. Posteriorly this ridge just touches the anterior end of the supraoccipital. Immediately in front of this bone it has a suture with the epiptyergoid; further forward its lower edge is free, but gradually declines, until at or about the front end of the parietal it vanishes. The lower surfaces of the pre-parietal and frontals form the roof of the brain-case in this region, and the lower surface of the anterior part of the brain is supported by an ethmoid ossification. This is a thin hemicylindrical shell of bone with a rib along its ventral surface in the middle, which indicates that it rested on a deep median septum now broken away and lost.

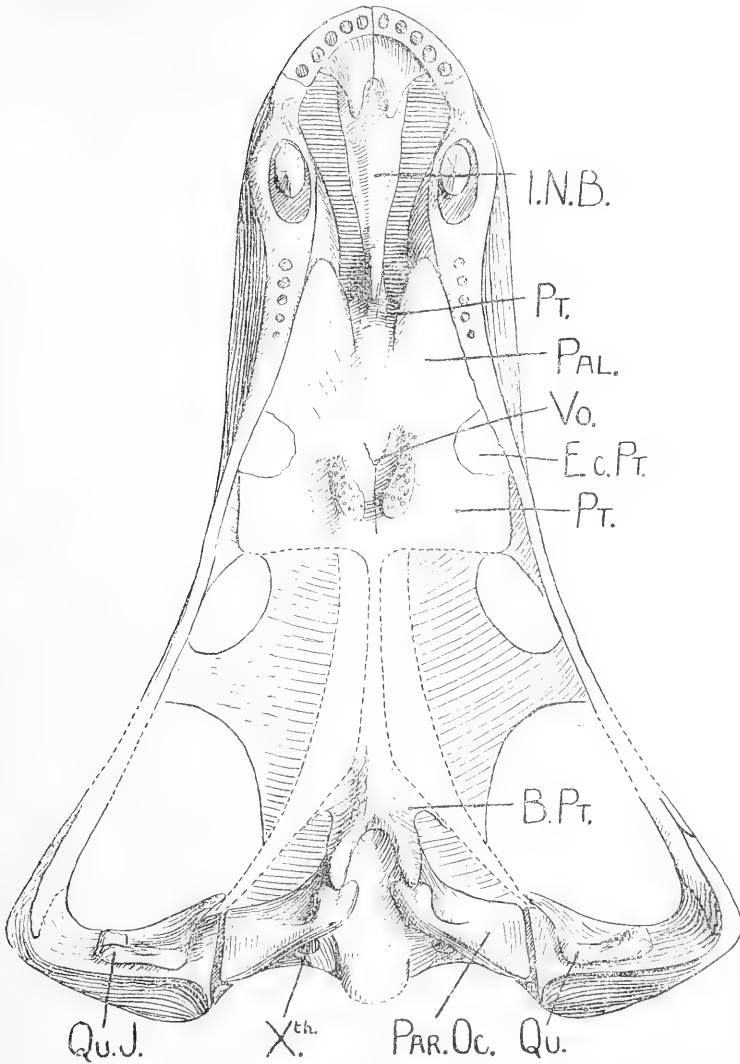
The posterior end of the ethmoidal cavity is widely open. The opening of the anterior end is much contracted and lies close up to the skull-roof.

The floor of the cavity close to its anterior end is perforated by a pair of large oval foramina, which face downward. These are separated only by a narrow septum and must be for the optic nerves, which hence had a remarkably long intracranial course.

The epiptyergoid is only represented by its upper end, which, though narrow antero-posteriorly, is thin. It has a suture with the parietal and with the front end of the supraoccipital, the latter connection being of considerable morphogenetic importance.

There is a medium-sized foramen for the Xth nerve, opening downwards and backwards below the exoccipital well above the

Text-figure 11.



Scymnognathus whaitsi Broom.

Posterior part from R. 4053. Snout reconstructed from a series of transverse sections of 49369 completed from R. 4052. Ectopterygoid region + detached area including the vomer R. 4053. $\times \frac{1}{6}$. B.P.T., basipterygoid process.

bottom of the skull. There is a single hypoglossal foramen in the usual position.

Taken as a whole, it is obvious that the brain-cavity was very small in relation to the skull, and especially that the cerebral hemispheres were still of much less bulk than the cerebellum. At the same time the very great proportional length of that part of the brain which lies in front of the fifth nerve foreshadows the great cerebral development which occurred in later allied forms.

The palate of *Scymnogathus whaitsi* is still not known as a whole, but the anterior part is very well shown in the sections of 49369, from a reconstruction made from which text-fig. 10 is mainly drawn, and in the solid in R. 4052. The pterygoidal flange and one transverse bone are preserved in position in R. 4053, and that individual retains a small fragment from the middle of the palate just in front of the anterior end of the long pterygo-parasphenoid bar. This fragment shows a pair of much raised ridges, which lie on the pterygoids and diverge outwards as they are traced forward. These are covered with a shagreen of small teeth. Between these the palate is deeply grooved; lateral to them it is depressed into deep hollows. The dorsal surface of the fragment bears a deep median keel. This fragment has been cut across by a transverse cut, so that it now shows three sections. That at the back shows that the keel is formed by a single bone whose lower edge is received into a groove on the upper surface of the fused pterygoids, which meet below it. In the middle section this median bone has a deeply grooved lower edge, the two thin ridges which form the side-walls of this groove being received in slits in the pterygoids. These latter bones meet in a median suture on the palate and here bear the massive tooth-bearing ridges. On the front section the median bone is exposed on the palate, forming the roof of the median groove and separating the pterygoids. The median bone thus corresponds exactly in position and relations with the posterior median bone in *Gorgonops* and the back of the vomer in *Diademodon*. The anterior part of the palate resembles that of *Gorgonops* in the relation of the internarial bar to the palatine process of the premaxillæ and in its shape.

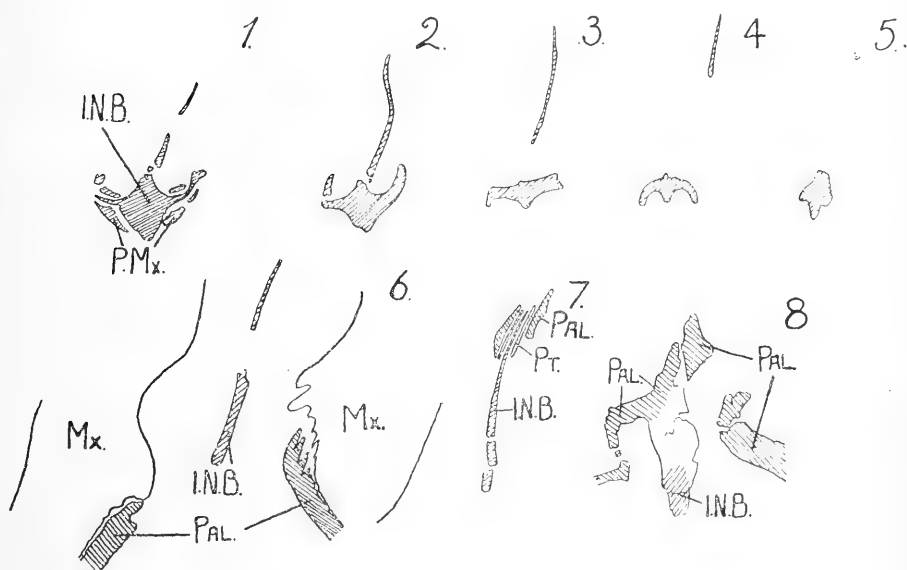
Near its anterior end the internarial bar is a single bone with a convex dorsal surface from which a ridge rises. This ridge, which is detached, apparently by fracture, extends upwards and backwards, obviously representing an ossification in the nasal septum. The lower surface has a low median ridge separating two well-defined grooves. As this bone is traced backward it gradually becomes narrower from side to side until in the region of the first molar tooth, where it is seen in section (text-fig. 12), it has become converted into a plate 35 mm. in depth and only two millimetres thick at the lower edge, where it is widest. The dorsal centimetre of this narrow septum is clasped between two

thin films of bone, whose outer surfaces are in contact with another pair of similar slender processes. Even in this region the lower edge of the median bone still lies considerably dorsal of the tooth-bearing margin of the maxilla.

In the next section, about 1 cm. further back, the median plate is shallower, its dorsal margin being curved downwards. The two pairs of plates which support its upper edge are thicker, but still retain their same relations.

The next slab has fortunately been split longitudinally and somewhat developed, so that it gives conclusive evidence that the lateral pair of processes described above are part of the

Text-figure 12.

*Scymnognathus whaitsi* Broom.

Series of transverse sections at about 1 cm. interval, across the snout of No. 49369. B.M.N.H. 1, anterior section; I.N.B., internarial bar; in 2-5 only the internarial bar is represented; in 6 the maxillæ and palatines are shown; in 7 only the anterior ends of the palatines and pterygoids. $\times \frac{1}{3}$.

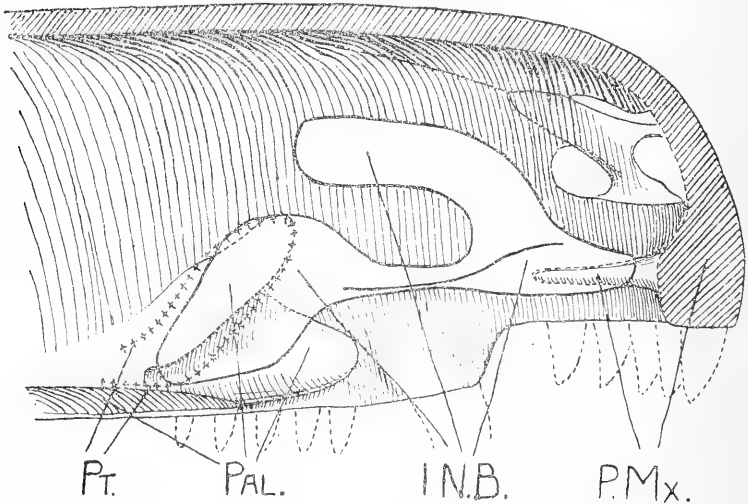
palatines. The inner pair pass down to the ventral surface and there form a little boss on the palate, which separates the two deep grooves on the palates. These grooves are so overhung by the more ventral parts of the palatines that their floor can scarcely be seen in a direct ventral projection. No sutures can

be seen in the little median boss, and it is probable that the median element of the internarial bar has terminated in it.

The vertically standing part of the palatine, which forms the side-wall of the groove just described, descends to the level of the lower border of the maxilla, where it passes into a flat, thick, horizontally lying plate, which extends outward to the lower edge of the maxilla with which it has a suture.

This horizontal part of the palatine forms the greater part of that bone, and extends backward and forward in contact with the maxilla, until by narrowing and increasing in depth it becomes converted into a mainly vertically disposed plate, which forms part of the side-wall of the posterior part of the very large internal nares. It then terminates.

Text-figure 13.



Scymnognathus whaitsi Broom.

Reconstruction of internal aspect of the left side of the snout cut through in the middle line. Internarial bar and ossification in the nasal septum unshaded and surrounded by a thick continuous line; anterior end of the pterygoid represented by a line of small crosses. Parts of palatine seen through other bones in broken line. Reconstructed from the sections of 49369, checked by R. 4052. $\times \frac{2}{3}$.

Thus the anterior part of the palate is essentially a flat plate of bone, whose middle part is cut out by a narrow but gradually widening groove which plunges steeply downward to the deeply sunk posterior margin of the posterior nares. This groove is divided into two by a narrow vertical septum, which descends nearly to the level of the general plane of the palate.

There can be little doubt, especially when the conditions in *Arctops* and *Gorgonops* are considered, that the inner pair of processes which support the internarial bar are the anterior ends of the pterygoids. It remains to be shown by other material whether the median internarial bone and the median vomer in the back of the palate are parts of the same bone or are, as is more probable, separated.

The strange way in which the median internarial bar rises as a thin but very deep septum from the much sunk posterior nares, nearly to the general level of the palate, seems to be only explicable if its ventral border supported the middle of a small soft secondary palate stretched between the maxilla and the palatines.

I have already described the mode of articulation of the squamosal with the brain-case and with the fused quadrate and quadrato-jugal in Proc. Zool. Soc. 1914, p. 1034, fig. 6.

The squamosal above the level of the post-temporal fossa bows out backward, so as largely to increase the size of the dorsal opening of the temporal fossa. It thus makes the occiput very deeply cupped, the interparietal region being narrowed and the outer part of the tabular running nearly antero-posteriorly.

At the extreme postero-lateral corner of the skull, the squamosal turns sharply into a process passing forward and inward in the zygomatic arch. This process is clasped by other bones both admesially and externally. One of these bones is the jugal. The other conceivably also jugal, but much more probably postorbital. A gap about 2 cm. long in both sides of the specimen prevents a definite decision on this point.

The squamosal at the corner is made of a very peculiar, extremely dense, though finely cancellous bone. This structure is found in this region in all Theriodonts I have examined.

LEPTOTRACHELUS EUPACHYGNATHUS, gen. et sp. nov.

Type: a skull and lower jaw, described in error as *Seymno-gnathus whaitsi* by the writer (Ann. & Mag. Nat. Hist. ser. 8, vol. x. p. 578, fig. 3, and Proc. Zool. Soc. 1914, pp. 1027, 1032, figs. 3, 4, & 5).

The material is a largely disarticulated skull varying in preservation, with one complete and one partially disarticulated ramus of the lower jaw. The skull is represented by the brain-case, interorbital region, left nasal, lachrymal, prefrontal, jugal, and squamosal in natural articulation, the right jugal, lachrymal, and prefrontal in natural articulation, but separated from the skull, an isolated maxilla, and quadrate and quadrato-jugal.

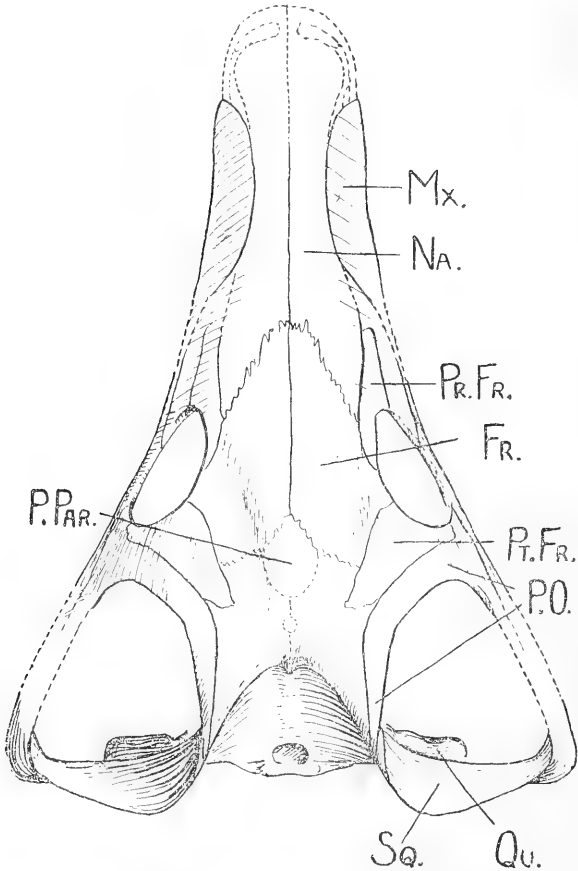
The mode of articulation of the quadrate with the squamosal is clear, and with the perfect lower jaw gives the length of the skull and the position of the maxilla. The large articulated part of the skull gives practically all the dorsal and the posterior part of the lateral surface directly. The occiput is essentially

completely preserved. All the sutures except those of the parietals with each other and the preparietal are well shown.

In text-fig. 14 it is probable that the anterior part of the snout is made a little too narrow.

I have already described and figured the basicranial and otic regions, the occiput, and the interior of the brain-case.

Text-figure 14.



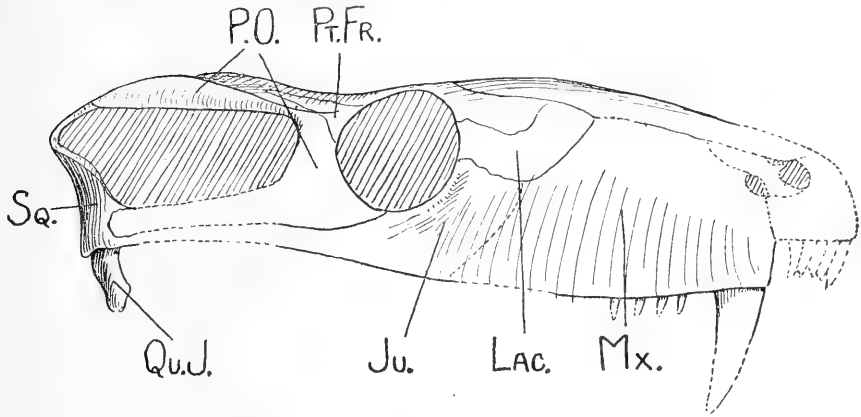
Leptotrachelus eupachygnathus, gen. et sp. nov. Type-skull.

Dorsal aspect. $\times \frac{2}{3}$.

The outside of the brain-case is illustrated in text-fig. 16. The foramen for the VIIth nerve lies just above and in front of the fenestra ovalis, opening downwards through the pro-otic. The

trigeminal "foramen" lies considerably forward and is more dorsal in position. It lies at the end of a long slit and is presumably really only an incision and not a foramen. The length

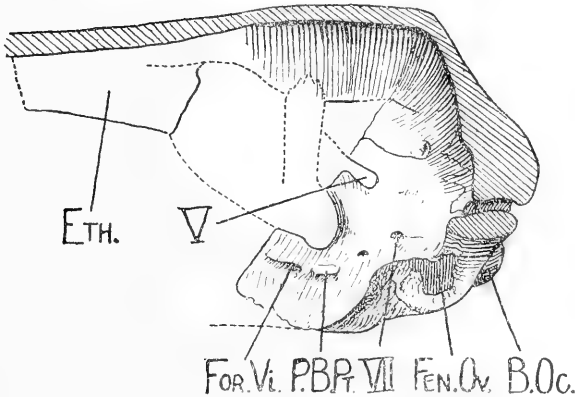
Text-figure 15.



Leptotrachelus eupachygnathus. Type-skull.

Right lateral aspect. $\times \frac{3}{4}$.

Text-figure 16.



Leptotrachelus eupachygnathus. Type-skull.

Left lateral aspect of brain-case, the parts of the skull lateral to the post-temporal fossa being removed as in text-fig. 10.

of the slit is rendered uncertain by the fracture of the anterior end of this part of the brain-case. In the part of the brain-case preserved there is no evidence of the large venous foramen

described above in *Scymnognathus whaitsi*. There is no trace of the great anterior projections of the basisphenoid which in *Scymnognathus* meet in median suture in advance of the pituitary.

There is an ethmoid, which, so far as its very incomplete exposure allows it to be seen, does not differ from that of *Scymnognathus*.

The squamosal of *Leptotrachelus* is remarkable for the great length of its lateral projection and the extreme suddenness of the postero-lateral corner. As in *Scymnognathus* its distal end is received between two bones, here almost certainly the jugal and postorbital.

The cup-shaped depression in the widened lower edge of the squamosal into which the head of the quadrate fits is very narrow, not half the width of the projection of the squamosal.

The quadrate is a relatively large bone about 30 mm. high by 15 mm. wide; it forms a nearly parallel straight-sided figure, the lower edge being a little marked off by a groove and forming the articular surface. The upper end is rounded and fits snugly into the hollow in the squamosal. The quadrato-jugal is fused with the articular margin of the quadrate; it then separates from that bone, leaving a small quadrate foramen, whilst farther dorsally it spreads out into a flat sheet of bone which covers the outer margin of the quadrate and laps over its posterior surface.

When articulated with the squamosal the quadrate and quadrato-jugal are largely visible from behind.

The maxilla of *Leptotrachelus* shows a single canine in use, with traces of the crown of a successional canine high up in the alveolus, and four cheek-teeth; it is possible that there was really a fifth cheek-tooth.

LYCOSAURUS PARDALIS Owen, Cat. Foss. Rept. 1876, p. 15, pl. 14.

The type-skull of *Lycosaurus pardalis* was re-examined and discussed by Broom, Proc. Zool. Soc. 1911-12, p. 1079, who gave it a dental formula: i. 5, c. 2, m. 4.

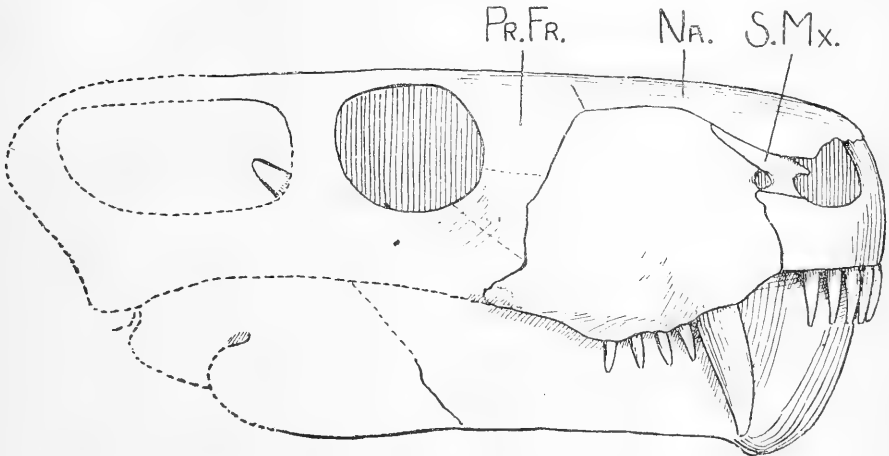
The type-skull (R. 1717, B.M.N.H.) from the *Cistecephalus*-zone (?) of the Suceberg is considerably crushed laterally, but has the anterior end of its snout complete and well-preserved; behind the canine on the left side the outer surface of the skull is complete to the orbit, the whole orbital margin is present and a bit of the edge of the parietal region. The other side is a weathered face which cuts further and further into the skull until it so far crosses the middle line as to expose the admedian surface of the left epipterygoid and completely to remove the brain-case. The squamosals are completely destroyed. The right lower jaw is, however, nearly perfect, having suffered only the loss of the posterior part of the angular so as to expose the articular—the position of the quadrate is thus fixed. The parts of the skull remaining are quite well-preserved and show many sutures.

It is obvious that the snout is short, high, and narrow, with no trace of the square section which occurs in all the *Gorgonopsids* described above.

The tooth-bearing edge of the maxilla is curved and passes gently into that of the premaxilla without the step of *Gorgonops* or *Scymnognathus*. There is, however, a diastema between the closely-set incisors and the canine.

There are clearly 5 incisors, 1 canine, and 4 or possibly 5 molar teeth. The small canine recorded by Broom immediately in front of the large one does not exist on the well-preserved left side, and his views seem to have been founded on a small strip of tooth in this position on the right side, which is really an exposed portion of the lower canine. The maxilla is short and deep.

Text-figure 17.

*Lycosaurus pardalis* Owen. Type-skull.

Reconstruction of the right lateral aspect, $\times \frac{2}{3}$. The parts represented in broken lines hypothetically restored.

The external nostril of *Lycosaurus* differs considerably from that of *Gorgonops*. It faces more laterally and is much larger; it is no longer overhung by so large a corner of the nasal, although there is still a trace of the older structure.

The facial part of the septomaxilla is much smaller, and the foramen between that bone and the maxilla is not only smaller but opens more directly outward. The septomaxilla in front of it seems to be rounded and grooved. Finally, the internarial process of the premaxilla is longer and stands more vertically, so that the end of the snout is deeper and less rounded in side-view.

The interorbital region is narrow, the postfrontal being a narrow pointed strip, as in the skull of *Arctognathus curvi-*

mola subsequently described (text-fig. 18). The parietal region is obviously of the Gorgonopsid type and cannot be very wide, although its width cannot be determined with any pretence to accuracy.

ARCTOGNATHUS CURVIMOLA (Owen), Cat. Foss. Rept. 1876, p. 71, pl. 68.

The skull (No. 47339 B.M.N.H.) described by Owen as *Lycosaurus curvimola* was found with *Dicynodon tigriceps* in the *Cistecephalus* beds of the Kagaberg, near Bedford, S. Africa. Its palate was developed by Mr. Hall and described by Prof. Seeley, Phil. Trans. B. 185. The skull was then examined by Dr. Broom, who noted that the parietal region seemed to be broad, and made for it the genus *Arctognathus*.

The actual preservation of this skull is good; but before it was buried the left maxilla and ectopterygoid, together with the bit of lower jaw in their vicinity, were separated from the rest of the head by a nearly plane split, moved outwards for about 15 mm. and there fixed in the sediment. How this very peculiar result was brought about is very difficult to understand, although tentative suggestions might be made.

Whilst lying at the surface the nodule containing the skull was exposed to weathering, which has cut down into it so completely to remove the right squamosal, the parietal region beyond the middle line, and the postorbital bar.

Fracture has removed the occipital condyle and part of the paroccipital process, but has left the stapes and quadrate with the lower jaw in articulation on the right side. Enough of the occiput is left to make the structure clear. The palate is well exposed and very well preserved, the right ramus of the mandible is perfect and well-exposed.

On the dorsal surface of the parietal region the suture between the parietals and the pineal foramen are very well shown on a weathered face, which lies a little below the original dorsal surface; the right side of this region retains its natural surface and shows the structure clearly.

The skull is short, broad, and deep. The snout is rounded in section and terminates in front in the internarial premaxillary processes, which form the extreme front end of the skull overhanging the oral margin.

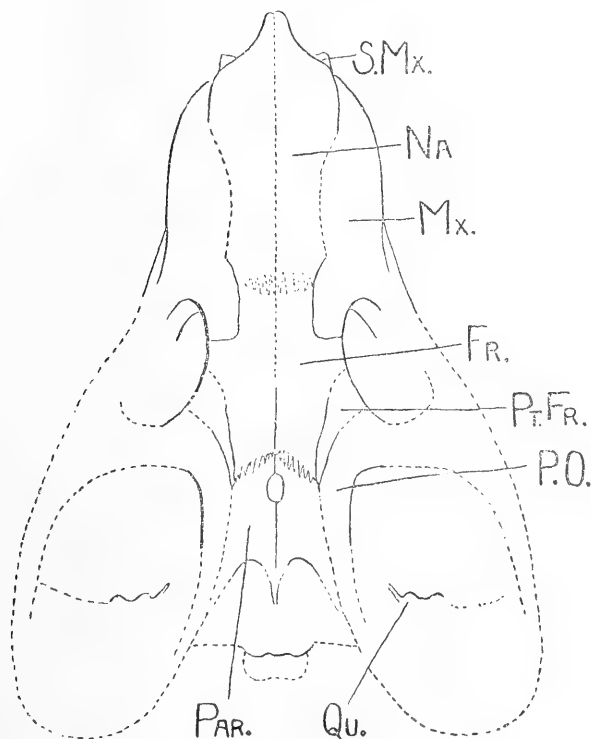
The very large nostril faces largely outward and is not overhung by an outstanding corner of the nasal. The septomaxilla is small, and the foramen between it and the maxilla very small.

The interorbital width is considerable, but the orbits look upward and forward as largely as outward. The frontal does enter into the orbital margin, but only through a short distance. The postfrontal is a narrow strip of bone wedged in between the frontal and the postorbital.

No trace of a preparietal is to be seen on the parts preserved,

the median suture is clearly shown from the front of the pineal foramen to a point between the frontals, and the well-marked suture between the frontal and parietal passes very little in advance of the pineal opening. These sutures are, however, exposed at a plane below the original dorsal surface, and there is a remote possibility which cannot, although very improbable, be entirely excluded, that the preparietal was represented by a

Text-figure 18.

*Arctognathus curvicolis* Owen. Type-skull.

Restoration of the dorsal aspect, the parts in broken lines being hypothetically restored.

minute scale of bone lying on the dorsal surface. The parietal region is about as wide as the interorbital.

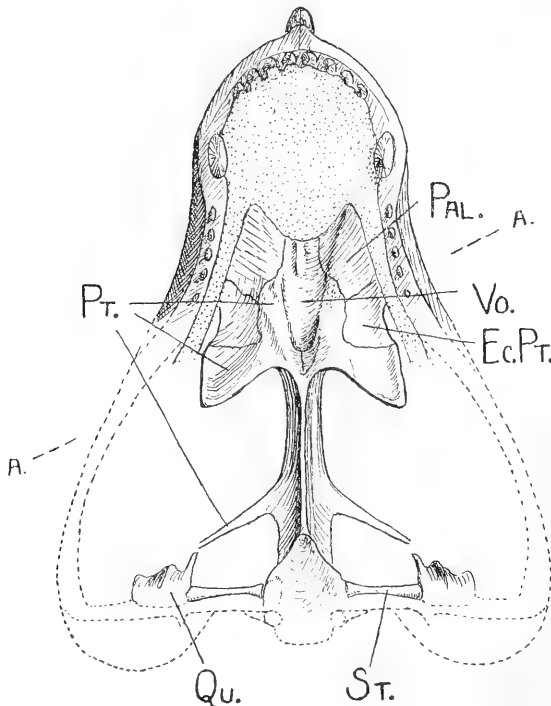
The maxilla is short and deep, its tooth-bearing margin is much curved and passes smoothly with no trace of a step into that of the premaxilla. The canines appear not to be completely erupted, and the four small cheek-teeth are also not very firmly

planted. The four incisors, though powerful, are not so disproportionately large as they are in earlier Gorgonopsids.

The palate of *Arctognathus* is very well-preserved, but its anterior end and two strips along the maxillæ are concealed by unremoved matrix and by the lower jaw.

The basioccipital is broken off through the vagal foramen, where it is thin and not very wide. The posterior part of the

Text-figure 19.



Arctognathus curvimola (Owen). Type-skull.

The palate, $\times \frac{3}{2}$. Stippled area covered by matrix and the lower jaw.

Parts in dotted lines hypothetical.

A.....A, direction of the section of "*Lycosaurus tigrinus*," text-fig. 20.

St., stapes.

basisphenoid forms a triangular area with raised lateral margins, representing the tubera of earlier forms. Above the edges the sides of the bone are flat and vertical, posteriorly they terminate in the region of the fenestræ ovales, these openings being concealed by the foot of the stapes. Anteriorly these vertical sides of the basisphenoid approach together until they are only

separated by a narrow ridge which runs forward to the palate proper. From the vertical sides of the basisphenoid horizontal processes arise; these basiptyergoid processes support the pterygoids. From their articulation with the basisphenoids the pterygoids pass backward towards the quadrates, but do not articulate with those bones, as they appear to terminate in free points before reaching them. The pterygoids pass forward, forming with the median ridge which continues the basisphenoid a bar whose ventral surface is almost cylindrical, broken only by the median fillet. At the hinder end of the palate the pterygoids suddenly widen, forming very deep powerful flanges. This part of the bone has a transverse suture with the ectopterygoid. Medially the two pterygoids meet in a visible suture which lies at the bottom of a small depression. This suture soon terminates at the brim of a much deeper and more sharply-marked hollow, which, as it passes forward, widens and is converted into a deep open groove forming anteriorly the whole roof of the much vaulted palate. Throughout its extent this groove has well-marked, indeed often vertical, sides. Anteriorly this groove is divided into two by a ridge which rises from its surface. At about the level of the last maxillary tooth this groove is bounded by roughened areas of bone, which appear to have borne teeth. These areas are undoubtedly on the pterygoids and are separated by visible sutures from the palatines, which lie laterally to the pterygoids in front of the ectopterygoids. Further forward these sutures, which form the inner border of the palatines, approach one another and descend into the groove, so that its side-walls are in front formed by the palatine. The ectopterygoids are separated from the palatines by visible sutures.

There is no trace of a suture down the mid-line of the groove, and its roof seems to be formed by a median bone, which terminates at the sudden end of the groove and must be bounded by sutures with the pterygoids along its edges; of these presumed sutures nothing can be seen in this specimen.

The type-specimen of *Lycosaurus tigrinus* Owen seems to throw light on the structure of the palate of *Arctognathus curvimola*.

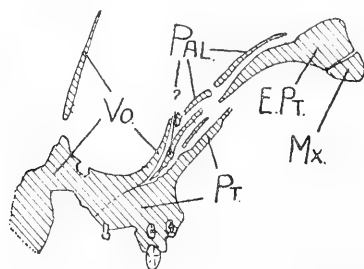
It consists of a fragment of a snout, broken off through the premaxillæ in front and by an oblique fracture on the left side, but showing much of the right maxilla. It has been so developed as to show a small strip of the surface of the right palatine and shows a section of the palate on the hinder end. This species is referred by Broom to a new genus *Arctosuchus*, and said to have a dental formula, i. 5, c. 1, m. 4 or 5, representing a much more primitive type of Theriodont than *Arctognathus*. The type-specimen only shows two incisors, a canine, and a few cheek-teeth, and it seems certain that Broom examined and used for his description a snout of *Scymnognathus whaitsi* which Lydekker had referred to *L. tigrinus*.

Except in the larger size and somewhat different direction of its canine, the type-specimen of *L. tigrinus* seems to agree

exactly in size and every point which can be compared with *A. curvimola*. The section of the palate shown on its posterior fracture is represented in text-fig. 20.

There is a median element bearing a high dorsal ridge, now detached, with a very deep groove on its mid-ventral surface and carried out laterally in a long wing, which is overlapped by the pterygoid. This bone bears a powerful irregular roughened projection carrying small teeth: laterally its surface is smooth, and is continued to the hinder end of the maxilla by that of the ectopterygoid. The two bones scarcely meet, but are joined together by a thin film of bone, undoubtedly the palatine, which covers their dorsal surfaces.

Text-figure 20.



Arctognathus. Type-specimen of *Lycosaurus tigrinus* Owen. $\times \frac{2}{3}$.

Obliquely transverse section as a plane corresponding to A.....A in text-fig. 19.

If this section be compared with that which the palate of *Arctognathus* would present if cut along the line A-A, there can be no doubt of the close affinity—indeed, specific identity—of the two forms, for even the possible measurements are in very close agreement.

Thus we have confirmation for the view that the roof of the median groove in the palate of *Arctognathus* is formed by a median vomer.

The epipterygoid of the type-specimen of *A. curvimola* is shown to meet the parietal in a long suture, exactly as does that of *Diademodon*.

The preceding series of description is based on the more complete and satisfactory remains of Gorgonopsids in the British Museum, largely *Endothiodon*-zone forms. Of recent years Broom and Haughton, either independently or together, have described many complete Gorgonopsid skulls, chiefly from the *Cistecephalus*-zone. They have, however, never given so complete an account of any form as that of *Scymnognathus* included in this paper, and it is seldom that they have given more than one

or, at most, two drawings of any one skull. Thus it is difficult to carry out any detailed discussion of the mutual relations of the known Gorgonopsids.

In order to discuss with any satisfaction the classification of a group, it is necessary to know the main outlines of its history, to understand the direction of the advances which make the structure of all late members of it differ from their ancestors, and to work out any adaptive modifications which characterize its different branches.

It is now generally agreed that the Gorgonopsids include the ancestors of the Cynognathidæ, and that the Pelycosaurs are a group which includes self-contained lateral branches springing from the very base of the stem of the mammal-like Reptiles. Thus by comparing the two extreme terms, *Varanosaurus* and *Diademodon*, we can gain at once a knowledge of the advances in structure which have occurred in the Anomodonts, and on the assumption that these changes have proceeded regularly we can determine the trend of advance during the evolution of the group. Discussion of intermediate forms will then enable us to decide whether this trend really expresses a true view of the mode of evolution, or whether the actual observed differences between the extremes represent the result of a series of fortuitous changes of indeterminate direction.

The work of Broili, of Case, of Williston, and the present writer has led to the view that *Varanosaurus* is the most primitive known Pelycosaur, forming a morphological ancestor to *Dimetrodon*, through a *Deiopeus*-like form. The view that *Diademodon* or *Trirachodon* is the most advanced of known Anomodonts results from the work of Seeley and Broom.

The differences between the skull of *Diademodon* and *Varanosaurus* are:—

In General Shape.

In *Varanosaurus* the snout is very long, square-cut in section, and roomy, compared with the rest of skull, with lateral nostrils and a long straight tooth-row. The large orbits are entirely laterally directed. The small temporal fossa lies entirely on the side of the skull and is almost hidden from above by the very broad parietal region. The occiput slopes forward, but is not deeply cupped. The sides of the skull are nearly straight. The skull is higher than wide.

In *Diademodon* the snout is short, small in volume, rounded in section, with nostrils looking more forward than laterally. The tooth-row is short and curved. The orbit is comparatively small and looks very largely forward. The temporal fossa is very large, lies entirely on the top of the skull, and is not visible from the side, the parietal region being drawn up into a narrow crest. The occiput slopes a little forward and is deeply cupped. The sides of the skull gradually approach one another to the orbits

but their direction is then changed as they form the slender snout. The skull is much wider than high.

In the Brain-case.

[The structure of the anterior face of the pro-otic and supra-occipital is not known in *Varanosaurus* and other regions are not very well shown. The following account of the Pelycosaur is based on *Deiopeus* and *Dimetrodon*.]

In Pelycosaur the basioccipital is thick, ending in a large rounded condyle. The large fenestræ ovales are placed on the bottom of the skull, far out at the side of the deep well-developed tubera. The paroccipital process is short and slender, supporting the squamosal and touching the tabular; it lies well above the lower surface of the skull. The pro-otic is small, its anterior face in no way overhanging the notch for the fifth nerve. The supra-occipital is entirely plate-like, not forming a roof over the brain in advance of the Vth nerve. The basisphenoid is massive, forming a sloping floor to the posterior part of the brain-case. It bears definite *Sphenodon*-like basiptyergoid processes, anteriorly it is in *Varanosaurus* continued forward by a long channel-shaped parasphenoid.

The parietal does not form any part of the side-walls of the brain-case. The eipterygoid is a slender rod of circular section.

The whole brain-cavity is very small in comparison with the size of the skull.

In *Dialemodon*, on the other hand, the basioccipital is small and plays at most a subsidiary part in the pair of occipital condyles. The small fenestræ ovales are placed on the bottom of the skull, not very far separated. Basisphenoidal tubera are represented merely by the edges of the triangular lower face of the basisphenoid. The paroccipital is a long powerful process supporting the squamosal and touched by the tabular; it lies on the lower surface of the skull.

The pro-otic is large, being carried forward by a great process which completely overhangs the trigeminal foramen.

The supraoccipital is produced forwards by two wings, which cover and form side-walls to a great deal of the brain-cavity in advance of the Vth nerve.

The basisphenoid is a small bone forming a nearly horizontal floor to the brain-case. It has small lateral basiptyergoid processes with the pterygoids attached to their flat lower surfaces; anteriorly it is carried forward by a slender process which reaches the palate and there spreads out into a broad vomer in the roof of the posterior part of the naso-pharyngeal ducts.

The parietal forms a good deal of the side-wall of the brain-case. The eipterygoid is a flat plate forming the side-wall of the brain-case for some distance and articulating with the anterior edges of the pro-otic. The brain-cavity is relatively very large.

The ear of a Pelycosaur, so far as can be inferred from the bone which housed it, lies low down on the side of the brain-case,

has small simple semicircular canals, and has a cochlea which leaves no evidence of its existence on the bones. The fenestra rotunda is represented by a notch on the ridge, which in the bony skull separates the vestibular cavity from the vagal foramen, and thus opens inside the brain-cavity. The stapes is always very large and is perforated, the fenestra ovalis being a large irregular hole. There is no groove for the external auditory meatus.

In *Diademodon* the inner ear retains its original position low down on the side of the brain-case and still shows only simple semicircular canals. It has, however, a well-defined cochlea housed in a crypt passing forward and inward, and curved forward through about a quadrant of a circle. The fenestra rotunda is a complete foramen, which opens indeed into the vagal foramen, but does so on the outer surface of the neural cranium, exactly as it does in the young *Ornithorhynchus*.

The stapes, although still of good size, is much smaller than in Pelycosaurs, and the fenestra ovalis is a neat round hole of small size. The external auditory meatus is housed by a deep groove.

The nose of *Diademodon* occupies a smaller space than that of *Dimetrodon*, but the area of its sensory epithelium seems to have been increased by a great development of turbinal cartilage, now only represented by a series of ridges, on the inner surface of the nasals and prefrontals which once supported them. Nothing of the kind occurs in Pelycosaurs.

Many other features in the nose of the Anomodonts can only be discussed in connection with the septomaxilla, palate, etc., and then only in a detailed discussion of individual forms.

The Roof of the Skull.

In *Varanosaurus* the parietals are short, very broad, and with the pineal foramen very far back. Their edges are separated from the temporal fossæ by a union of the postorbital and squamosal. There is a large postfrontal lying on the roof of the skull. The frontal is a large bone always entering into the orbital margin. The prefrontals are large bones, almost equally divided between the dorsal and lateral surfaces of the skull, each bearing a depression on the outer face just in front of the orbit. The nasals are narrow slips of bones. There is a small supratemporal.

In *Diademodon* the parietals are long, very narrow, and with the pineal foramen between their anterior ends. They form the inner margins of the temporal fossæ for a very long way, the squamosal and postorbital being widely separated. There is no postfrontal. The frontal is a small bone, not entering the orbital margin. The prefrontals are small bones on the rounded snout, with no depression in front of the orbit. The nasals are wide, especially posteriorly. There is no supratemporal.

In side-view the skull of *Varanosaurus* shows a long shallow maxilla, completely separated from the nasal by the long lachrymal extending from the orbit to the septomaxilla. There is no very marked specialization of the dentition, all the teeth from the premaxilla backward being similar in form and not very dissimilar in size. The quadrato-jugal is exposed on the side-wall of the skull and the jugal stops considerably before the quadrate.

Diademodon has a short deep maxilla reaching the nasal in a long suture. The lachrymal is a small short bone. The dentition is fully divided into incisor, canine, "premolar," and "molar teeth."

The quadrato-jugal no longer appears on the surface of the skull and the jugal extends back to its extreme hinder end.

The suspensorium of *Varanosaurus* consists of a large quadrate with a definite pterygoid wing, whose posterior surface is covered by the pterygoid. The outer edge of the quadrate is attached to the quadrato-jugal, there being no quadrate foramen. The upper part of the posterior surface of the quadrate is covered by the squamosal, that bone passing so far inwards as to touch the pterygoid.

In *Diademodon* the quadrate is a very small bone, either with or without a pterygoid wing, but in no case articulating with the pterygoid. The outer edge of the quadrate is fused with the quadrato-jugal, from which it is separated only by a small foramen, the articular surface being formed about equally by either bone. The whole posterior surface of the joint bone is covered by the very large squamosal, which extends down to the condylar edge.

The primitive Pelycosaur palate has the following characters:—The pterygoid is a triradiate bone, articulating by a movable facet with the basiptyergoid process, from which point the quadrate ramus rises and runs backward as a vertically placed sheet of bone, passing behind the quadrate. The lateral wing of the pterygoid passes directly outward from the region of the basiptyergoid and terminates in the usual flange.

The anterior part of the pterygoid forms a large part of the essentially flat palatal surface and articulates with the prevomer. It meets its fellow in median suture in *Varanosaurus*. The dorsal surface of the pterygoid is raised into a ridge near the middle line of the skull. In later forms (*Dimetrodon*, e. g.), the ridge is much exaggerated and its median surface passes smoothly into the ventral surface. The palatines are small flat bones. The prevomers are distinct. The anterior end of the palate is not known in any primitive Pelycosaur, but from the conditions in later forms there is no doubt that the posterior nares were small and lay in the general plane of the rest of the palate, which was essentially flat. In such later Pelycosaurs as *Dimetrodon*, owing to the step in the lower edge of the maxilla, the palate is considerably vaulted, and the posterior nares lie above the level of the cheek-teeth.

In *Diademodon* the pterygoid articulates by a rigid suture with

the lower surface of the basipterygoid process, and there is no quadrate ramus, the bone terminating at its attachment. The transverse ramus does not arise from the basipterygoid region, but very much further forward, the posterior part of the bone being a slender strip, which is united with its fellow and the parasphenoid to form a slender bar.

The transverse ramus arises very suddenly from this bar, the bone being drawn downward into deep and very powerful flanges.

There is no anterior ramus, the bone ending in a transverse suture with the palatine at the region where it joins the jugal.

The transverse bone is very small and is not included in the flange at the foot of which it lies.

The palatine is a very large bone, forming a great deal of the posterior part of the palate, then turning downward to form the lateral wall of the posterior part of the nasopharyngeal duct, and, finally, developing a secondary plate, which forms a floor to that passage.

The two palatines are separated by a median vomer, which forms the roof of the nasopharyngeal passage, apparently terminating behind in a pointed slip separating the anterior ends of the pterygoids, but really passing backward to the basisphenoid.

The prevomers seem to have vanished entirely.

The maxillæ send inward secondary plates, which continue those of the palatine forward. The premaxillæ have palatal processes, which pass dorsally to the secondary plates of the maxillæ and touch the anterior end of an ossification in the nasal septum, viz., a mesethmoid.

In *Varanosaurus* the epipterygoid is a slender rod rising vertically from the dorsal surface of the pterygoid just in advance of the basipterygoid articulation.

In *Diademodon* the epipterygoid is a large flat sheet of bone forming a side-wall to the brain-case and articulating by a very long suture with the parietal and frontal above, having a suture with the pro-otic behind, articulating with the basipterygoid process below, and ending in a suture with the pterygoid. Behind the basipterygoid and below the point of exit of the maxillary, mandibular, and motor portions of the fifth nerve, the epipterygoid is continued backward by a process occupying the position of a quadrate ramus of the pterygoid. The ramus in certain species articulates with the front face of the quadrate.

The preceding pages record the more important differences between the most primitive and the most advanced known Anomodont; they bring out the direction of the evolutionary advances and show how enormous is the structural gap between them, a gap represented in time by the relatively small interval between the bottom of the Permian and the middle of the Triassic system.

It remains to show how completely this morphological gap can be bridged by the material available. Although, as Case and Williston have repeatedly and emphatically pointed out, the Pelycosaur is a self-contained group dying out with *Dimetrodon* and

Edaphosaurus, they show evolutionary changes which are in the main in the same direction as those which lead from *Varanosaurus* to *Diademodon*, coupled, of course, with many individual specializations. Although it is not essential for the purpose of this paper, it is, I think, useful to point out certain of the more striking of these advances, using *Varanosaurus*, *Deiopeus*, and *Dimetrodon* as the series of forms. These animals lived side by side, and this series is only a morphological one.

In general shape *Dimetrodon* shows an advance on *Varanosaurus* in that the snout is much deepened, is square in section only immediately in front of the orbit, and is, in general, wedge-shaped with a rounded dorsal edge. The parietal region is narrower, and leaves the temporal fossæ visible from above. The occiput is more vertical. In the brain-case *Dimetrodon* shows an advance over *Deiopeus* in that the basioccipital is thinner, the basisphenoidal tubera smaller, and the paroccipital process larger. The anterior margin of the pro-otic lies further in advance of the internal auditory meatus. The brain-cavity is considerably deeper and wider posteriorly. The fenestra ovalis of *Dimetrodon* is smaller than that of *Deiopeus* and the stapes lighter. The roof of the skull of *Dimetrodon* differs from *Varanosaurus* in the following ways:—the parietals are less wide and the pineal foramen further forward. The postorbital is visible from above. The pair of frontals have acquired a cruciform shape owing to a widening of the interorbital surface. *Deiopeus* provides an exact intermediate, the increased width of the interorbital surface having arisen by an increase in size of the pre- and post-frontals, so as to leave a gap which is filled up by a special process of the frontal.

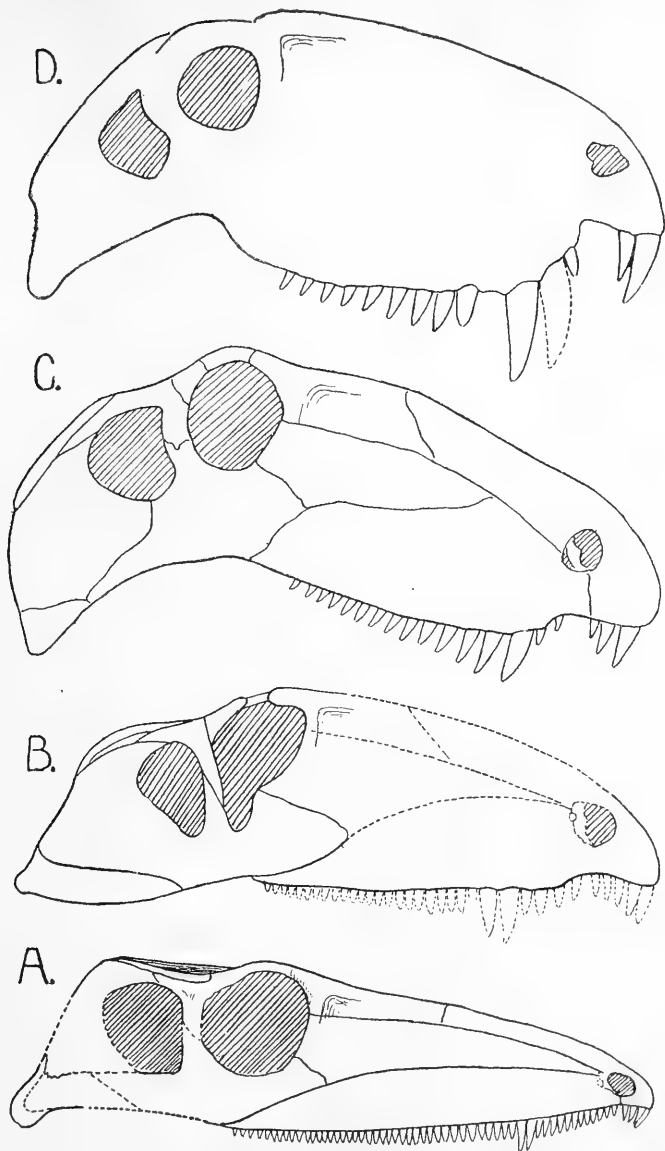
In side-view the skull of *Dimetrodon* shows a shortened and deepened maxilla touching the nasal in a short suture. The dentition is sharply divided into incisors and cheek-teeth by a diastema. The third maxillary tooth is much larger than the first two, and the lower border of its socket lies well below the dentigerous border of the premaxilla.

The lachrymal does not reach the septomaxilla. The orbit is placed high up in the skull.

It seems probable that the deepening of the maxilla and the "step" depend on the necessity of finding room for the roots of, and the development of, replacing teeth for the greatly lengthened maxillary teeth.

The condition of the canine may depend on the following considerations:—A large canine in the upper jaw presupposes a similar tooth in the lower jaw; such teeth, which are designed for killing animals, are most useful in the front of the mouth. The lower jaw, as a whole, bites inside the upper jaw. The first tooth of the lower jaw cannot be much enlarged, because of the difficulty of making a pit for its reception near the middle line in the palatal process of the premaxilla; hence the lower canine cannot be quite at the end of the jaw. A large lower canine almost involves a diastema in the upper jaw for it to bite into, because

Text-figure 21.

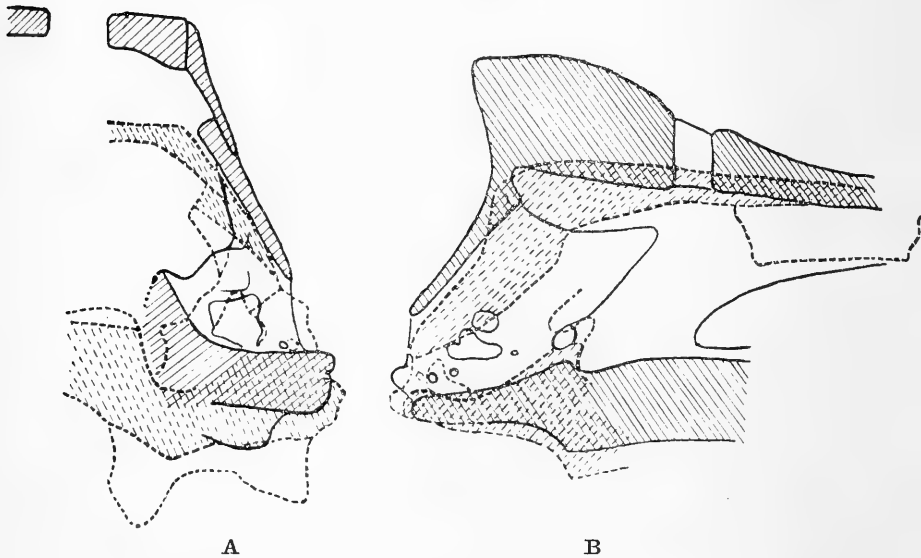


Series of drawings of the right lateral aspect of Pelycosaur skulls,
reduced to the same length.

- A. *Varanosaurus acutirostris* Broili, restored from the type-skull in Munich, partly after Broili. B. *Deiopus leptocephalus* Cope, restored from the type-skull in the American Museum. C. *Sphenacodon ferox* Marsh, after Williston. D. *Dimetrodon gigas* Case, from a photograph published by Case.

being laterally placed, the formation of a pit in the palate for its reception so narrows the dentigerous part of the maxilla outside it as to leave no room for a tooth. The same factors will render difficult any great enlargement of the next tooth, and the upper canine thus comes to lie behind the diastema and separated from it by at least one small tooth. Considering the mechanics of the whole arrangement, it appears useful to make the dentition more or less symmetrical about the diastema by enlarging a premaxillary tooth to correspond with the canine, so that the single lower canine forces the prey into the gap between two large upper teeth. The dentition so designed is realized in *Dimetrodon*.

Text-figure 22.



- A. Superimposed outlines of sagittal sections of the brain-cases of *Deiopeus* in broken line and *Dimetrodon* in continuous line reduced to the same length, to show the thinning of the basis cranii, the enlargement of the brain-cavity, and the forward growth of the pro-otic.
- B. Superimposed outlines of sagittal sections of the brain-cases of *Leptotrachelus* in broken line and *Diademodon* in continuous line reduced to the same length, to show : the thinning of the basis cranii, the forward growth of the pro-otic, the enormous increase of the cerebellar cavity, and the relatively slight growth of the cerebral region.

The great deepening of the maxilla demanded by the canine automatically squeezes out of existence the anterior part of the lachrymal.

Deiopeus and *Ophiacodon* provide an exact intermediate between

Varanosaurus and *Dimetrodon* in dentition, as Case has already shown.

In the palate *Dimetrodon* differs from *Varanosaurus* in that the transverse flanges of the pterygoids have moved much forward from the basipterygoid region. The condition in *Deiopeus* is not known. Thus many of the structural changes which separate the advanced from the primitive Pelycosaurs are in the same direction as the general advances of the Anomodonts from first to last.

The earliest known Gorgonopsid is *Galesuchus gracilis* Haughton, from the *Tapinocephalus*-zone.

This skull I have not seen, but judge that it is so much weathered that the original shape of the squamosals cannot be seen. Only the dorsal aspect has been figured. The skull is very remarkable, differing much from all later Gorgonopsids and even more from Pelycosaurs. Its only primitive features seem to be the extremely sloping occiput (the apparent slope being possibly exaggerated), the high position of the foramen magnum and foramen jugulare, the large deep paroccipital processes, the great size of the frontal, and the lateral direction of the orbits. It is, however, so incompletely known that a full discussion of its affinities is impossible.

The most primitive known Gorgonopsid is *Arctops*. This retains as primitive features, which it shares with the Pelycosaurs:-- the square section of the snout with a depression on the preorbital surface overhung by the prefrontal, the lateral direction of the orbits, the extreme parietal width, and the shortness of the parietals. The resemblances in the basicranial and otic regions have been discussed (P. Z. S. 1914, p. 1027).

The palate retains a primitive structure in the non-fusion of the prevomers.

The skull shows advances over *Varanosaurus* in the following ways:--Owing to the need of increasing the size of the temporal muscles the squamosal is bayed outward, a modification which makes the temporal fossa visible from above; this change not only allows of greater thickening of the temporal muscles during their contraction, a function which is believed by Gregory and Adams to be the factor which determines the origin of fenestration, but also enables the outer part of the temporal muscle to acquire a new origin on the upper edge and inner surface of the zygomatic arch, thereby establishing an independent masseter muscle. At the same time this widespread zygomatic arch passes much laterally to the quadrate and leaves that bone, with the quadrato-jugal attached to its outer margin, lying entirely within the back of the enlarged temporal fossa; these bones, having thus lost the support that they originally received from the junction of the quadrato-jugal with the jugal and squamosal by sutures, can only be adequately supported by a more powerful abutment on the paroccipital process and by an extension of the squamosal down their posterior surface.

At the same time the lateral extension of the squamosal renders

the back of the skull much wider than the neck, and makes the tympanic membrane lie much nearer the middle line than the side of the skull. As it is necessary to keep this membrane exposed to the outer air, any swelling of the neck will automatically lead to the formation of an external auditory meatus; the beginnings of this passage are seen in *Arctops* in a groove on the posterior surface of the squamosal, just outside the end of the paroccipital process.

On the ventral surface *Arctops* has advanced over *Varanosaurus* in the shift forward of the great pterygoidal flanges to a position far in advance of the basipterygoid processes; this change results in a further great enlargement of the cavity for the temporal muscles, and allows the development of great pterygoidal muscles with an insertion on the dorsal surface of the palate.

This shift forward of the flanges has occurred in *Dimetrodon*, but the conditions in *Arctops* differ from those in the earlier form in the fusion of the posterior parts of the pterygoids and parasphenoid into a massive ridged girder. This change adds greatly to the strength and rigidity of the skull, but its details cannot readily be explained by mechanical considerations; the most important of these is the replacement of normal basipterygoid processes by the laterally directed flat lappets which occur in all Theriodonts.

In the palate itself the more important changes are the development of a median groove, a necessary preliminary to the establishment of a secondary palate, which is brought about by that change in the dentition involving the development of a "step" between the maxillary and incisor teeth which has been discussed under *Dimetrodon*, and the extreme posterior position of the hinder ends of the posterior nares; this latter change is itself probably to be associated with the incipient secondary palate, leading as it does to a longer air-passage whose posterior end is not so easily closed by the presence of food in the anterior part of the mouth.

Another advance in *Arctops* is the more vertical position of the occiput.

Gorgonops is in some ways as primitive as *Arctops*, with which it shares very broad parietal and interorbital regions and a square sectioned snout. The orbit faces laterally in both forms, and each has a remarkably broad interparietal, a feature in which they resemble Deinocephalians.

Gorgonops has a pair of large frontals, which are cruciform in plan exactly as in the later Pelycosaur.

The prefrontal is a large bone which overhangs a well-marked depression on the preorbital surface.

Gorgonops shows advances over *Varanosaurus* which, so far as the parts are known, include all those which occur in *Arctops*, with the following additions:—The external nostril in *Gorgonops* is much complicated by the great development of the septomaxilla and the foramen behind it. This foramen, first recognised by

Case in *Dimetrodon*, occurs in all the more primitive Anomodonts and is still of uncertain function. In all Pelycosaurs the septomaxilla is a small bone resting on the maxilla and premaxilla at the back of the nostril, being touched by the nasal and forming with the other bones the foramen, which I propose to call the septomaxillary foramen.

In *Dimetrodon* the lower edge of the septomaxilla, where it rests on the maxilla, is turned inwards and forms a partial floor to the nasal passage. The anterior border of the septomaxilla is provided with a process which partially divides the external nostril into a lower and an upper part.

It is probable that the process on the anterior edge of the septomaxilla is associated with the original turbinal, simply forming the anterior end of that ridge. In the living lizards and snakes, the septomaxilla lies inside the nostril as it does in the Captorhinids, the collateral ancestors of the Pelycosaurs; it has in them a characteristic and uniform situation, in that it is ossified in the membrane dividing the main nasal cavity from Jacobson's organ, running nearly horizontally from the maxilla to the cartilaginous nasal septum.

In Anomodonts I have only heard one possible suggestion for the function of the septomaxillary foramen, that it served as an outflow for the ductus naso-lachrymalis, the liquid poured out from it serving to keep the muzzle wet as in Artiodactyls. This view is in harmony with the known position of the duct in early amphibia and reptiles. It, however, does not afford any satisfactory explanation of the great size of the foramen in *Gorgonops*.

The very peculiar conditions in the Deinocephalian *Mormosaurus* (Proc. Zool. Soc. 1914, p. 757, figs. 1 & 2) suggest another explanation. In this animal the ordinary external nostril, which in early reptiles always lies between the premaxilla, the septomaxilla, and nasal, appears to be represented by a minute foramen between the septomaxilla and the nasal. The large opening which is the functional nostril seems to be really a septomaxillary foramen, as it lies between the premaxilla, the maxilla, and septomaxilla, a situation which is never occupied by the ordinary nostril in early reptiles, but agrees with that of the septomaxillary foramen in the earlier Theriodonts. Thus this foramen must be of the nature of a nostril. The characteristic position of the septomaxilla in *Squamates* suggests that the foramen leads into Jacobson's organ, and it will follow that that organ was the functional olfactory organ of *Mormosaurus*; the shallowness and small size of the upper part of the nasal cavity, which distinguishes *Mormosaurus* from such Deinocephalia as *Moschops* with a normal septomaxillary foramen and nostril, can thus be accounted for.

The advances over *Varanosaurus* which are shown in the nose of *Gorgonops* are:—(1) the direction of the nostril forwards instead of laterally, a change which renders the appreciation of odours coming from the direction in which the animal is pro-

ceeding more delicate, because owing to a Pitot effect more air will be driven into the nasal cavity; (2) a great increase in the size of the septomaxillary foramen, possibly associated with a further elaboration of Jacobson's organ; (3) a great increase in the size of the facial part of the septomaxilla—this may be due to purely mechanical reasons.

Another advance very clearly shown in *Gorgonops* is a great deepening of the maxilla and a concurrent reduction of the lachrymal, the prefrontal showing little reduction.

The palate of *Gorgonops* is advanced in the great size of the internal nares, in the width, depth, and backward extension of the median groove, in the internarial bar being single, and in the occurrence of a median vomer in the back of the palate.

The very large size of the pterygoids and the forward position of the roughened and possibly tooth-bearing areas on these bones are primitive features.

The basicranial region shows no structural detail.

Scymnognathus whaitsi shows many resemblances to *Gorgonops* in its snout.

It shows advances over *Arctops* in the thinner basioccipital, smaller basisphenoidal tubera, and less massive paroccipital processes.

The brain-case is advanced over that of the Pelycosaur *Dimetrodon* in the great forward extension of the pro-otic and supraoccipital and the junction of the latter bone with the epipterygoid; a remarkable feature is the forward process of the basisphenoid, which forms a floor to the brain-case in advance of the pituitary fossa.

The most striking advances over *Arctops* are the great reduction in width of the parietal region, the lengthening of the parietals, and especially the enormous increase in spread of the squamosals. The turning backward of the upper part of the squamosal at the posterior margin of the temporal fossa makes that opening even larger, and increases the length of certain fibres of the temporal muscles.

So far as known, similar differences separate *Scymnognathus* from *Gorgonops*, the latter genus having much larger frontals than the former.

By the great expansion of the width of the back of the skull, the orbits of *Scymnognathus* are made to look partly forward.

Another small but important advance in *Scymnognathus* is that certain fibres of the temporal muscle have secured an origin from the dorsal surface of the parietal region.

Scymnognathus is probably less advanced than *Arctops* and *Gorgonops* in its less vertical occiput. In the palate *Scymnognathus* is probably less advanced than *Gorgonops* in the small size of the median groove, and its restriction to the anterior part of the palate and to a narrow space round the hinder end of the posterior nares.

The incompletely known *Leptotrachelus* shows an important

stage in the advance in structure of the basiscranial region, already discussed in P. Z. S. 1914, p. 1027, figs. 3 & 4; it is in this region more advanced than any other known *Endothiodon*-zone Gorgonopsid. It retains as primitive features the very large quadrate, large postfrontal and frontal, and a sloping occiput.

Thus the *Endothiodon*-zone Gorgonopsids show definite advances over the Pelycosaur in the direction of *Diademodon*. Each form is advanced in certain features whilst retaining a more primitive structure in others, so that an imaginary animal, built up by throwing together the most advanced features found in all the actual animals, would be far more advanced than any one is on the average; although in no point would it be more advanced than a known form. In fact, the evidence existing here, small though it is, suggests that there is a limit to the total amount of advance possible to the members of a group in a given time, and that these changes may be distributed either over the whole animal or concentrated on a definite region, which will then present a structure of much more advanced type than is found in allied contemporaneous forms. A somewhat similar conclusion seems to have been reached by W. D. Matthew from the study of the more abundant material of fossil mammals.

Discussion of the Gorgonopsids of the *Cistecephalus*-zone is rendered difficult by two factors—the incomplete descriptions and insufficient figures of many of the perfect skulls in S. Africa and New York, and the fact that the *Cistecephalus*-zone is a long one and that we do not know the relative ages of the Gorgonopsids from it. It will appear from the evidence to be brought forward in this paper that the forms from Dunedin and Nieuweveld localities are early, those from New Bethesda and the Kagaberg which are associated with *Dicynodon tigriceps* considerably later in time. There is, however, no stratigraphical evidence that this is so.

From the *Cistecephalus*-zone Broom and Houghton have described several forms as species of *Scymnognathus*—*S. tigriceps* B. & H., *S. parvus* Br., *S. minor* Br., *S. angusticeps* Br., *S. serratidens* Hau., are all from the Nieuweveld. These forms may very possibly be congeneric; they agree with *Scymnognathus* in having i. 5, c. 1, m. 4-5, but quite certainly do not belong to that genus. They differ from *Scymnognathus whaitsi* in the following characters:—

The snout is very much deeper, its anterior end instead of being rounded is vertical (cf. Broom, P. Z. S. 1913, p. 225, pl. 36), the external nostril is much larger, the septomaxillary foramen smaller. The anterior end of the nasal does not fully overhang the nostril. The top of the snout may be ridged, and the square section with a preorbital depression overhung by the prefrontal is entirely lost (cf. *S. serratidens*, Ann. South Afr. Mus. vol. xii. p. 89, pl. xiii.). The snout is much shorter and the prefrontal in consequence smaller.

There is no step in the upper jaw, the curved tooth-bearing edge of the premaxilla passing smoothly into that of the maxilla. In *S. tigriceps* the squamosals are not nearly so much spread, the skull being much deeper in proportion to its width. If we may trust the existing description of a not very satisfactory preparation, the palate of *S. tigriceps* differs from that of *S. whaitsi* in the loss of the anterior projection of the pterygoid and the great extension of the palatines. On the other hand, judging from the description by Houghton of its endocranial surface, the brain-case of *S. tigriceps* may have greatly resembled that of *S. whaitsi*.

Thus the *Cistecephalus*-zone animals referred to *Scymnogathus* do not belong to that genus, but differ from it by a series of advances which will be seen to be all in the direction leading to *Diademodon*. Certain of these species appear to resemble *Lycosaurus pardalis* considerably, agreeing with that animal in dentition, the short high snout with a rounded dorsal surface, the large nostril, the vertical internarial bar, the small exposure of the septomaxilla, the absence of a step in the upper jaw, the short and deep maxilla, and the small prefrontal. All of them, however, seem to retain a large postfrontal bone.

Two other remarkable forms, apparently from the lower part of the *Cistecephalus*-zone, *Scylacops capensis* and *Gorgognathus longifrons*, are of interest because they strongly recall *Endothiodon*-zone forms.

Gorgognathus with its immensely long low snout somewhat resembles *Scymnogathus whaitsi*, and its very broad interorbital and intertemporal surfaces agree with *Gorgonops*. It is, however, advanced in the following characters:—The loss of the step in the jaw, the rounded snout, and especially the vertical occiput. Houghton has pointed out another advanced feature in the structure of the basicranial region. *Scylacops* is a small unusual form with a low broad snout: it is advanced in the exclusion of the frontal from the orbital margin, in the rather vertical occiput, in the loss of the step in the upper jaw, and especially in the loss of the anterior ramus of the pterygoid; it appears to retain a rather primitive *Gorgonops*-like nose and has only small temporal fossæ. Broom's figure of the occiput suggests that it is advanced in the shallowness of the paroccipital processes. [It is probable that the fragment of a *Gorgonopsid* skull which I described (*Ann. & Mag. Nat. Hist.* 1913, vol. xi. p. 65, figs. 1-4) belongs, if not to *Scylacops*, at any rate to a closely allied form.]

Arctognathus curvimola is a far more advanced form than any so far discussed in this paper; it presumably comes from a higher horizon in the *Cistecephalus*-zone than *Gorgognathus*, etc. It shows advances in the following features:—The snout is short, narrower than the orbital region, rounded over the mid-line. The nostrils are very large and the septomaxillary foramen small. The nasals do not overhang in front. The interorbital and intertemporal surfaces are narrow, the orbits facing outwards,

upwards, and a little forwards. The postfrontal is very small, the preparietal is absent. The maxilla is very short and deep, there is no step in the upper jaw. The prefrontal is short and probably small. I have already shown that the basicranial and otic regions are very advanced (Proc. Zool. Soc. 1914, p. 1028). The epipterygoids are widened and flat, very much as in *Diademodon*. The posterior end of the quadrate ramus of the pterygoid no longer reaches the quadrate. The pterygo-parasphenoidal girder, instead of having a flat ventral surface from which a deep median crest rises, is rounded, with the crest represented by a low fillet.

The palate is most conveniently compared with that of *Gorgonops*, which represents an earlier stage leading to it.

The great median groove is deepened and its roof is entirely formed by a median vomer, which presumably represents a forward growth of the posterior median bone of the *Gorgonops* palate. Anteriorly the ridge rising from the vomer in *Arctognathus* suggests that there was a soft secondary palate into which a secondary bony plate may have grown out in the concealed part of the palate.

The tooth-bearing roughened area of the anterior ramus of the pterygoid lies much further back than in *Gorgonops*, and the pterygoid no longer reaches the posterior nares.

The quadrate of *Arctognathus* is much smaller than that of *Scymnognathus*.

The conversion of *Arctognathus* into a "Cynodont" like *Cynognathus* demands only the following changes:—Still further thinning of the basis cranii, further reduction of the quadrate wing of the pterygoid, the development of a connection between the quadrate wing of the epipterygoid and the paroccipital; further retraction of the anterior ramus of the pterygoid, so as to reduce the roughened areas to a pair of small knobs on each side of the posterior end of the median groove; a little reduction of the ectopterygoid; the development of secondary plates from the maxilla and palatines in the existing soft secondary palate; the conversion of the narrow intertemporal area into a sagittal crest, to increase the length of the temporal muscles; the loss of the postfrontal, and a further reduction of the frontal and prefrontal, leading to an increase in size of the posterior part of the nasals. These changes are all in the same direction as those which convert a Pelycosaur like *Varanosaurus* into a Theriodont like *Gorgonops*, and an animal like *Gorgonops* into a form like *Arctognathus*, and are, on the whole, smaller than those which are necessary to carry out the earlier improvements; in fact, *Arctognathus*, which is technically a Gorgonopsid, is structurally closer to *Cynognathus* than it is to *Gorgonops*.

Amongst other advanced forms allied to the Gorgonopsids and coming from the *Cistecephalus*-zone are *Cynosuchus* and *Whaitsia*, which have both been excellently described, though not completely figured, by Houghton.

Whaitsia is a remarkable form with a somewhat primitive basicranial region, and a palate which in general agrees with *Gorgonops*, but differs in the development of a special process passing out on each side of the internarial bar so as to divide each posterior nostril into two. [The meaning, morphology, and function of this arrangement are quite uncertain, the anterior vacuities are not exactly homologous with the anterior palatine incisions of mammals and Cynodonts, because the posterior border of these incisions is always formed by the anterior edge of the secondary plate of the maxilla.] *Whaitsia* is very advanced in the reduction of the wide parietal region to a narrow sagittal crest, which characterizes it, and in the extreme reduction of the dentition.

The preceding discussion shows that the Gorgonopsids include a series of forms which exhibit in their skulls a gradual series of changes by which so primitive an animal as *Arctops* passes insensibly into a Cynognathid. It establishes clearly the existence of a series of evolutionary trends, which persist without change from the beginning of the Anomodonts in *Varanosaurus* to their end in *Diademodon*, and indeed to lead on to mammals. It remains to discuss the other primitive Theriodonts included in Broom's order Therocephalia and the Deinocephalia, to see how far these evolutionary trends apply also to them, and to consider the relation of these forms to the Gorgonopsids, which are plainly the central group of the Theriodonts.

No Therocephalian is at all well known, despite the very large number of forms which have been described. We know the dorsal and lateral surfaces of the skull in a good many forms (*Scylacosaurus*, *Lycosaurus*, *Scaloposaurus*, etc.), the palate is known more or less completely in others (*Scylacosaurus*, *Scymnosaurus*, *Scaloposaurus*, etc.). The basicranial region is known in no Therocephalian, neither has any occiput been figured. Houghton has described the brain-case of *Alopecognathus*, but his figure is not in all points (*e.g.*, the character of the supra-occipital and the relations of the interparietal and parietal) very convincing.

The most important materials of Therocephalia in the British Museum are the more or less complete skulls of *Scaloposaurus* from the *Cistecephalus*-zone and *Scylacosaurus* and *Scymnosaurus watsoni* from the *Tapinocephalus*-zone.

SCYMNOSAURUS WATSONI Broom, Proc. Zool. Soc. 1915, p. 169, fig. 6.

Lycosuchus? Watson, Proc. Zool. Soc. 1914, p. 1036, fig. 7.

Type: a skull with seven cervical vertebræ in natural articulation, other vertebræ and fragmentary limbs doubtfully associated. *Tapinocephalus*-zone, Uitkyk, Dist. Prince Albert, Cape Province.

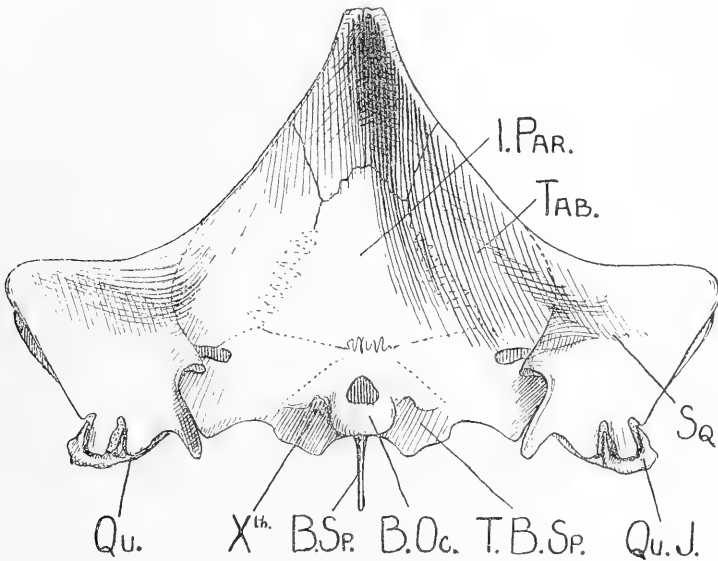
The skull of the type is curiously preserved: it is embedded in a calcareous nodule, which breaks with a conchoidal fracture and

is so loaded with a very fine siliceous mud as to be glass-hard, completely blunting a carefully hard-tempered chisel after a single blow.

The skull is broken through along the plane of the palate, part of that structure adhering to each block. The skull is then broken through by a split which passes through the brain-cavity and removes the whole left posterior corner of the skull behind the orbit. Finally, another split traverses the occiput, part of that surface adhering to each surface.

Where weathering has softened the matrix, very good preparations are easily made, and in these regions, especially where

Text-figure 23.

*Scymnosaurus watsoni* Broom. Type-skull.Occipital aspect. $\times \frac{1}{2}$.

the bone has been cleaned by weathering, the preservation is extraordinarily good. Development of the unweathered regions is a very difficult and extremely slow and tedious process. Nevertheless, I have been able to make a satisfactory preparation of the inner surface of the cranial cavity.

The occiput now shows nearly every detail of its structure, although a direct view of its posterior surface cannot be seen. Its outline is well shown and the posterior surfaces of the quadrates and squamosals are clean.

Dr. Broom's figures give a good idea of the general shape, the structure of the dorsal and lateral aspects not being shown.

My former figure gives a good idea of the palate, whose structure is well shown. It, however, does not clearly illustrate the exact mode of articulation of the quadrate to the squamosal and the structure of the extreme postero-lateral corner of the skull and the auditory groove. This inaccuracy, which is not of a very serious nature, was due to a misunderstanding by about 30° of the orientation of the detached left corner, which was at that time the better exposed.

The basioccipital condyle is largely concealed by the attached atlas, but is partly exposed from below and cut by fractures which give sections through it. It is rounded and nearly twice as wide as it is deep. It is short and immediately in front of it, at a plane a little in front of the general occipital surface, lie the very broad and massive basisphenoidal tubera. These have a flat posterior surface overhung by the projecting exoccipitals, which are separated from them by the small vagal foramen and perforated by small foramina for the XIIth nerves. The structure of the anterior part of the basisphenoid has already been described.

The paroccipital process is very massive; not only is it thick from back to front, but the small post-temporal fossa is placed high up so that the process is deep. Although the fenestra ovalis is not visible there can be no doubt, from consideration of the general structure, that it lies far out.

Very little of the supraoccipital is visible from behind, the interparietal terminating only a short distance above the foramen magnum.

The joint supraoccipital and interparietal form a very thick mass whose posterior surface stands nearly vertical.

The occiput, as a whole, forms an equilateral triangle with an angle at the top. To the lower parts of the lateral sides of this triangle two others are added, standing out as fins; these are composed of those parts of the squamosals which articulated with the jugals.

The lower and median parts of the main triangle are flat and stand vertically, the lateral borders are turned back, so that viewed as a whole the occiput is deeply cupped, the back-turned margins gradually approach one another and, finally, fuse to form the very deep sagittal crest.

The extreme upper part of the occiput is formed by the parietals, the interparietal terminating far below the summit.

Laterally the parietals are covered by the tabulars, which form the margin of the occiput for some distance, strengthened by production of the parietals along their anterior faces and more laterally by a similar covering of squamosals, which, indeed, overlap onto the parietals.

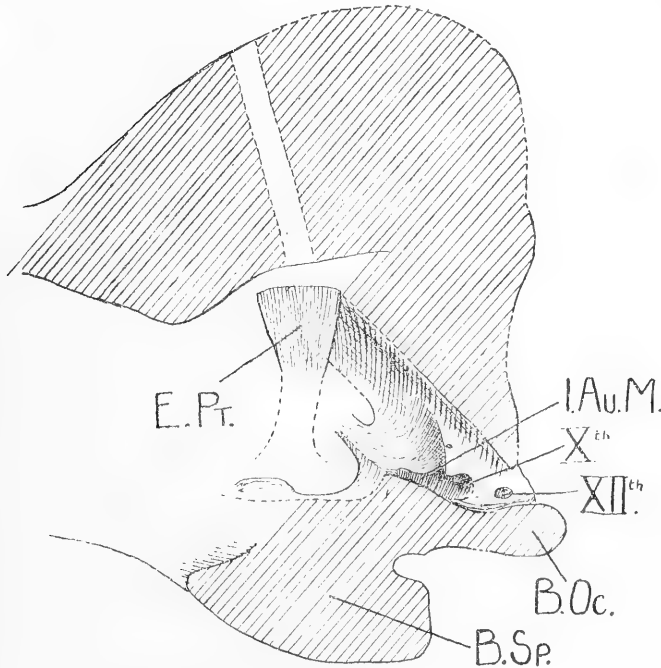
The squamosals articulate, as just described, with the parietals and tabulars, and then extend outward into powerful processes, their upper parts being turned backward so as greatly to increase the size of the dorsal opening of the temporal fossæ.

The ventral halves of their posterior surfaces are vertical,

continuing the plane of the paroccipital processes, with whose ends they are rigidly articulated. The posterior surface of the lower part of the squamosal is separated from that of the paroccipital by the usual ridge, which borders a groove for the external auditory meatus.

This ridge continues upwards until, just below the level of the post-temporal fossa, its hinder margin is turned inwards as a scroll with a thickened edge in a very unusual manner, not understood by me when I published my figure of the palate.

Text-figure 24.



Scymnosaurus watsoni Broom. Type-skull.

Brain-case in sagittal section seen from the left side. Epipterygoid of left side seen in outer view. $\times \frac{2}{3}$.

I.Au.M., internal auditory meatus.

This scroll overhangs the occiput, but very rapidly subsides into the general surface of the squamosal, just at the point where that bone begins to bend backward.

The lower edge of the squamosal is thin and is split by two notches associated with the attachment of the quadrate.

The quadrate, or in all probability the fused quadrate and quadrate-jugal, is relatively small, nothing of its hinder surface being

visible except the extreme articular edge and the two processes which interlock with the squamosal. There is evidence that it is no higher than the paroccipital process, but its upper edge and front face are not seen. The bone extends only very slightly laterally of the outer process, forming the extreme end of the lower margin of the occiput. Above its end the border of the squamosal runs upward and slightly outward, its front face being supported by the jugal.

The plan of this very remarkable occiput is repeated in a less exaggerated form in *Scylacosaurus sclateri*, so far as the still very incomplete preparation of the British Museum skull allows of a comparison.

The brain-cavity of *Scymnosaurus* behind the epipterygoid is now fairly well exposed. Its general characters will be best understood from text-fig. 24. The foramen magnum is extremely small, but the brain-cavity is somewhat larger than would be anticipated; although not high it is fairly broad, especially in advance of the exit of the vagus. It is of normal Anomodont type with an opening to the inner ear placed very low down and with this opening confluent with the foramen for the Xth nerve. The sunken edge which separates these openings is continued upwards by a ridge on the wall of the brain-cavity, which separates the narrow medullary from the wider cerebellar region. The pituitary fossa, although not cleared of matrix, is undoubtedly shallow. There is a powerful process below the notch for the Vth nerve, and the supraoccipital, with possibly a strip of the pro-otic, extends forward as side-walls as far as the epipterygoid, passing median of that bone.

The limb-bones doubtfully associated with the type-skull are small and very slender, so that if they really belong to it the proportions of the animal must have been like *Hyænodon*. If they do belong the agility which they imply may be the explanation of the unexpectedly large cerebellar cavity, which, however, shows no trace of floccular fossæ.

It is interesting to compare *Scymnosaurus* with *Scymnognathus*, which is of about the same size, though later in time. The two animals are carnivorous and have very similar dentition, especially in the feeble molar series.

The Therocephalian is the more advanced in the following characters:—

1. The reduction of all parts lying below the base of the brain, the basioccipital, basisphenoid, and especially the quadrates.
2. The reduction of the intertemporal region to a narrow sagittal crest.
3. The shortening of the snout.
4. The lengthening of the temporal fossæ.

Scymnosaurus rather recalls *Scymnognathus* in its square-cut snout, *Scylacosaurus* is much more advanced in the rounding of

the dorsal surface of the nose, in both forms the extreme lowness of the face in early Gorgonopsids is lost, the maxilla being deep and the anterior part of the skull in general high.

The incisor-teeth in *Scylacosaurus* are small and the premaxilla shallow below the nostril.

There is no step between the canine and the incisors, the teeth forming a curved row like that of the latest Gorgonopsids and the Cynognathids.

A preparietal appears to be lacking in Therocephalia, otherwise the interorbital region does not differ greatly from that of Gorgonopsids.

In the palate the Gorgonopsids are all more primitive than the two Therocephalians in not possessing a suborbital fossa. They are, however, all far more advanced in their possession of the vaulted palate, which leads so directly to the development of a secondary palate, and in the complete suppression of an interpterygoid fossa.

The median part of the palate of *Scymnosaurus* even projects slightly above the general level, that of *Scylacosaurus* is essentially flat.

Scymnosaurus shows an advance on *Scylacosaurus* in the median vomer which appears on the palate.

Both Therocephalians agree with one another in certain special features, such as the extent to which the ectopterygoid contributes to the pterygoid flange (in which they differ from the Gorgonopsids); and in their general appearance, in the structure of the occiput, etc., they in no way recall the Cynognathids, as do all the Gorgonopsids dealt with in the preceding parts of this paper.

Scymnosaurus and *Scylacosaurus* are *Tapinocephalus*-zone forms, and there is no evidence of any animals with similar structure in the succeeding *Endothiodon*- and *Cistecephalus*-zones.

No certain Therocephalian is known in the *Endothiodon*-zone (as I understand it), unless Broom's *Ictidognathus* is of that age.

In the *Cistecephalus*-zone *Scaloposaurus*, represented only by the type-skull from Stylkrantz, is the only satisfactorily preserved form. It has been well described and figured by Owen and Broom, whose accounts should be referred to. The little skull differs exceedingly from *Scymnosaurus*, the temporal fossæ are short, there are no pronounced sagittal and lambdoid crests, the squamals are not expanded, and the postorbital apparently does not reach the jugal behind the orbit. [This may be only on account of weathering of the surface.]

On the palate there is evident a wide interpterygoid vacuity, agreeing with the much narrower opening in *Scymnosaurus*; there are large suborbital vacuities as in that form. Nothing is shown of the anterior part of the palate, nor are the details of the basis cranii well displayed.

Thus the extant material of Therocephalia sheds no light on

the evolution of that group, and the known forms are so few that no classification is possible.

It is, I think, reasonable to assume that the Therocephalia have sprung from the Gorgonopsid stock, and that they represent a series of distinct branches which display a much more rapid advance in structure than the conservative main stem. These advances are, on the whole, along the trends of Gorgonopsid evolution, quite early Therocephalians thus agreeing in certain features with Cynognathids. It is, as I have already shown, probable that *Bauria* and its allies are descendants of Therocephalia, representing the product of a parallel series of changes to that which resulted in *Cynognathus* imposed on a different ancestor.

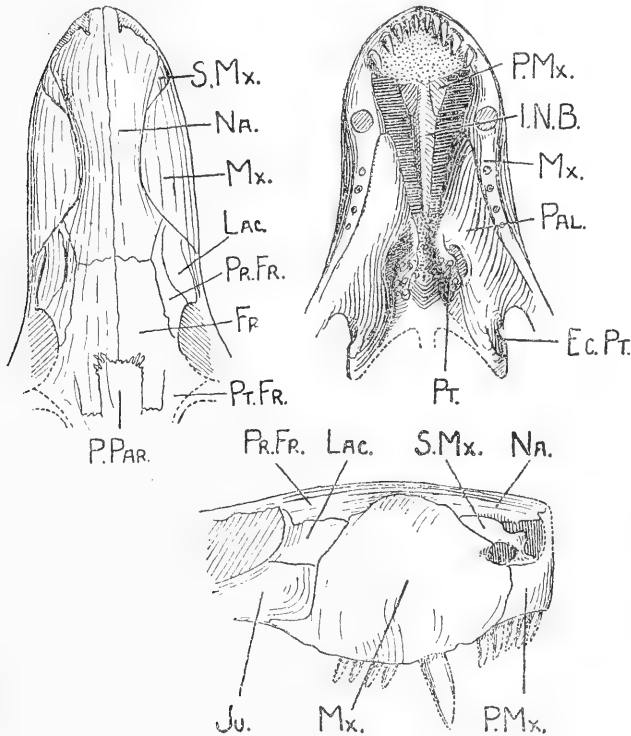
In the preceding part of this paper, I have dealt only with a selected series of Gorgonopsids which present resemblances to the Cynognathids, and have tacitly assumed that these forms are the main stock. There are, however, many other Gorgonopsids which appear to represent side-branches, displaying either accelerated evolution of certain features or else individual specialisations.

Of these forms the earliest and one of the best known is *Ælurosaurus felinus* Owen. This form was first described by Owen, Q. J. G. S. vol. xxxvii. p. 261, pl. ix., Seeley subsequently figuring an incompletely prepared palate. Broom later corrected certain features of Seeley's description of the side of the skull.

The British Museum includes, in addition to the type, two snouts which were regarded by Lydekker as *Æ. felinus*. Broom left manuscript-labels concurring in the identification, and a detailed examination which I made of them showed that the external surface and dentition are in complete agreement. One of the specimens had no lower jaw attached and the palate has been developed, with the remarkable result that it is shown to differ very considerably from the type, being probably generically distinct. The whole circumstance is of importance, because it shows that a specimen showing only the outer surface of the snout and dentition of a Gorgonopsid may be an inadequate type. In text-fig. 25 I give three slightly reconstructed views of the snout of B.M.N.H. R. 855 from the *Endothiodon*-zone? of Beaufort West. This type is very advanced in the depth and rounded section of the snout, in the suppression of a step in the maxilla before the canine, and in the relatively slight overhang of the anterior border of the nasal. It retains a very large septo-maxillary foramen and a large facial exposure of the septomaxilla. The palate unfortunately shows no sutures, but gives a good view of the general form. In general form this palate differs very considerably from that of *Arctops*, *Gorgonops*, *Scymnognathus*, etc. The median region is excavated into a very narrow groove bounded laterally by massive processes, whose palatal surfaces bear small teeth in sockets. Lateral to the process is a small fenestra or possibly a very deep pit with a well-defined margin ;

further laterally the palatine forms a deep groove, flattening out as it is traced forward until it becomes the nearly vertical surface of that anterior part of the bone which bounds the outer side of the posterior nares. The pterygoid flanges are powerful, but differ from the ordinary Gorgonopsid type in that the ectopterygoids extend down to their summits. There is a single internarial bar whose ridged lower surface lies far above the lower edge of the maxilla.

Text-figure 25.



Ælurosaurid, ? gen. et sp.

Dorsal, right lateral, and palatal views of the anterior part of a skull.
R. 855, B.M.N.H. $\times \frac{3}{2}$.

The palate is of the same type as that of *Ælurosaurus felinus*, but differs in the much smaller development of tooth-bearing areas and in the much more caudal position of the hinder ends of the posterior nares.

An analysis of the structure presented by a series of animals belonging to the Theriodontia thus suggests that that group is a

natural one, the conservative main stem which leads on to the Cynognathids being represented by a series of Gorgonopsids of which *Gorgonops* itself is one of the most primitive members. From this stem side-branches arise, which retain the broad parietal region and other primitive features, but present either an accelerated development of certain regions or are individually specialised. From still earlier members of the main stem arose the groups of animals, resembling one another in the precocious conversion of the broad intertemporal region into a sagittal crest and in the acquirement of suborbital vacuities, which are usually included in the Therocephalia and belong to many independent stirps, each in all probability being dependent on the main Gorgonopsid stock. It is shown that there is a series of evolutionary trends which persist throughout the whole group of Anomodonts from *Varanosaurus* to *Diademodon*, and that the special rapid advances which separate the Therocephalia from the Gorgonopsids, in the main, merely follow out the pre-determined evolutionary track proper to the group.

Thus any classification of the Theriodontia is necessarily complicated, as involved and difficult of construction as that of the *Theria* themselves. Existing material is so incomplete that any attempt at detailed classification, even if only into families, is dangerous, in that it will load the literature with undefined groups, whose characteristic forms may only be known from the front end of the skull or the dentition.

The detailed descriptions of skull-structures in this paper show how unreliable, even for generic distinction, are the characters presented by the teeth of Theriodonts.

Thus, for the present, I am inclined to retain my former division of Theriodontia into Gorgonopsidæ, Therocephalidæ, Cynognathidæ, and Bauomorpha, fully recognising that these groups—or, at any rate, the first two—cover a multitude of forms not directly of common origin and only held together by two or three striking characters.

It remains to discuss the connections of the Theriodontia with the other groups of South African Anomodonts—the Deinocephalia, Dromosauria, and Dicynodonts.

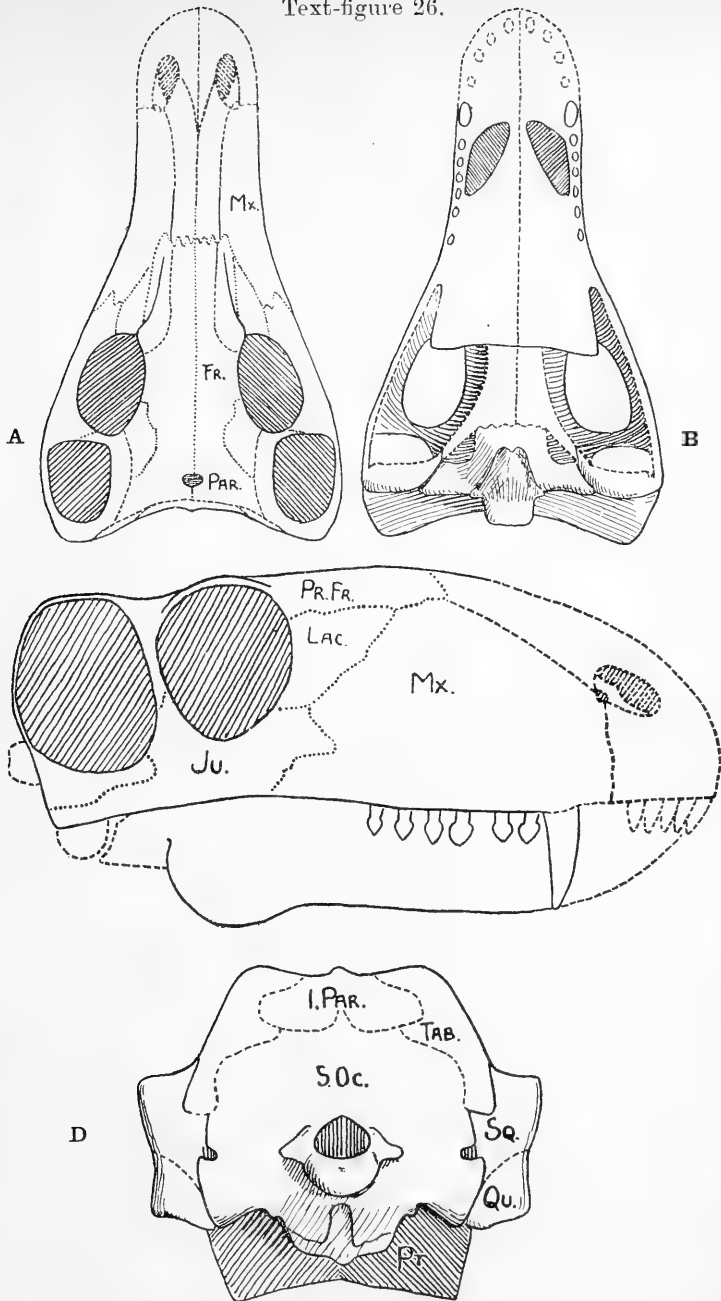
In the copper-bearing sandstones and associated limestones of the Ural Mountains, which immediately succeed the Artinsk beds and are shown by a comparison of reptile and amphibian faunas to be slightly older than the *Tapinocephalus*-zone, are found three types of Anomodonts, each represented by skulls or jaws: of these *Deuterosaurus* is clearly a Deinocephalian of the Tapinocephaloid group recalling many South African forms.

Deinosaurus (= *Chiorhizodon*) is represented by jaws, in one case associated with a palate whose dorsal surface is well exposed.

Rhopalodon is a name covering not only several jaw-fragments but also a complete skull, which was described by Prof. Seeley.

Of this skull, remarkably beautiful lithographic drawings of the

Text-figure 26.



Rhopalodon fischeri Kutorga.

Restoration of skull from the figures published by Seeley, Phil. Trans. B. 185, 1894.
and the brain-case figured by von Meyer, 'Palaeontographica.'

Parts in broken lines hypothetical, sutures in dotted line suggested by the
original figures.

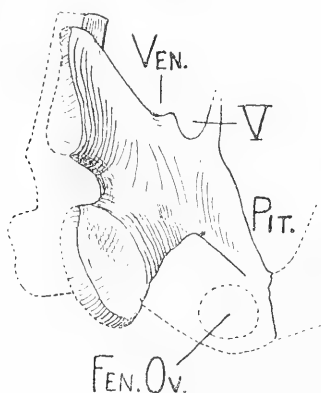
dorsal surface and right side were published by Seeley, and that author also gave less intelligible figures of the palate and of the much damaged occiput.

This skull has the lower jaw in position, and except for the loss of the end of the snout appears to be (as are the other bones from the same rocks) very well preserved and undistorted.

The skull itself is in Russia and quite unreachable, but in the light of our present knowledge of Anomodont structure it is possible by a careful study of the drawings and of Prof. Seeley's description to gain a clear idea of its more important features. In text-fig. 26 I have drawn four reconstructions of this skull on the indications available.

For the occiput I have used that figured by von Meyer as *Deuterosaurus*, which cannot belong to that genus because it is

Text-figure 27.



Brain-case of *Rhopalodon?*

Right lateral aspect. $\times \frac{2}{3}$.

From a cast in the British Museum of the specimen figured by von Meyer as *Deuterosaurus*.

only half the size of that in the skull figured by Seeley, and does not appear to agree at all in structure. It is, on the other hand, of very nearly the same size as the occiput of Seeley's *Rhopalodon*' skull, shows no features incompatible with the wreck of that region in this skull, and must presumably belong either to *Rhopalodon* or the very similar *Deinosaurus*.

Rhopalodon at once recalls the Pelycosaur in appearance and in certain structural features. It has a high compressed snout passing backward into a square-cut lachrymal region, with a depression overhung by a projecting ridge on the prefrontal, just as in *Dimetrodon*. The jugal in its shape at once recalls that of the earlier genus. It differs from *Dimetrodon* in the much

larger temporal fossæ, visible from above, in the outward bowing of the zygoma, in the vertical occiput, and in the smaller lachrymal—all changes which follow the ordinary trends of Theriodont development.

The neural cranium, as shown in von Meyer's figures and in text-fig. 27, is Pelycosaur-like in general build, and especially in the complete absence of that forward growth of the supraoccipital and pro-otic above the notch for the Vth nerve which occurs in Theriodonts, and in the occurrence of a special notch for a vein above the incisura prooticis.

This occiput is, however, specialised in the development of a mass of bone below the basioccipital condyle, which is presumably associated with a very vertically placed fenestra ovalis. The development of this plate is the explanation of the extreme depth of the pituitary fossa.

The palate of *Rhopalodon* recalls that of *Dimetrodon* in its massive flanges on the pterygoids and in the row of teeth which decks them. The very large internal nares also recall certain advanced Pelycosaurs.

In certain ways the skull of *Rhopalodon* resembles that of the more primitive Gorgonopsids; the dorsal surface of the skull, for example, is very like that of *Gorgognathus*. The side view differs, however, in the great depth of the snout and in the relatively powerful molar dentition.

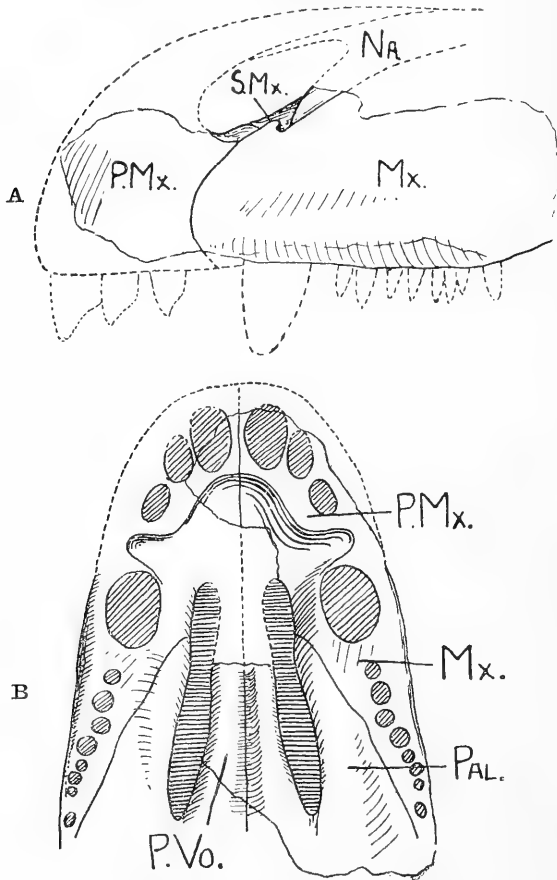
Although Seeley's figures are not very readily interpreted in that region, it seems that the quadrate of *Rhopalodon* is large and well exposed from behind, and that its outer edge lies on the outer surface of the skull exactly as in the South African Deinocephalia, and not at all as in the Gorgonopsids, although it represents a state from which that in the latter group could readily be derived. The brain-case of *Rhopalodon* differs from that of any Gorgonopsid in the vertical plate below the condyle and in the non-extension of the supraoccipital, etc., forward.

It is unfortunate that no part of the palate behind the flange is preserved, but judging from the front of the fragment of basisphenoid preserved in the occiput, and the general structure, there can have been no narrow bar separating the subtemporal fossæ as in Gorgonopsids, but the conditions must have been more as in the South African Deinocephalian *Mormosaurus*. There is, in fact, no doubt that *Rhopalodon* is not a primitive Gorgonopsid, but is a primitive Deinocephalian, with the members of which group it agrees in all the characters in which it differs from the Theriodonts. Its general resemblance to primitive Theriodonts suggests, however, that we are very near the point of separation of these two orders.

The present seems a suitable opportunity for adding to the description which I gave (Proc. Zool. Soc. 1914, p. 770, etc.) of a skull referred to *Titanosuchus*. I recently found a block fitting on to the fragment of maxilla of that specimen which contains the anterior end of the maxilla, parts of the premaxillæ, septo-

maxilla, etc. This addition shows that there are only three premaxillary teeth, that the end of the snout is longer than in the original figure, and that it is rounded. Thus the skull belongs to a new genus and may be called *Anteosaurus magnificus*, gen. et sp. nov., holotype R. 3595, B.M.N.H.

Text-figure 28.



Right lateral and palatal views of the anterior part of the skull of the holotype of *Anteosaurus magnificus*, gen. et sp. n.

Parts in broken lines restored, areas surrounded by thin irregular lines present in the specimen. $\times \frac{1}{3}$.

The general structure will be best understood from text-fig. 28. The septomaxilla is a small bone lying within the nostril, to which it forms a floor, passing inward nearly to the middle line.

It articulates with the nasal posteriorly, with the maxilla in the middle, there being apparently no septomaxillary foramen, and with the premaxilla in front.

The palatine extends forward to the middle of the canine tooth, forming the greater part of the outer wall of the long narrow posterior nares; at the hinder end of the opening it has a suture with the prevomer, which appears to form the whole inner border of the nostril.

The prevomers are unfused, each provided with a high, thin dorsal ridge, similar flanges from the pterygoids passing between and separating those of the prevomers.

The whole structure is like that of the Tapinocephaloid *Mormosaurus*, and especially like that of the detached nose which seems to belong to *Lamiasaurus*.

The structure of these palates raises doubts as to the formation of the internarial bar in Gorgonopsids by the fusion of a pair of prevomers, because in the Deinocephalia the pterygoids separate the posterior ends of the prevomers, whilst in Gorgonopsids they clasp the outer sides of the posterior ends of the internarial bar. The difficulty is not, however, an insuperable one.

The relation of the Dicynodonts to other Anomodonts is a subject on which there has been much difference of opinion, but which can be more satisfactorily discussed now that many details of Gorgonopsid structure are known.

The characteristic features of all Dicynodonts are:—

1. The occipital condyle is triple, the exoccipitals forming its upper parts.
2. The supraoccipital is only slightly drawn forward to form side-walls to the brain-case.
3. The fenestra ovalis lies at the end of a long tube communicating with the vestibule.
4. The temporal fossæ are very large.
5. The face is short.
6. The premaxillæ are edentulous and the maxilla is carried out laterally to the molar teeth, if any be present, and its margin is a sharp ridge covered by a horny sheath.
7. There is a rudimentary secondary palate.
8. The prevomers are fused, forming a roof to the depressed median part of the palate.
9. There are no definite pterygoid flanges.
10. There is an interpterygoid vacuity reaching back to the basipterygoid process and forward to the prevomer.
11. Both quadrate and quadrato-jugal form the articular condyle for the lower jaw.
12. The squamosal is of characteristic shape with a wide flat zygomatic part rising from the upper part of a flat body, the lower part of whose front face is covered by the quadrate and quadrato-jugal.
13. The dentaries are fused and extremely massive.

When the structure of the skull of a Gorgonopsid was discovered, Broom and I independently pointed out the many resemblances which it presented to Dicynodonts in the intertemporal, basicranial, and other regions.

These resemblances are real, but, with the exception (?) of the occurrence of a preparietal, lie entirely in the common possession of primitive Anomodont characters, such as the broad parietal surface and the main features of the basis cranii. When considered in more detail, the structure of such a Dicynodont as *Endothiodon* seems to show no such resemblance to that of a Gorgonopsid as to imply any closer connection between the two groups than either of them bears to the Deinocephalia or Dromosauria. The secondary palate of *Endothiodon* is different in type from that of *Diademodon* and all the forms of Gorgonopsids leading up to it. In them, as in mammals, the original vaulting of the palate is brought about by a down-growth of the tooth-bearing edge of the maxilla below that of the premaxilla; the internarial bar remains attached to the ends of the palatal processes of the premaxillæ, and when the secondary plates of the maxillæ grow out they lie ventral to the palatal parts of the premaxillæ. In fact, the original surface of the palate lies on the roof of the naso-pharyngeal duct, the sides of the palate growing down below it.

In *Endothiodon* (text-fig. 29), on the other hand, the palatal surface of the premaxillæ lie in the same plane as that of the maxillæ and transverse bones, the posterior nares open into a deep groove, excavated in the original palate, which is roofed by a great forward growth of the prevomers over the region formerly occupied by the large posterior nares.

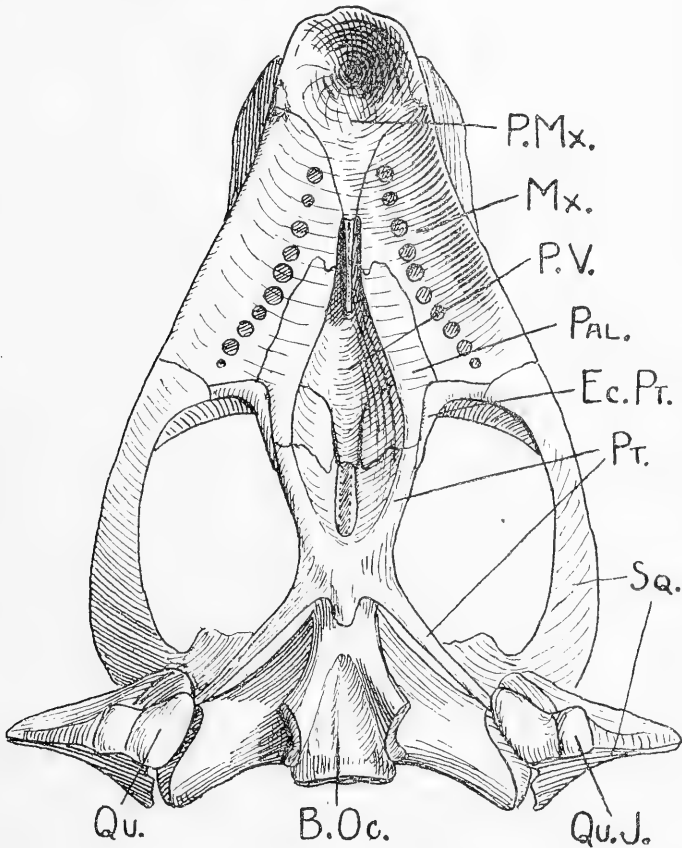
Thus it appears that the palate of Dicynodonts does not present a real resemblance to that of Gorgonopsids, but represents a different mode of development of a secondary palate, identical with that of a Chelonian. One of the most striking features of the Dicynodont palate is the loss of the pterygoid flanges, which are only represented by slight eminences on the edge of the narrow posterior part of the palate over the pterygo-transverse suture. This loss seems to be due to the very great expansion of the temporal muscles squeezing them out of existence, their presence not being necessary to insure accurate closure of the mouth in an animal without a closely-fitting dentition—in some cases their function being taken over by the long canines, which often present wear-faults on their inner sides in large Dicynodonts.

When allowance is made for the changes resulting from the development of the horny covering of the edges of the jaws and the extension of the crushing palate, it is readily seen that the main plan of the anterior part of the *Endothiodon* palate is reducible to that found in Therocephalia, except for the absence of suborbital fenestræ.

Posteriorly, however, there is in Dicynodonts no trace of the

long narrow girder which in the Theriodonts extends from the basiptyergoid processes to the flanges of the pterygoids, and it is therefore probable that the Dicynodonts separated from the Theriodonts before the establishment of this feature—that is, at about the same time as the Deinocephalia. At the same time, in

Text-figure 29.

Palate of *Endothiodon? microps* Broom.

Drawn from R. 4044, B.M.N.H.; the quadrates, quadrato-jugals and jugals, and quadrate rami of the pterygoids, from other material.

the Dicynodonts as in the Deinocephalia and all other S. African Anomodontia in which the facts are known, the descending flanges of the pterygoids lie well in advance of the basiptyergoid processes, a position which is markedly different from that found

in all non-mammal-like reptiles, but which has arisen within the group, as it does not occur in *Varanosaurus*.

The relation of the Theriodontia to the Dromosauria is obscure, because of our very slight knowledge of the detailed skull-structure of the members of that group. In general build the Dromosaur skull differs from that of the Theriodonts and also of the Pelycosaurs in the extreme shortness of the face. In this feature, and also in the depth of the squamosal below the root of the zygoma, it recalls the Dicynodonts, differing from them, however, in retaining a very short temporal fossa. The Dromosaur skull recalls that of *Bolosaurus*, and also still more strongly that of *Palaeobathria*, if my interpretation of Credner's figures of that animal be correct. There are in the structure of the post-cranial skeleton no characters which show significant resemblances to any other South African form, and it seems not improbable that the group represents the end members of an Artinskian group which survived into Upper Permian times.

Thus, in my opinion, the three orders Deinocephalia, Dicynodontia, and Theriodontia may have arisen from a common stock whose direct conservative descendants are the Gorgonopsids, and the Dromosauria may represent a more widely separated stock of the Anomodontia.

One other line of argument which I have not before considered is concerned with the dentition.

In a discussion of the *Dimetrodon* dentition on p. 70, I pointed out that it is desirable in a carnivorous animal with an enlarged canine towards, but not actually on, the front end of the lower jaw to have enlarged premaxillary teeth before the diastema to balance the large canine behind that gap. In such earlier Gorgonopsids as *Gorgonops* and *Scymnognathus*, the incisors are actually of great relative size, much bigger than the cheek-teeth, though, of course, not rivalling the great canines.

In Deinocephalia, both Tapinocephaloids (e. g., *Deuterosaurus*) and Titanosuchids (e. g., *Anteosaurus*), the incisors may be of very great size, and in the former group very curiously converted into effective crushing-teeth. Both these animals have an enlarged canine, followed in the one case by a single molar, in the other by a row of eight very small teeth; in *Deinosaurus* (*Chiorhizodon*) there is a single enlarged canine followed by ten smaller cheek-teeth, all larger than the single incisor preserved.

Thus in this feature the Deinocephalia present a definite resemblance to the Gorgonopsids, one which is shared also by *Dimetrodon*.

In later Gorgonopsids, as I have shown above, the incisors become relatively smaller, and the "molars," although not increased in number above the original five, become relatively larger.

There is some evidence of an irregular replacement of all the teeth of a Gorgonopsid.

When the Cynodontia are reached we find a still further decrease in the relative importance of the incisors, together with an increase in the number of cheek-teeth in *Cynosuchus* to 8, all still much smaller than the incisors, in *Nyctosaurus* to 8, all larger than the incisors, *Galesaurus* ? 10, *Cynognathus* 9, *Diademodon* ? 12, *Trirachodon* 9. This sudden increase in the number of cheek-teeth seems to be associated with the development of a bony secondary palate, which allows of prolonged mastication being carried on without obstruction of the nasopharyngeal passages.

It is important to note that the anterior five "molars" of *Cynognathus crateronotus* are sharply distinguished from those which succeed them, and that in *Diademodon*, when the four anterior cheek-teeth are similarly distinguished by structure, these teeth and these alone amongst the cheek-teeth give indications of replacement.

In fact, the evidence brought forward by Broom (Bull. Amer. Mus. Nat. Hist. vol. xxxii. p. 465), although it is not quite so conclusive as one could wish, does tend to show that these Cynodonts had a thoroughly mammalian dentition with premolars replacing milk-predecessors and molars never replaced.

Comparison with Gorgonopsids suggests that the premolars are the original cheek-teeth, the molars representing a new backward growth of the dental lamina, in which the teeth all belong to a single generation, and from their origin have never had either predecessors or successors.

I hope to return to a consideration of the whole problem of dental succession in early reptiles shortly.

The Gorgonopsids being characterized throughout their history by the possession of a very short series of molar teeth, we have to consider the problem presented by the fact that whilst some Therocephalia, e.g., *Scymnosaurus* and *Hyaenosuchus*, resemble them in this feature, others, *Alopecodon* etc. amongst large forms and *Icticephalus* and *Scaloposaurus* amongst the small, retain a large series of molars, without, so far as known, having a secondary palate, and possess in addition small incisors.

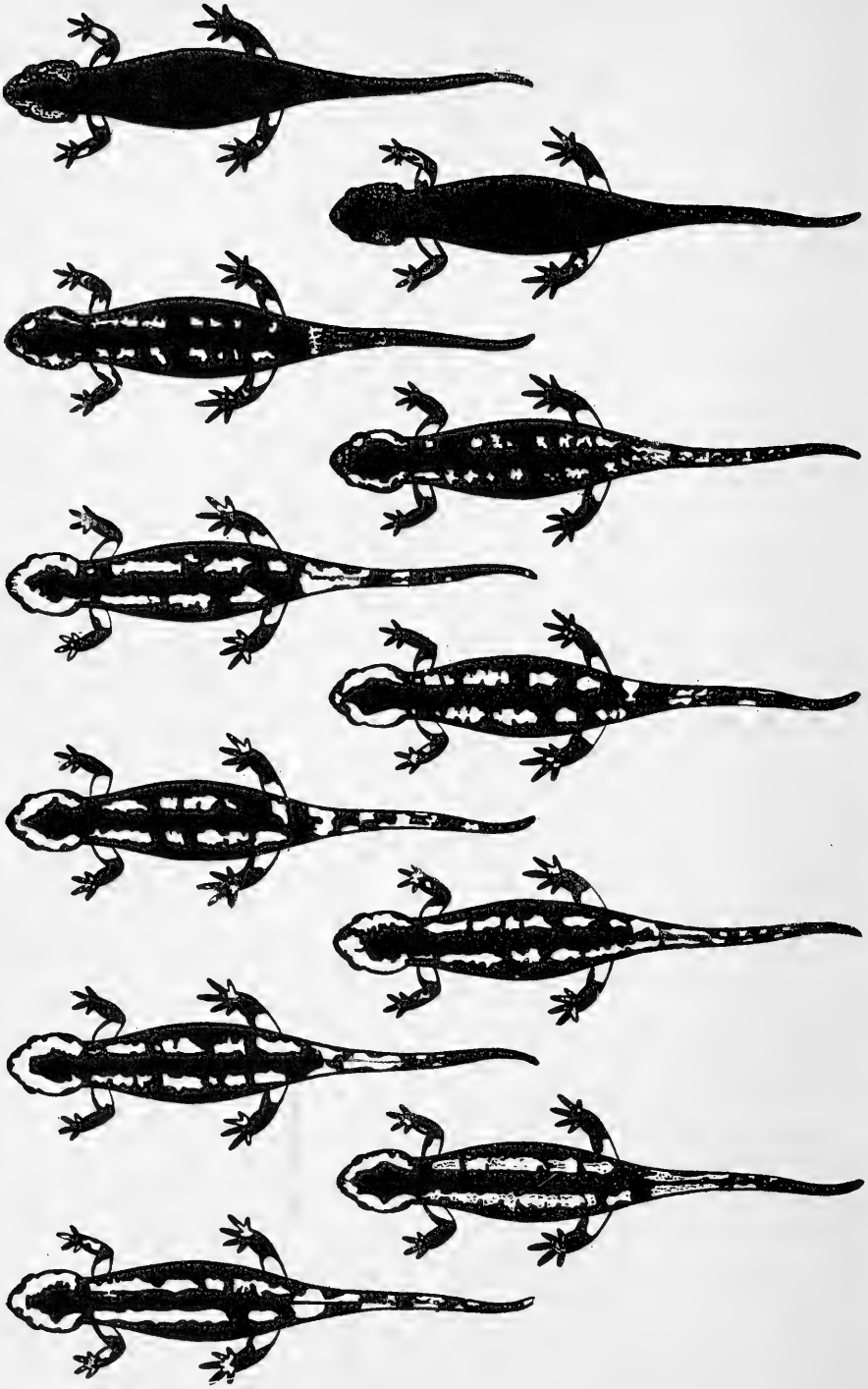
It seems reasonable to regard these latter animals as unmodified, the dentition being derived directly from their ancestors, whilst *Hyaenosuchus* represents a parallel reaction to that of the Gorgonopsids to similar feeding habits. All detailed discussion of the dentitions of Theriodontia are rendered nugatory by our complete absence of knowledge of the postcranial skeleton, for only by a study of the whole structure is it possible seriously to consider the habits and adaptations of an animal, and teeth react perhaps more quickly than any other structures to external impressions.

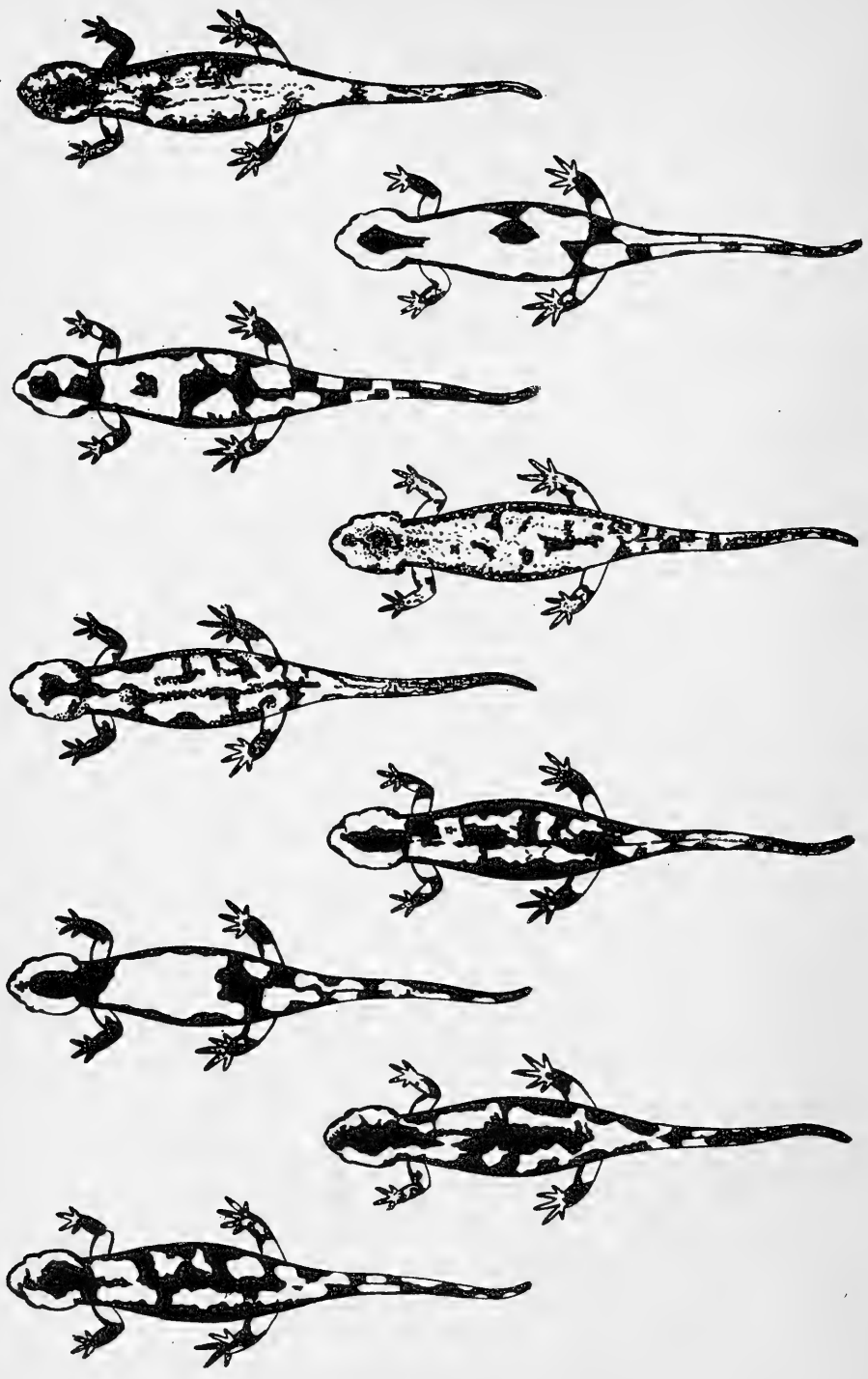
In any case the occurrence of these Therocephalians with a long tooth-row and small incisors, and of a similar structure in *Clitherhizodon*, shows that the heavy incisors of Gorgonopsids

and Deinocephalia have been independently acquired by these two groups.

The study of Theriodont structure and evolution, which is the content of this paper, thus leaves us still without any satisfactory classification of that group, but in its establishment of a series of evolutionary trends, which persist throughout the history of the Anomodontia, has I hope laid a solid foundation on which a natural arrangement may in future be built up when increased knowledge allows an examination of the "adaptive radiation" of the order to be entered on. Meanwhile, the forms whose skulls are well known fill in with considerable completeness the great morphological gap which exists between the Lower Permian Pelycosauria and the Lower and Middle Triassic Cynodonts, and in this way enable us to understand the material steps in the evolution of almost all the structures of a Cynodont skull from those in so primitive a reptile as *Seymouria* or, indeed, in the still more primitive Embolomeres amphibian. Dealing as it does with many diverse faces of the subject with which it is concerned, this paper does not lend itself to summarisation, but the point of widest interest brought out in it is undoubtedly the demonstration of the occurrence of the same evolutionary trends in so many allied branches in the Pelycosauria, Gorgonopsids, Therocephalia, and Deinocephalia; and the fact that the changes brought about in accordance with these trends often serve an adaptive purpose and appear to depend on mere mechanical necessities.

My thanks are due to the Percy Sladen Trustees for defraying part of the expenses of my visits to South Africa and Texas. To Dr. A. Smith Woodward and Dr. C. W. Andrews I am indebted for many facilities and much kindness in the British Museum, and to the Department of Industrial and Scientific Research I owe the stipend which has enabled me to carry out this work.





COLOUR-CHANGES OF THE SPOTTED SALAMANDER (SALAMANDRA MACULOSA).

4. Experiments on Colour-changes of the Spotted Salamander (*Salamandra maculosa*), conducted in the Society's Gardens. By E. G. BOULENGER, F.Z.S. (Curator of Reptiles).

[Received October 29, 1920; Read March 8, 1921.]

(Plates I. & II. : Text-figure 1.)

The remarkable experiments conducted in recent years at the Biologische Versuchs-anstalt, Vienna, by Kammerer on the action of modified environment on certain Batrachians have attracted much attention, and a good deal of criticism. Prof. E. W. MacBride, F.R.S., to whom I am indebted for much help and advice, suggested to me last year that an attempt to repeat the experiments conducted by Kammerer with the Spotted Salamander (*Salamandra maculosa*), on the correlation between the coloration and the conditions under which Salamanders may be subjected to, would be of special interest. According to Kammerer, an increase of the bright colour takes place on a yellow soil, especially when the animals are kept in terraria coloured yellow in such a manner that yellow rays of light fall on the Salamanders, whilst the reverse takes place when they are kept in the dark on black humus. Further, he claimed to have succeeded in the extremely difficult task of inducing his Salamanders, which he kept under the above conditions, to breed in captivity, and states that the offspring inherited the characters of their parents, being yellower or blacker than the normal, according to the surroundings in which the first generation had been placed. During the past year I have been keeping under conditions similar to those referred to by Kammerer a large number of Salamanders received from the French Jura, thanks to the kindness of Mme. Phisalix of the Pasteur Institute, but it is as yet too early to expect any striking changes, and the present paper deals with the results obtained by repeating certain experiments conducted by Kammerer's pupil, Secerov, who kept Salamander larvæ in aquaria under yellow or black conditions*. Secerov unfortunately started his experiments with only four larvæ, the offspring of a Salamander of the variety *taniata*. Two of these larvæ were placed in an aquarium coloured yellow and two in an aquarium coloured black. The results he obtained were as follows:—

That Salamanders kept in yellow surroundings when in the larval stage were on transformation yellower than their mother: that the spots were larger and had a tendency to fuse together.

That the reverse takes place when Salamander larvæ are kept in black surroundings, the transformed animal being darker than the mother: that the spots are smaller and more numerous.

* 'Biologisches Centralblatt,' 1914.

In January of this year (1920), I was given a pregnant Salamander of the variety *teniata*, which I was informed was received from Western Germany. In this specimen (see text-fig. 1), in which neither the black nor the yellow can be said to predominate, the dorsal spots are confluent into broad bands along each side.

On February 2nd this Salamander gave birth to 32 young, and half the larvæ were immediately placed in aquaria 16 inches square, entirely painted orange-yellow, whilst the other half were placed in similar aquaria painted black all over. In the

Text-figure 1.



course of their larval life 12 of these young Salamanders died, 7 of those placed in the yellow aquaria, and 5 of those in the black aquaria. Of these, however, two in each set died only just prior to transformation, having developed the yellow and black pigments of the perfect animal. It will be observed from the figures on Plates I. & II. that in these experiments the results obtained by Secerov were fully confirmed, the majority of the Salamanders which had been kept in yellow surroundings when in their larval condition being on transformation yellower than the mother, and the spots larger and fused together: the Salamanders

kept in black surroundings being on transformation darker than the mother, and the spots smaller and more numerous.

To appreciate fully the markings on these Salamanders it is, however, necessary to bear in mind the fact that it is possible to define two forms of *S. maculosa*. As I pointed out in a paper brought before this Society some years ago*, authors in dividing this Salamander into a number of varieties have dwelt on supposed structural characters, whilst ignoring the disposition of the markings. I showed that two principal forms existed, namely, the typical form and the variety *teniata*: the former, in which the yellow appears as markings of various shapes disposed anyhow over the body, being more or less an eastern form; the latter, in which the dorsal spots are regularly disposed in two parallel series continuous with the markings on the parotoids, being a more western form. The markings in the last referred to variety may form regular bands or be broken up into numerous small spots, which, however, always retain their duplex disposition, not encroaching over the black vertebral area, or, if they do so, as is rarely the case, they will be connected by a cross-bar in an H-shaped form. The habitat of the *forma typica* appears to be bounded to the west by the Erz Mountains, the Danube, the Alps, and the Rhone, Salamanders from east and south of that line belonging to it. All over France, west and north of the Rhone, Belgium, S. Holland, Western Germany, Spain, and Portugal the variety *teniata* alone occurs, with very rare exceptions. Both are found together only on the line of demarcation, such as in the French Jura, where the variety *teniata* predominates, but is not completely fixed.

Even amongst Salamanders from the neighbourhood of the line of demarcation it is rare to experience any difficulty in classifying them into either of the two forms, and I was therefore much puzzled by Secerov's results, as neither of his Salamanders kept during their larval life under yellow surroundings were quite normal *teniata*. One of these Salamanders was specially abnormal, as two spots on the anterior part of the body fused together over the vertebral area; and I should have felt some doubt in referring it to the variety *teniata*, had I not known the mother to be a very typical specimen of this form.

The results I have obtained help to solve the problem, as they show that in the majority of cases, if the offspring of a Salamander of the western variety *teniata* is kept when in the larval conditions in yellow surroundings, the markings will differ in their disposition from those of the parent, and be similar in their arrangement to what we find in the typical eastern form, in which the spots are disposed in an irregular fashion over the vertebral area.

* "A Contribution to the Study of the Variation of the Spotted Salamander," P.Z.S. 1911.

Plate II. shows the nine Salamanders kept during aquatic life in yellow surroundings on or just prior to their transformation, and it will be observed that six are referable to the typical form, two are somewhat doubtful, and one only could possibly be regarded as belonging to the variety *teniata*. Plate I. shows those kept in black aquaria, and it will be noticed that the spots are disposed in parallel series, as would be expected from the offspring of Salamanders of the striped variety.

On transformation the young of specimens of the variety *teniata* from the French Jura, which is, as referred to above, on the line of demarcation where both forms occur, are often referable to the typical form; the spots, however, in the course of time change their disposition, breaking up, and disappearing on the vertebral area, so that within a year the Salamanders are similar to their parents in the arrangement of their markings. I have no doubt that we shall find this to be the case with the Salamanders which in their larval form have been brought up in yellow surroundings, and that the spots will in time assume the same duplex disposition as presented by their parents, and brethren brought up when in the larval form in black surroundings.

5. Contributions to the Morphology, Classification, and Zoogeography of Indian Oligochæta. By J. STEPHENSON, D.Sc., F.Z.S., Lecturer in Zoology in the University of Edinburgh.

[Received November 6, 1920: Read February 22, 1921.]

(Text-figure 1.)

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I.—THE AFFINITIES AND SYSTEMATIC POSITION OF THE GENUS *EUDICHOGASTER* MCHLSN., AND SOME RELATED QUESTIONS.

The genus *Eudichogaster* was established in 1902 by Michaelsen (2) for *E. ashworthi*, then first made known, and for several other worms which had been originally described as species of *Dichogaster* (or *Benhamia*), but which were placed by Michaelsen in the Tierreich volume of 1900 in the genus *Trigaster*. The separation of these three genera is based on the presence or absence and on the position of the calciferous glands; *Trigaster* has none, *Eudichogaster* has them in xi. and xii. (with, it may be, x. or xiii. in addition), *Dichogaster* has them in xiv., xv. and xvi., or in xv., xvi. and xvii. The diagnosis of the genus *Eudichogaster* is as follows:—

Setæ four pairs per segment. Prostatic pores two pairs on xvii. and xix., or one pair on xvii. (? or xviii.). Spermathecal pores two pairs on viii. and ix., or one pair on viii., or in groove 7/8. Two gizzards in front of the testis segments. Calciferous glands two or three pairs, in xi. and xii., or x., xi. and xii., or xi., xii. and xiii. (in one species no proper calciferous glands recognizable). Micronephridial. One or, more usually, two pairs of testes. Prostates tubular.

In the paper in which the genus was established, Michaelsen placed it in the Trigastriinæ. In 1903, however (3), he leans to the view that it is to be derived from *Octochætus*, and therefore to be included in the Octochætinae, though he does not carry out this implication in the tables. In 1909 (4) he definitely adopts this view. In 1910 (5) he abandons it, and, deriving *Eudichogaster* from *Trigaster*, again places it in the Trigastriinæ. The object of the present communication is, by bringing forward additional evidence, to decide the question in favour of its inclusion in the Octochætinae, by showing that it is descended from *Octochætus*, not from *Trigaster*.

The classification of the Megascolecidae, to which both sub-families, the Octochætinae and Trigastrinae, belong, proceeds on phylogenetic lines; and a very considerable degree of success has been reached in the filiation, and consequently in the definition and arrangement of genera. The origin of the family, as is now generally recognized, is to be sought in the "original Acanthodriline," a form which is represented at the present day by the genus *Notiodrilus* as defined by Michaelsen in the Tierreich volume (1). Its essential characters (for our present purpose) are as follows: A pair of male pores on xviii., two pairs of prostates opening separately on xvii. and xix., a single œsophageal gizzard, four pairs of setæ per segment, one pair of meganephridia per segment, no calciferous glands.

The important characters of the genera which enter into the following discussion may be stated thus:—

Diplocardia, one remove from the original Acanthodriline, and the ancestor of the Trigastrinae, differs from the original Acanthodriline only in having two gizzards. It is found in North and Central America.

Trigaster, descended from *Diplocardia*, differs from the latter genus in being micronephridial; the posterior male organs are either of the acanthodriline type or they may have undergone the "microscoleine reduction" (disappearance of the posterior pair of prostates, and union of the male pores with the anterior prostatic openings on xvii.); there are two or three gizzards, but no calciferous glands. *Trigaster* is found in Mexico and the West Indies.

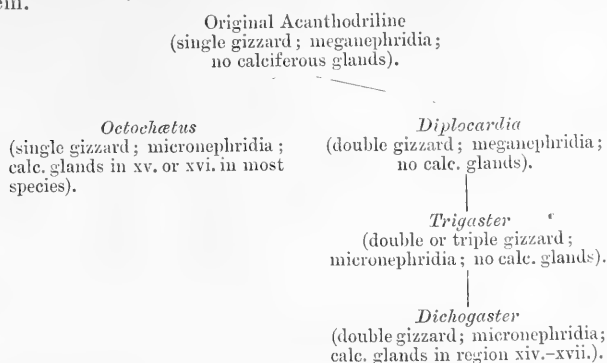
Dichogaster is similar to *Trigaster*, except that there are calciferous glands in two or three of the segments xiv.–xvii. A point to which attention has been called is that while in *Trigaster* the setal interval *cd* is greater than *ab*, in *Dichogaster* these intervals are approximately equal. *Eudichogaster* was supposed to resemble *Trigaster* in this respect, but in a few species *ab* is equal to *cd*. *Dichogaster* is endemic in tropical Africa, and probably in Central America and the West Indies, but has spread widely in the tropics and warmer temperate zones.

The first development, therefore, in the above line of descent (*Diplocardia*-*Trigaster*-*Dichogaster*), and the primary characteristic of the Trigastrinae (I include *Diplocardia* in the Trigastrinae, v. post.), is the reduplication of the gizzard.

The genus *Octochætus* belongs to a different line. It differs from the original Acanthodriline in being micronephridial, and in having a pair of calciferous glands in segment xv. or xvi. (a few species, to which more particular reference is made subsequently, are without calciferous glands); it has the single gizzard and other characters of the ancestral form. It occurs in India and New Zealand.

The other genera of the subfamily need not be mentioned here. The first development in the Octochætinae, and therefore their

primary characteristic, is the splitting up of the nephridial system.



Eudichogaster, whose position is now under discussion, has a double gizzard, is micronephridial, and has calciferous glands (except in one species) in two or more of segments x.-xiii.; in some species the posterior male organs have undergone the microscolecin reduction. It is purely Indian in distribution.

The view, now held by Michaelsen, that *Eudichogaster* is derived from *Trigaster*, and therefore to be included in the Trigastriinæ, is based primarily on the close anatomical similarity between the two genera; the only essential difference is that calciferous glands are absent in *Trigaster* and present in *Eudichogaster*. Moreover, there is one species of *Eudichogaster* in which calciferous glands can scarcely be said to be present at all. Michaelsen, in describing *E. bengalensis* (5) says:—"a pair of lateral calciferous glands in each of segments x.-xiii., not externally demarcated." In giving additional notes on the same species (9) I have stated that "the bulgings of the œsophagus in segments x.-xiii. are thin-walled and are not at all set off from the lateral walls of the œsophagus; they are not calcareous glands any more than the similar part of the tube in, for example, *Pheretima posthuma* is a series of calcareous glands"; and in support there follows a description of the appearances seen on opening the tube. Here, then, is a form which according to strict definition is a *Trigaster*; though I imagine no one will quarrel with either Michaelsen or me for including it, on geographical grounds, in *Eudichogaster*.

Michaelsen also regards the similarity of the nephridial condition as being decisively in favour of the derivation of *Eudichogaster* from *Trigaster* rather than from *Octochaetus*. The species investigated for the purpose of this comparison were *Eudichogaster ashworthi*, *Trigaster lankesteri* subsp. *calwoodi*, and *Octochaetus thurstoni*. In *Eudichogaster ashworthi* there occurs in each segment a number of small loose micronephridial

tufts, each apparently with a funnel; in addition, in the hinder segments there is on each side, near the ventral nerve cord, a larger nephridium in the form of a fairly large rosette, with a funnel in the preceding segment. *Trigaster lankesteri* has the same arrangement, while *Octochaetus thurstoni* has numerous micro-nephridia throughout the body, without any trace of the larger organs. The only morphological change, therefore, which is necessary in order to evolve *Eudichogaster* from *Trigaster* is the development of calciferous glands; and indeed these are scarcely present in one species of *Eudichogaster*.

Michaelsen admits that the geographical facts do not at first sight appear favourable to this view. As has been noted, *Eudichogaster* is purely Indian, while *Trigaster* belongs to Mexico and the West Indies. But the widespread occurrence of *Dichogaster*, a descendant of *Trigaster*, in tropical Africa is evidence, according to Michaelsen, of a former land-bridge across the Atlantic; and Michaelsen supposes that either (1) *Eudichogaster* originated from *Trigaster* in America, spread eastwards across the land-bridge to Africa, colonized Africa or parts of it, and then spread eastwards again across another land-bridge to India (it is not found in Africa at the present day because it has been extirpated there by the dominant Eudrilines and the later evolved *Dichogaster*); or (2) that *Trigaster* itself spread eastwards by the same bridges, and gave rise to *Eudichogaster* at the eastern extremity of its range, *i. e.* in India, itself later being extirpated in the middle portion of its range, *i. e.* in Africa, by the Eudrilines and its own descendant *Dichogaster*, as before.

In putting forward the view that the ancestor of *Eudichogaster* is *Octochaetus* and not *Trigaster*, it may be admitted that, as Michaelsen says, *Eudichogaster* and *Trigaster* are very much alike morphologically. At the same time, I think we now possess evidence of a much closer similarity between *Eudichogaster* and *Octochaetus* (or at least some species hitherto reckoned as *Octochaetus*) than Michaelsen was aware of. The gap between the two genera is bridged almost, if not quite, as completely as that between *Eudichogaster* and *Trigaster*. The points to be discussed are the gizzards, the calciferous glands, and the nephridia.

I have described (11) in *Octochaetus pallidus* a commencing doubling of the gizzard:—"The gizzard is barrel-shaped, in segment vi.; the œsophagus is distinctly strengthened in segment v. also, where shining longitudinal muscular bands are seen. This seems to be the beginning of a double gizzard, such as seen in *Eudichogaster*, *Dichogaster* and *Trigaster*; I do not, however, suggest at present that any of these genera are derived from this species, or indeed from the genus *Octochaetus* at all."

I may here call attention to the relation of the septa to the condition of duplicate gizzard. *Octochaetus pallidus* is one of the rather few species of the genus which retain all the septa in the anterior part of the body (behind the level where they first

definitely begin). The presence of septa between the successive gizzards seems to be a necessity for their development as separate structures, and two gizzards probably could not develop in the majority of species of *Octochaetus*, where one, two, or three septa are absent in the gizzard region; an extension of the muscularity of the oesophagus would simply result in an increase in the size of the existing gizzard. In *Trigaster*, with two or three gizzards, the septa are all present. I am not acquainted with the facts in all the numerous species of *Dichogaster*, but the septa are certainly often present; in *D. malayana*, where there is no septum 5/6, separate gizzards are, according to my observation (9), scarcely discernible in segments v. and vi.—they seem to have “run together,” as it were. In the single species of the genus *Monogaster*—essentially a *Dichogaster* in which there is only one gizzard—the septa in the gizzard region are wanting (6) and the two gizzards of the *Dichogaster* ancestor have doubtless “run together.” In those species of *Dichogaster* where septa are absent in the region of the gizzards (e. g. *D. crawi*) we may perhaps predict that the gizzards will not remain long separate, and that the condition of *Monogaster* will be arrived at. We may conclude that the duplication of the gizzard, while impossible in the majority of species of *Octochaetus*, would be possible in the primitive group consisting of *O. bishambari*, *pachpaharensis*, and *pallidus*, and seems to be in process of accomplishment in *O. pallidus*.

Next with regard to the calciferous glands: in *Eudichogaster* these organs are in segments x.—xii. or thereabouts, in *Octochaetus*, usually, in segments xv. or xvi. It would, I think, be difficult to derive *Eudichogaster* from *Octochaetus* if these were constant characters of the two genera (though Michaelsen, deriving *Dichogaster* from *Eudichogaster* (4), sees no difficulty, apparently, in assuming a dislocation of the glands backwards; in deriving *Eudichogaster* from *Octochaetus*—from the usual type of *Octochaetus* that is—the dislocation would have to be forwards). But the more primitive species of the genus *Octochaetus* (*O. bishambari*, *pachpaharensis*, and *pallidus*) have no calciferous glands; in *Eudichogaster bengalensis*, as has been seen, they are at a very low level of development; the morphological similarity, in this respect, between these species of *Octochaetus* and *Eudichogaster* is just as close as that between *Trigaster* and *Eudichogaster*, and the derivation of the one from the other just as easy.

It will be remembered that one reason for deriving *Eudichogaster* from *Trigaster* rather than from *Octochaetus* was the similarity of the nephridial condition in *E. ashworthi* and *T. lankesteri*, and the dissimilarity between *E. ashworthi* and *O. thurstoni*. But a wider survey of the nephridia of the latter two genera shows that not all *Eudichogaster*s are in the same condition as *E. ashworthi*, and that not all species of *Octochaetus* are like *O. thurstoni*. Of the six species of *Eudichogaster* where the descriptions are sufficiently detailed to be of use, in only one other (*E. prashadi*) is the nephridial system capable of being

described in the same way as in *E. ashworthi*; it follows therefore that if *E. ashworthi* is similar to *Trigaster*, the majority of species of *Eudichogaster*, so far as known, are not. Speaking very broadly, there is indeed some similarity between all these six species of *Eudichogaster* and *Trigaster lankesteri*; in all, a certain number of the micronephridia are of large size, much larger than in *Pheretima*, for example, or *Eutyphæus*, to take two well-known micronephridial genera. But this feature occurs also in some species of *Octochaetus*--in exactly those three species previously referred to; in these there are seven, three, or even apparently only one nephridium on each side in each segment, which make up in size what they lack in number. The majority of species of *Eudichogaster*, in fact, approach in their nephridial condition somewhat more closely to such forms as *Octochaetus pallidus* and *O. pachpaharensis* than to *Trigaster lankesteri* *.

I am, however, not inclined to attach very great weight to any argument from the nephridia. The possession of a certain number of micronephridia of fairly large size does not necessarily show genetic relationship: it occurs, for example, in species of *Megascolides* and *Megascolex*, which belong to a different subfamily, the Megascolicinae. Indeed there are very diverse conditions within these two genera themselves.

I think the above considerations show that the passage from *Octochaetus* to *Eudichogaster* is just as easy morphologically as that from *Trigaster*, and that there is no difficulty in deriving *Eudichogaster* from an *Octochaetus* ancestor which had the characters of the group *pallidus*, *pachpaharensis*, and *bishambari*.

But if the morphological evidence is equally balanced, the geographical evidence is strongly on the side of the descent of *Eudichogaster* from *Octochaetus*. *Octochaetus* is a characteristic Indian genus, found throughout the land; *Eudichogaster* is exclusively Indian, and is found in a broad belt across the middle

* In *Eudichogaster ashworthi*, towards the hinder end of the body the innermost of the transverse series of micronephridia enlarges so as to resemble a meganephridium; the number of micronephridia in each segment appears to be small,—in var. *kinneari* it is about six on each side. In *E. prashadi* much the same occurs,—there are about five on each side, regularly arranged behind each other in succeeding segments till towards the hinder end, where the innermost becomes larger and the others smaller, less regular, and more numerous. In *E. barodensis* the three most dorsally situated micronephridia on each side of each segment are larger than the rest, while at the hinder end the innermost (most ventral) also enlarges. In *E. bengalensis* there are two pairs of large nephridia per segment in addition to a number of small micronephridia; towards the hinder end the inner of the two larger nephridia becomes more conspicuous than the other. In *E. chittagongensis* there are three or four nephridia on each side in each segment, arranged behind each other in succeeding segments, the outermost in each transverse row being the longest; near the hinder end the innermost increases in size and becomes more conspicuous. In *E. trichochaetus* there are four longitudinal rows on each side of the body, but here the innermost series is the smallest. In *E. parvus*, though the nephridia are “diffuse,” they are of considerable size.

In *Octochaetus pallidus* the micronephridia in the post-clitellar segments are about seven on each side in each segment, and they increase in size from the ventralmost to the fifth, the two most dorsal being smaller again; this difference in size disappears towards the hinder end. In *O. pachpaharensis* there are three on each side per segment behind the genital region, and in front even fewer.

of the country. *Trigaster* is not known outside Mexico and the West Indies. Deriving *Eudichogaster* from *Octochætus*, we need no such hypothesis as that advanced by Michaelsen—the origin of *Eudichogaster* from *Trigaster* in America, and its spread by means of land-bridges across the Atlantic and Indian Oceans (or alternatively the spread of *Trigaster* itself by the same means) as far as India. *Eudichogaster* would have arisen where we find it—in India, where its ancestor also lives.

I conclude, therefore, that *Eudichogaster* arose from *Octochætus* in India. It must therefore go into the Octochætinae, not the Trigastriinae.

RAMIELLA, gen. nov.

I propose now to consider the more primitive species of the genus *Octochætus* to which reference has been made in the preceding paragraphs.

In 1914 (7) I described a worm which I placed in the genus *Octochætus* under the name *O. bishambari*, although it differed from all species of *Octochætus* then known in having no calciferous glands, and in having only one nephridium on each side in each segment. Measured by its size, indeed, this nephridium would be a meganephridium, and the worm would not be an *Octochætus* at all, but an Acanthodriline—a "*Notiodrilus*,"—and would correspond to the original Acanthodriline, the origin of the Megascolecidae. This, however, seemed impossible; there are no representatives of the Acanthodrilinae in India (except one introduced species of *Microscolex*); and the single nephridium does not, according to the evidence of sections, come into relation with the septum in the normal way, and is therefore to be looked on as a hypertrophied micronephridium, the only one left of a former larger series.

In 1920 (11) two more forms closely related to the preceding came to light. While both, *Octochætus pachpaharensis* and *O. pallidus*, are without calciferous glands, the first has only three (or anteriorly perhaps fewer) micronephridia on each side per segment, and the second only about seven.

This reduction in the number of micronephridia is probably—certainly in the case of *O. bishambari*—to be looked on as secondary, while the absence of calciferous glands is probably primitive. Other primitive features are the presence of all the septa in the anterior part of the body (behind the level at which they first definitely begin), and the absence of spines or teeth on the penial setae.

It is apparently from this group that *Eudichogaster* has arisen, as I have argued above. Since the group is a well-defined one, is differentiated from the remaining species of *Octochætus* by morphological characters of importance—absence of calciferous glands, reduction in the number of micronephridia—and has different relationships from those of other species, I propose to erect for them a new genus, *Ramiella*, which I associate with

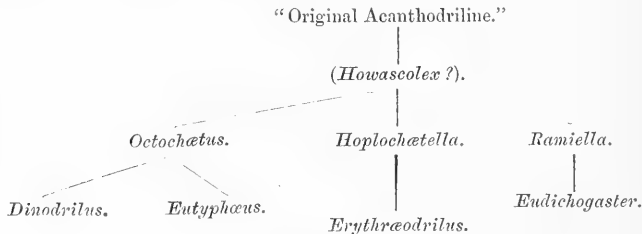
the name of my former colleague, Prof. Shiv Ram Kashyap of Lahore.

Diagnosis:—Setæ eight per segment. Male pores on xviii.; two pairs of prostatic pores, on xvii. and xix. Spermathecal pores two pairs, in 7/8 and 8/9, or on viii. and ix. Gizzard in vi. All septa present after their commencement. No calciferous glands. Micronephridia; micronephridia relatively large, few in number. Testes and funnels free in x. and xi.

Distribution:—India (Mahableswar, S. Rajputana, Saharanpur).

It will be noted that the species extend in a line from the Western Ghats to the Western Himalayas, the most primitive (at least the one in which the reduction in the number of nephridia has made least progress) being at the southern end, the most modified at the northern.

The relationships of the genera of Octochætinae may be set forth in the accompanying tree:—



(On the question of the inclusion of *Howascolex* in the ancestral line of the Octochætinae see (8), and the references there given. On the inclusion of *Hoplochetella* and *Erythraodrillus* in the Octochætinae see (10).)

Probably no genealogical tree expresses relationships with exactitude; every genus is strictly speaking at the end of a short side line. Thus *Ramiella* probably comes off the main stem shortly above the position of *Howascolex*; the original meganephridium seems to have broken up in a different way in these two genera—in *Howascolex* to have become one still fairly large and a number of minute nephridia, in *Ramiella* to have dissolved into a few moderate-sized organs.

The Derivation of the genus Dichogaster.

There remains the question of the origin of the genus *Dichogaster*. In 1903 and 1909 Michaelsen regarded it as derived from *Eudichogaster*; while in 1910 he states that morphologically it is best derived from *Eudichogaster*, though geographically it would appear easier to derive it from *Trigaster*; the geographical argument is, however, not by any means absolutely cogent—there is nothing in the facts essentially opposed to the derivation from *Eudichogaster*.

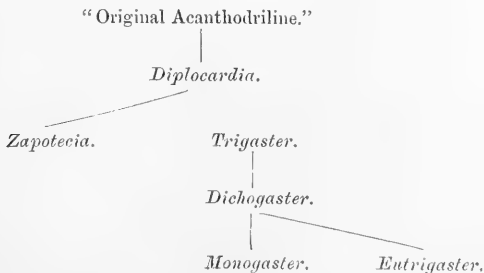
To this view of the origin of *Dichogaster* I cannot agree. In

Eudichogaster the calciferous glands are in segments x.-xiii., or some of them; in *Dichogaster* as a rule in xv.-xvii. It is not so easy for me as it is for Michaelsen, apparently, to imagine a "dislocation backwards" of the glands; it is easier for me to conceive *Dichogaster* arising from *Trigaster* which has no such glands, than from *Eudichogaster* which has them, but in a different place. Apart from that, the geographical argument seems to me decisive: *Trigaster* belongs to Mexico and the West Indies, and these regions are probably part of the endemic home of *Dichogaster*; *Eudichogaster* is altogether Indian, and it is very doubtful whether there is any endemic species of *Dichogaster* in India at all—certainly there is none anywhere near the *Eudichogaster* region. The place of origin of *Dichogaster* was pretty certainly not India. I derive *Dichogaster* therefore from *Trigaster*.

Diplocardiinae and Trigastrinae.

There is a line of descent, the Megascolecinae, which leads from the "original Acanthodriline," and in which the initial change is the disappearance of the anterior prostates and the union of the posterior prostatic pores with those of the vasa deferentia on segment xviii. There is another line, the Octochætinae, in which the initial change is the breaking up of the meganephridia into micronephridia. Similarly, there is a third line, the initial change here being the reduplication of the gizzard.

This third line (there are still several others) has commonly been divided up into the two subfamilies of the Diplocardiinae and Trigastrinae. These subfamilies, indeed the two combined, are smaller than the Megascolecinae or the Octochætinae; the Diplocardiinae comprise only *Diplocardia* and *Zapotecia* (*Diplocardia* having two and *Zapotecia* three gizzards, a distinction which is not held to be of generic importance in the case of *Trigaster*, which contains species with both); while the Trigastrinae, after the removal of *Eudichogaster*, comprise *Trigaster*, *Dichogaster*, *Monogaster*, and *Eutrigaster* (with three gizzards, and three pairs of calciferous glands in segments xv., xvi. and xvii.). I believe there would be a gain in uniformity and an increase in convenience in uniting the subfamilies under the one head of Trigastrinae.



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II.—ON POLYPHYLY IN THE OLIGOCHAETA.

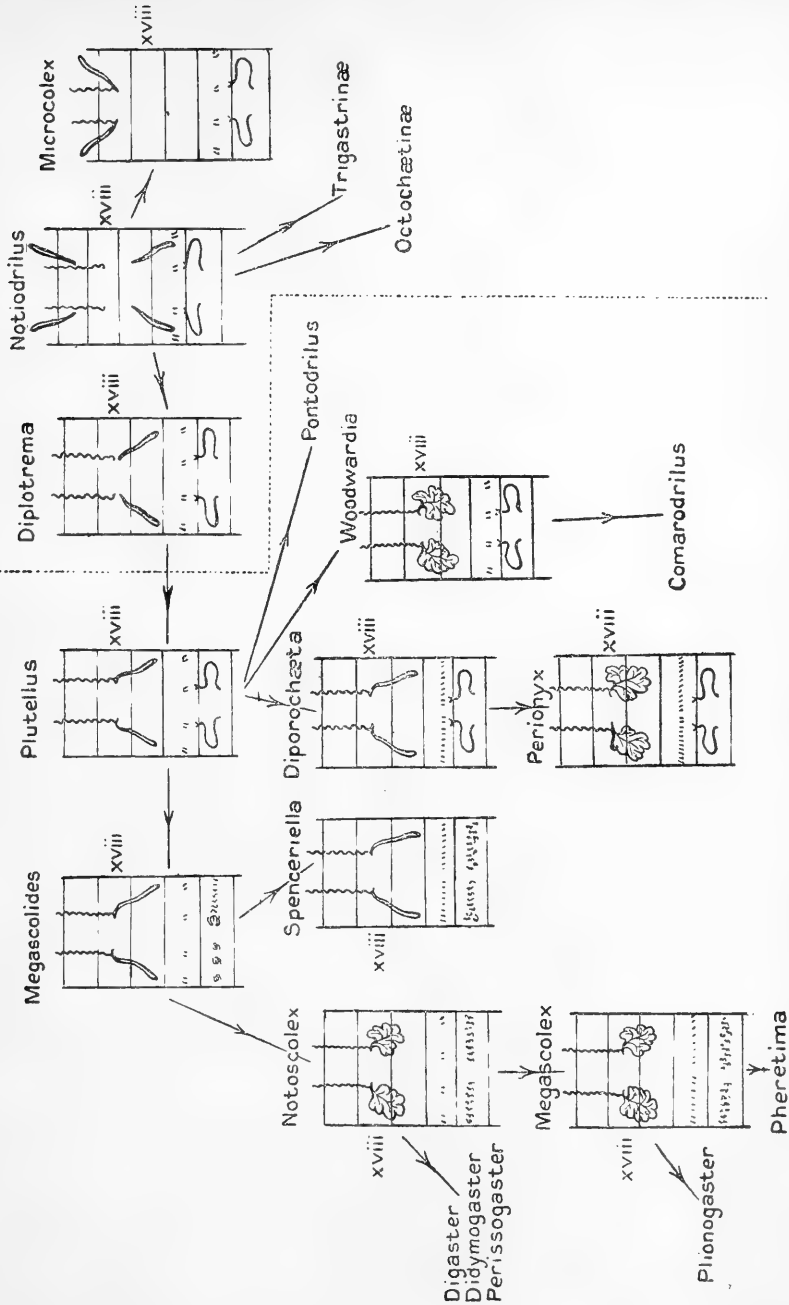
The material which I wish to use in this discussion is derived from the Megascolecidae, and largely from the subfamily Megascolecinae. It will be necessary first to show how the various genera of this subfamily are related (v. text-fig. 1).

The whole of the family Megascolecidae is to be derived from an original form which has essentially the characters of the genus *Notiodrilus* as defined by Michaelsen in the Tierreich volume of 1900. These are: Testes and funnels two pairs, free in segments x. and xi.; vasa deferentia of each side uniting in their backward course so that there is only one pair of male apertures, on xviii.; two pairs of tubular prostates, with unbranched central canal, opening on xvii. and xix.; setae four pairs per segment; one pair of meganephridia per segment; a single gizzard far forward, in segment v. or vi.

The Megascolecinae, however, take their origin from a form which is one remove from this—*Diploctrema*, in which the anterior pair of prostates have disappeared and the posterior pair of prostatic pores have moved forwards to open on xviii. near the apertures of the vasa deferentia.

In *Plutellus*, the first genus of the Megascolecinae, the prostatic pores have fused with the openings of the vasa deferentia on xviii. so that there is but one pair of pores; and this remains throughout the subfamily as its distinguishing character. In the remaining genera the changes are of three chief kinds—the setae may take on the perichetine arrangement, the four pairs multiply in number and become spread out to form a more or less complete ring round each segment; the nephridia may be broken up,

Text-figure 1.



The Relationships of the Megasclecinae (the Megasclecinae comprise the genera to the left of the dotted line).

with the substitution of a number, sometimes a very large number, of small micronephridia for the single pair of meganephridia in each segment; and the single central canal of the prostate may branch, with the consequence that the organ is no longer tubular and cylindrical in form, but racemose. In a small group of genera there is a development of two or more gizzards, instead of the single gizzard of *Plutellus*.

Plutellus, then, has meganephridia, eight setæ per segment arranged in four pairs (the lumbricine arrangement), and a pair of tubular prostates opening on segment xviii. in common with the vasa deferentia. From *Plutellus* is derived *Megascolides*, in which the nephridia are breaking up or have broken up; this apparently does not always take place in the same way: in one group of forms there are three or four nephridia on each side of each segment, all about the same size, while in other cases there is one large one and a number of quite small ones; however, all stages of the process are united in this genus, so long as the prostates and setæ retain their original condition. The next stage is *Notoscolex*: the prostates now become branched; in a number of cases the branches of the central canal are so insignificant that they have no effect on the form of the gland, and can only be demonstrated in sections—the genus, however, is defined as including all forms in which there is any branching at all. Following this we come to *Megascolex*, where the setæ take on the perichætine arrangement; here again there are a number of intermediate stages; in a number of species the anterior segments retain the lumbricine arrangement, and the increase in the number of setæ takes place gradually as we move backwards; in others the anterior segments show an increase too, but the paired arrangement still holds—there are six pairs, or eight pairs, instead of four; and so on. The last genus along this line is *Pheretima*; the essential characters are those of *Megascolex*, but the gizzard is further back, the testes and male funnels are enclosed in testis sacs instead of being free in the segments (this occurs occasionally in *Megascolex*), and on the whole the ring of setæ is more closed up—has smaller gaps in the dorsal and ventral lines than is usual in *Megascolex*.

But there are other lines starting from *Plutellus*. In the line just considered the first change was the breaking up of the nephridia; in another line the multiplication of the setæ comes first. This change, occurring in the basal genus *Plutellus*, gives *Diporochæta*, the generic characters of which are therefore tubular prostates, meganephridia, and perichætine setæ. It is, of course, impossible to derive this form from any of the first line, since those all have micronephridia; the meganephridial condition is the primitive one, and a meganephridial cannot be derived from a micronephridial form. From *Diporochæta* is derived *Perionyx*, in which the prostates have branched; this genus therefore possesses meganephridia, perichætine setæ, and racemose prostates. As in the case of *Megascolides* and *Notoscolex*,

the transition between these two genera is gradual, and in some cases the branching of the central canal of the prostate or its absence can only be determined by microscopic examination.

In the third line which starts from *Plutellus* the initial change is the modification of the prostates; *Woodwardia*, having thus racemose prostates, lumbricine setæ, and meganephridia, cannot be placed on either of the other lines, since in them either the setæ or the nephridia are modified from the start. From *Woodwardia* is probably to be derived *Comarodrilus*, in which the nephridia in front of the clitellum, but only these, are broken up, the gizzard has become vestigial, and the originally paired spermathecal pores have fused in the middle line.

The genus *Spenceriella* has the primitive form of prostate, but is micronephridial, and has the perichætine arrangement of setæ; it is probably to be derived from *Megascolides* by multiplication of the setæ. It could however equally come from *Diporochata* by the breaking up of the nephridia.

A group of small genera are characterized by the reduplication of the gizzard. *Digaster* and *Didymogaster* have two gizzards, and are distinguished from each other by the number and position of the spermathecae; *Perissogaster* has three gizzards situated anteriorly, as in the two former species. The condition of the other systems indicates that these are all to be derived from *Notoscolex*. *Plionogaster*, in which there are several gizzards more posteriorly situated, at the beginning of the intestine, is to be considered as originating from *Megascolex*.

Finally *Pontodrilus* is to be mentioned. The majority of species are littoral in habitat; one is terrestrial, and one is limnic. It is derived directly from *Plutellus*; the gizzard has become vestigial, and nephridia are absent from the first twelve or fourteen segments.

Attention may here be drawn to two points. The first is that the genera of this subfamily can be arranged in phylogenetic order. We know which characters are primary, which secondary—and therefore we know which forms must have come first in evolution; in addition, we have in several cases intermediate forms (between *Diplostroma* and *Plutellus*, which are united by Michaelsen (14a); between *Megascolides* and *Notoscolex*; between *Notoscolex* and *Megascolex*, which Michaelsen also merges (16); and between *Diporochata* and *Perionyx*, which again are united by Michaelsen (16)). The whole tree is still before us, and all stages in the evolution of the subfamily are there for detailed examination. While there is room for doubt in some details, the main outline will probably stand firm.

The second point is that evolution has proceeded along a few definite lines; the essential changes are confined to a few systems, and follow a definite direction in each case. We have the change in the arrangement of the setæ, from the lumbricine to the perichætine; the change in the nephridial system,

from the meganephridial to the micronephridial; and that in the prostates, from the tubular to the racemose form; in some cases we have changes in the gizzard, in the direction of reduction or reduplication. Especially, in this subfamily, the first three systems are the important ones; in the majority of genera the gizzard remains the same, and the genera are defined by the condition of the setæ, nephridia, and prostates. Since classification represents relationships, or ought to, as closely as possible, and since these three systems are those which have been affected in the course of evolution, it is these which form the basis of our generic definitions.*

Without going into detail, I may refer, in amplification of the foregoing, to two other subfamilies of the same large family.

The Octochætinae, like all the subfamilies of the Megascolicidæ, are ultimately derived from the original *Notiodrilus* form. The first change is the breaking up of the nephridia; the whole subfamily is therefore micronephridial. In two of the branches of the subfamily the increase in the number of the setæ takes place. In one genus we have a doubling of the gizzard (*Eudichogaster*, which I place in the Octochætinae, cf. No. 1 of the present series). When changes in the male organs occur they take a different line from those which characterize the Megascolicinae; the "microscolicine reduction" which is found in certain genera, consists in the disappearance of the posterior pair of prostates and the translation forwards of the openings of the vasa deferentia to join the anterior prostatic pores on segment xvii.

The Trigastrinae, like the Octochætinae, are a much smaller subfamily than the Megascolicinae. The first change in the *Notiodrilus* ancestor along this line is the doubling of the gizzard; subsequently we may have the breaking up of the nephridia and the microscolicine reduction of the male apparatus. The only other development is the appearance in certain genera of calciferous glands; the genera are therefore defined in terms of the gizzards, nephridia, male apparatus, and calciferous glands.

In these subfamilies we thus see the same thing—evolution proceeds along a few definite lines, in a definite direction in each system. Sometimes one, sometimes another system is the first to start evolving, sometimes one, sometimes another follows—and so we get a number of combinations, which characterize the different genera.

* I do not mean to say that the diagnoses of the genera of Megascolicidæ, as we usually have them, are confined to the systems mentioned, though there is a tendency so to limit them; compare, for example, the diagnoses of the Megascolicinae given by Michaelsen in the *Tierreich* (6) with those by the same author in 1907 (9). A diagnosis usually contains an element of description, statements which hold good for all hitherto known individuals of a species, or species of a genus, but which are not necessary parts of our conception of the species or genus. Thus we often see recorded the description of species which necessitate the widening of the current diagnosis of a genus.

I now wish to argue that a number of genera of Megascolecidae are probably polyphyletic. I take as a text a sentence of Benham's, in his paper on the Oligochætes of the Subantarctic Islands of New Zealand (4):—"According to Michaelsen, species of *Microscolex* may arise at different times, in different parts of the world, from different species of *Notiodrilus*. This thesis involves so profound a modification in the accepted ideas of evolution that space will not permit me to discuss the problem here." I think we may take it, then, that the general view with regard to the multiple origin of species, genera, and larger groups is one of scepticism; the orthodox view is that each group has arisen once and once only.

But we have to remember that the essential variations in the genera of this family are not innumerable, but limited. It is not the case that the modes of variation are so numerous, and the possible combinations therefore so greatly more numerous still, that there is no reasonable chance of the same combination of characters ever being repeated—this seems to be the foundation of the orthodox view. The combinations of characters that distinguish the various genera can be obtained in more than one way, and the characters and their combinations are few enough to render it possible that this has happened; I would even say probable that this has happened, and perhaps often.

Let us remember that the perichætine arrangement of setæ is secondary to the lumbricine, the micronephridial condition secondary to the meganephridial, and the racemose prostate to the tubular, and that these changes have demonstrably taken place more than once; and let us take such a form as *Megascolex*, with perichætine setæ, micronephridia, and racemose prostates. It may have arisen from a form with lumbricine setæ, micronephridia, and racemose prostates (i.e. *Notoscolex*) by the multiplication of the setæ; or it may have arisen from a form with perichætine setæ, racemose prostates, and meganephridia (i.e. *Perionyx*) by breaking up of the nephridia. Both these modes of origin have, in fact, been suggested; the point seems to be decided—for some species of *Megascolex*, at any rate—by finding a number of intermediate forms between *Notoscolex* and *Megascolex*. There is a third possibility, from a form with perichætine setæ, micronephridia, and tubular prostates, by the change of the tubular into the racemose prostate—this would mean that *Spenceriella* was the ancestor.

Or take *Perionyx*, with perichætine setæ, racemose prostates, and meganephridia. It might be derived from a form with lumbricine setæ, meganephridia, and racemose prostates (i.e. *Woodwardia*) by multiplication of setæ; or from one with perichætine setæ, tubular prostates, and meganephridia (i.e. *Diporocheata*) by the branching of the prostatic lumen. Here the existence of intermediate forms has decided in favour of the latter.

Spenceriella is a very small genus, with one species in India

and two in Victoria in Australia. It can be derived from *Megascolides* by multiplication of setæ, or from *Diporochæta* by the breaking up of the nephridia. Both these genera, *Megascolides* and *Diporochæta*, occur both in India and Victoria. It is at least not improbable that *Spenceriella* has been evolved separately in India and Australia, from one or other of these genera, perhaps from the same, perhaps from a different one, in the two parts of its range.

It is to be noted also, that confining ourselves to that considerable group of genera of the Megascolecinae with a single gizzard, which are distinguished by the characters of these three systems, the logical end of *any* line of evolution is *Megascolex*. The order in which the changes in the three systems have occurred varies in the different lines; the nephridia may be the first to undergo their characteristic evolution (*Megascolides* line), or the setæ (*Diporochæta* line), or the prostates (*Woodwardia* line). But as we follow out the lines other changes are added; and if, in any line, all three systems pass from the primitive to the derived condition, we arrive at *Megascolex*, with perichæatine setæ, micronephridia, and racemose prostates.

There seems therefore to be an *a priori* probability that groups of worms possessing certain combinations of characters, that is certain genera, may have arisen more than once, and that the genera as we have them to-day are polyphyletic.

But we are not dependent altogether on *a priori* reasoning. The case to which Benham refers is the multiple origin of *Microdrilus* from *Notiodrilus*. The two genera are distinguished by the condition of the posterior male organs—in *Microscolex* the "microscolecine reduction" has taken place (this indeed is the origin of the term). On Possession Island (one of the Crozet group, some distance south-east of Cape Colony) Michaelsen found two species of worms, obviously very closely related, one with the original condition of the male organs (i. e. a *Notiodrilus*), the other with the microscolecine condition (i. e. a *Microscolex*); the deduction is that the latter species has been evolved on the island from the former. The two species agree in the peculiar pigmentation, in the arrangement of setæ, glandular modification of the integument in the neighbourhood of the genital pores, in the form of the penial setæ, form of the prostates, and size and shape of the spermathecal diverticula. The *Microscolex* was represented by numerous examples, and so was not an individual chance variation; and Michaelsen is doubtless right in holding (8, 9) that it has been evolved in this remote region from the *Notiodrilus* which occurs there. Of course, other species of *Microscolex* have evolved elsewhere, from other species (conceivably from one species) of *Notiodrilus*; and thus *Microscolex* has arisen at least twice, from different ancestors and at different times.

Benham, however, is wrong if, in the sentence I have quoted above, he means to imply that Michaelsen holds heretical views on evolution. Michaelsen is strictly orthodox; he will not have it that different species of a genus may arise at different places from different species of a parent genus; he merges the two genera concerned, and calls all the species *Microscolex* (8).

Again, in the Abor country, in a remote spot in the Eastern Himalayas, a worm is found named by me *Perionyx annulatus* (18); like other examples of the genus it has racemose prostates and perichætine setæ; but while the rest of the genus has only meganephridia this worm has, in addition to meganephridia, micronephridia also in all the postgenital segments. But the presence of micronephridia is just what distinguishes *Megascolex* from *Perionyx*, and by definition the worm should go in *Megascolex*. A large number of species of *Perionyx*, however, have a rather characteristic appearance—the dorsal surface is deeply pigmented, of a dark purple colour; the setæ are exceptionally numerous, and the breaks in the middorsal and midventral lines are very small; the male pores and spermathecal pores are close together near the midventral line and, internally, the gizzard is considerably reduced. These characters are not set down in the generic diagnosis; some of them are scarcely definite enough, and they are not features of all the species, though, in varying degree, they are of many; they are, however, all possessed by *Perionyx annulatus*. Lastly, *Perionyx annulatus* occurs in the heart of the *Perionyx* region, and more than a thousand miles from the Indian *Megascolex* region. There is only one possible conclusion—that this worm, by definition a *Megascolex*, has evolved where we find it from a *Perionyx*, and that it has nothing to do in its origin with any other Indian or Australian *Megascolex*. Very similar is *Megascolex dubius*, which also seems to have arisen, far away from the *Megascolex* region, from a *Perionyx*.

I have already said, however, that *Megascolex* has originated from *Notoscolex* (lunbricine setæ, micronephridia, and racemose prostates) by increase in the number of the setæ; and indeed we get so many intermediate stages in this increase that this is no doubt true for at any rate a large number of species; *Megascolex* is therefore diphyletic.

But this does not end the complexity. Michaelsen (14) has pointed out the close relation of certain Ceylon species of *Megascolex* to certain Ceylon species of *Notoscolex*—the group of *Megascolex travancorensis* to that of *Notoscolex ponnudianus*. The argument is the same as in the case of the *Notiodrilus* and *Microscolex* of Possession Island; the species of *Megascolex* have in all probability arisen from the local representatives of *Notoscolex*. There is also a similar correspondence between species of *Notoscolex* and species of *Megascolex* in another restricted area, the N. Island of New Zealand; here, too, the inference is that the second have arisen from the former.

Once more, *Spenceriella* possesses the perichæetine arrangement of setæ, micronephridia, and tubular prostates, differing only in the latter respect from *Megascolex*, which has the more advanced racemose form of the glands. But Michaelsen has lately (16) transferred two species of *Spenceriella* to *Megascolex*; though the branching of the central canal was not to be inferred from anything in the external form of the glands, it was found to exist in a slight degree on microscopical examination of sections. It is scarcely rash to look on these apparently transitional species as descended from species of *Spenceriella*, which they so much resemble. They can hardly be descended from either *Notoscolex* or *Perionyx*; the transitional species in these cases are characterized by the incomplete setal rings, or by the incompletely broken up nephridia, and have, apparently, the fully developed racemose prostates, as is usual in *Notoscolex* and *Perionyx*.

In other words, species which anatomically belong to the same genus, *Megascolex*, have arisen from two less specialised genera, *Notoscolex* and *Perionyx*, and at least at three separate times; quite possibly *Spenceriella* is the origin of certain other species. Probably, of course, this much understates the truth; it is only a few small groups of species of *Megascolex* that we can thus trace back at present; the great bulk of species have probably originated at still other times and in still other places.

Michaelsen, having before his eyes the separate origin of *Megascolex* from *Notoscolex* in New Zealand and Ceylon, gets over the polyphyletic difficulty by merging the two genera into one (16). But this is too short a way with the difficulty; if, wherever we find a polyphyletic origin, we merge the genera concerned, then of course no genus will be polyphyletic, and orthodoxy will triumph. And it may be noted that even this device of fusion is not effective where a genus has a double origin from two other genera. Assuming that some species of *Megascolex* have arisen from *Notoscolex*, others from *Perionyx*, the fusion of *Notoscolex*, *Megascolex*, and *Perionyx* into a single genus leaves us where we were, since the genus now has a double origin from *Megascolides* and *Diporochoeta* (cf. text-fig. 1).

Take now the case of *Pontodrilus*. From its ancestor *Plutellus* it differs in two primary respects—the gizzard has become vestigial, and there are no nephridia at all in the first twelve segments; it is littoral in habit, and is very widely distributed in the warmer regions of the globe. Benham in 1903 (3) discovered in a lake in New Zealand a worm with the above anatomical characters, which he called *Plutellus lacustris*, on the ground that the features wherein this worm agreed with *Pontodrilus* and differed from *Plutellus* appeared to be adaptive and related to an aquatic habitat; he implies, though he does not expressly state, that this worm had an origin from *Plutellus* independent of that of the bulk of the species of *Pontodrilus*, and cannot therefore be united with them in the

same genus. Michaelsen transferred the worm to *Pontodrilus* (9), adding later (12) that it might be a *Plutellus*, an example of convergence—though besides the primary features there were others also which characterized both the new worm and the previously known species of *Pontodrilus*. Benham (4) appears to take the same view. Lastly, Michaelsen (11, p. 22) appears to have definitely adopted the view that it is a *Pontodrilus*, since he speaks of the apparent absence of *Plutellus* from New Zealand.

Some time ago I found an entirely terrestrial *Pontodrilus* in material from the centre of Ceylon (19); this may, possibly, be the ancestor of all the littoral forms (their littoral habit is of course secondary); on the other hand, it may equally well be a descendant of some one of the species of *Plutellus* which are indigenous in Ceylon, while the bulk of the species of *Pontodrilus* originated elsewhere. In any case, we seem to have a distinct possibility—I will not say more—that worms which must, anatomically, be placed in the genus *Pontodrilus* have arisen at various times and in various places.

An extremely curious case is afforded by a genus newly described by Michaelsen as *Monogaster* (15). It is essentially a *Dichogaster* (subfam. Trigastriinæ) in which the two gizzards have, as it were, run together again, probably in consequence of the disappearance of the septum between them. In the evolution of *Dichogaster* the steps from the original *Notiodrilus* ancestor have been as follows:—First the doubling of the gizzard, then the development of the micronephridial condition, and then the development of calciferous glands in certain postgenital segments. In *Monogaster*, therefore, the gizzards having secondarily united, the essential characters are the micronephridial condition, the calciferous glands, and a single gizzard. But these are exactly the characters of *Octochætus*, which belongs to an altogether different subfamily, the Octochætinæ. In this line the initial change was the breaking up of the nephridia, and this has been followed in *Octochætus* by the development of calciferous glands, here too, as in *Dichogaster* and *Monogaster*, in the segments behind the ovaries; the gizzard has never been double. There is nothing in the arrangement of the male organs to distinguish *Monogaster* from *Octochætus*; the calciferous glands in *Monogaster* are three pairs, in segments xv., xvi. and xvii., while in *Octochætus* they are one or two pairs, in xv., xvi., or both: but this could not be a ground for generic distinction. There is a difference in type between the micronephridia in the two genera,—numerous and tubular in *Octochætus*, fewer and saclike in *Monogaster*; but beyond this the only distinction is in the distribution—*Monogaster* comes from Africa, from the *Dichogaster* region, while *Octochætus* has never been found farther west than the Malabar coast of India. The line of descent of each is perfectly plain; still the case illustrates my contention, that the same end may

be reached by different paths; in other words, certain groups with the same anatomical characters may have a polyphyletic origin.

Must it then be an article of faith that each genus has arisen once and once only? Variations may be innumerable—no doubt every organ and part may vary and does vary independently; but the variations that mean anything, that come to anything from the point of view of evolution, are not innumerable—they are limited both in their seat and in the direction they take. And it would seem that similar steps are being taken in many parts of the range of a group; with the consequence that the end condition is similar also. In other words, we have a polyphyletic origin of certain groups.

Objections may be raised to the above line of argument. It may be said, for example, that what I have been discussing are cases of convergence, which nobody has ever denied. Or it may be said that if, as I have claimed, *Megascolex* or any other genus has a multiple origin, then it is not a true genus, and that the group we know as *Megascolex* really consists of several genera with different lines of descent.

The term "convergence" is applicable to the case of *Monogaster* and *Octochaetus*, just discussed; it is applicable to that of the group of species of *Megascolex* descended from *Perionyx* and the group descended from *Notoscolex*, as well as that descended from *Spenceriella*, if this origin should be confirmed. But it is not applicable to the different groups of species of *Megascolex* descended from different *Notoscolex* forms, nor, generally, to the multiple origin of one genus from another single genus: there is no convergence here—the developments are parallel.

Further, along with the use of the term convergence there seems to go an idea that a careful morphological examination, or a consideration of distribution, will ultimately suffice to distinguish groups of different origin, and that a different descent will always betray itself to sufficiently careful and minute investigation. My point is that it may not do so. Naturally, in giving specific instances to support the *a priori* argument, I have had to give cases where *some* features of certain species of a genus seem to countenance a separate origin for these species; otherwise if there had been no anatomical features at all to support the hypothesis of a double origin, the argument could have been deductive only. I have tried to show that in the genus *Megascolex* we can with some probability separate off small groups here and there which have originated at different times, from different ancestors—these ancestors, too, belonging to more than one genus. But, even if these groups were separated off, are we prepared to say that the large number of species which remain (the great majority of the genus) own a single origin?—that we have been able to discriminate all such independent groups? Such a claim would be, to my thinking, extremely rash.

As to the further point, that *Megascolex* is not a true genus but a group of genera, the matter is largely one of words. If anyone wishes to paraphrase my conclusion, and say that "different lines of descent may give rise to forms that it is impossible to separate generically by anatomical characters," I have no quarrel with him. I believe, however, that the sentence "genera may be polyphyletic" expresses this conclusion with equal correctness. For what is a genus? It is, of course, an assemblage of species having certain characters in common: are we justified in going further, and saying "A genus is an assemblage of species having certain characters in common, and owning a common descent"?

I do not think so. In the first place, the term genus was used in the first sense long before the doctrine of descent had won acceptance. Another and more important reason is that, as must be evident from what has preceded, we do not know what the lines of descent certainly are, even in so well known a group (and one so favourable for our purpose) as the Megascolecidae. If we choose the second conception, we shall find it impossible, in the present state of knowledge, to divide up the polyphyletic group known as the genus *Megascolex* into assemblages of species having certain characters in common and owning a common descent.

Yet genera, definite assemblages, we must have; we must have groups above species, and these groups must necessarily have limits of some kind. Since we cannot, in the present state of knowledge, define these groups by their descent, we must define them by their anatomical characters, and perhaps by their distribution. In some cases we can say that in all probability a group so defined is a genetic unity; in many cases we do not know whether this is so or not; in some we shall suspect or feel convinced that it is not. But till we are able definitely to mark out new groups on genetic lines, we cannot relinquish the old anatomical groups.

A classification is one thing, a phylogenetic tree another. No one believes more firmly than I do that phylogeny ought to be the basis of classification; but candour must admit that as yet it is incapable, in many cases, of constituting such a basis. Our classification must necessarily, for practical reasons, present itself as a complete scheme; our phylogenetic trees are and will long remain woefully incomplete. As our ideas of phylogeny become more and more settled, our classification must be revised to correspond with it. But so long as we see anatomical groups which we suspect, or can demonstrate, to be of diverse origin, without being able definitely to separate them up according to their descent, so long we shall have to put up with polyphyletic genera.

For bibliography see end of next section.

III. SOME GENERAL CONSIDERATIONS ON THE GEOGRAPHICAL DISTRIBUTION OF INDIAN OLIGOCHÆTA.

The geographical distribution of Indian Oligochæta has been treated at length by Beddard and Michaelsen (Beddard 1, 2; Michaelsen 7, 10, 11). The earlier writings of both authors are valuable for the discussions of the means by which the migrations of Oligochæta are in general effected; but the large collections of Indian worms investigated by Michaelsen in 1909 and 1910 (10, 11) increased our knowledge of the actual facts of distribution to such an extent that the special conclusions in the later works supersede those arrived at in the earlier.

(1) *The Migrations of Oligochæta.*

Oligochæta may for the present purpose be divided into three groups—limnic, littoral, and terrestrial, each with its distinctive modes of spreading.

Limnic forms have a great diversity of means of dispersal. They may spread directly throughout a river system, through all the canals and into all the tanks and reservoirs supplied from it. Their cocoons are easily transported in the mud which adheres to the feet of wading birds; some forms are known to encyst, and hence may be transported in this manner even in the adult state. An Enchytraeid has been found frozen in a block of ice, and recovered (Beddard, 1).

As a consequence the same genera—sometimes the same species even—are found in widely distant places. The case is similar to that of the Rotifera and Protozoa, of which the same genera and species are found in ponds and streams all over the world. There appears to be but one genus, *Branchiodrilus*, of the limnic Oligochæta which is peculiar to India, while a number of species are found both in England and India, or in Europe and India (species of *Nais*, *Chaetogaster*, *Dero*, *Aulophorus*, *Pristina*, etc.).

Littoral forms live on the shore, exposed at times to submersion in salt water. Like the last group, these have a wide distribution: being, unlike earthworms in general, immune to salt water, they can be transported in masses of seaweed, or more commonly their cocoons are so transported, entangled in masses of weed or other detritus. Not only can they take possession of a whole coast, and spread along the shore-line, but they may in this way travel over sea for long distances. The most noteworthy genus is *Pontodrilus*, which occurs along the coasts of India, and has a circummundane distribution.

Terrestrial forms constitute the bulk of the Oligochæta. Here the means of spreading are more limited; for the most part earthworms are dependent on their own activities for reaching new regions, and hence their wanderings must be very slow. According to Michaelsen, worms which are found outside their burrows apparently wandering about have for the most part been

obliged to leave their homes by illness, or by unfavourable conditions such as the flooding of the burrows; many worms, if extracted from their holes, are unable to make new ones, and must die. Some, however, certainly possess the power of active wandering, as is shown by the numbers sometimes found under heaps of manure. But it is obvious that the peopling of a territory by earthworms through their own exertions can only be very slow.

Not only so, but they are limited in their wanderings by desert tracts—some degree of moisture in the soil is essential. Snow-covered mountain ranges are another obstruction. And especially the sea limits them, the majority of earthworms being quite unable to pass even a narrow arm of salt water.

We have to recognise, however, that not all the terrestrial forms are so strictly limited in their means of dispersal as the above would imply. A tree-trunk floating down stream, or earth between the hoofs of cattle, may transport worms or their cocoons. More important is the part that man has played; Lumbricids, natives of Europe, have been introduced all over the world along trade routes; in W. Australia they are almost the only earthworms to be found near the towns; the indigenous fauna is to be sought in the remoter parts of the country. One of the commonest worms of the Punjab is *Allolobophora caliginosus*; certain species of *Pheretima* have been carried round the globe, far from the region where the genus is endemic. Small worms are more likely to be carried in this way than larger ones; and small species of *Dichogaster*, an African genus, are common throughout the Malay Archipelago, and not rare in India. Botanical Gardens are obviously likely to be centres of dispersal for such introduced species in a new country. Records at Kew and Hamburg leave no doubt of the reality and abundance of these transfers through the agency of man.

There are also, of course, differences in the powers of the worms themselves. Some species seem to be able to travel more widely than others, and more quickly, and to adapt themselves to new surroundings and establish themselves more easily; and it may thus happen that a species spreads over a large region quite apart from human interference. It is not always possible to distinguish between these cases and those of introduction by man; and Michaelsen has adopted the name peregrine for the widely wandering species, whether they owe their diffusion to man's agency or to their own unaided powers.

For the purposes of Zoogeography, the distribution of fresh water and littoral forms is of little or no importance; and the same holds for the peregrine forms among the terrestrial group. Thus, in discussions on the place of origin and past history of the genera or larger groups, as well as in coming to conclusions as to the past distribution of land and water, we are limited for our facts to earthworms in the strict sense, and to those among them that have a definite and limited range. But,

having purified our material in this way, Michaelsen holds that we have in the Oligochæta a group which is capable of yielding results for palæogeography second to those of no other group in importance and certainty; the worms cling to the soil in the most literal way, can only make use of the earth in their wanderings, and by the facts of their present distribution can thus demonstrate in the plainest manner the existence of land connections where, it may be, there is now only a wide stretch of ocean.

(2) *The Facts of Distribution and their current Explanation.*

The material which is available for use in the following discussion is derived from the following groups:—The subfamilies Megascolecinae, Octochætinae, and Trigastrinae of the great family Megascolecidae; the family Moniligastridae; and scarcely anything else.

(a) *The Megascolecinae.* For the phylogenetic relationships of the genera of Megascolecinae the previous article and its text-figure may be referred to.

Diploctrema, from which the subfamily takes its origin, occurs in Queensland and New Caledonia. *Plutellus* is found in Ceylon, S. India, and the E. Himalayas; in Australia and Tasmania; several species occur in the western part of N. America. *Megascolides* occurs in S. India, in W. India, and in the E. Himalayas; in Australia and Tasmania; and it has one species in western N. America. *Notoscolex* is found in the Indian region mainly in Ceylon, but also in S. India and in the E. Himalayas; outside India it occurs in Australia and New Zealand. *Megascolex* is found especially in Ceylon, to a somewhat less extent in S. India, and hardly anywhere else in the Indian region; outside India it is found in Australia, Tasmania, the N. Island of New Zealand, and Norfolk I. (between New Zealand and New Caledonia). *Pheretima* is a genus of which many members have wandered widely; its proper home, however, is S.E. Asia and the neighbouring islands—the whole of the Malay Archipelago; from Burma on the one side it reaches to Japan on the other; a few endemic species are found in India proper, but they hardly entitle India to be considered as part of its proper home; one species is perhaps endemic in Queensland, and perhaps one in the Comoro Is. *Diporochæta* is only represented by one species in India, and the record is an old one: no locality is given, but it was probably found in S. India; the headquarters of the genus is Victoria and Tasmania; species are also found in Queensland, New Zealand, and (one species) on the Chatham Is. (east of New Zealand). *Perionyx* occurs as the dominant genus in the E. Himalayas, and is also scattered over India generally; it occurs also in Victoria, Tasmania, and the Auckland Is., and one species is found in Sumatra and Java (as usual, peregrine species are omitted from this review).

Woodwardia is found in Ceylon and S. India, and in Burma; also in Australia and in Java. *Comarodrilus* is purely Indian—there is only one species, found in the extreme south. *Spenceriella*, a small genus, occurs in S. India and Victoria.

A few other small genera of terrestrial Megascolecinae, characterized by an increase in the number of gizzards, do not occur in India; two are Australian, one is common to Australia and New Zealand, and one occurs in the Philippines and Moluccas.

It will be seen that nearly the whole of the Indian genera (all except the small genus *Comarodrilus*) are represented in Australia; a number are found also in New Zealand, a few in the islands near New Zealand, and a few in the islands of the Malay Archipelago.

The conclusion drawn from the occurrence of the parent genus *Diptotrema* in Queensland is that the subfamily took its rise from somewhere in this region, which is not very far from the centre of the area now inhabited by the subfamily. The descendants have travelled further afield—towards India, towards Tasmania, towards New Zealand and the neighbouring islands, and northward throughout the Malay Archipelago to Japan. And of course the important point is that they must have travelled by land. The reason for the absence of so many of the genera from the islands intervening between Australia and India is that here the mighty genus *Pheretima* has crushed all competitors; it is the youngest, most highly specialized, and most vigorous genus of the subfamily; it is still spreading, many species are among those most commonly introduced by man, and they show themselves most successful colonists.

Michaelsen does not, however, assume the prolonged existence of a broad land connection between the regions mentioned. The relations were much more complicated, and were often changing. Perhaps there was not a complete bridge at any time; the normal condition of the region intervening between Australia and New Zealand on the one hand and India on the other was that of an archipelago, which extended to Ceylon and S. India over the present Bay of Bengal. The boundaries of the islands often changed: sometimes they joined, sometimes they separated,—and no doubt in a different place; and in this way paths became available for the continued expansion of the various genera.

Moreover, since certain Indian genera have such a definitely limited area (certain of those already noticed being confined to S. India, *Perionyx* being chiefly an inhabitant of the Himalayan region, and *Eutyphæus*, to be mentioned subsequently, being confined to the Gangetic plain), India itself was split up into a number of large islands. Thus the Malay Archipelago is the only remaining part of a larger archipelago which existed in the early Tertiary, of which the middle part is submerged, and the Western has consolidated to form the present India. The

occurrence of two of these genera (*Plutellus* and *Megascolides*) in North America is supposed to point to their having travelled over the Angara continent.

The other groups are less extensive; they reinforce the above conclusions, and permit the formulation of a few more.

(b) *The Octochætinae*. This subfamily, as stated in the previous article, originated from the common *Notiodrilus* ancestor by a breaking up of the nephridial system; the lines along which evolution has advanced have also been mentioned.

There is a form *Howascolex* in Madagascar in which the breaking up of the nephridia has not proceeded far, meganephridia coexisting with micronephridia. In *Octochætus* the breaking up is complete. *Dinodrilus* is derived from *Octochætus* by a multiplication of the setæ to the number of six pairs instead of four; the microscolecine reduction of the posterior male organs without change in the number of setæ leads to the genus *Eutyphæus*. A continued increase of the number of setæ and the consequent formation of complete chains was supposed to lead to the evolution from *Octochætus* of *Hoplochætella*; and in a previous section I have given reasons for supposing that *Eudichogaster* is also derived from *Octochætus* by a reduplication of the gizzard.

Octochætus is widely distributed in India, and occurs also in New Zealand, but not elsewhere—not in Australia. *Dinodrilus* occurs in New Zealand only. *Hoplochætella* was first found in India, and species which were referred to it were subsequently discovered in New Zealand, but these probably belong to a different genus (20). *Eutyphæus* and *Eudichogaster* are purely Indian genera.

Here, then, we have relationships which differ from those of the *Megascolecinae*; they exclude Australia, and concern only India and New Zealand. The conclusion is that at the time of the dispersal of the *Octochætinae* there was a connection between India and New Zealand which did not extend to Australia; perhaps it passed entirely to the north, through the great islands of the Malay Archipelago. The *Octochætinae* do not occur at present in the Malay Archipelago because they have been unable to survive in competition with the dominant *Pheretima*.

(c) *The Trigastriinae*. This is a small subfamily—very small as far as India is concerned. The essential character here is a duplication or triplication of the gizzard. The parent genus *Diplocardia* differs only in this respect from the *Notiodrilus* ancestor of the whole family (*Diplocardia* and a closely similar genus *Zapotecia* have been regarded as constituting another subfamily, the *Diplocardiinae*). From *Diplocardia* is derived *Trigaster*, in which the meganephridia have given place to micronephridia; it therefore has the original arrangement of the male apparatus, lumbricine setæ, micronephridia, and a

reduplication of the gizzard. From *Trigaster* is derived *Dichogaster*, in which calciferous glands are developed in segments xv.-xvii. or thereabouts.

The geographical relations of this subfamily are quite different from those of the preceding groups. *Diplocardia* is found in North and Central America, and its descendant *Trigaster* in Central America and the West Indies. *Dichogaster* is endemic in Central America and the West Indies, and also in tropical Africa; all the species that are found in India are introduced, with the possible exception of one only. *Eudichogaster*, a purely Indian genus, is derived from *Trigaster* by Michaelsen (by the development of calciferous glands in segments x.-xii. or thereabouts); but in a previous section (No. I. of the present series) I have given my reasons for believing that this genus belongs to the Octochætinae.

The view of Michaelsen is that *Trigaster* spread from its original home in Central America and the West Indies by means of a land-bridge to Africa, and thence, by a land-bridge in the Pliocene, to India, where it gave rise to *Eudichogaster*, itself disappearing in India in the transformation. *Dichogaster* had its origin from *Trigaster* on the American side of the Atlantic, crossed the Atlantic by the same bridge as *Trigaster* and reached Africa; its indigenous range at present extends no further—indeed it does not seem to have as yet quite reached the eastern shores of Africa (though a large number of peregrine species are known from farther east, including India). *Trigaster* has been exterminated in Africa by the dominant genera *Eudrilus* and its own descendant *Dichogaster*, which between them quite dominate this region, in the same way that so many genera of Megascolecidae have disappeared from the Malay Archipelago in consequence of the spread of *Pheretima*.

(d) *The Moniligastridae*. This family consists of only a few genera. Without going into the relationships of these, it may briefly be stated that *Desmogaster*, the supposed ancestral genus, is found in Borneo, Sumatra, and Lower Burma, and its descendant *Eupolygaster* has a similar distribution. *Drawida*, the largest genus of the family, is predominantly S. Indian (though its range has recently been shown to be more extensive than was believed); *Moniligastris*, a small genus very close to *Drawida*, belongs to the same region.

Michaelsen supposes that S. India and Ceylon were peopled by this family by means of a land-bridge across the Bay of Bengal, and rejects the supposition that the forerunners of the present S. Indian Moniligastrids could have travelled by land round the head of the Bay; they would have left some trace of their passage in that region (a number of endemic species of *Drawida* have, in fact, been recently shown to inhabit this region). Besides, the bridge was in existence when the Megascolecinae passed over to S. India, and so was available for the Moniligastridae too.

(3) *The Objections to the current Explanations.*

I may preface the present section by a brief statement of the reason why I feel a difficulty in accepting the existence of land-bridges as an explanation of the above facts of distribution. It is this.

Terrestrial Oligochæta are, I believe, a recent group, and some of the genera we have been considering are among the most recent of the earthworms. They have probably arisen in the most recent geological periods. But the general aspect of the fauna of Australia and New Zealand shows that no land connections with Asia have existed during these periods. It is necessary therefore to find other explanations for the existence of so large a common element in the earthworm fauna of these regions.

(a) *Terrestrial Oligochæta a recent Group.*

The food of earthworms is vegetable mould; and presumably there were no earthworms in existence until the vegetable mould was present in sufficient quantity to nourish them. We may thus put their rise at some time not earlier than the spread of dicotyledonous plants, which took place during the Cretaceous period. This would limit the evolution of the first earthworms, the differentiation of the several families, and the evolution of the numerous genera of these along lines of descent similar to those we have followed out in the Megascolecine and other groups, to little more than the Tertiary and Quaternary.

The recent origin of many of the present-day genera seems also to be indicated by the extraordinary variability of a large number of genera and species. As examples, it may be mentioned that the variability of genital papillæ and other markings is a common difficulty of systematists; that the number of gizzards in the genus *Drawida* varies fairly widely in many species; that in one and the same genus of Megascolecidae we may meet with species with testis sacs or with free testes and funnels; in another with the original ("acanthodriline") arrangement of the male organs, with the microscolecine reduction, or with the "balantine" reduction (disappearance of anterior prostates, and union of openings of vasa deferentia with the posterior prostatic pores); in another, with paired or fused genital orifices; or with spermathecae varying in number from two to seven pairs or even more; or with seminal vesicles which may vary in number or position or both—indeed these variations of the seminal vesicles are sometimes found within the same species. The consequence is that the generic and specific diagnoses are uncommonly wide as compared with those of other groups.

Even so, the systematist often has extraordinary difficulty in referring his specimens correctly. He seems to get so many intermediate forms; in the case of single specimens it is sometimes impossible to say whether more ample material would justify the erection of a new species, or would show a range of

variability that would link it on to an existing species. The number of described "forms" and varieties is therefore large. Sometimes, as in the case of *Pontodrilus*, critical examination and the increase of knowledge results in the union of a whole series of species under a single name.

Not only are transitions between species common, but the same is true for genera. In speaking of the *Megascolecina* in the previous article it has been noted that literally all stages in the passage from the lumbricine to the perichæatine arrangement of setæ, from the meganephridial to the micronephridial condition, and from the tubular to the racemose prostates are met with. The same holds for other characters which have been used as generic distinctions, *e. g.* the well-developed or the vestigial gizzard, the degree of approximation of the genital apertures, etc. The consequent difficulty of separating genera has led Michaëlsen to fuse a number of genera, with, I think, a great sacrifice of convenience.

In speaking of the S. Indian earthworm fauna, I have noted (19) that the genus *Megascolex* seems to have "recently undergone a notable blossoming forth, with the production of a large number of forms and intermediate forms, and that in consequence it is extremely difficult to separate species from varieties, and varieties from examples of individual variability. The (Indian) range of *Megascolex* is of very limited extent, yet the number of species is extraordinarily large; and still every collector, wherever he chooses to explore, brings back numerous novelties." Of the same kind is the discovery of what I have called a "nest" of related species of *Drawida* in the Chittagong district (20), and of species of *Hoplochetella* in a limited region of Western India (20). The same blossoming forth is seen in the Lumbricidæ, where the distinction of species, and especially of genera, is notoriously difficult; genus passes into genus—often into more than one genus—and the same kinds of changes appear to be in progress in different parts of the tree, to such an extent that the confusion is almost inextricable. There is thus an appearance of incomplete differentiation, and a lack of that fixity and extinction of intermediate forms which we are accustomed to associate with old established groups.

Add to this the mere length of the line of descent from the supposed late Secondary ancestral earthworms to such forms as *Megascolex* and *Pheretima*, the latter portion of which has been traced in the previous article. It seems highly improbable that in such a vigorous group, and one so capable of adaptation to new environments, the differentiation of genera should have ceased soon after its first rise—so long ago, say, as the Eocene.

(b) *The Question of Land-Bridges in general.*

That the outlines of land and sea have changed during geological time is of course universally admitted; but as to how great

the changes have been opinions vary; the tide sways backward and forward, and no agreement has been reached. Zoologists will remember that Wallace inclined at first to the opinion of numerous and great changes—such fundamental changes as the bridging of the Indian Ocean by the hypothetical continent Lemuria; but that later he came to believe in the essential permanence of all the great ocean basins. On the whole, however, the zoologists are to be found among the bridge-builders, and they have the company of some distinguished geologists; but it is perhaps true to say that geological opinion at present is inclining to the theory of permanence.

Needless to say, no one would deny vertical movements of the order of 100 fathoms or so; no one could refuse to believe that England had been united to the mainland, or that a large part of the Malay Archipelago had been united to the continent of Asia. And a rise of 100 fathoms would unite all the large masses of land into one, with Australia as a doubtful exception; seen in a N. Polar projection, we should have a mass of land round the N. Pole, with three tongues, S. America, Africa, and Malaya radiating outwards towards the S. Pole. The soundings are not sufficient to determine whether there is a continuous bridge to Australia above the 100 fathom line or not. New Zealand, Madagascar, the West Indies, and numerous small oceanic islands would remain separate. A lowering of 100 fathoms would isolate N. and S. America, Asia and Africa; and Europe would form a complex of islands and peninsulas much like the East Indies to-day. It is changes of this order that are considered allowable by the more conservative school, not such changes as would bridge the N. or S. Atlantic or Pacific Oceans.

What appears to have brought about something of a change of opinion in recent years is the increasing support accorded to the theory of isostasy. The earth's crust is in a condition of approximate equilibrium, the crust being less dense under the mountains and continental masses in general, more dense under the ocean floor—this is shown by the measurements of gravity. It may be too venturesome to say that the mountains float like icebergs in water; but the idea is that the land-masses project because they are lighter, while the bed of the oceans has sunk because this portion of the crust is heavier; and without the most extensive lateral motion of the matter of the crust the general arrangement of continental masses and ocean cannot change.

In addition to the measurements of gravity is the fact that there are no abyssal deposits on the continental platforms wherever these have been adequately studied; *i. e.*, the continents have never been deeply submerged, though shallow seas from time to time there may have been. And the continental shelf is so marked, obvious, and universal a feature of the earth's surface that it affords the strongest kind of evidence of the antiquity of the ocean basins and the limits beyond which the continents have not extended. I have mentioned the effect of

raising the level of the land of the globe by 100 fathoms; an elevation of five times this amount would alter the boundaries very little more. W. D. Matthew sums up the evidence strongly in favour of general permanency (5):—"The geologic evidence for the general permanency of the abyssal oceans is overwhelmingly strong. The continental and oceanic areas are now maintained at their different levels chiefly through isostatic balance, and it is difficult to believe that they could formerly have been reversed to any extensive degree."

(c) *The Objection to the Indo-Australian Bridges.*

I propose later to enumerate the several land-bridges which have been invoked to explain the distribution of the genera of earthworms common to India and other parts of the world. But there is none of them the former existence of which seems to be better attested than that between Australia and India; this has almost become axiomatic in the minds of students of the Oligochæta. The reason is, as has been said, the large number of genera that are common to India and the Australian region.

There can be no reasonable doubt that the western part of the Malay Archipelago has been joined on to the Asiatic mainland at no distant time; according to Wallace, "all the wide expanse of sea which divides the islands of Java, Sumatra, and Borneo from each other, and from Malacca and Siam, is so shallow that ships can anchor in any part of it, since it rarely exceeds forty fathoms in depth"; while the eastern part of the Archipelago has, with equal probability, formed a part of Australia. Michaelsen assumes not only the passage of numerous genera of Megascolecidae from the Australian side, but (or perhaps as an alternative) suggests that some may have passed back into Australia from outside (16).

But how does the hypothesis of land-bridges square with the other known facts of distribution? I have given some reason for thinking that the whole of the earthworm fauna of the world, and in particular that part of it with which we are dealing at present, is of recent origin. *Megascolex*, for example, is one of the youngest genera; its immediate ancestor *Notoscolex* is one stage further back; both are separated by a long line of ancestors from the earliest earthworms, which alone seems sufficient to bring their origin down to late Tertiary times; *Megascolex* appears to be evolving still, and has not as yet settled down to the comparative fixity of an old-established genus.

Now it is well known that, broadly speaking, Australia has no indigenous Eutherian population. The great groups of terrestrial Eutherians originated in the Eocene—some in the very early Eocene—and spread rapidly thereafter. How, on the supposition of a land-bridge, are we to let the Australian earthworms out to India without letting the Asian mammals into Australia? If the door is open for the particularly slow-moving worms, it is open

for the quick-moving Carnivora; in asking for land-bridges to explain the distribution of the Oligochaeta we get much more than we want. There can never have been a land connection between Australia and the great land mass to the north-west since the Eocene.

Still stronger is the case of the supposed connection between India and New Zealand. This is a necessity, according to Michaelsen, in order to explain the occurrence of the Octochætinae in both lands; and since the Octochætinae do not occur in Australia, the bridge in this case avoided Australia. New Zealand does not even contain Marsupials; yet *Octochætus*, the genus common to India and New Zealand, is not a particularly archaic genus, and its occurrence in both India and New Zealand would, on Michaelsen's view, have to be explained by, presumably, late or middle Tertiary land connections. But New Zealand is an oceanic island, and probably has never been connected at any time* with the larger land-masses, certainly not in Tertiary times.

It is quite possible that similar objections might be brought against the other land-bridges which have been postulated to explain the existence of related or identical genera of earthworms in distant lands. I have specially mentioned the above because it is so obvious, once attention has been drawn to it. The general principle is that, earthworms being a recent group, and requiring, on the hypothesis of dispersal by land, connections of some considerable permanence, other groups will have been able to pass even more easily; and the dispersal of earthworms by land-bridges cannot be assumed unless there is a large degree of similarity between other elements of the fauna also.

(4) *Contributions towards a more satisfactory Solution.*

I trust that, in what follows, I shall not be considered to be treating too lightly the claims of zoogeography to a hearing in the discussion of the problems of palæogeography. As Michaelsen

* Michaelsen's time-scheme can be put together somewhat as follows:—The oldest components of the Indian earthworm fauna date from the Upper Jurassic, when India was connected broadly with both Angara and Australia; *Plutellus* and *Megascolides* wandered off into Angara, reaching western N. America in the later Cretaceous. The chief part of the evolution took place in the Tertiary, the period of the changing land-bridges. In the Pliocene the now consolidated Indian peninsula became connected on the W. or N.W. with lands which had earlier received their earthworms from Tropical Africa (*Eudichogaster*).

It will be seen that he puts the evolution of the group earlier than I do; but I do not find anything which invalidates the line of argument and general conclusions of section 3a above, especially that of the quite recent origin of the phyletically youngest genera such as *Megascoler*. The word used by Michaelsen for the period of the origin of the Indian Oligochaeta fauna is "Malm," which corresponds (Ziegler, Zool. Wörterbuch) to the Upper Jura. *Plutellus* and *Megascolides* are supposed to have then been in existence; is there any other example of genera of a variable and evolving group persisting since that period, especially genera, such as these, which are connected by intermediate gradations not only with each other, but with the genera below and above them (*Diptotrema* and *Notoscoler*), genera, that is, which are still not sharply marked off from their ancestors and descendants?

says, "Since the present geographical distribution of earthworms depends in the first place on the configuration of land and sea in recent geological epochs, it is to be looked on as a valuable document for the history of the earth." We are not bound, that is, to accommodate our conceptions of the wanderings of the ancestors of the present-day fauna to the views founded on geological evidence only; we also are in possession of important documents, and their evidence may perhaps be of superior cogency to that of geology. A zoologist is not likely to underrate the value of the evidence furnished by zoology; only we must be sure what its value is.

And firstly, in the present case, even if there were no geological evidence, even if we were not told that "the geologic evidence for the general permanency of the abyssal oceans is overwhelmingly strong," it would be our duty not to introduce land connections unnecessarily. It is an old philosophical rule that "causæ non sunt multiplicandæ præter necessitatem"; in the present case we may substitute "bridges," and say "pontes non sunt multiplicandi præter necessitatem." We have a number of agencies which are in existence before our eyes to-day: The slow extension of distribution by the normal wanderings of earthworms, the extirpation of indigenous worms by younger forms of later introduction, the existence of natural rafts on the sea, the known ability of certain worms and their cocoons to endure salt water, the polyphyletic origin of certain genera, and moderate changes of land and sea; and it may fairly be demanded that we exhaust the possibilities of these before we have recourse to the construction of bridges which we cannot see and which are at any rate much more hypothetical in nature.

Again, I speak only of those bridges which have been postulated in order to explain the distribution of Oligochæta, and especially of those Oligochæta which occur in the Indian and Australian regions. My contention is that the greater part of these are unnecessary in this connection; whether they are a necessary assumption or not for other reasons, I must leave to others.

And first with regard to natural rafts. Matthew recalls the fact that these have several times been recorded as occurring over a hundred miles off the great tropical rivers such as the Ganges, Congo, Amazon, and Orinoco; and for one such observed, a hundred may have drifted out unnoticed. Wallace, in his 'Island Life,' speaks of "those floating islands which are *often* (italics mine) formed at the mouths of great rivers. Sir Charles Lyell describes such floating islands which were encountered among the Moluccas" (*i. e.* between Celebes and New Guinea, where there is no large river) "on which trees and shrubs were growing on a stratum of soil which even formed a white beach round the margin of each raft. Among the Philippine Islands similar rafts with trees growing on them have been seen after hurricanes, and it is easy to understand how, if the sea were

tolerably calm, such a raft might be carried along by the current, aided by the wind acting on the trees, till after a passage of several weeks it might arrive safely on the shores of some land hundreds of miles away from its starting-point."

Overseas colonization is a very remote chance, it is true, in any given length of time; but, says Matthew, if we multiply the almost infinitely small chance that such colonization takes place in any given length of time, such as a year, by the almost infinite duration of geological periods, we obtain a finite and quite probable chance. For example, the time during which natural rafts have been observed covers about three centuries, while the duration of Cænozoic time is estimated as three million years; if we allow that ten cases of natural rafts have been recorded during these three centuries (the wording of the extract from Wallace given above would, however, seem to indicate that this is an understatement), a thousand may have actually occurred in this time, and hence thirty million in the whole Cænozoic (this is a miscalculation—it should be ten million). He then makes certain assumptions regarding the occurrence of living mammals on such rafts—as to the chances of there being a couple, or a gravid female, and as to the dangers of landing; and his conclusion is that the number of cases during the Cænozoic in which mammals will have established themselves on the larger oceanic islands is of the order of 300—quite enough at any rate to cover the dozen or two known cases. With invertebrates the chances would be much greater.

And certainly, whatever the possibilities of the transfer of mammals by rafts, the transfer of earthworms must be far more probable. Such rafts as have been described above may or may not bear mammals—Matthew's calculations are based on the supposition that they do so only once in a hundred times; but every one will probably contain earthworms, in the soil, under the bark of living trees, in the axils of their leaves, or in rotting wood. Nor are worms restricted to the larger rafts: the smaller worms of euryhaline groups (those that can withstand salt water) and especially their cocoons, may probably be transported for long distances in masses of tangled seaweed; Michaelsen, himself a bridge-builder, presses this point against Benham in explaining the distribution of *Microscolex* in the Subantarctic regions (13).

It may be asked, too, whether earthworms are in general so readily killed by salt water as is assumed. It is well known that many Enchytræids and Tubificids are regularly found on the shore; and among the higher groups the genera *Pontodrilus*, *Pontoscolex*, and *Microscolex* have the same habitat often, though not always; I have received *Hoplochetella* from the shore of western India, though the genus was not previously known from such localities. It is at least possible that many worms are capable of speedy acclimatization to salt, just as a fresh-water Amoeba can be acclimatized by the gradual addition of salt to its water. And it is remarkable how difficult it is to come at any definite

experiment on the subject of worms and salt water; the statement that they are destroyed by it seems to be commonly accepted, without comment and without reference.

There are, of course, other possibilities of transport for worms, or for their cocoons—the mud on birds' feet for example; Benham calculates that a strongly flying bird could pass from Australia to New Zealand (1200 miles) in 36 hours. But the possibility that I most wish to insist on, after that of the occurrence of rafts—because I do not think that it has as yet received any attention—is that of the polyphyletic origin of some, at least, of the genera common to the Indian and Australian regions. I believe that this will go some distance towards explaining the presence of these common elements in the two faunas; evolution has proceeded on parallel lines, and the younger genera have not wandered from India to Australia or from Australia to India—they have been independently evolved in each region.

In my first sketch of the present argument the whole question of polyphyly in these genera was discussed in this place; it was, in fact, in reviewing their geographical distribution that I was brought up against the subject. But the space that I was obliged to devote to it seemed too great to assign to a subordinate heading, and I decided to treat it independently. The whole of the previous article, however, may logically be placed here, as a contribution towards a more satisfactory explanation of the facts of distribution.

We may finally proceed to a separate *consideration of the several bridges* which have been postulated; and here I shall usually take the conclusions of Michaelsen (with whom Beddard is in general agreement) as the basis of my own discussion, since he is the author who has treated the matter most fully. Michaelsen requires all the bridges to be mentioned, and the splitting up of India into islands as well; however, he regards himself as conservative in this matter. In a controversy with F. Sarasin (11) he says, "I am reproached with being too wanton in my bridge-building. I do not think that such a charge can be substantiated; on the contrary, I believe that we do not reckon sufficiently with the mobility of the earth's crust in this region" (*i. e.* the Indo-Australian region).

These bridges are as follows:—A bridge between Asia and N. America, to explain the occurrence of *Plutellus* and *Megascolides* in the western part of N. America; a transatlantic bridge between the W. Indies and Central America on the west and Africa on the east, and a bridge between Africa and India, to explain the occurrence in India of the Trigastriinæ; one between Australia and Further India over the present Malay Archipelago, and one across the present Bay of Bengal, said to be requisite to account for the distribution of the Megascolecinæ and Moniligastridæ; a particular bridge, at a particular time, between India and New

Zealand, to explain the distribution of the *Octochætinae*; and lastly, we may add, in the opposite sense, a number of arms of the sea, stretching across India and dividing it into a number of islands, which formed a western extension of what is now the Malay Archipelago.

The bridge to N. America may be admitted. It would pass from the eastern end of Siberia to Alaska, and demands no considerable elevation of the floor of the ocean—indeed, a rise of 1000 feet would convert the N. Pacific into dry land as far south as the 60th parallel.

The case is otherwise with the bridge between Africa and India. What is asked for is something like the Lemuria of Wallace, or the Gondwana continent postulated by many geologists. The important question here concerns *Eudichogaster*, according to Michaelsen a member of the *Trigastriinae*, and descended from *Trigaster*, which is endemic in the W. Indies and Mexico. Michaelsen supposes that either *Trigaster* crossed the Atlantic (by an Americo-African bridge) and made its way across Africa, and thence by the bridge now under discussion to India, where it evolved into *Eudichogaster* (suffering extermination in the African part of its range); or *Eudichogaster* originated from *Trigaster* on the American side, passed across in the same way, and was exterminated in Africa but maintained itself in India. But I think I have shown in a previous section that it is at least equally probable that *Eudichogaster* originated from *Octochætus* (or *Ramiella*); on this supposition *Eudichogaster* arose in India, to which it has thus always been confined.

I have myself argued that the Indian genus *Hoplochætella* may be descended from *Howascolex*, found in Madagascar (20), and Lemuria or Gondwana would form an easy path for its transport. But *Hoplochætella* is—or at any rate a number of species are—euryhaline, and are found on the shores of western India; and we must reckon with the possibility of transport from Madagascar in seaweed or other tangle; the S.W. monsoon blows in the required direction for several months of the year.

Dichogaster has reached most of the islands of the Malay Archipelago, and some of the Polynesian islands, as well as India, and there is no doubt that small species of this genus are frequently transported by man in the way of trade. It is admitted that there is no need whatever to introduce land-bridges to explain the wide occurrence of these species all over the East.

The last reason for assuming the former existence of the Indo-African bridge would be the presence of a Moniligastrid (though one widely different from the Oriental Moniligastridæ) in tropical East Africa. This African Moniligastrid is not descended from the Oriental branch of the family, nor the Oriental from the African; this follows from the position of the gizzards—in front of the genital segments in the African, behind in the Oriental worms. The alimentary tube, without special thickening in the common ancestor, has developed into a series of gizzards

in one place in the African, in another place in the Oriental branch. There is therefore no question of African forms having travelled to India, or of Indian forms to Africa; the question is, where did the common ancestor live? We can only say, we do not know. Smith and Green, the discoverers of the African form, do indeed suppose this ancestor to have arisen somewhere in Gondwanaland, whence the Syngenodriline branch migrated to Africa, the Monilogastrine to the Oriental region (17); but so far as I know there is no special reason for the supposition.

Wallace, as is well known, gave up Lemuria, and became a believer in the permanence of the ocean basins. Matthew states that there is no necessity for Gondwana, from a palæontological point of view—not even in the Palæozoic, if the interpretation of the facts of distribution is made along the lines he lays down (origin of groups in the north, spread towards the south, the more primitive groups first and furthest); the weakness of the original evidence for the former existence of Gondwana is forgotten, and new discoveries are interpreted in the light of it, as if its existence were well established.

The Americo-African bridge, from Central America to tropical Africa, does not concern us so closely, and in showing reason to believe that *Eudichogaster* originated in India, we entirely do away with the necessity for it so far as India is concerned. Whether the large number of African Dichogasters can be explained as easily as the large number of Indian and far Eastern species of this genus—as having been carried to their new homes in the way of trade or human intercourse—seems doubtful. At the same time, in assuming a land-bridge we are probably getting more than we ask for; what we want is a passage for the extremely slow-moving earthworms, and when it is a matter of thousands of miles this passage must be one of some permanency; what we actually get, therefore, is an easy and abundant passage, for a long space of time, for all the elements of the fauna, and a mingling of the animals of the two regions to an extent which has certainly never happened. I can only conclude that we are probably better off, on the whole, without the Americo-African bridge.

The objections to the Indo-Australian and Indo-New Zealand bridges have already been sufficiently insisted on. And not only are the objections more striking than elsewhere, but—at least in the case of the Australian bridge—the difficulty in dispensing with the connection is also smaller. The actual distance to be accounted for, as is well known, is not great. A union of the eastern part of the Malay Archipelago with Australia, and of the western part with Further India, is not only a feasible but a necessary supposition on every ground; a land-bridge spanning the interval between the eastern and western parts of the Archipelago is objectionable except for the specific purpose of accounting for the distribution of the Oligochaeta. Wallace placed the boundary between the two dissimilar faunas of the Australian and Oriental

regions between the islands of Bali and Lombok; this is the interval where the assumption of a land-bridge raises many more difficulties than it explains. But the interval is only fifteen miles; and while birds' feet and natural rafts offer a sufficient mode of transfer for worms and their cocoons, they cannot serve to transplant the mammals—not a whole mammalian fauna at any rate. It is, too, in the genera of the Megascolecinae, the group which is common to India and Australia, that we have seen most reason to believe in polyphyletic origins; as bearing on the probability of polyphyly it is interesting to recall what Michaelsen says (7) concerning the broad differences between the Indian and Australian groups of *Megascolex*—that the Australian species are simpler, at a lower level of evolution, and more uniform, while the Ceylonese species are often further advanced and in many cases approach *Pheretima*. We can thus manage quite well with the verè causæ we know, but the bridge would only embarrass us.

The distance to be overcome in the case of New Zealand is greater; but the general faunistic objections to a land connection with S.W. Asia (which is supposed to have avoided Australia) are greater also. We are compelled, therefore, to invoke the same agencies as before.

Michaelsen's plea for a bridge across the Bay of Bengal, by which worms from Australia, and also from Further India, could reach the south of the peninsula and Ceylon without going round by the head of the Bay, depends for its force on the presence in S. India and Ceylon of genera which are not found elsewhere in India; the argument is that if these genera had passed through the lands about the head of the Bay, they would have left there some trace of their passage. Thus *Drawida*, a Moniligastrid, common in S. India, and descended from a form which was probably not unlike *Desmogaster* (now found in Burma, Sumatra, and Borneo), was, when Michaelsen wrote, unknown from the intervening region, except for a few records of peregrine species. But more recent discoveries have shown that, both in the E. Himalayas and near the coast at the head of the Bay, there are a number of endemic species of *Drawida*; and it can no longer be urged that the Moniligastridæ cannot have passed round that way because they have left no trace of their passage. Certain genera of the Megascolecinae also were supposed to show the same limitation of distribution. *Notoscolex* was only known from S. India and Ceylon, and the same was true of its descendant *Megascolex*. Lately, however, the E. Himalayas have been shown to harbour three species (and a variety) of *Notoscolex* (*Megascolides oneilli* is a *Notoscolex*); so that here again it can no longer be claimed that a bridge across the Bay of Bengal is necessary because otherwise the genus would have left some trace of its passage round the head of the Bay. And the polyphyletic origin of *Megascolex* is, I think, clear enough to allow us to dispense with the supposition that it migrated into India from outside, whether round the head of the Bay or by a land-bridge across it.

Finally, I do not think that Michaelsen's view that India was, in the past, divided by stretches of sea—shallow arms of the sea—into a number of disconnected islands, is necessary. A number of Indian genera do show, as he remarks, a limitation more or less definite to certain tracts of the country. These are *Megascolex* and *Notoscolex*, to the south of the peninsula and Ceylon; *Dravida*, though this genus can now scarcely be said to be even roughly limited to the south; *Eutyphæus*, to the Gangetic plain; *Eudichogaster*, to a broad belt across the middle; and perhaps *Hoplochætella*, to western India. *Perionyx* has not now the strict limitation to the Himalayan region that was previously thought; nor is *Octochætus* limited to any one part of the country—it seems to occur throughout. It is, on the whole, the youngest genera that are limited in distribution, and it would seem possible to explain this by supposing that they have not as yet had time to spread very widely, rather than that their dispersal has been hindered by arms of the sea. The conclusions of geology, moreover, seem to be against Michaelsen's view. "It has been conclusively proved that the peninsula of India has never been beneath the sea since the Carboniferous period at least." (Encyc. Britt., xi. ed., art. Asia, section Geology.)

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6. On the Structure of the Reptilian Tarsus.

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(Text-figures 1-27.)

In 1864 Gegenbaur established the general homology of the elements of the tarsus with those of the carpus, and gave us a series of names for the elements which have been used by most later writers.

The typical carpus in the higher forms was shown to be made up of a radiale and an ulnare with an intermedium between them, a centrale near the middle of the carpus, and five distal carpalia. In the hind limb the tibia and fibula undoubtedly correspond with the radius and ulna of the fore limb and the five distal tarsalia as unquestionably agree with the five distal carpalia, but as the proximal part of the tarsus usually has only three elements, there has always remained some little doubt as to how to homologise them with the four proximal carpals.

Gegenbaur considered that the two proximal elements of the mammalian tarsus—the calcaneum and astragalus—corresponded with the ulnare, the intermedium, and radiale of the fore limb, and that they ought to be regarded as the fibulare and conjoined intermedium and tibiale, while the third element, the navicular, he looked upon as the centrale of the tarsus. As the intermedium and radiale are frequently united in mammals, it seems very natural to conclude that the intermedium might be permanently fused with the tibiale in the tarsus.

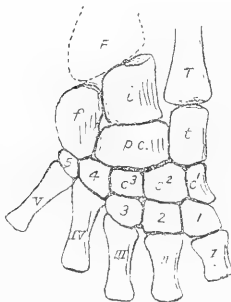
Gegenbaur's view has been followed by the majority of later comparative anatomists and palæontologists. When it was seen, however, that there was no evidence from either palæontology or from the study of the skeletogenesis in favour of the astragalus being a composite element, most workers came to favour the view that the astragalus is the tibiale alone and that the intermedium has been early lost, though some few preferred to look on the astragalus as the intermedium and to consider that it was the tibiale that was lost. At the present time, though the large majority of authorities support the former view, the question is by no means settled, and I think there are good reasons to believe that the generally accepted view is a mistaken one. Within recent years, palæontology has given us so much new light that it seems necessary to reopen the question.

If we had well-preserved tarsi of all the Carboniferous and Permian amphibians and reptiles known, there would be no difficulty in giving the complete evolutionary history of the tarsus in its later stages. Unfortunately, the tarsus of most of the early Tetrapods remained largely cartilaginous, and even where the elements are ossified it is rarely that we find them in

undisturbed positions. Still, we have a few early tarsi sufficiently well preserved to suggest to us the main lines of evolution.

The most primitive Tetrapod tarsus known is that of the Temnospondylous amphibian, *Trematops milleri* Williston, from the Lower Permian Beds of North America (text-fig. 1). Here we find the tarsus composed of four large proximal elements, one of which is situated centrally, five distal tarsalia and three centralia lying above the first, second, and third tarsalia. The element articulating with the end of the tibia we ought, I think, to call the tibiale, even though it is not, as I hope to show, the same element as articulates with the tibia in the higher forms. The other two proximal elements must be regarded as the fibulare and the intermedium. These determinations are those of Williston, and it is difficult to see how they can be disputed. Williston points out that there has been a passage for vessels between the fibulare and the intermedium.

Text-figure 1.



Text-figure 2.



Text-fig. 1.—Right tarsus and metatarsus of *Trematops milleri* Williston*, slightly modified after Williston.

Text-fig. 2.—Right tarsus and metatarsus of *Uranocentrodon senekalensis* v. Hoepen†. The tarsal elements are figured in true relative position, as seen in two different specimens. Letters indicate the probable position of the elements which have remained cartilaginous.

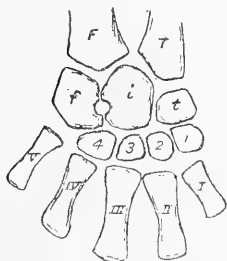
* An American Lower Permian Temnospondylous Amphibian.

† A South-African Upper Permian Temnospondylous Amphibian.

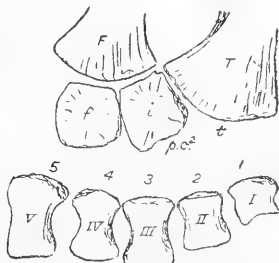
Our South African Upper Permian Temnospondylous form, *Uranocentrodon senekalensis* v. Hoepen (text-fig. 2), gives us a further development of the amphibian tarsus. Though the tarsus is here imperfectly ossified, we have two specimens with the elements in almost undisturbed relations, so that we can be fairly sure of their determinations. As will be seen from the figure I give, there are three large, proximal, well-ossified elements and three imperfect ossified distal elements. If we had not the clue afforded by *Trematops*, we might determine the proximal elements as the fibulare, intermedium, and tibiale. We might perhaps, even

more readily regard them as the fibulare, tibiale, and centrale from their superficial resemblance to the calcaneum, astragalus, and navicular of the mammalian tarsus. It is, however, quite manifest that, whatever the tibia supports, it is not the element lying on the tibial side of the fibulare. We can readily see that this element is the one which we have identified as the intermedium in *Trematops*. It is similarly situated, and it has between it and the fibulare a passage for vessels exactly as in *Trematops*. The element situated distal to this intermedium is manifestly the proximal centrale. The tibiale has remained, like the majority of the other elements of the tarsus, cartilaginous. The other ossified elements of the tarsus are figured as they occur. I identified them as the first and fourth distal tarsals and one of the centrales. Houghton, in describing the tarsus in the Bloemfontein specimen, regards the distal elements as the first and third, but the Pretoria specimen has the element in undisturbed

Text-figure 3.

Text-fig. 3.—Right tarsus and metatarsus of *Scincosaurus crassus* Fritsch*. After Jaekel.

Text-figure 4.

Text-fig. 4.—Right tarsus and metatarsus of *Limnoscelus paludis* Williston†. The positions of the missing elements, which were probably cartilaginous, are indicated by letters.

* A Microsaurian amphibian.

† A primitive Cotylosaurian reptile.

articulation with the head of the fourth metatarsal. Houghton agrees in regarding the third small ossification as the centrale. When the cartilaginous elements are restored, it will be seen that the tarsus is almost exactly similar to that of *Trematops*.

The most interesting feature of the *Uranocentrodon* tarsus is the tendency that it exhibits of the elements on the tibial side to become reduced.

The next tarsus which we are able to study is that of the Microsaurian *Scincosaurus crassus* Fritsch. (text-fig. 3). Whether the Microsauria are to be regarded as reptile-like amphibians or as amphibian-like reptiles need not at present concern us, as it is agreed by most that if they are amphibians they are apparently the nearest to the primitive reptiles. It is extremely fortunate

that we have this tarsus well preserved, as it shows us how the reptilian tarsus has been derived from the primitive amphibian type. As figured by Jaekel, it has three proximal elements and four distal. The elements articulating with the fibula are manifestly those we have identified in the more primitive type as fibulare and intermedium, and they are so identified by Jaekel. The third proximal element articulates with the tibia and is manifestly the tibiale. It is much smaller than the other proximal elements. The distal elements are the first four distal tarsalia. Between the fibulare and the intermedium is the tarsal foramen.

The great difference between the Microsaurian tarsus and that of the Temnospondylous types is that in the former all the central elements have disappeared or become generally reduced and cartilaginous.

In the earliest undoubted reptiles known—the Cotylosauria—the tarsus has only been preserved for us in a very few forms.

In *Limnoscelis paludis* Williston (text-fig. 4), though the tarsus is not perfectly preserved and was probably largely cartilaginous, we have the two principal elements preserved in position. Williston identifies them as the fibulare and the united tibiale and intermedium, but it seems much more probable that they are the fibulare and the intermedium, and that the tibiale is either lost or was cartilaginous, and this latter view is admitted by Williston as not impossible.

Another very primitive type of which we know the tarsus is *Eosauravus copei* Williston (text-fig. 5), from the Middle Pennsylvanian of North America. Unfortunately, the head of this animal is unknown, and we are thus in doubt whether or not it is a Cotylosaur. The tarsus has the elements preserved in only slightly disturbed relations. There are two large proximal elements, which a comparison with other early types leads us to consider as the fibulare and intermedium. There are five distal tarsals, and a small element on the tibial side of the tarsus which is probably the reduced tibiale. The metatarsals are somewhat displaced, and it is not improbable that the distal tarsals and the tibiale are also a little displaced.

In *Seymouria baylorensis* Broili (text-fig. 6) the nearly perfect tarsus has been discovered by Williston. It consists of two large proximal elements and a third small one, and apparently five distal tarsals. The two large tarsals are regarded by Williston as the fibulare and tibiale, and the small proximal element the centrale. I interpret them as in *Scincosaurus*—the fibulare, intermedium, and tibiale.

The only other Cotylosaur in which the tarsus is satisfactorily known is *Procolophon trigoniceps* Owen (text-fig. 7), and though *Procolophon* in having a roofed temporal region is usually placed with the Cotylosaurs, yet, being a late Triassic form, it has advanced in many respects so far from the Cotylosaurs of the Permian of North America that it ought, perhaps, really to be

placed in a distinct order—the Procolophonia. The tarsus is known with the elements in undisturbed position. There are two ossified proximal elements and four distal tarsalia. The two proximal elements have a passage between them, and are manifestly the homologues of the large elements in *Scincosaurus* and thus the fibulare and intermedium. There has possibly been a cartilaginous tibiale, which is not preserved, as it seems necessary to have an element to the tibial side of the intermedium to support the first tarsale. Goodrich's figure of the *Procolophon* tarsus, which is taken from Watson's much-reduced restoration, gives rather a misleading idea of the structure. In *Procolophon* the radiale in the carpus has evidently been cartilaginous, and it is thus not at all remarkable that the corresponding tibiale in the tarsus should also remain cartilaginous.

When we follow the line of mammalian descent through the American Pelycosaurs and allied forms and through the South African Therapsids, we have as many well-preserved tarsi as we require.

Text-figure 5.



Text-figure 6.



Text-figure 7.



Text-fig. 5.—Right tarsus and metatarsus of *Eosaurus copei* Williston*. After Williston. The distal tarsals are evidently somewhat displaced. The large oval element between the intermedium and the first metatarsal is probably the displaced tibiale. The smaller element lying proximally to it is probably the first tarsal. The largest distal tarsal is probably the fourth tarsal.

Text-fig. 6.—Right tarsus and metatarsus of *Seymouria baylorensis* Broili †. After Williston.
The third and fourth tarsalia are lost.

Text-fig. 7.—Right tarsus and metatarsus of *Procolophon trigoniceps* Owen ‡. From a specimen in the Albany Museum. The elements are preserved in almost undisturbed relations. There was most probably a small cartilaginous tibiale in the position indicated by the letter "t."

* A primitive Reptile of unknown affinity.

† A primitive Cotylosaurian reptile.

‡ A late Upper Triassic Cotylosaurian reptile

The most primitive type we know is *Ophiacodon mirus* Marsh (text-fig. 8). Here there are two large proximal elements, manifestly those which become the calcaneum and astragalus of the mammal, with five distal tarsals and two small elements lying distal to the astragalus. The calcaneum and astragalus are manifestly again the two elements which in lower types we have identified as fibulare and intermedium; and the five distal tarsals present no

difficulties. The two elements in the centre of the tarsus, however, may readily give rise to difference of opinion. By Williston, Case, and others who have written on the type they are regarded as first and second centralia. The inner of the two is the element which becomes the mammalian navicular. The outer one is an element which becomes early lost, and is only known in a very few Permian forms.

If we identify, as I think we must do, the astragalus with the intermedium, we must either regard the tibiale as lost, or find it is the inner of the two supposed central elements. This inner element supports the first tarsal, and though it appears to have slipped away from the tibial articulation, it is still not far removed from the tibia. If we are right in identifying the inner proximal elements in *Scincosaurus* and *Seymouria* as the tibiale,

Text-figure 8.



Text-figure 9.



Text-fig. 8.—Right tarsus and metatarsus of *Ophiacodon mirus* Marsh*.
After Williston. Slightly modified.

Text-fig. 9.—Right tarsus and metatarsus of *Casea broilii* Williston †.
After Williston.

* An early Theromorph.

† An aberrant Theromorph.

then there is good reason to believe that the navicular of the Pelycosaurs, the Therapsids, and the Mammals is also the tibiale which by the lengthening and narrowing of the tarsus has become slightly altered in position. In the Cotylosaurs the distal tarsals are nearly twice as wide as the fibulare and the intermedium. In the more active Pelycosaurs the tarsus has become so narrowed that the distal tarsals together measure often less and rarely much more than the width of the two large proximal elements. If the tibiale is to be retained at all it can only be by becoming wedged in between the intermedium and the first and second tarsalia. This, I believe, is what has happened;

and it is remarkable, as I hope to show presently, that a similar shifting of the tibiale is also seen in Sauropsida, and perhaps it has arisen independently in this group.

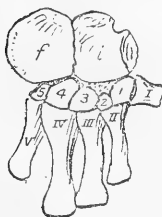
In *Casea broilii* Williston (text-fig. 9) the small central element has disappeared, and we thus have a tarsus that, except for retaining the fifth tarsale, is essentially mammalian in structure.

In *Varanops brevirostris* (Williston) (text-fig. 10) the tarsus is like that of *Casea* and *Ophiacodon*, except that not only has the centrale disappeared, but the tibiale is evidently cartilaginous.

In the Therapsids the tarsus is almost typically mammalian in structure. There is never a centrale, and the tibiale is always placed, as is the navicular in the mammal, between the intermedium and the first and second tarsals.

In Anomodonts the tibiale is frequently cartilaginous either wholly or in part. Many years ago I figured the tarsus in a small form which I referred to *Udenodon gracilis* Broom. Shortly afterwards I found that the skeleton belonged to the same animal

Text-figure 10.



Text-figure 11.



Text-figure 12.



Text-fig. 10.—Right tarsus and metatarsus of *Varanops brevirostris* (Williston). A primitive Pelycosauroid reptile. After Williston.

Text-fig. 11.—Right tarsus and metatarsus of *Emydopsis trigoniceps* (Broom), a small Anomodont reptile. The drawing is mainly from the specimen in the Albany Museum, but partly restored from other specimens. The condition of the tibiale varies greatly in Anomodonts. In some it is completely cartilaginous, in others well ossified. It probably affords part of the articulation for the tibia.

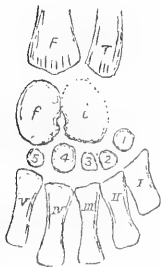
Text-fig. 12.—Right tarsus and metatarsus of *Galechirus scholtzi* Broom, a small Dromasaurian reptile. The elements are figured as found, but the intermedium is evidently slightly rotated.

as the skull which I had called *Oudenodon trigoniceps* Broom. We now know that this small Anomodont has a few small molars, and must be placed in a new genus, *Emydopsis*. I give a new figure of the tarsus (text-fig. 11). The interesting point about it is that the tibia probably articulates with the tibiale. In another small Anomodont tarsus I have belonging to an undescribed species, the tibia also appeared to articulate with the tibiale.

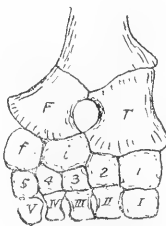
In the more mammal-like forms—the Gorgonopsians and the Cynodonts—the tibia and fibula articulate only with the intermedium and the fibulare.

The most primitive known tarsus of the lizard-like group is that of *Broomia perplexa* Watson. Though the top of the skull of this animal is unknown, almost all the rest of the structure is known, and fortunately the tarsus is almost perfectly preserved. As in the large majority of early reptiles, there are two large proximal elements. There are five distal tarsals and two other small elements. The two proximal elements have the usual foramen between them, and are doubtless the fibulare and intermedium. The two small elements are regarded by Watson as the first and second centralia. I regard the inner one as the imperfectly ossified tibiale. The distal end of the tibia as found is in a position to articulate with what I regard as the cartilaginous position of the tibiale. Watson, in his restoration, shifts the tibia to make it articulate with the intermedium, which he regards as the fused intermedium and tibiale. If we articulate the tibia as Watson has done, the three first digits seem practically without any proximal support—a condition which

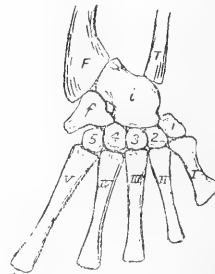
Text-figure 13.



Text-figure 14.



Text-figure 15.



Text-fig. 13.—Right tarsus and metatarsus of *Palæohatteria longicaudata* Credner. A primitive Permian reptile of doubtful affinity. Regarded by Williston, Watson, and others as a Therapsidan: by the writer and others as an early Sauropsidan. After Jaekel.

A cartilaginous tibiale was probably present.

Text-fig. 14.—Right tarsus and metatarsus of *Miosaurus nordenskjöldi* Hulke. A Triassic Ichthyosaur. After Wiman.

Text-fig. 15.—Right tarsus and metatarsus of *Stereosternum tumidum* Cope. A Lower Permian Mesosaurian. After M'Gregor.

seems very improbable. The second small element is doubtless, as Watson holds, a centrale. I give a figure of the tarsus as found, as restored by Watson, and as I am inclined to restore it (text-figs. 16–18).

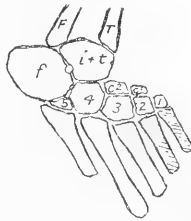
There is another primitive reptile which one wishes one knew more about. I refer to *Palæohatteria longicaudata* Credner. Though first described over thirty years ago, and apparently known by very satisfactory and nearly complete skeletons, we are still in much doubt about the animal and its affinities. For many years it was believed by every one to be a primitive two-arched

reptile allied to *Sphenodon*. But a few years ago Williston came to the conclusion that it was a Pelycosaur or a near ally, and Watson holds a similar opinion, stating that "it now seems almost certain that *Palæohatteria* is really a Therapsid." It is difficult for one who has no chance of seeing the actual types to know which authorities he ought to follow, and though the tendency is always to follow the latest, I personally do not feel at all satisfied that Williston and Watson are right in this matter. The skull as restored by Jaekel—and his restoration seems to me the best we have yet had—is very unlike that of any Pelycosaur or Therapsid: the shoulder-girdle is entirely unlike and the pelvis is only a little like. The humerus also has only a very slight resemblance to that of a Pelycosaur or Therapsid. Fortunately the tarsus is fairly well preserved, and, as figured by Jaekel, has two large proximal elements, which he considers, as also I do, to be the fibulare and intermedium (text-fig. 13). The only other ossified elements are the five distal tarsals. Possibly there has been a cartilaginous tibiale. If so, the only difference between

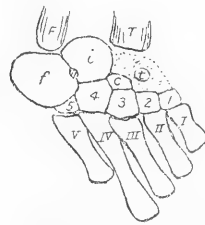
Text-figure 16.



Text-figure 17.



Text-figure 18.



Text-fig. 16.—The right tarsus and metatarsus of *Broomia perplexa* Watson. A primitive Permian Sauropsidan. The remains as found. Left reversed. After Watson.

Text-fig. 17.—The tarsus and metatarsus of *Broomia* as restored by Watson.

Text-fig. 18.—The tarsus and metatarsus of *Broomia* as restored by the writer.

the tarsus of *Palæohatteria* and that of *Broomia* would be that the former had lost the small centrale.

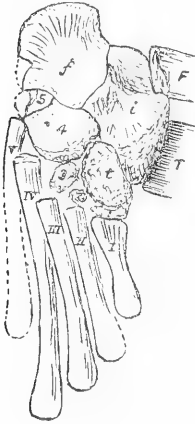
On the evidence of the published figures of *Palæohatteria* I am inclined to regard it as a primitive Diapsid reptile, a little more advanced than *Broomia* and a little more primitive than *Youngina*.

Youngina is the only known Permian Diapsid in which the tarsus is fully ossified and almost perfectly preserved (text-figs. 19 & 20). In this tarsus there are two large proximal elements—the fibulare and intermedium with the tarsal foramen between them, five distal tarsalia, and a large element situated between the intermedium and the first, second, and third tarsalia, which I believe to be the tibiale.

The fibulare is a flat bone which has a very distinct heel process. The intermedium is very large and with a large

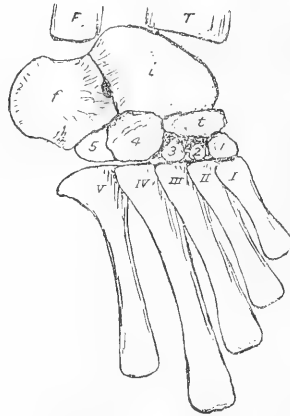
articular surface for the tibia. It articulates with the fibulare, the tibiale, and the fourth tarsal. The tibiale is relatively small, and is wedged in between the intermedium and the first, second, and third tarsalia. Though the tibia does not articulate with it in most positions of the foot, it seems probable that it does when the front is turned inward, as is manifestly possible. The three first distal tarsals are all small but well ossified. The fourth is very large; its relations will be seen in the figure given. The fifth tarsal is moderately large and flat; it articulates with the fourth tarsal by a suture which allows very little movement between the two.

Text-figure 19.



Text-fig. 19.—Left tarsus and metatarsus of *Youngina capensis* Broom *, as preserved. The foot has the plantar surface displayed, and the metatarsals are somewhat distorted. Twice nat. size.

Text-figure 20.



Text-fig. 20.—Right tarsus and metatarsus of *Youngina capensis* Broom, viewed from the dorsal side, with the metatarsus restored in position. The tibiale, first, second, third, and fourth tarsals of the right side are preserved in position, and have their dorsal aspects displayed. The fibulare and part of the intermedium of the left side have had their dorsal surfaces exposed and are added to the drawing reversed.

* A Permian two-arched reptile of the order Eosuchia.

The metatarsals are long, slender, and moderately straight bones. The fifth metatarsal, which we should have expected to be of the *Sphenodon* hooked type in this undoubted two-arched reptile, is a long slender bone, nearly as long as the fourth metatarsal, and it shows no trace of the peculiar hooking. The upper end is expanded, and the outer process probably was attached to the fibulare by a ligament.

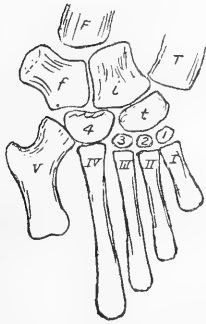
The remarkable points in the foot of *Youngina* are this primitive generalized fifth metatarsal, and the fact that the tarsus

is almost typically Therapsid or even mammal-like. A few years ago I figured a well-preserved tarsus under the name *Galesphyrus capensis*, believing it to be a Dromasaurian. The few points in which it differs from the Dromasaurians are points in which it agrees with *Youngina*, so that it is much more likely that it is an Eosuchian.

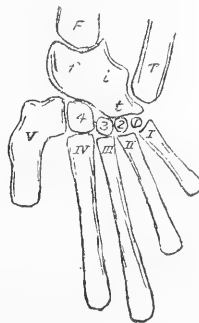
Another very interesting tarsus is that of the South African Upper Triassic Rhynchosaurian, *Howesia browni* (text-fig. 21). The tarsus is almost perfectly preserved though doubled over, and the restoration I give is probably nearly correct. There is a large fibulare with a heel process, a large intermedium, and a smaller tibiale. There are four distals, and the fifth metatarsal has the *Sphenodon*-like specialization.

The tarsus of the adult *Sphenodon* is well known, and Howes and Swinnerton have given us something of the embryonic

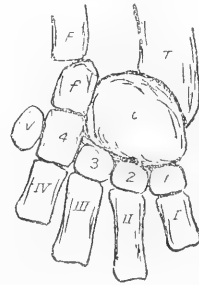
Text-figure 21.



Text-figure 22.



Text-figure 23.



Text-fig. 21.—Right tarsus and metatarsus of *Howesia browni* Broom; a Triassic Rhynchosaurian.

Text-fig. 22.—Right tarsus and metatarsus of an embryo of *Sphenodon punctatus* Gray. The embryo is of Dendly's stage R. Ossification has commenced in the metatarsals. Though the proximal tarsal cartilaginous mass shows no clear evidence of its nature at this stage, earlier embryos show that it is composed of three elements, and I think only three.

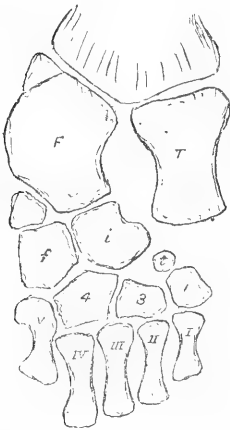
Text-fig. 23.—Right tarsus and metatarsus of an embryo of *Testudo* sp. The embryo is of the stage where chondrification is well advanced, but where ossification has scarcely begun. The very marked difference between this tarsus and that of the *Sphenodon* embryo is of interest.

condition. Only those who have studied developing cartilage and procartilage know the difficulties of this mode of research. At times we get remarkable results, but too often they are inconclusive. I give a figure (text-fig. 22) of the tarsus in a young embryo of *Sphenodon*, which I was able to examine through the kindness of Prof. Dendly. Though ossification of the metatarsals is just commencing at this stage, there is no clear evidence of the composite nature of the large proximal element. Howes and Swinnerton showed that there was evidence at an earlier stage

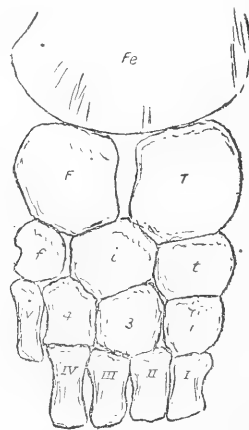
of its being made up of a fibulare, an intermedium, a tibiale, and a centrale. I think it more probable that there are only in it the fibulare, intermedium, and tibiale. The evidence for a centrale is not at all satisfactory. If, however, it is really the conjoined fibulare, intermedium, and tibiale, then the whole tarsus becomes strikingly similar to that of *Howesia*.

I give a figure of the tarsus of a very young embryo of *Testudo* sp. (text-fig. 23). Here there are only seen two proximal elements and four distal tarsals. There is no evidence of the larger proximal elements being more than a single element, and I am inclined to regard it as intermedium alone. Other Chelonians are known to have an additional element between the larger proximal element and the first and second tarsals.

Text-figure 24.



Text-figure 25.



Text-fig. 24.—Right tarsus and metatarsus of *Plesiosaurus rugosus*. After Owen.

Text-fig. 25.—Right tarsus and metatarsus of *Peloneustes philarchus* Seeley. After Andrews.

Goodrich considers this to be the centrale. I regard it as the much reduced and displaced tibiale. The fifth metatarsal is shortened up.

In most of the later Diapsidans we find a tarsus which is either of the *Sphenodon* type or a modification of it.

In the aquatic reptiles we find many interesting types. *Ichthyosaurus* is too specialized to be of much morphological interest, but the Triassic form, *Miosaurus*, shows us how the Ichthyosaurian paddle has originated. I believe the tarsus to be made up of fibulare and intermedium with the five distal tarsals, and to be thus almost identical with the tarsus of *Mesosaurus* or *Stereosternum*, which there is some reason to consider as perhaps its nearest allies.

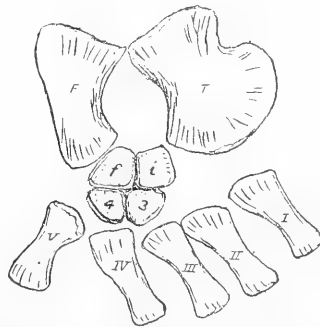
The Plesiosaurian tarsus (text-figs. 24, 25) presents little difficulty. The fibulare and intermedium are well ossified, but in the earlier forms the tibiale is often partly or wholly cartilaginous. In later types the tibiale is well developed. There are only three distals, which I believe to be first, third, and fourth. The fifth metatarsal is shortened up as in Chelonians.

The Pythonomorphs show a most interesting type of tarsus. In *Mosasaurus* (text-fig. 26) there are only three tarsal elements, which are manifestly the fibulare, the intermedium, and the fourth distal tarsal. In *Platecarpus* (text-fig. 27) there are four tarsal elements—the fibulare, intermedium, and the third and fourth distal tarsals. In both types there is a specialized fifth metatarsal.

Text-figure 26.



Text-figure 27.

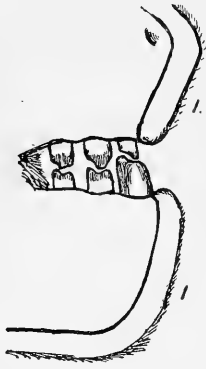


Text fig. 26.—Right tarsus and metatarsus of *Mosasaurus lemouneri* Dollo. A European Pythonomorph. After Dollo.

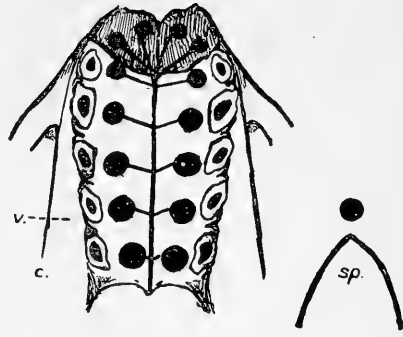
Text-fig. 27.—Right tarsus and metatarsus of *Platecarpus abruptus* Marsh. An American Pythonomorph. After Williston.

In the reptilian and amphibian tarsus the most remarkable features are the almost constant presence of the fibulare and the intermedium, and the great variability of the tibiale. Rarely is the tibiale a large element: very frequently it remains entirely or partly cartilaginous. In many types it is completely absent. In the mammal-like reptiles and in the primitive Diapsidans it is wedged in between the intermedium and the first and second tarsalia.

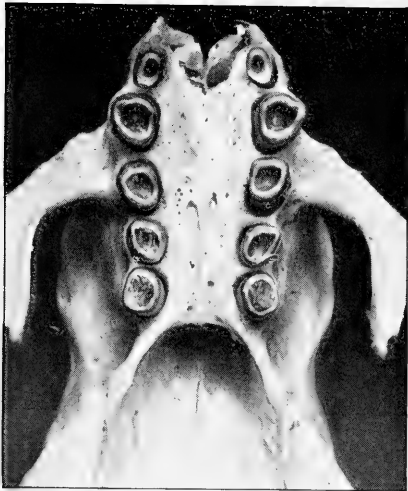
The central elements, of which there are four in some amphibians, are early greatly reduced and lost. The only one which for a time remains in early reptiles is apparently the homologue of the proximal centrale in *Trematops*. In only a few Permian forms is it still present, and in no Triassic or later reptile is there any trace of it.



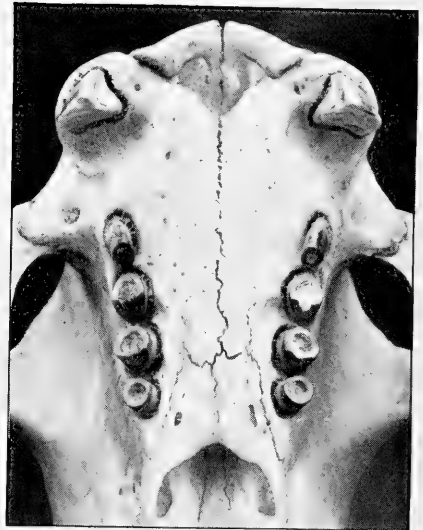
A



B



C



D

ANATOMY OF THREE-TOED SLOTH (*Bradypus tridactylus*).

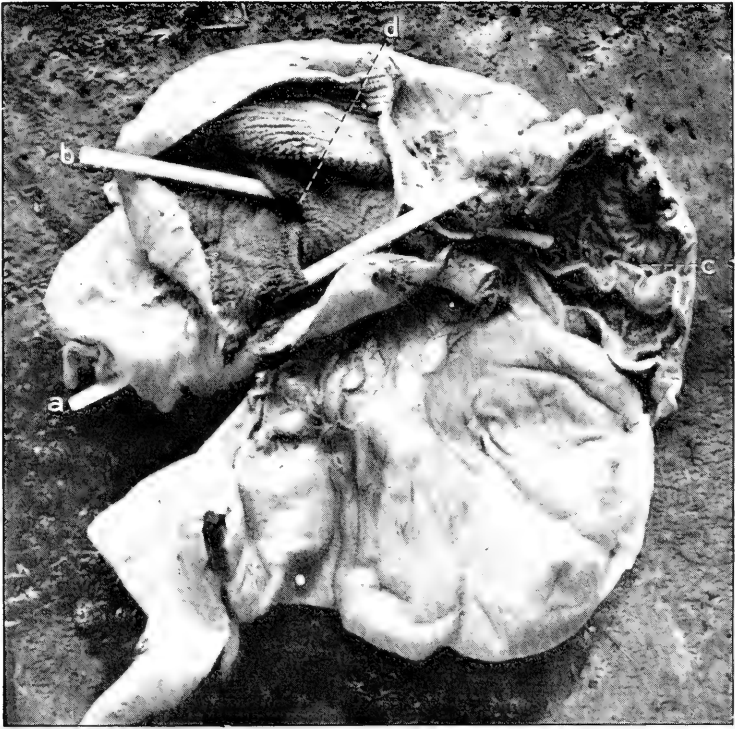


A



B

ANATOMY OF THREE-TOED SLOTH (*Bradypus tridactylus*).



A

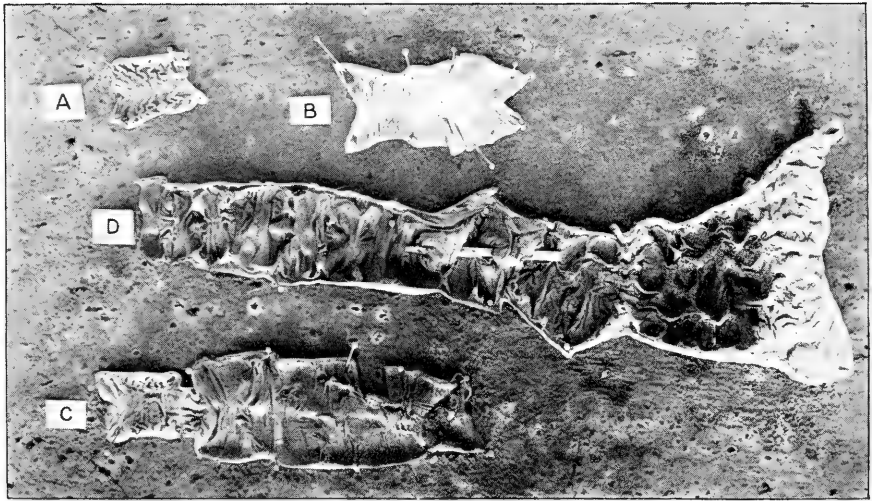


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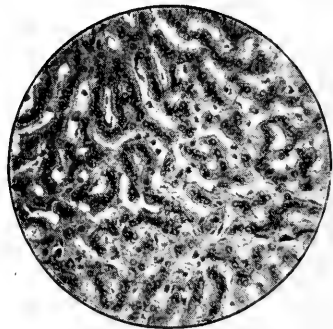
ANATOMY OF THREE-TOED SLOTH (*Bradypus tridactylus*).



A



B



C

ANATOMY OF THREE-TOED SLOTH (*Bradypus tridactylus*).

7. A Contribution to the Anatomy of the Three-toed Sloth (*Bradypus tridactylus*). By CHAS. F. SONNTAG, M.D., F.Z.S., Anatomist to the Society.

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(Plates I.-IV. & Text-figures 10-15.)

The observations recorded here were made on the body of a female *Bradypus tridactylus* which died a few hours after admission to the Society's Gardens. It was deposited, so I was unable to make a complete dissection, and my investigations were, in consequence, limited to the mouth, tongue, and organs of the thorax and abdomen. Some of the conditions observed have not been recorded before, and others differ from those which have already been described. The organs were compared with those of *B. gularis* or *cuculliger*, which are preserved in the Museum of the Royal College of Surgeons.

THE MOUTH.

The Vestibule.

The form and communications of the vestibule depend on the shape of the maxillæ and the size and distribution of the teeth. When the skull is examined it is seen that the premaxillæ are edentulous, so there is a gap in front between the first pair of teeth in the upper jaw (Plate I. C), and there is a similar gap in the lower jaw. Consequently, when the lips are everted, one can see the tip of the tongue. In *Choloepus*, on the other hand, the prominent rostrum, or beak, of the lower jaw diminishes the gap in the centre.

The mucous membrane does not form a vestibular pocket in front, as in most mammals, for it passes direct from the margins of the jaws to the free edge of the lips. Consequently, the vestibule in front has no wider area than the orifice of the lips (Plate I. A).

The first pair of upper teeth are small, and the second pair are large and project laterally (Plate I. C). Between the mid-line in front and the second pair of teeth the upper jaw expands, but it narrows behind them, and, as the cheeks are not closely applied to the sides of the jaw, the vestibule is patulous and increases in width from before backwards (Plate I. B, *v*). In the case of the lower jaw, however, the cheeks are closely apposed against the gum and the vestibule is reduced to a mere slit.

Posteriorly the communications between the vestibule and mouth-cavity behind the last pairs of teeth in both jaws are exceedingly small.

In *Choloepus* the vestibule and mouth-cavity communicate through the gaps between the first and second pairs of teeth in both jaws (Plate I. D).

The Hard Palate (Plate I. B).

The hard palate is 2·7 cm. long, ·8 cm. wide between the first pair of teeth, 1 cm. wide between the second pair of teeth, and ·7 cm. wide between the last pair, so it first expands and then contracts. It is encircled just internal to the teeth by a series of *palatal tubercles* which, however, have no counterparts on the dorsum of the tongue. On each half of the palate there are seven of these—one opposite each tooth, one anterior to the first tooth, and one at the side of the mid-line: the first and second are borne by the premaxillæ. The tubercles increase in size from before backwards, and the fifth pair is the largest.

The palate has the same chocolate colour as the labial margins. Running along the mid-line is a white streak which sends out branches to end on the mesial sides of the tubercles. In the posterior part this streak overlies the crest shown in Plate I. C.

When the mucosa is removed from the subjacent bone, it is seen that the palatal tubercles do not cover bony eminences, and the bone differs greatly from that of *Cholæpus* (Plate I. D).

In *B. tridactylus* there is a strong median crest on the posterior half, and there is a gutter on each side of that ridge. Anteriorly each gutter is converted into a tunnel by a fenestrated bridge of bone; the tunnel on the right side reopens on to the free surface, but the left one does not. Both gutters, however, communicate posteriorly with the nasal fossæ.

In the mid-line in front there is a groove which widens from behind forwards, but, as the premaxillæ were lost in the preparation of the skull, I am unable to give a complete description of it.

The bone is much perforated by small foramina. Some of these open into the afore-mentioned tunnels and the others into the nasal cavity.

No sutures are present outlining the various elements comprising the bony palate as in *Cholæpus*.

The bony palate of *Cholæpus* differs in many ways from that of *Bradypus*. It is much larger and its constituent bones are clearly outlined by sutures. There is no gutter nor ridge on the posterior part, but many foramina of different sizes are present. Of these, there is a large pair on the palate bones lying posterior to the fifth pair of teeth, and a large pair on the maxillæ in front. The former, probably, correspond to the gutters of *Bradypus*.

The Soft Palate.

The soft palate, which measures 1·2 cm. from before backwards, is pink in colour. It is attached to the posterior extremity of the hard palate in front, and to the prominent pterygoid plates laterally. No hamular pterygoid processes are palpable through it, but the convex free borders of the plates can easily be felt. Its posterior edge is concave backwards, and its oral surface

bears a small tubercle in the mid-line at a distance of 1 mm. from the free edge (Plate I. B). There is, however, no uvula, as was pointed out by Rapp (10).

The Teeth.

The teeth have been fully described in their structural and developmental aspects by Rapp (10), Semon (11), and others, and I have nothing to add to their accounts.

The Tongue (text-fig. 10).

Rapp (10) has given some scanty details of the tongue, so a detailed description is required.

My fresh specimen has the following *measurements*:—Length from the apex to the epiglottis, 3·85 cm.; length of the oral part, 2·89 cm.; length of the pharyngeal part, ·96 cm.; greatest width (*i. e.* between the lingual attachments of the anterior faucial pillars), 1·7 cm.; width of the apex, ·7 cm.; thickness in the vallate papillary region, 1·25 cm.; thickness at a point 1·4 cm. posterior to the apex, 1·1 cm.; thickness of the apex, ·4 cm.

The tongue is, therefore, short, narrow, and thick. Its width first decreases rapidly, but later maintains a constant dimension to the apex. The thickness remains almost uniform, on the other hand, in the posterior two-thirds and then rapidly decreases towards the apex.

The *apex* has a fine mesial notch, and is covered with small conical and large flat fungiform papillæ. There is a faint *mesial sulcus* which, however, is irregular, and the lens shows how it is replaced in parts by fungiform papillæ; the latter are, however, invisible to the naked eye. The *lateral borders* are massive, and have a single row of large fungiform papillæ; they also possess vertical rows of conical papillæ with backwardly-directed points. No *lateral organs* are present, as shown by Gmelin (13).

The two *circumvallate papillæ* lie side by side, and both are circular and polished. When the tongue is fresh their free surfaces are flush with the surface of the tongue. When, however, it is placed in preserving fluid the papillæ are retracted within their fossæ, thus demonstrating an action similar to what occurs in Monotremes and some Marsupials. The vallums are prominent, granular, and surrounded by conical papillæ. Mayer (14) saw three papillæ.

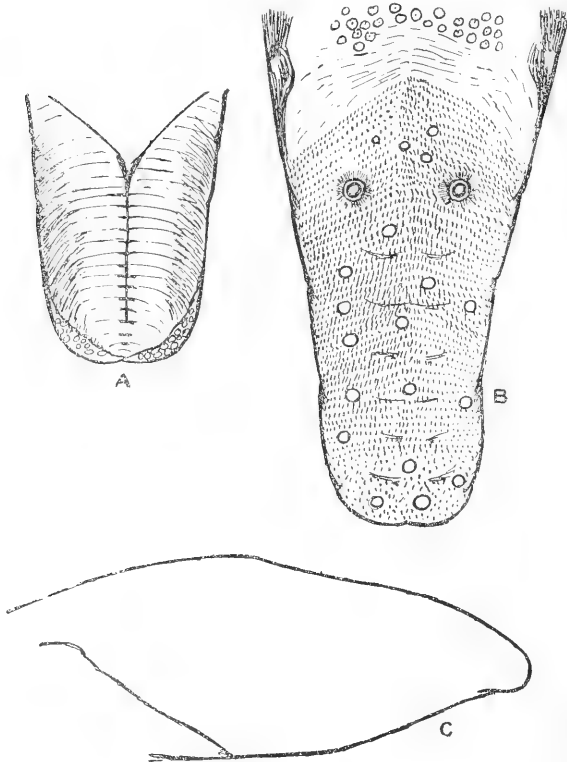
The *fungiform papillæ* are large, flat, and not numerous. They have the usual arrangement in clusters and rows of varying degrees of obliquity which characterises the Mammalian tongue. They extend from the apex back beyond the vallate papillæ, but they stop short of the zone of lymphoid tissue on the base. They form a single row on the lateral borders of the tongue, but the papillæ of the row are discrete.

The *conical papillæ* are all filiform and possess one or more points; those in the mid-line have their points directed backwards, but those at the sides look backwards and inwards. They

increase in size from before backwards and from without inwards, and they are discrete, so there is no overlapping. They extend beyond the vallate papillæ, and there is a sharp line of demarcation between them and the lymphoid tissue at the base.

On the base of the tongue there are many *lymphoid nodules*, some of which have central apertures, and there is a line, convex backwards, separating the papillary and lymphoid areas.

Text-figure 10.



The tongue. A: inferior surface. B: dorsum. C: lateral view.

No *lytta* is present as Rapp showed (10).

The *inferior surface* has a narrow papillary border. There is a fine mesial notch, but no mesial ridge, sulcus, nor frenum. The surface is marked by fine horizontal ridges, but there are no plicæ fimbriatæ. The papillary border forms thick masses at either side of the apex.

The tongue, according to Rapp, is mechanical rather than gustatory in function.

THE STOMACH.

The external appearances have been described by Cuvier (3), Meckel (7), Carus (2), Otto, Boulart, and Pilliet (9), and the internal appearances of the stomach of *B. cuculliger* have been described by Rapp (10) and Klinckowström (6). Many details can be added, however, to their accounts. Moreover, the internal appearances and the relative positions of the various compartments are different in *B. tridactylus* and *B. cuculliger* or *gularis*.

The stomach bed in my specimen is unusual, for the position of the pancreas is peculiar; that organ is contained within the duodenal loop and none of it lies dorsal to the stomach. Again, the stomach bed does not contain the spleen, for the latter, in Sloths, lies on the right side of the pylorus. The kidneys lie far back in the abdomen, and the suprarenal capsules are separated from them, but lie in the normal position. Consequently, the adrenal bodies are dorsal relations of the stomach, but the kidneys are posterior. In my specimen the stomach has the following relations:—

Anterior—liver and diaphragm.

Posterior—intestines and kidneys.

Ventral—ventral abdominal wall.

Dorsal—vertebral column, main blood-vessels, suprarenal capsules, root of the mesentery.

To the left—abdominal parietes.

To the right—spleen, pancreas, duodenum.

These peculiar arrangements make the disposition of the peritoneum, which is described below, noteworthy.

In my specimen the gravid uterus touched the greater curvature.

Divisions of the Stomach.—I agree with Klinckowström's division of the stomach into three groups of compartments:—

1. The Paunch, or Fundus Stomach, with its cæcal appendage (Plate II. A, c and B, I.I.I.).

2. The Cardiac Stomach with three divisions (Plate II. A, d and II. B, d. c. d, 2).

3. The Pyloric Region composed of two parts—glandular and muscular (Plate II. B 3).

In *B. tridactylus* the main divisions, and most of the subdivisions, can be distinguished on the surface. The paunch is marked off from the cardiac stomach by a notch on the left part of the greater curvature (Plate II. A, A) and a faint ridge running from the notch to the base of the cæcal appendage. This ridge marks the anterior limit of a number of fissures running forward from the greater curvature, but these are not so deep as in *B. cuculliger*. The cardiac stomach is easily marked out from the pylorus; it is capacious and has thin walls, but the pylorus is a thick, muscular, U-shaped tube.

The relative positions of these divisions are different in *B. tridactylus* and *B. cuculliger*. The reader is referred to the works of Rapp (10), Klinckowström (6), and Oppel for descriptions of the latter. Klinckowström's paper is the best, for it is profusely illustrated. Moreover, there is an excellent specimen of the stomach of *B. gularis* in the Museum of the Royal College of Surgeons. Klinckowström described the histology.

When the stomach of *B. tridactylus* is examined from the ventral aspect (Plate II. A), one sees the paunch (Plate II. A, c) posterior and to the left; the cardiac stomach (Plate II. A, d) anterior and to the right; and the ventral part of the pylorus (Plate II. A, h) lying most to the right. The entire pylorus is not visible on the ventral surface as in *B. cuculliger*. When the stomach is viewed from the right, one sees the U-shaped pylorus consisting of dorsal and ventral limbs, and a posteriorly-placed bend (text-fig. 14 A, *py*). The dorsal limb emerges from the cardiac stomach, and the ventral limb communicates with the duodenum. In *B. cuculliger* the limbs are anterior and posterior with the bend to the left. When the stomach is viewed from the dorsal aspect, one sees the paunch posterior, the cardiac stomach anterior, and the dorsal limb of the pylorus to the right. The U-shaped pylorus is seen in Plate II. B 3.

The simple, conical, cæcal appendage of *B. tridactylus* is longer and more slender than in *B. cuculliger*. Its position may vary, but in my specimen it first passed from the posterior and right part of the paunch to the right. It was then recurved on itself, and its apex rested on the cardiac stomach. It is also more slender than in *Cholæpus*.

No author has described the peritoneal sheet connecting the cæcal appendage to the paunch (Plate II. A, b). This is triangular, and fills up the space between them. Its apex lies along the anterior border of the appendage, and there is a sharp free border looking forwards and to the right. The right gastric vessels run between its layers as they separate to surround the appendage (Plate II. A, j).

The right gastric artery reaches the ventral surface of the stomach to the right of the œsophagus and passes posteriorly and to the right. It ends about the middle of the cæcal appendage. It is accompanied by the right gastric vein, and all the gastric lymphatic glands lie alongside it.

Rapp (10) and Klinckowström (6) have described the internal structure of the stomach of *B. cuculliger*, and that of *B. tridactylus* agrees with it in most points. Their accounts, however, can be amplified in several ways. Speaking generally, the cardiac stomach has a mechanical function, the paunch and appendage are secretory, and the pylorus has both properties.

The division between the paunch and cardiac stomach is marked by a strong, thick ridge (Plate II. B, a) and a second ridge into which the point of the pin is inserted, corresponding to the white line seen externally on the ventral surface. It marks

the transition between the rugose smooth mucosa of the paunch and the hard mucosa of the cardiac stomach.

The *three divisions of the cardiac stomach* are separated by partitions, and the septum between the two ventral compartments runs for some distance along the inner surface of the paunch (Plate II. B, *pin*). Microscopic sections of this septum (Plate IV. B) show the transition between the stratified epithelium of the cardiac stomach and the glandular lining of the paunch. The septum between the dorsal and left ventral compartments (Plate II. B, *c*) is small and strong. The former septum is absent in *Choloepus*. The epithelial transition is similar to the junction of the œsophagus and a simple stomach.

The *inner surface of the paunch* is beset with rugæ whose characters differ on the two sides of the septum running back from the cardiac stomach. On the left side they run in all directions and are mostly small; on the right side they are mostly large, and pockets are enclosed between them and the gastric wall. One very large septum bisects the cæcal appendage; in Plate II. B one of the halves is laid open, and a glass rod passes down through the other one. Between the rugæ, which are soft and flabby, the mucosa has innumerable small glandular pits.

On the right side there are several small, firm ridges passing to the large ridge between the paunch and cardiac stomach, but they are absent on the left side, for the soft mucosa extends right forward to that ridge (Plate II. B, *a*); and these small ridges are seen above *d* in Plate II. B.

The *interior of the cæcal appendix* has been incompletely described by Rapp (10) and Klinckowström (6), and no illustrations are provided by them. Its inner structure is shown in Plate II. B, and a cross section is diagrammatically represented in text-fig. 12, B. It is ridged by many longitudinal folds, but these are reduced to six in number in the terminal third. The upper two-thirds of the cavity is bisected by a large septum, and small partitions attached to it enclose two pockets on either side. These all open towards the paunch, and the arrows in text-fig. 12 B pass through the two passages on either side of the main septum.

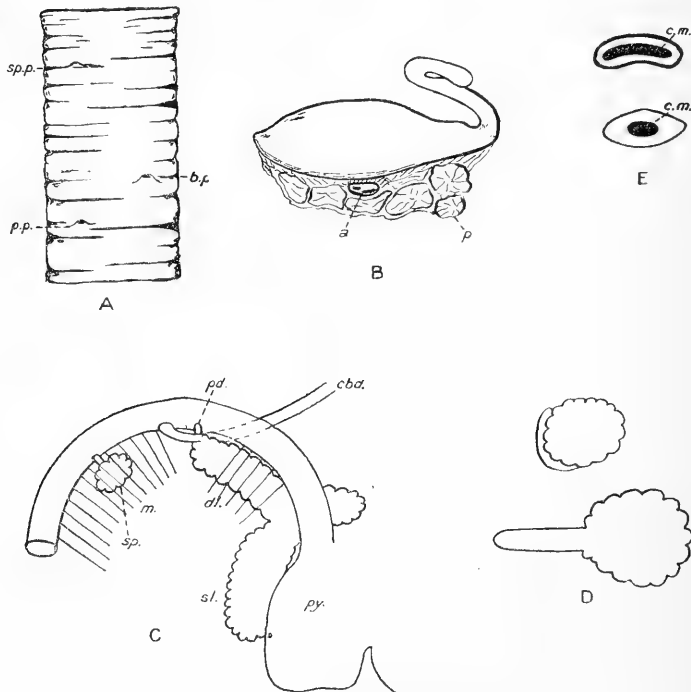
A prominent muscular ridge (Plate II. B, *b*) runs from the greater curvature into the left ventral compartment of the cardiac stomach, and ends on the septum between the latter and the dorsal compartment. A second ridge runs from the septum between the two ventral compartments to meet the former ridge, and between them is the opening between the dorsal and left ventral compartments of the cardiac stomach.

The œsophagus is continued right into the pylorus by a groove running through the left ventral and dorsal compartments of the stomach. It is shown in Plate III. A, *a*, and its characters are the same as those already described by Rapp and Klinckowström.

The *pyloric region*, which is U-shaped, has dorsal glandular

and ventral muscular divisions. Its histological characters have been thoroughly described (6), and I have nothing to add to that account. Running along the floor is a ridged groove continuous with the groove from the paunch into the cardiac stomach, and Rapp (10) thinks it has a ruminating function. The communication between pylorus and duodenum is guarded by a strong valve (Plate III. C, *a*), but Rapp states that there is no pyloric sphincter.

Text-figure 11.



A: Interior of the duodenum. *b.p.*, bile papilla; *p.p.*, pancreatic papilla; *sp.p.*, papilla of accessory pancreas.

B: The spleen with accessory spleen (*a*) in the pancreas (*p*).

C & D: The pancreas. *c.b.d.*, common bile-duct; *p.d.*, pancreatic duct; *m.*, mesentery; *py.*, pylorus. Description of other figures in text.

E: Section across the suprarenal capsules. *c.m.*, medulla within cortex. The upper is the left, and the lower is the right capsule.

The stomach is, therefore, very complex and contains divisions corresponding to most of those of the Ruminantia, but the reticulum of these animals is absent.

THE DUODENUM (text-fig. 11, A).

I have nothing to add to those descriptions of the macroscopic appearances which have already been published. I must, however, record the conditions of the bile and pancreatic ducts which differ from those mentioned by Francaviglia (4). The pancreatic duct opens into the duodenum 2.9 cm. distal to the pylorus; it is situated on a papilla. At a point 1.1 cm. posterior to the pancreatic papilla there is a large bile papilla, and 2.7 cm. posterior to the latter there is a small papilla for the duct of an isolated mass of pancreatic tissue. All the papillæ lie on transverse folds of mucosa.

The entire duodenal mucosa is thrown into circular folds which are large at the pyloric end, and small and numerous at the jejunal end.

THE JEJUNUM AND ILEUM.

Dr. Chalmers Mitchell (8) has described the macroscopic appearances in *B. infuscatus*, and mentions the presence of a large cæcal pouch and a small rudimentary cæcum opposite to it. The latter is not present in my specimen, but the remainder of the intestine is the same as that described in Dr. Mitchell's paper. There is no ileo-cæcal valve.

The mucosa exhibits alternating smooth and rugose areas (Plate IV. B, A & B), and there is a strong development of rugæ at the posterior end of the ileum.

THE LARGE INTESTINE.

In Plate IV. A, c & d, the entire large intestine is exhibited, but the lower end of the ileum is also shown in the former. The canal is, therefore, short, and maintains an almost uniform calibre till the rectum is reached, but the latter gradually expands and its walls become progressively thicker and more muscular. At the anus the walls are exceedingly thick and strong.

The whole of the colon and rectum are bile-stained, especially in the posterior part of the latter, and these parts offer a marked contrast to the pink ileum and anus.

The interior of the large intestine presents several interesting appearances. The colon has many circular folds of varying sizes, but the two most posterior ones form complete diaphragms. In the centre of each of these there is an opening surrounded by a sphincteric valve, the anterior one being the larger. In Plate IV. B, d, a spicule of wood is passed through the two openings. John Hunter (12) described three valves in the Two-toed Sloth.

The posterior septum separates colon and rectum, and the appearances of the mucosa differ in these two divisions. In the latter it is excavated into a number of pockets which contain pellets of faecal matter. These are deepest in the posterior part of

the rectum where the bile-staining is deepest. It also appears as if there had been a strong septum across the rectum, for there is a ridge round the wall.

The anus is surrounded by a tough, strong sphincter, and the mucosa is thrown into many longitudinal folds.

The structure of the whole alimentary tube must be taken into account, in order to understand the physiological significance of the conditions in the rectum. The stomach is complex, as in Ruminants, but the intestinal tube is short, so it is necessary that there be some arrangement to obtain the maximum absorption area in the latter. This is attained by the excavation and folding of the mucous membrane of the latter, and the sphincteric valvular openings in the septa across the colon only allow a small amount of material to pass at a time into the rectum. The powerful anal sphincter muscle is also required to ensure a sufficiently prolonged stay of the intestinal contents, for absorption of water (?) may take place slowly in the rectum.

The reticulum of the Ruminants is absent in the stomach of the Sloth, and the hollows in the rectum resemble the pockets of a reticulum.

THE PANCREAS (text-fig. 11, c & d).

Rapp (10) and others state that the pancreas extends across the abdomen dorsal to the stomach, but in my specimen it is almost entirely contained within the duodenal loop; none of it lies dorsal to the stomach. It presents features, therefore, which resemble those of the Reptilia.

It is V-shaped and has splenic and duodenal limbs (*sl* and *dl*). The former lies between the right border of the ventral limb of the pylorus on the left and the left border of the spleen on the right. The latter lies along the left border of the duodenum, and the angle of the V runs for a short distance anterior and dorsal to the duodenal loop. A short distance distal to the posterior end of the duodenal limb there is a small isolated piece of pancreas (*sp*).

The entire organ is surrounded by peritoneum, the splenic limb being enveloped by the layers of the dorsal sheet of the great omentum, and the duodenal limb and isolated mass being included between the layers of the common mesentery.

The splenic limb consists of a cylindrical massive part and a lateral lamina, but the latter is wrapped round the former (text-fig. 11, D). Within the massive portion there lies a small spherical accessory spleen. The small isolated piece of pancreas is oval in shape.

The pancreatic duct, contained within the gland, runs along close to the anterior border, receiving tributary ducts as it goes. When it emerges from the end of the duodenal limb it is crossed at right angles by the common bile-duct. It opens into the duodenum at the summit of a prominent papilla. Francaviglia (4), however, saw the duct open along with the common bile-duct.

The small isolated piece of pancreas has its separate duct and papilla.

Histology.

When the pancreas is examined under the low power ($\times 180$) it is seen to possess a loose, open texture. The glandular alveoli are either isolated or aggregated loosely into groups, and all are supported by delicate connective tissue. The ducts may be invisible when the cells are loaded with granules, but they appear as clear circular central areas when the cells are not so loaded. Multinucleated areas of different kinds are seen.

Under the high power ($\times 480$) the gland-cells are seen to contain granules of different sizes and different degrees of coarseness, and the bases of the cells are the most granular parts. The nuclei are circular, large, and present well-marked granules and networks; in some the granules predominate, but in others the reticulum is the chief feature.

The multinucleated areas differ greatly in appearance, but can be arranged in three groups:—

1. Many nuclei and little surrounding protoplasm.
2. Many nuclei with much protoplasm which stains faintly.
3. Many nuclei with much protoplasm which stains deeply.

In all, the nuclei are of varying shapes and sizes.

The connective tissue may appear as delicate strands round the alveoli, or it may form a strong network within the meshes of which the alveoli are contained. The meshwork is also cellular, and the nuclei are circular or long and narrow.

THE LIVER.

I have nothing to add to existing accounts of the macroscopic appearances.

Histology (Plate IV. C).

Under the low power it is seen how the cells have the usual arrangement in columns, but each cell has golden-yellow pigment granules in the centre. There appears, therefore, to be a yellow axis running along the centre of the column, for all the cells are filled from end to end with the pigment.

The high power reveals how a few cells are destitute of pigment, so pigmented and non-pigmented cells are to be described. The *unpigmented cells*, which are in the minority, are cubical, hexagonal, or pentagonal in shape. Their protoplasm is faintly granular, and their nuclei are large, round, and granular. The *pigmented cells* cannot have their limits so easily defined, for the pigment granules are tightly packed and obscure their contiguous walls. The granules are coarse or fine and form a central axis, but they never obscure the large, spherical, granular nucleus of the cell. The axis is bordered on either side by the cytoplasm of the cell which is finely granular, but the granules do not consist

of pigment. These granules may, however, have a pathological significance.

THE SPLEEN.

The spleen, as Rapp pointed out (10), lies on the right side of the pylorus. It is, in my specimen, separated from the latter by the splenic limb of the pancreas, with which it is surrounded by the layers of the dorsal sheet of the great omentum (text-fig. 11, B). Its total length is 7.7 cm., width of the oval part 1.3 cm., and thickness .75 cm.

It consists of an oval posterior part, and a long narrow anterior part which is twice bent on itself, but the latter has a small thick concealed process. On the inner side there is a small circular accessory spleen lying within the splenic limb of the pancreas.

The right-sided position of both pancreas and spleen introduce modifications in the peritoneum. In my specimen the conditions induced by the former make the peritoneum different even to that of forms of *B. tridactylus* in which the spleen and pancreas lie as described by other authors.

The position of the spleen offers a problem for the embryologist.

THE PERITONEUM.

The Great Omentum (Plate II. A, F).

The great omentum is attached to the right side of the ventral limb of the pylorus, but nowhere is it fixed to the greater curvature of the stomach. It has dorsal and ventral sheets, each composed of two fused layers.

The *ventral sheet* (text-fig. 12, A, *vs*) is attached to the right border of the whole of the ventral limb of the pylorus, and the right border of the first part of the duodenum. It separates into two layers which surround these structures. The ventral layer is continued from the pylorus on to the ventral surface of the cardiac stomach, and the dorsal layer passes from the ventral to the dorsal part of the pylorus, thereby forming the left wall of the lesser sac. On the dorsal limb of the pylorus it meets with the dorsal sheet of the great omentum which has returned from the pancreas and spleen.

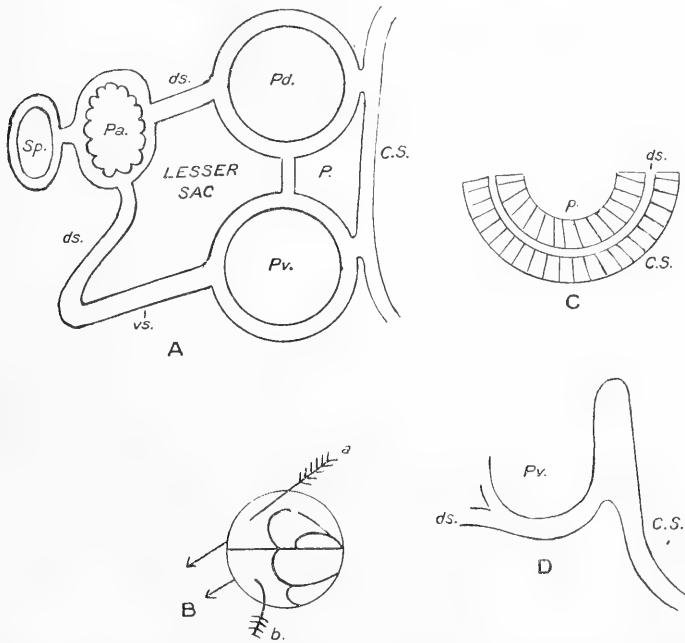
At the convexity of the pylorus the ventral and dorsal sheets meet, thereby closing the lesser sac posteriorly, and the ventral sheet fuses anteriorly with the mesoduodenum (dotted line in text-fig. 14, A).

The *dorsal sheet* (text-fig. 12, A, *ds*) passes dorsally and to the right from the free edge of the omentum and, at the ventral border of the pancreas, it splits into right and left layers. The former passes round on to the right surface of the splenic limb of the pancreas, and is carried off round the spleen which it completely encloses; returning to the pancreas again it covers the right surface. The left layer covers the left surface of the pancreas and, at the dorsal border, the two layers come together

again and run to the dorsal limb of the pylorus. One layer passes thence on to the dorsal surface of the cardiac stomach, and the other unites with the dorsal layer of the ventral sheet. Between the serous covering of the cardiac stomach and the layers passing between the two limbs of the pylorus there is a peritoneal pocket (text-fig. 12, A, p).

When the dorsal sheet is traced to the pyloric curvature it separates into anterior and posterior layers. The former becomes continuous with the part of the ventral sheet running between the two pyloric limbs (text-fig. 12, C, p), and the latter passes

Text-figure 12.



A : Section across the great omentum. Dorsal (*ds*) and ventral (*vs*) sheets embracing spleen (*Sp.*), pancreas (*Pa.*), and ventral and dorsal parts of pylorus (*Pv.* & *Pd.*).

B : Section across the caecal appendage of the stomach.

C & D : The relation of the dorsal sheet of the great omentum (*ds*) to the pyloric curvature. The layers pass to the peritoneal pocket (*p*) and the cardiac stomach (*cs*).

round the bend and is reflected on to the right surface of the cardiac stomach (text-fig. 12, C, *cs*).

The posterior pole of the spleen is connected by a fold of peritoneum to the ventral surface of the cardiac stomach, encircling the ventral pyloric limb and curvature. It shuts in a peritoneal pocket containing the ventral limb.

The meso-appendix, which binds the cæcal appendage to the posterior surface of the cardiac stomach, is formed by peritoneum derived from the coverings of both ventral and dorsal surfaces of the stomach. Its attachment to the cardiac stomach is much shorter than to the anterior border of the appendage.

The Gastro-Hepatic Omentum.

The gastro-hepatic omentum runs from the œsophagus, convex lesser curvature of the stomach, and duodenum as far distally as the entrance of the common bile-duct (Plate II. A) to the diaphragm at the left side of the liver, and along the left half of the posterior surface of the liver. It is wide and fan-shaped with the base lying posteriorly and the narrower end fixed to the diaphragm and liver. It fuses with the common mesentery, and the structures forming the ventral boundary of the wide Foramen of Winslow are common to both of them (Plate II. A, L).

When the serous coats of the stomach are traced to the right they are seen to separate and surround the first part of the duodenum and become continuous with the common mesentery (Plate II. A, c). This connection, therefore, forms an additional means whereby the gut is fixed to liver and diaphragm.

The Lesser Sac of the Peritoneum (Plate II. A; text-fig. 12, A).

The long axis of the lesser sac describes an S-shaped course from the Foramen of Winslow to the free edge of the great omentum, and its general direction is posterior and to the right. It is also tapering, for the Foramen of Winslow and part abutting against the liver are much wider than the omental end. It also lies mostly to the right of the stomach, and part of it is anterior. Consequently, the disposition is different from that of most Mammals, where it lies dorsal to the stomach. This curious arrangement is due chiefly to the position of the pancreas, spleen, and great omentum, and the relations of the layers of the omentum to the limbs of the pylorus.

The boundaries of the lesser sac from behind forwards are:—

To the right—pancreas and spleen enveloped by the layers of the dorsal sheet of the great omentum.

To the left—the two limbs of the pylorus and the beginning of the duodenum.

Dorsally—the so-called ligamentum hepato-cavo-duodenale of Klaatsch, which is a continuation of the right half of the suspensory sheet of the liver and covers the vena cava inferior.

Ventrally—the great omentum, pylorus, first part of the duodenum, and the fused sheet produced by the lesser omentum and common mesentery.

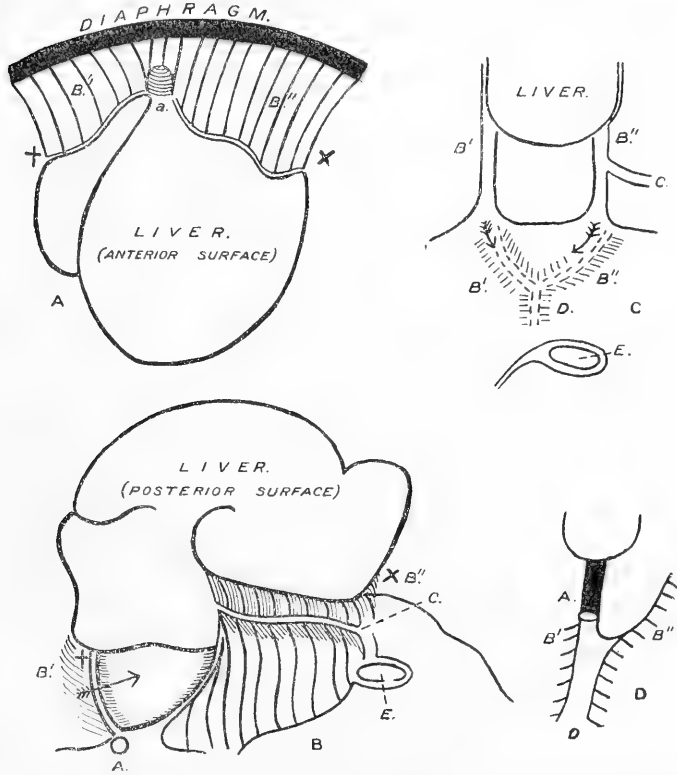
The above conditions resemble in many respects those of some

of the Reptilia, and Klaatsch (5) has described the peritoneum exhaustively in them.

The Foramen of Winslow is also very wide as in the case of Reptiles. It has the usual boundaries.

In Plate II. A the ventral wall of the lesser sac has been removed round the letters MGIJKL and one sees the pancreas (P) in the dorsal wall of the sac.

Text-figure 13.



The suspensory ligaments of the liver and the manner in which their continuations enter into the formation of the anterior part of the common mesentery. Two halves, B' and B'' of A, pass round the edges of the liver at the points + and X. They eventually become the mesentery D of figs. C and D. A and a, inferior vena cava. c: lesser omentum. E: œsophagus.

Ligaments of the Liver.

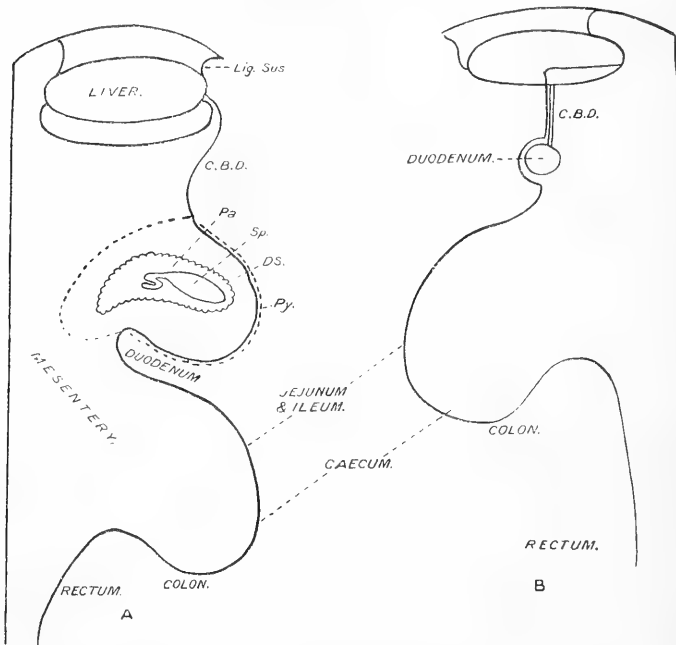
When the liver is depressed so as to show the anterior surface (text-fig. 13, A), one can see how it is connected to the diaphragm by a V-shaped sheet of peritoneum whose apex is dorsal. The

limbs of the sheet play important parts in the formation of the mesentery and the ligamentum hepato-cavo-duodenale of Klaatsch.

The right limb is inserted into the floor of a groove. It passes round the right border of the liver and separates into two layers which pass along the sides of the vena cava inferior. One-half covers the right abdominal wall, and the other covers the dorsal abdominal wall and can be traced into the common mesentery (text-fig. 13, *Cd* and *Dd*).

In the angle between the two limbs the vena cava inferior, arched over by peritoneum, can be seen (text-fig. 13, *A*, *a*) running to the diaphragm.

Text-figure 14.



The common mesentery viewed from the right (A) and left (B). *Lig. Sus.*, suspensory ligament; *C.B.D.*, common bile-duct; *Pa.*, pancreas; *Sp.*, spleen; *Py.*, the dorsal and ventral limbs and flexure of the pylorus; the unmarked dotted line is the line of fusion of the great omentum and mesentery.

The left limb of the sheet is the true suspensory ligament. It passes into the fissure between the left and right lobes of the liver. It turns round the left hepatic margin, and is attached to the posterior surface from the left border to the origin of the common bile-duct. The lesser omentum fuses with it. It is continued as the common mesentery, and is combined therein with part of the ligamentum hepato-cavo-duodenale. Between the

two halves is the anterior part of the lesser sac (text-fig. 13, B), which opens into the Spigelian Recess of the liver.

The Mesentery.

The mesentery has an attachment from liver to pelvic floor which begins anteriorly to the right of the mid-line, but passes posteriorly and to the left to reach it. It is composed at first of the suspensory ligament, and its free edge is attached first to the diaphragm, then along the posterior surface of the liver (Plate II. A, N). Its free edge then, containing the common bile-duct, runs from the portal fissure to the duodenum. Finally, it follows the intestine to the pelvic floor. It has attached to it the layers of the great omentum. It sends a tubular sheath round the œsophagus (text-fig. 13, B, E).

The stomach is attached to it anteriorly by the lesser omentum, and to the right by the connection round the duodenum (text-fig. 14, B).

No peritoneal bands connect the duodenum to the colon.

Dr. Chalmers Mitchell (8) and others have described the peritoneum from duodenum to anus, and the only fact which I have to add to their accounts is the prominent ridge produced in the mesentery by the posterior mesenteric vessels.

The Suprarenal Capsules.

The left capsule is flat and ovoid and measures:—

Length	1·8 cm.
Width	·75 „
Thickness	·35 „

The right capsule, as is shown by the following figures, is longer, narrower, and thicker:—

Length	2 cm.
Width	·6 „
Thickness	·5 „

Both lie a considerable distance anterior to their corresponding kidneys. On section the right capsule shows a round cortex and medulla, but these are long in the case of the right one (text-fig. 11, E).

The Thoracic Organs.

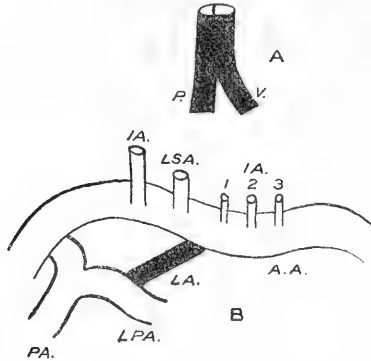
Burne (1) and Rapp (10) have described the heart and large vessels, but the branches of the aortic arch in my specimen are different to their accounts. It gives off from right to left the innominate, left subclavian, and three intercostal arteries (text-fig. 15, B).

The posterior border of the arch is connected to the left pulmonary artery by a very prominent ligamentum arteriosum; this measures 1 cm. long and 2 mm. wide, but is quite impervious.

The left vagus and phrenic nerves are fused in the anterior part of the thorax, there being only superficial furrows to mark the distinction between them (text-fig. 15, A).

The lungs have large alveoli, as shewn by John Hunter (12).

Text-figure 15.



A: The adhesion of the left vagus (v) and phrenic (p) nerves.

B: The aortic arch (A.A.) giving off innominate (I.A.), left subclavian (L.S.A.) and three intercostal (1 A, 1, 2, 3) arteries; L.A., ligamentum arteriosum; P.A. and L.P.A., pulmonary and left pulmonary arteries.

THE GENERATIVE ORGANS.

The internal generative organs of the female have been described by John Hunter (12), Klinckowström (6), and Rapp (10). Those of my specimen were not examined, for the gravid uterus was at once removed for embryological research.

The external genitalia and anus are all enclosed in a species of cloaca, and the clitoris is a small semicircular flap. The male organs also exhibit a primitive condition, and John Hunter (12) has described them as follows:—"The penis is a short flat body enclosed in a prepuce which is within the verge of the anus. It is not above two tenths of an inch in length, and terminates in an obtuse point. It has a groove which runs along the under surface, and which makes the point somewhat forked."

No os penis is present.

Ballowitz (15) has described the spermatozoa.

THE PELVIC BONES.

The skeleton of the specimen, described above was recently obtained by me from Mr. Gerard, and the pelvis was compared with that of a male animal which was preserved in the Society's Prosectorium. There are numerous and striking differences between them; these are seen in the measurements of the different

diameters, the shape of cross-sections of some of the bones, the sizes of openings, and the development of crests and eminences. Speaking generally the female pelvis is rounder and more capacious, for it has to accommodate the large trumpet-shaped rectum, and leave a passage for the fetus during parturition.

For purposes of measurement I have chosen the following diameters which are made use of in human obstetric anatomy, but have modified them slightly:—

1. *Conjugate*—from the centre of the inner border of the pubis to the front of the centrum of the first sacral vertebra.

2. *Transverse*—between the widest points of the lateral pelvic walls; that is between the inner surfaces of the acetabula.

3. *Oblique*—from the sacro-iliac joint to the mid point of the bone between the mid line in front and the anterior border of the obturator foramen.

4. *Interspinous*—between the iliac spines.

5. The *measurements of the outlet* are taken between the widest points dorso-ventrally and transversely.

The proportions present in male and female pelves are as follows:—

<i>Diameters.</i>	<i>Male pelvis.</i>	<i>Female pelvis.</i>
Interspinous diameter	9·8 cm.	10·1 cm.
Conjugate of inlet	7·7 "	7·5 "
Transverse, ,,	5·5 "	6·8 "
Oblique ,,	7 "	7·5 "
Conjugate of outlet	5·5 "	5·7 "
Transverse, ,,	5 "	5·8 "
Width of pubis	2 "	2·3 "

Ischiadic Foramina.

Antero-posterior diameter	2·3 "	1·8 "
Transverse ,,	1·6 "	1·3 "

Obturator Foramina.

Antero-posterior diameter	1·6 "	1·7 "
Transverse ,,	2·2 "	2·5 "

The following differences are also present between a male and female pelvis:—

<i>Male pelvis.</i>	<i>Female pelvis.</i>
Ischial tuberosities well marked.	Ischial tuberosities very small.
Pubis circular on section.	Pubis flat on section.
Iliac spines incurved.	Iliac spines not incurved.
Inlet less defined.	Inlet well defined by a sharp crest.
Ischia more sloping from last sacral vertebra.	
Transverse processes of caudal vertebræ sloping.	Transverse process of caudal vertebræ horizontal.

THE SACRAL AND CAUDAL VERTEBRÆ.

Owen mentions in his 'Comparative Anatomy of the Vertebrata,' that there are six sacral and eleven caudal vertebræ. In both my specimens there are seven sacral and nine caudal vertebræ, but there is a greater degree of fusion, and less distinctness, between the sacral centra in the female pelvis. Flower gives the number of caudal vertebræ as 6-10.

THE BLOOD.

Gulliver (16) has pointed out that the red blood corpuscles are very large, and gives their measurement as $1/2778$ th inch in diameter in a young *B. didactylus*. He also states that the Elephant is the only mammal with larger corpuscles.

SUMMARY.

The new facts recorded in this communication are:—

- a. The full description of the mouth and tongue.
- b. The comparison between the palates of *Bradypus* and *Choloepus*.
- c. The external relations of the compartments of the stomach, and the distribution of lymphatic glands in the stomach-wall.
- d. Details of the internal structure of the stomach, and a complete account of the interior of the cæcal appendage.
- e. The unusual and reptilian-like situation of the pancreas, which results in complications in the peritoneum. The latter is fully described for the first time in *Bradypus tridactylus*.
- f. The vessels arising from the aortic arch are different to previous accounts.
- g. The ligamentum arteriosum of *Bradypus* is described for the first time.
- h. The duct papillæ in the duodenum are different from the form which has already been described.
- i. The comparison between the male and female pelvis.

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EXPLANATION OF THE PLATES.

PLATE I.

- A. The anterior end of a section through the head. *ll*, lips.
- B. The roof of the mouth: *c*, cheeks; *v*, vestibule; *sp*, soft palate.
- C. The bony palate of *Bradypus tridactylus*.
- D. The bony palate of *Choloepus*.

PLATE II.

The external (A) and internal (B) structure of the stomach. In B the ventral wall has been thrown upwards and to the right, and the dorsal cardiac compartment and pylorus separated and thrown to the left.

- A, C and B, I, L, L: paunch.
 A, D and B, *d*, *c*, *d*, 2: cardiac stomach.
 A, EII and B 3: pylorus.

Description of other letters in text.

PLATE III.

The interior of the dorsal compartment of the cardiac stomach (A), dorsal part of pylorus (B), and ventral part of pylorus (C).

- A *a*: rod running through the ruminating gutter to the pylorus. *b*, rod communicating with the paunch (*c*). *d*, pleated mucosa.
 B *a*: epithelial ridges bounding glandular areas (*b*). *c*, ruminating gutter. *d*, hard pleated mucosa continued from the cardiac stomach.
 C *a*: pyloric sphincter with beginning of duodenum (*b*). *c*, cardiac stomach.

PLATE IV.

- A: The interior of the intestinal tract. *a* and *b*, pieces of the small intestines. *c* and *d*: the lower end of the ileum, colon, and rectum.
 B: Section through the septum between cardiac stomach and paunch.
 C: Section of the liver.

8. Report on Deaths which occurred in the Zoological Gardens during 1920. By N. S. LUCAS, M.B., F.Z.S., Pathologist to the Society.

[Received January 31, 1921: Read February 22, 1921.]

On Jan. 1st, 1920, there were living in the Gardens :—

586 mammals,	1333 birds,	411 reptiles.
(826)	(2162)	(486)

To these were added during the year :—

450 mammals,	1138 birds,	693 reptiles.
(446)	(1356)	(683)

Giving a total of :—

1036 mammals,	2471 birds,	1104 reptiles.
(1272)	(3518)	(1169)

The total of deaths which took place during the year 1920 was 1101. This was made up as follows :—

333 mammals,	490 birds,	262 reptiles.
(356)	(857)	(467)

This gives a percentage of deaths to animals living in the Gardens during the year of :—

32·1	19·8	20·1.
(27·9)	(24·3)	(39·4)

If only those animals which had lived in the Gardens for six months or more are considered (it being assumed that these are acclimatized), the number of deaths is as follows :—

167 mammals,	230 birds,	50 reptiles.
--------------	------------	--------------

Giving a percentage of deaths of :—

16·1	9·3	4·5.
(16·9)	(16·4)	(13·8)

As this is the first year in which the numbers have come up to pre-war standards, or nearly so, the figures for 1913 are given in brackets corresponding to each of the above.

Comparing these figures, those for mammals remain very constant. The increase in 4·2 per cent. of the death-rate may be considered as due to the higher ratio of unacclimatized mammals. If only the acclimatized are taken, there is a drop of 0·8 per cent.

The total number of birds in the Gardens shows a drop of approximately 1100. The bird population in 1913 was nearly 50 per cent. greater than now. The total and acclimatized death-rate has diminished. In the latter case this is very marked. A reference to the diminished figures for avian tuberculosis and

mycosis will shed some light on this fall. How much of this diminution in the incidence of these diseases is due to the birds being less crowded it is difficult to say. If the numbers of birds rise to pre-war height, it will be interesting to watch the corresponding effect on these diseases.

The decrease in the death-rate among the reptiles is still more marked, being nearly half, even when newly-imported individuals are considered. This is due to the absence of an epidemic of pneumonia, which in 1913 claimed 138 victims, while the total deaths from lung diseases for 1920 is 61.

If only the more acclimatized specimens are considered, the death-rate is remarkably low. This is probably due to the fact that those which had been in the Gardens for more than six months were mostly reptiles which had survived the difficult period of the war and were rather specially well acclimatized.

Notes on the Analysis of the Causes of Death.

1. *Pleurisy*.—It is interesting to note the rarity of this disease among animals in comparison with its common incidence among humans.

One case occurred in a green cercopitheque, the other in a macaque.

2. This occurred in a grey mongoose.

3. This was found in an Indian hunting dog, and was due to a nematode, *Spiroptera sanguinolenta*.

4. This occurred in a Burnett's cercopitheque.

5. It is difficult to account for the diminution in the deaths from nephritis. The figures this year are 8, 31, and 0 for the three classes, while in 1913 they were 90, 135, and 6. At first sight it might seem that this was due to a difference in opinion as to the cause of death, but as there has been no corresponding rise in any other disease or diseases, this cannot be the cause. So little is known as to the cause of nephritis, that it is impossible to assign a reason.

6. In a budgerigar.

7. Enteritis still remains the chief cause of death among the birds. One organism, that of *B. aertryck*, has been isolated from a newly-imported grey touracou and a newly-imported parrakeet.

8. These occurred in a ring-tailed lemur, a badger, and a bonnet macaque.

9. In a black-backed jackal.

10. In a bonnet macaque. This was an old individual.

11. In a fairy blue-bird.

12. In a violet tanager.

13. The high death-rate from tuberculosis among the mammals as compared with that of birds is of interest.

Among the mammals 69 deaths occurred, of which 43 were those of macaques in the canal-bank aviary. Of the remaining 26, five occurred in the Lion House, leaving 21 for the other

Analysis of Causes of Death.

Disease.		Mammals.	Birds.	Reptiles, etc.	
<i>Diseases of Respiratory Organs.</i>	Lobar pneumonia	14	...	...
	Broncho-pneumonia	38	41	10	
	Congestion of lungs	29	30	23	
	Bronchitis	29	62	28	
	(Edema of lungs .....	...	5	...
	(1) Pleurisy	1	...	...
	Pleurisy with effusion	1	...	...
	Abscess of lung	1	...	...
	(2) Paragonimiasis of lung	1	...	...
	Collapse of lung (rickets)	4	...	...
<i>Diseases of Cardiovascular System.</i>	Granuloma of lung	1	...	...
	Pleurisy and pericarditis	1	...	...
	Pericarditis	1	9	1	
	Endocarditis	1	...	...
	(3) Ruptured aneurism	1	...	...
	Ruptured heart .....	...	1	...
	Ruptured artery	3	2	...	
	Anaemia .....	...	...	1
	(4) Anaemia of spleno-me- dullary type	1	...	...
	<i>Diseases of Genito-urinary System.</i>	(5) Nephritis	8	31	...
(6) Cystic kidney .....		...	1	...
Necrosis of kidney .....		...	1	...
Egg-binding .....		...	4	...
Inflammation of oviduct .....		...	3	...
Carcinoma of testicle .....		...	1	...
<i>Diseases of alimentary tract.</i>	Stomatitis .....	...	...	2
	(Esophageal abscess .....	...	1	...
	Gastritis	4	...	6	
	(7) Enteritis	34	124	24	
	(8) Intussusception	3	...	...
	(9) Intestinal obstruction } ? old intussusception }	1	...	...
	(10) Volvulus	1	...	...
	Granuloma of intestines	1	1	...	
	(11) Ulceration of cloaca .....	...	1	...
	(12) Fibroma of cloaca .....	...	1	...
	Peritonitis	5	...	...
	Granuloma of mesentery	1	...	...
<i>Diseases of Liver...</i>	Fatty degeneration of liver .....	...	10	1
	Cirrhosis of liver	2	3	...	
	Portal pyaemia	1	...	...
	Ruptured liver .....	...	1	...
	<i>Diseases of Pancreas.</i> }	Pancreatitis	2
<i>Diseases of Nervous System.</i> }		(Edema of brain	1
	<i>Diseases due to Infection.</i>	(13) } Tuberculosis	69	7	2
(13a) } Mycosis		2	21	1	
Anthrax		1	...	...
Toxaemia		8	2	...	
Helminthiasis		2	5	7	
<i>Various</i>		Sarcoma	2	...
		Abscess of ribs	1	...
	Ascites ? cause .....	...	1	...
	Debility	7	...	...
	Inanition .....	...	...	42
	Senility .....	...	1	...
	Under anaesthetic	1	...	...
	Exposure	8	...	...
	Killed by accident or by order	22	44	3	
	Eaten by rats	2	11	8	
	Decomposed	7	19	64	
	Not diagnosed	7	23	22	
	Not examined	9	2	16	

houses and enclosures. In 1913 there were 31 deaths of this disease, of which 15 came from an epidemic in what is now called the Rodent House, so that, deducting the epidemics, there is a slight rise in the death-rate from tubercle this year as compared with 1913.

Of the 26 cases occurring this year, seven only had been in the Gardens less than six months, and of two the date of arrival was accidentally omitted. Of the remaining 17, eleven had been in the Gardens over a year and a half. One, a blesbok, had been there nine years.

It is therefore difficult on these figures to give any opinion as to the method of the introduction of the disease to the Gardens.

The small death-rate among the birds may have the same origin as that of mycosis.

13a. Among the cases of mammalian tuberculosis was that of an axis deer with disease of the genital organs, which is extremely rare in the lower mammals. The animal had been in the Gardens for many years.

EXHIBITIONS AND NOTICES.

February 8th, 1921.

Prof. E. W. MACBRIDE, D.Sc., F.R.S., F.Z.S., Vice-President,
in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the months of November and December 1920.

NOVEMBER.

The registered additions to the Society's Menagerie during the month of November were 102 in number. Of these 48 were acquired by presentation, 25 were deposited, 21 were purchased, 6 were received in exchange, and 2 were born in the Menagerie.

The following may be specially mentioned :—

1 Common Otter (*Lutra lutra*), from Lincolnshire, purchased on November 16th.

1 Japanese Deer (*Sika sika*), bred in England, presented by Ernest J. Gripper on November 4th.

3 Alpine Marmots (*Marmota marmotta*), from St. Moritz, presented by the Curverein, St. Moritz, on November 29th.

DECEMBER.

The registered additions to the Society's Menagerie during the month of December were 66 in number. Of these 33 were acquired by presentation, 25 were deposited, and 8 were purchased.

The following may be specially mentioned :—

2 Beech-Martens (*Martes foina*), from Denmark, purchased on December 7th.

1 Timber-Wolf (*Canis occidentalis*), from N. America, presented by Capt. R. A. Angie on December 3rd.

Mr. E. G. BOULENGER, F.Z.S., exhibited, and made remarks upon, a Black Salamander (*Salamandra atra*), which, in the course of its captivity in the Gardens, had developed yellow spots on the body.

Prof. J. P. HILL, F.R.S., exhibited, and made remarks upon, a series of lantern-slides of the Fetus of a Three-toed Sloth (*Bradypus tridactylus*).

February 22nd, 1921.

Sir S. F. HARMER, K.B.E., F.R.S., Vice President,
in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the month of January 1921:—

The registered additions to the Society's Menagerie during the month of January were 122 in number. Of these 49 were acquired by presentation, 64 were deposited, and 9 were purchased.

The following may be specially mentioned:—

1 American Bison (*Bison americanus*), ♂, bred at Woburn, deposited by The Duke of Bedford, K.G., on January 28th.

1 Dromedary (*Camelus dromedarius*), ♂, from Mogador, Morocco, purchased January 31st.

1 Verreaux's Amethyst-Starling (*Philodauges leucogaster verreauxi*), from Durban, South Africa, new to the Collection, presented by Harold Millar on January 15th.

1 Sundevall's Seed-eater (*Serinus scotops*), from South Africa, new to the Collection, purchased on January 21st.

Prof. G. ELLIOT SMITH, F.R.S., F.Z.S., exhibited a series of photographs of a living example of *Tarsius*, and said:—

The accompanying photographs of a living *Tarsius*, taken by a Chinese boy at Kuching, Sarawak, have just been received from Mr. W. E. Le Gros Clark, who went out to Borneo last autumn to take up the position of medical officer at Kuching. Dr. Charles Hose tells me that the usual and characteristic attitude of *Tarsius* is that shown in these pictures, but during his long period of service in Sarawak he was unable to get any satisfactory photographs of this singularly elusive creature. Hence we owe Mr. Le Gros Clark our deepest gratitude for making us familiar with the somewhat unexpected appearance of this surviving member of the Eocene family from which our own Simian ancestors were derived.

Before he left for Borneo last autumn, I asked Mr. Le Gros Clark to collect all the information he could get of the habits of *Tarsius* and *Tupaia*, to secure photographs of the living animals, and obtain the material for anatomical and embryological research on these important genera. Moreover, I specially impressed upon him the importance of studying the retina of living or freshly-killed examples of *Tarsius* for the purpose of determining whether or not a *macula lutea* was present.

Immediately upon his arrival at Kuching, Mr. Le Gros Clark was able to secure the two photographs reproduced here, and also the fresh corpse of an adult female (? pregnant), which he has



A LIVING EXAMPLE OF *TARSIUS*.

dissected. The uterus has been preserved for Professor J. P. Hill to examine. Mr. Le Gros Clark gives me the important information that neither with the ophthalmoscope nor by direct examination of the retina after opening the eye was he able to detect any sign of a yellow spot (macula lutea). At the same time he cautiously refrained from denying its presence. Dr. H. Woollard has been investigating the specimens of *Tarsius* given to me many years ago by Dr. Charles Hose for the purpose of preparing a monograph on the anatomy of *Tarsius*. He was unable to find the macula lutea in his preparations of the retina, nor was he able to discover any trace of it in a series of excellent histological preparations lent me by Dr. W. L. H. Duckworth of Cambridge.

The macula lutea is a very obtrusive feature of the retina in monkeys, and can easily be seen even in badly preserved material. Hence it could hardly have been overlooked in the fresh retina of *Tarsius*, if it had been present. Hence Mr. Le Gros Clark's observations, taken in conjunction with Dr. Woollard's work at University College, make it practically certain that in *Tarsius* this distinctive feature of the retina of the Anthropoidea (among mammals) is lacking. In this respect *Tarsius* agrees with the Lemurs, and differs from all monkeys.

In the Anthropoidea the development of the macula lutea is associated with a distinctive arrangement of the fibres of the optic tract. Instead of a complete decussation of the optic nerves there is only a semi-decussation, the fibres coming from the lateral half of each retina remaining uncrossed. Dr. Woollard tells me that he is unable to find any evidence of such an arrangement in *Tarsius*, which, like the Lemurs, seems to have either a complete or almost complete decussation.

These observations are of far reaching significance from the light they shed on the cardinal factors that brought the Anthropoidea into existence.

I have repeatedly called attention to the influence of the adoption of an arboreal life upon the cerebral cortex and the behaviour of mammals, which is so clearly displayed in the Menotyphlous Insectivora by comparing *Macroscelides* with *Tupaia*. In the Tree-Shrew the importance of the sense of smell is diminished, and those of vision, touch, and hearing greatly enhanced. The further emphasizing of these adaptations brought the Primates into existence. Among the Prosimiæ the reduction of the size of the nose in one group, the Tarsioidæ, allows the eyes to come to the front of the face so that their fields of vision overlap. The enormous enhancement of the importance of vision which is thus effected leads to the sudden expansion of the cortical area for vision and its further specialisation in structure. The sense of sight now completely supplants that of smell as the dominant guide to the animal, and the alteration of the position of the eyes enables the animal to look forward, both in the literal and the metaphorical senses of the expression.

But though *Tarsivus* has binocular vision, it has no macula lutea to enable it to appreciate the details of the objects seen, nor has it any automatic mechanism for producing the conjugate movements of the eyes necessary for bringing the two images of objects seen on to the corresponding areas of the two retinae. In other words, *Tarsivus* has not yet acquired true stereoscopic vision. But the wide range of movement of the head on the neck shows that the co-ordination of the two eyes is becoming biologically useful to the animal; but as it has no mechanism for automatically regulating the positions of the eyes the one to the other, it moves its head as the cat does.

These enhanced powers of observation opened the possibility for one branch of the Eocene Tarsioidea to guide its hands with greater precision for the performance of skilled movements, and so incidentally enhanced the sense of touch. Hence both the tactile and the motor areas in the cortex underwent a great expansion and elaboration; and at the same time the prefrontal cortex began to grow rapidly as a mechanism was built up for co-ordinating the movements of the eyes. When this happened specially sensitive areas (maculae luteae) were differentiated in the two retinae, and the optic tracts became rearranged for the purpose of stereoscopic vision. These far-reaching changes led to the transformation of the brain and converted a Tarsioid into a monkey.



PROCEEDINGS

OF THE

GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

ZOOLOGICAL SOCIETY

OF LONDON.

1921.

PART II.



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9. On the Reproductive Organs of the Ascidian *Kükenthalia borealis* (Gottschaldt). By Dr. AUGUSTA ÄRNBÄCK-CHRISTIE-LINDE*.

(Text-figures 1-8.)

[Received October 7, 1920 : Read March 8, 1921.]

The subfamily of the *Polyzoineæ*, to which *Kükenthalia borealis* (Gottschaldt) has been referred, is regarded as an intermediate group between the *Styelidæ* and the *Botryllidæ*. According to Michaelsen †, who has given descriptions of this group of Ascidians in several papers, it comprises about ten genera, distributed in almost every region all over the world.

In the Arctic region it is represented by a single genus with one species, *Kükenthalia borealis*.

The species was first described by Gottschaldt ‡ under the name of *Goodsiria borealis*. It was re-described by Hartmeyer § in 'Fauna Arctica' under the new generic name *Kükenthalia*.

As it thus appears, the species has been the object of thorough examination by several eminent zoologists. However, it has not hitherto been possible, so far as I know, to make out its internal structure, owing to the unsatisfactory knowledge of the reproductive organs.

Gottschaldt (*l. c.*) merely writes as follows: "Die Geschlechtsorgane liegen in der Tunica (es wurde ein einziges ziemlich grosses Ei gefunden)."

Two years later Bonnevie || described a few colonies of the species which had been dredged by the Norwegian Atlantic Expedition, 1876-1878. They were described under the name of *Goodsiria coccinea* (Cunningham). With regard to the reproductive organs, the author states that they "are found in small polycarps in the muscular stratum," a statement which proves to be a mistake.

Hartmeyer writes (*l. c.* p. 260):—"Weiblicher Geschlechtsapparat diffus (grössere und kleinere Eizellen überall in den Innenkörper eingestreut sowie in den Blutbahnen der Darmwandung und der jungen Knospen); männlicher Geschlechtsapparat bisher nicht nachgewiesen." "Ein besonderes Ovarium ist nach unseren Untersuchungen nicht vorhanden" (*l. c.* p. 258).

In the paper of Michaelsen we find the same statement.

* Communicated by Dr. F. A. BATHER, F.R.S., F.Z.S.

† Michaelsen, W., "Revision der compositen Styeliden oder Polyzoinen." Mitteilungen aus d. Naturhist. Museum in Hamburg, Jahrgang 21. Hamburg, 1901.

‡ Gottschaldt, R., "Die Synascidien der Bremer Expedition nach Spitzbergen im Jahre 1889." Jen. Z. vol. xxviii. Jena, 1894.

§ Hartmeyer, R., "Die Ascidien der Arctis." Fauna Arctica, Bd. iii. Jena, 1903-1904.

|| Bonnevie, K., "*Ascidie simplices* and *Ascidie compositæ*. From the North Atlantic Expedition." The Norwegian North Atlantic Expedition, 1876-1878. Christiania, 1896.

According to this author, male gonads, as well as female ones, are unknown. And he is of opinion that, with regard to the reproductive organs, the genus in question differs from all other *Polyzoineæ*, and even from all other *Styelids*.

Nor did Bjerkan* succeed in enlightening us on the matter, though, as he says, he had a great mass of colonies for examination.

Being occupied with studies on the Northern and Arctic Ascidians belonging to the collections of the Swedish State Museum, I have had opportunities of examining *Kükenthalia borealis*.

My investigations of the species are not yet completed. However, as important facts concerning the reproductive organs have been established, I publish the results already arrived at, hoping that they will augment our knowledge of an organic system of which one has hitherto tried in vain to get a clear conception.

The material examined was collected off Spitzbergen, Waygat Islands, 60 fathoms, August 1861, and in Ice Fjord, Safe Harbour, 30 fathoms, June 1864. I have also had at my disposal a colony from Greenland, 65° 15' N. lat., 53° 30' W. long., collected in June 1883; depth 75 fathoms.

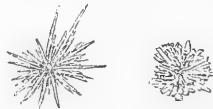
The specimens are preserved in alcohol.

SPICULES.

Introductorily I will here mention that small spicules occur in the test of *Kükenthalia borealis*.

As is known, the species forms colonies which are massive, usually rounded, and not very large; they are attached by a

Text-figure 1.



Kükenthalia borealis (Götsch.).

Spicules. $\times 110$.

narrow base. The zooids are not arranged in systems, and the atrial as well as the branchial aperture of each zooid opens independently on the surface. The test of the colony is well developed. Internally and at the base it is soft and gelatinous, externally it is leathery. To this might be added also that the capsules which surround the individuals of the colony are firm and tough.

The test owes its consistency, partly at least, to the presence of the above-mentioned spicules which are scattered in it. In larger colonies the spicules are abundant, in smaller ones they seem to be less numerous.

* Bjerkan, P., "Die Ascidien des nördlichen Norwegens." Tromsø Museums Aarshefter 24-25. 1908.

They show some variability with regard to size and shape. The general plan of the structure is, however, the same. Text-figure 1 shows two varieties of spicules which occur in different colonies. From a comparison it appears that the crystals are arranged about a common point forming like a sphere, studded with irregular, short, sharp points, or they radiate forming a stellate group with rays of irregular length. Sometimes a ray is elongated like a stalk.

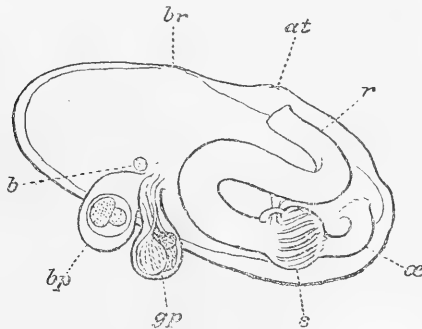
According to the literature, spicules often occur in different groups of Ascidians, but such structures do not seem to have been observed before in any genus of the *Polyzoineæ*. The possibility is, however, not excluded that they have been overlooked, since their presence has been until now unobserved in *Kükenthalia*. But if this should prove not to be the case, the spicules, having been found only in *Kükenthalia*, are to be regarded as a characteristic of the Arctic form.

As spicules might be of some value for comparative and systematic studies, an investigation of their occurrence in the different genera of *Polyzoineæ* would be of interest.

THE REPRODUCTIVE ORGANS.

A more important result of this investigation is, as will be shown, that the reproductive organs, testes as well as ovaries, have been found in *Kükenthalia borealis*.

Text-figure 2.



Kükenthalia borealis (Gottsch.).

Zooid seen from the left side, test partly removed. $\times 8$.

at. Atrial aperture. br. Branchial aperture. b. Bud. bp. Brood-pouch. gp. Genital pouch with testis and ovary. æ. Esophagus. r. Rectum. s. Stomach.

The organs are in the form of a hermaphrodite structure, the male glands as well as the ovary and the ducts being enclosed in a long, sac-like outgrowth of the mantle which extends into the common test. This outgrowth is here named the genital pouch.

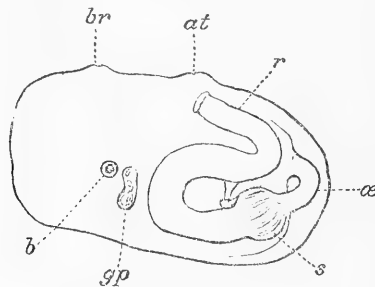
In some individuals another sac-like structure, generally of greater size, has been observed. It is situated at the upper side of the above-mentioned one, and projects like the latter into the common test. When an individual contained developing embryos, they were enclosed in this sac. No doubt it develops to receive the embryos, and it is consequently to be regarded as a brood-pouch.

In the zooids most advanced in development there are thus two pouches which are to be referred to the reproductive organs (*cf.* text-fig. 2).

In the individuals examined, reproductive organs have been observed only on the left side of the body; they are placed ventrally, on the outer side of the mantle, and are embedded in the test.

Only one genital pouch—consequently only one brood-pouch—has been observed in each zooid. If the individuals are seen from the inside of the colony, the position as well as the number of the organs in question is easily determined. The members of the

Text-figure 3.

*Kükenthalia borealis* (Gottsch.).

Zooid seen from the left side, test partly removed. $\times 7$.

at. Atrial aperture. *br.* Branchial aperture. *b.* Bud. *gp.* Genital pouch with testis and ovary. *æ.* Oesophagus. *r.* Rectum. *s.* Stomach.

colony are arranged in one layer and are placed close to each other side by side; only the ventral part is free. From here the reproductive organs extend between the individuals, and only one genital pouch is visible between them, projecting from the left side of each zooid.

As in the genus *Gynandrocarpa*, the reproductive organs of *Kükenthalia* seem thus to consist of a single hermaphrodite structure. In the former it is placed on the right side, in the latter on the left.

In the different zooids of the same colony the reproductive organs show various degrees of development. In some zooids the genital pouch with the gonads was very large and of considerable length, in others it was hardly distinguishable (*cf.* text-figs. 2 & 3).

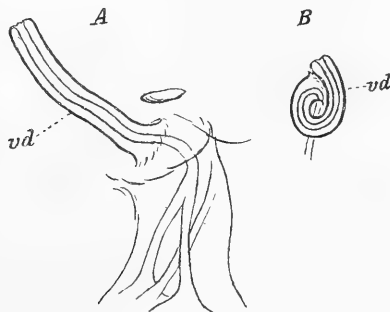
A brood-pouch was developed only in few zooids. It could not be decided whether all the zooids of the colony were mature, the material being little fit for dissection. From the above-mentioned facts one might, however, conclude that the members of the colony do not attain sexual maturity at the same time, probably owing to different age.

As appears from text-figures 2 and 3 the part of the genital pouch which contains the genital glands is of a bulb-shaped form. On one side a large swelling, enclosing the distal part of the oviduct, is visible, and its form varies, owing to the degree of development of the brood-pouch, as will be described in the following.

MALE.—The testis is composed of numerous spermatoc vesicles and a long vas deferens.

As has been mentioned above, the testis is placed on the outside of the body-wall, invested by an outgrowth of the mantle, projecting into the common test. The vas deferens, which is a duct of considerable length, extends into the peribranchial cavity and opens into it.

Text-figure 4.



Kükenthalia borealis (Gottsch.).

Vas deferens. $\times 33$.

A. Vas deferens, usual form. | B. Vas deferens, coiled up.
vd. Vas deferens.

The spermatoc vesicles are pyriform glands which are arranged in two bundles, on account of which the testis appears to be bipartite. The male glands open into two sperm-ducts, each bundle having its duct, and these unite as a rule into a main sperm-duct, the vas deferens (*cf.* text-figs. 4 A & 5).

In one individual examined another arrangement was observed. Here the two ducts did not join, but entered separately into the peribranchial cavity, thus forming two vasa deferentia.

After its entrance into the peribranchial cavity, the sperm duct

generally bends somewhat to the side, extending along the inner wall of the cavity. This arrangement was observed in all specimens but one. In the latter, a rather large individual with a strongly developed testis, the distal part of the vas deferens was coiled up (*cf.* text-fig. 4 B), and its opening lies close to that of the brood-pouch.

As this arrangement has been found in a single individual only, I do not venture to draw any conclusions from it. The possibility seems, however, not excluded that it might be of some importance for the fertilization, in this case probably the self-fertilization of the individual. The fact that ova and spermatozoa are not seldom found mature at the same time in the same individual appears also to support the view that self-fertilization can take place; whether it is usual is another question.

Though most Ascidians are hermaphrodite, it is, however, not probable that self-fertilization generally takes place. On the contrary, in many groups arrangements have been observed which seem to prevent it. As an instance of such an arrangement, I will mention that ova and spermatozoa are often produced at different times, and are consequently not found mature together.

From sections it appears that, in zooids belonging to colonies caught in June, masses of spermatozoa fill up the sperm-ducts. Other cells are macerated, but the spermatozoa are in good condition—a fact which ought to be noticed, the material being preserved in alcohol and dredged so many years ago. It confirms the observation made many times before that the spermatozoa are more resistant than other cells, and that they are highly resistant, even to maceration.

FEMALE.—In zooids most advanced in development the female organ consists of a small ovary with a wide oviduct and a very large brood-pouch.

As is shown by text-figure 5, a small rounded vesicle with a wide duct is situated at the side of the male glands in the genital pouch. Sections through it did not show much of its structure, the tissues being rather macerated. The presence of eggs makes it, however, evident that the vesicle is to be regarded as an ovary.

In several individuals one very large egg, covered with follicular epithelium, was observed here, apparently ready to pass through the oviduct (*cf.* text-fig. 7).

As mentioned above, the ovary is placed at the side of the male glands and is quite separated from them. Seen from the left side of the zooid, the one bundle of male glands is partly covered by the other, and the ovary has its position opposite their middle line. If one imagines the gonads spread out, the ovary would thus have its position between the two bundles of male glands.

The oviduct extends from the above-described ovary between the two sperm-ducts towards the brood-pouch, and opens into the distal part of the latter with a very wide aperture (*cf.* text-fig. 5). The lumina of the brood-pouch and the oviduct become thus

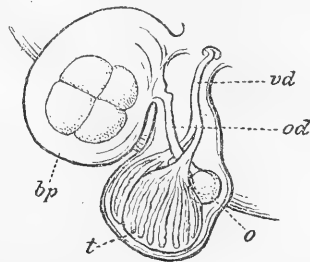
distally confluent, and they communicate with the peribranchial cavity by a short, narrow aperture which is well observable near the vas deferens (*cf.* text-fig. 8).

These facts are of a special interest; then, owing to the above-mentioned arrangement, the passage of the egg is secured: the oviduct opening widely into the brood-pouch, the egg, having left the oviduct, must be laid into the brood-pouch, where it probably remains until it is fully developed.

The oviduct is of considerable width, especially the distal part, which is rather sac-like, and the wall is deeply folded on one side.

Text-figure 6 represents a transverse section of the genital pouch on a level with the bifurcation of the vas deferens. The latter is on the point of forking, on account of which it appears somewhat broad. The figure shows how the oviduct is somewhat compressed from side to side; it is lined with a low epithelium.

Text-figure 5.



Kükenethalia borealis (Gottsch.).

The reproductive organs from the outside. $\times 23$.

bp. Brood-pouch. *o.* Ovary. *od.* Oviduct. *t.* Testis. *vd.* Vas deferens.

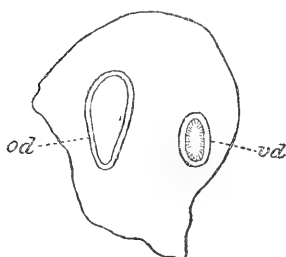
More distally, on certain parts of the wall, a strongly ciliated epithelium was observed. As appears from the figure, the ciliated epithelium of the vas deferens is also well developed.

The brood-pouch has the form of a large double-walled sac with a constricted neck. It generally contained one embryo. In some individuals it is of considerable length and width, projecting beyond the genital pouch. Text-figure 5 represents it at a stage somewhat less developed.

In individuals containing no embryos a brood-pouch has also been observed, though highly reduced with regard to form and size. Such an interesting stage is shown by text-figure 7, where the brood-pouch is represented by a short blind sac or an appendix in connection with the oviduct; and in zooids with rudimentary reproductive organs, as for instance in that represented by text-figure 3, the presence of such a blind sac can also be stated, as will be seen from text-figure 8. The last-mentioned

figure shows three transverse sections of the genital pouch with the ducts, which are cut obliquely. The brood-pouch is represented by a short blind sac; like the oviduct, it is compressed from side to side. In text-figure 8 *a* the oviduct and the brood-pouch

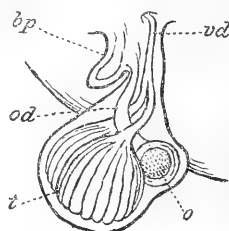
Text-figure 6.

Text-fig. 6.—*Kükenthalia borealis* (Gottsch.).

Transverse section of the genital pouch. $\times 110$.

od. Oviduct. *vd.* Vas deferens.

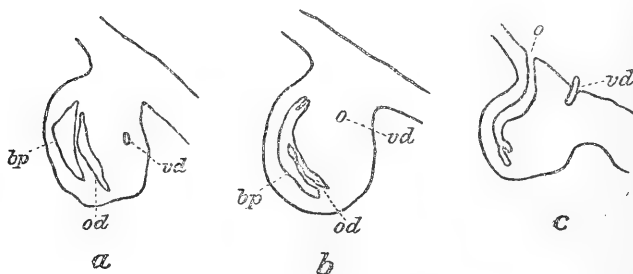
Text-figure 7.

Text-fig. 7.—*Kükenthalia borealis* (Gottsch.).

The reproductive organs from the outside. $\times 23$.

bp. Brood-pouch. *o.* Ovary. *od.* Oviduct. *t.* Testis.
vd. Vas deferens.

Text-figure 8.

*Kükenthalia borealis* (Gottsch.).

Sections through the genital pouch, showing the distal part of the oviduct and the rudimentary brood-pouch; cut obliquely. $\times 50$.

bp. Brood-pouch. *od.* Oviduct. *o.* Opening into the peribranchial cavity.
vd. Vas deferens.

are still separated; fig. *b* shows how the oviduct opens into the brood-pouch, and in fig. *c* the opening into the peribranchial cavity is visible.

Whether this blind sac is to be regarded as a vestigial trace or possibly as a rudiment of the brood-pouch, is a question which

ought to be examined in connection with that of the origin and formation of the whole complicated female organ. As it is difficult to state anything for certain about the age of the individuals hitherto examined, we cannot draw any conclusions from the above-mentioned facts as to the presence of a rudimentary brood-pouch, even before the first egg has been laid.

Another matter of interest is the question of the homology of the brood-pouch in *Kükenthalia*. Before deciding it, it ought to be investigated whether the brood-pouch of the species in question arises as a direct projection from the peribranchial cavity, or whether it is possibly formed in connection with the oviduct with which it, when fully formed, is so intimately connected.

In other Ascidians in which a brood-pouch develops to receive the embryos, it is generally a diverticulum of the peribranchial cavity.

Though the systematical position of *Kükenthalia borealis* will not be discussed in this paper, I will, however, point out that, as the structure of the reproductive organs has been made the chief character in distinguishing the genera belonging to the group *Polyzoine*, the facts which have been ascertained by this investigation will no doubt be of decisive importance for the systematic position of *Kükenthalia*. Comparing the reproductive organs of the last-mentioned genus with those of the other genera of the group, we find that the most striking difference is the presence of a brood-pouch in *Kükenthalia*. Though the *Polyzoine* have been the object of thorough investigation, especially with regard to the structure of the reproductive organs, nothing which corresponds to a brood-pouch seems to have been observed. One might thus conclude that it occurs only in the Arctic form, of which it is consequently characteristic.

With respect to the genital pouch, the beginning of analogous structures may possibly be found in some genera, though they have not attained the same degree of development as in *Kükenthalia*.

In certain respects, points of agreement may be found between *Kükenthalia* and *Gynandrocarpa*, as, for instance, they agree with regard to the reduced number of the gonads and the structure of the testis (*cf.* Herdman*, pl. 44. fig. 4).

NON-GONADIAL SEXUAL PRODUCTS.

Though I now venture to maintain that the presence of gonads, testis as well as ovary, in *Kükenthalia borealis* is put beyond a doubt, and that it has been proved that ova and spermatozoa are produced in special organs, there are, however, certain facts concerning the reproduction of the species which still seem

* Herdman, William A., "Report on the Tunicata collected during the voyage of H.M.S. 'Challenger' during the years 1873-76," Part 2, vol. xiv. London, 1886.

unexplained. Such a fact is, for instance, the presence of sexual products, *i. e.* ova, in the mesoderm.

Isolated ova have been observed before in the mesoderm of *Kükenthalia*, but it has not been made out where they originate. As no gonads, only isolated ova were met with, Michaelsen concluded that the female organs of *Kükenthalia* consist of ova diffusely placed in the mesoderm. Michaelsen writes as follows: "Diese Gattung weicht durch den Bau der weiblichen Geschlechtsorgane von allen übrigen *Polyzoen*, ja, von allen *Styeliden* überhaupt, ab. Ich bezeichnete die Gestaltung desselben als 'diffus,' da die sich entwickelnden Eizellen an kein bestimmt lokalisiertes Organ gebunden sind, sondern sich weit zerstreut im Innenkörper und in den Blutbahnen anderer Organe, so besonders des Darmes, sowie in den jungen Knospen, vorfinden. Der ursprüngliche Ort der weiblichen Gonaden ist unbekannt..." (*l. c.* p. 112).

Though female organs of other structure have now been found, the observation that isolated eggs occur in the mesoderm proves to be right. According to my observation, they are, however, met with less abundantly than has been stated above. As it hardly can be thought that they originate in the above-described ovary, one must suppose that they are produced in the mesoderm, where they occur, though in no special gonads, *i. e.* non-gonadially. This supposition seems to be verified by my observation of small ovaries or, rather, groups of eggs which are situated in the mesoderm close to the wall of the peribranchial cavity and in the vicinity of bud-rudiments.

In *Kükenthalia*, buds occur on both sides of the body; on the left side they are to be seen in the vicinity of the reproductive organs above described. In the mesoderm of those bud-rudiments eggs have been observed, and even in very small bud-rudiments very large eggs are often visible. In all probability the eggs originate in the parent animal, the generative cells being supposed to wander from the latter; but the question is whether they are differentiated in the bud or have wandered at an advanced stage from the parent animal into the bud. But this is a problem which can be decided only after thorough investigation of the further development of the non-gonadial ova as well as of the formation of the reproductive organs of the bud.

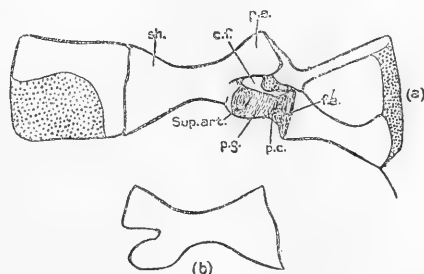
10. On the Variation of the Scapula in the Batrachian Groups Aglossa and Arcifera. By JOAN B. PROCTER, F.Z.S.

[Received October 29, 1920: Read March 8, 1921.]

(Text-figures 1-10.)

The variation of the scapula in the Batrachia Ecaudata is of considerable interest, both on account of its wide range and of its comparative stability within a genus. The present study has been confined to the Aglossa and the Arcifera as representing the most primitive types now living. I have examined all the skeletons in the collection of the British Museum, but this material, although large, is not as complete as one could wish.

Text-figure 1.



Bufo hematiticus. $\times 2$.

(a) Pectoral girdle from without; (b) scapula from within.

p.a., *pars acromialis*. p.g., *pars glenoidalis*. sh., *shaft*. sup.art., *superficial articulation*. f.a., *fovea acetabulum*. c.f., *central foramen*. p.c., *paraglenoid cartilage*.

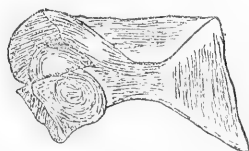
In the majority of species the scapula is about equal to the præcoracoid in length; it is usually rather slender in the middle and expanded at each end. The proximal end consists of two parts, generally separated by a cleft: the upper or *pars acromialis* is either in contact with the head of the præcoracoid, or narrowly separated from it by *acromion cartilage*; the lower or *pars glenoidalis* is much depressed and concave, forming the bottom of the glenoid cavity—it may be in contact with the end of the coracoid, or separated from it by *paraglenoid cartilage*. This cartilage also forms a subtriangular knob projecting below the head of the præcoracoid, and attached to the head of the humerus by a ligament. The portion of the scapula between the glenoid cavity

and the supra-scapula will be alluded to as the *shaft*. A circular depression is often situated in the thickness of the shaft, where it becomes one with the *pars glenoidalis*: it is called the *superficial articulation*, and forms the distal wall of the glenoid cavity; opposite to it is the *fovea acetabulum*, a similar depression in the *extremitas scapularis* of the coracoid, which forms the proximal wall of the glenoid cavity.

In order that the varying proportions in the different genera may be fully appreciated, the length of the præcoracoid will always be given as 10 units*, and all other measurements standardized to this scale; in this way the comparative reduction and development can be seen at a glance, as the normal length of the scapula should be about 10 also.

In fossil frogs of the genus *Palæobatrachus*, the scapula was shorter and more compact than in the majority of modern genera, being three- to four-fifths the length of the præcoracoid, and about once and a half as long as broad at its expanded end. The *pars*

Text-figure 2.

Scapula of *Palæobatrachus* sp. ? ×2. (After Wolterstorff.)

acromialis was not distinct from the *pars glenoidalis*, but, according to Wolterstorff, a groove can be seen on the inner surface of the bone, in place of the cleft shown by modern forms.

The following figures are standardized from actual measurements given by Wolterstorff †.

Examples.

	<i>P. fritschii.</i>	<i>P. grandipes.</i>	<i>P. wetzleri.</i>
Length of præcoracoid ...	10	10	10
„ scapula	6	6·4	7·3
Breadth of „ (proximal)	3	3·6	4·5
„ „ (distal) ...	4	4·5	5·5
			6·7

Although the size of the scapula varies in comparison with the præcoracoid, its own proportions are remarkably stable. Wolterstorff says of it ‡: “Es finden sich nur wenige vielleicht nicht einmal spezifische Verschiedenheiten.”

* Units of length.

† ‘Ueber fossile Frösche, insbesondere das Genus *Palæobatrachus*’ (Theil i. 1886; Theil ii. 1887).‡ *Op. cit.*

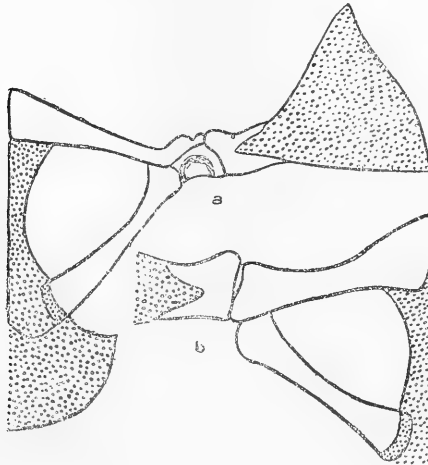
PIPIDÆ.

As in *Palæobatrachus*, the genera of this family have the scapula entire, without the cleft which separates the *pars acromialis* from the *pars glenoidalis*, at least partially, in all other families. This, together with the marked reduction of the scapula, constitute diagnostic characters for the Pipidæ.

XENOPUS Wagl.

X. lævis Daud.—Scapula vestigial; subtriangular. Shaft and *pars acromialis* completely absent; *pars glenoidalis* containing the circular depression of the glenoid cavity. Head of præcoracoid in contact with supra-scapula. Occasionally the scapula is

Text-figure 3.

Pectoral girdle of *Xenopus lævis*. $\times 2$.

(a) scapula distinct; from without.

(b) scapula not distinct; from within.

apparently wanting, having fused with the head of the præcoracoid; in most specimens this fusion is more or less marked, making the boundaries of the vestigial scapula difficult to trace.

Example.

Length of præcoracoid	10 units.
" scapula (at base)	2.4 "
Breadth of " (expanded end)	2.1 "
Length of supra-scapula	10.3 "

X. muelleri Ptrs.—Scapula as in *X. lævis*. A figure of the pectoral girdle is given by Peters*, in which it is absent. In

* Peters, 'Reise nach Mossambique' (1882) Taf. xxvi. 12 a.

his specimen it is evidently incorporated in the præcoracoid, as described above.

X. calcaratus Buchh. & Ptrs.—Scapula as in *X. lævis*, but more easily distinguished, as the glenoid cavity extends to the upper border.

X. clivii Peracca.—Scapula with a distinct, but vestigial, triangular shaft, the apex of which narrowly separates the head of the præcoracoid from the supra-scapula; *pars glenoidalis* as in *X. lævis*; *pars acromialis* absent.

Example.

Length of præcoracoid	10 units.
" scapula (at base)	3·3 "
" " (upper edge)	·55 "
" " shaft	1·7 "
Breadth of " (expanded end)	2·8 "
Length of supra-scapula	9·4 "

In the tadpoles and young of *X. lævis*, *X. calcaratus*, and *X. muelleri* the reduced condition of the scapula is somewhat less marked than in the adults; an extremely short shaft is present, precisely as in the adult of *X. clivii*. If ontogeny may be taken as a guide to phylogeny, *X. clivii* should be considered the most primitive species in the genus.

This vestigial form of scapula, which even in *X. clivii* does not exceed two-fifths of the præcoracoid in length, and which may be completely suppressed in other species, renders *Xenopus* unique both among the Aglossa and Arcifera.

HYMENOCHIRUS Blgr.

H. boettgeri Tornier.—Scapula much reduced, but less so than in *Xenopus*. Distal end expanded, proximal end narrowed, entire; the whole wedge-shaped. Proximal end strongly overlapped on outer surface by head of præcoracoid. No glenoid cavity.

Example.

Length of præcoracoid	10 units.
" scapula (greatest)	5·5 "
" " (upper edge)	3·1 "
Breadth of " (expanded end)	3·3 "
" " (least)	2·2 "
Length of supra-scapula	8·9 "

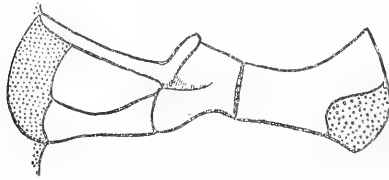
PIPA Laur.

P. americana Laur.—Scapula compact, very much reduced, almost triangular when seen from within. Shaft vestigial; *pars acromialis* strongly overlapped by head of præcoracoid on inner surface; a strong crest and protuberance on outer surface, bordering the glenoid cavity; *pars glenoidalis* much depressed when seen from without, not distinct from *pars acromialis* when seen from within.

Example.

Length of præcoracoid	10 units.
" scapula (lower border).....	5 "
" " (free upper edge)	3.1 "
" " shaft	2.2 "
Breadth of " (distal end)	3.5 "
Length of supra-scapula	9.4 "

Text-figure 5.

Pectoral girdle of *Discoglossus pictus*, $\times 2$; from within.

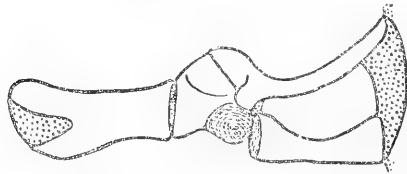
BOMBINATOR MERR.

B. igneus Laur.—Scapula much reduced, subtriangular in shape; upper edge shorter than distal edge. Shaft vestigial; *pars acromialis* much reduced, forming an oblique suture with head of præcoracoid; *pars glenoidalis* much depressed, longer than *pars acromialis*, from which it is separated by a notch rather than by a cleft.

Example.

Length of præcoracoid	10 units.
" scapula (lower border).....	4.3 "
" " (upper ").....	2.6 "
" " shaft	1.7 "
Breadth of " (distal end).....	3.2 "
Length of supra-scapula	9.1 "

Text-figure 6.

Pectoral girdle of *Bombinator maximus*, $\times 2$; from without.

B. pachypus Blgr. and *B. orientalis* Blgr.—Scapula as in *B. igneus*.

B. maximus Blgr.—Scapula as in *B. igneus* in shape and proportions, but differing in that the upper border and adjoining

head of præcoracoid are thin almost to transparency, forming a semicircular crest, the diameter of which follows the free upper edge.

The proportions of the scapula are remarkably stable within the genus *Bombinator*, and are highly characteristic.

ALYTES Wagl.

A. obstetricans Laur.—Scapula short, but less reduced than in *Discoglossus* and *Bombinator*. Upper border forming a semicircular crest thin to transparency, resembling *Bombinator maximum* in this respect. Shaft reduced; *pars acromialis* narrow, in contact with head of præcoracoid; *pars glenoidalis* broad, depressed, equal in length to *pars acromialis*; the two overlapping, so that the dividing cleft is pierced horizontally and only visible obliquely.

Example.

Length of præcoracoid	10 units.
" scapula (lower edge)	4·3 "
" " (upper ")	3·6 "
" " shaft	2·2 "
Breadth of " (distal end).....	4·3 "
Length of supra-scapula	10 "

PELOBATIDÆ.

In this family there is a wider generic diversity in the proportions of the scapula, which is not, however, greatly developed in any genus. In all, the glenoid cavity is excessively deep, somewhat undermining the *pars acromialis*, the lower edge of which circumscribes it above.

SCAPHIOPUS Holbr.

S. solitarius Holbr.—Scapula well developed, longer than præcoracoid; as long as the supra-scapula. Proximal end well developed, subcircular. Shaft long, wedge-shaped; *pars acromialis* large, with crest-like upper border, lower border projecting over and round glenoid cavity in a strong ridge; *pars glenoidalis* small, strongly depressed, the dividing cleft short and broad, forming a small oval foramen in the glenoid cavity, pierced vertically.

Example.

Length of præcoracoid	10 units.
" scapula (upper or lower border)...	13 "
" " shaft	9·4 "
Breadth of " (distal end).....	5·3 "
" " (middle)	2·5 "
Length of supra-scapula	13 "

PELOBATES Wagl.

P. fuscus Laur.—Scapula well developed, thick, once and a half as long as præcoracoid. Shaft oblong, twice as long as broad; *pars acromialis* broad, the lower border of its outer surface with a ridge which runs round the glenoid cavity; *pars glenoidalis* much depressed; dividing cleft short, forming an oval foramen pierced horizontally.

Example.

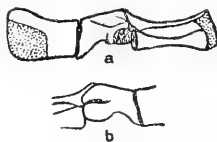
Length of præcoracoid	10 units.
" scapula (lower edge)	15 "
" " shaft	10·4 "
Breadth of " (distal end)	5 "
Length of supra-scapula (lower border)	15 "

P. cultripes Cuv.—Scapula precisely as in *P. fuscus*.

PELODYTES Fitz.

P. punctatus Daud.—Scapula much reduced, squarish in shape. Shaft shorter than broad at distal end; *pars acromialis* as broad as long, lower border of its outer surface forming a prominent ridge running round the glenoid cavity; *pars glenoidalis* much

Text-figure 7.

Pectoral girdle of *Pelodytes punctatus*. $\times 2$.

(a) from without; (b) scapula from within.

depressed, subcircular; dividing cleft short, pierced horizontally, only visible when viewed obliquely.

Example.

Length of præcoracoid	10 units.
" scapula (upper border)	5·6 "
" " shaft	4·4 "
Breadth of " (distal end)	4·4 "
Length of supra-scapula (upper edge)	9·4 "

In shape the scapula of *Pelodytes* is very similar to that of *Palaeobatrachus*, which it resembles in many ways. *Palaeobatrachus*, however, lacks the proximal dividing cleft, which, though outwardly invisible, is present in *Pelodytes*.

BATRACHOPSIS Blgr.

B. melanopyga Doria.—Scapula well developed, about once and a quarter as long as præcoracoid; slender in the middle,

distal end broader than proximal. Shaft long, wedge-shaped; *pars acromialis* with straight oblique upper border, upper half of proximal end free; *pars glenoidalis* much depressed, slightly undermining *pars acromialis*; dividing cleft short, pierced horizontally, only visible when viewed obliquely.

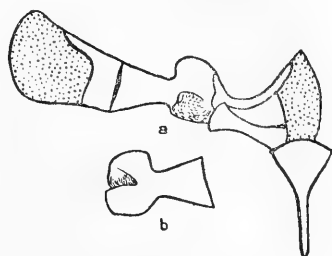
Example.

Length of præcoracoid	10 units.
" scapula (upper or lower edge) ..	12.2 "
" " shaft	9.4 "
Breadth of " (distal end)	6.1 "
" " (middle)	2.5 "
" " (proximal end)	5 "
Length of supra-scapula	11.6 "

MEGALOPHRYS Kuhl.

M. pelodytoides Blgr.—Scapula well developed in all its parts, as long as the præcoracoid. Shaft wedge-shaped, as long as broad at distal end; *pars acromialis* with an oblique straight crest along its upper border, rising to a sharp point proximally; lower ridge of outer surface with a prominent ridge running round the glenoid cavity; upper half of proximal end free; *pars glenoidalis* much depressed; dividing cleft short and broad, pierced obliquely, forming a foramen, which is longer when viewed from within than when viewed from without.

Text-figure 8.



Pectoral girdle of *Megalophrys parva*. $\times 2$.

(a) from within; (b) from without.

Example.

Length of præcoracoid	10 units.
" scapula	10 "
" " shaft	6.2 "
Breadth of " (distal end).....	6.2 "
Length of supra-scapula	11.3 "

M. major Blgr.—Scapula similar in form to that of *M. pelodytoides* with the exception of the *pars acromialis*, the crest of which has a paracentric upper edge; upper half of proximal end free.

M. parva Blgr. (= *Xenophrys mcnticola* Gthr.).—Scapula as

in *M. major*. In this species the præcoracoids are reduced, and do not meet each other in the middle; the scapula is, therefore, longer than the præcoracoid, but not longer than its distance from the edge of the epicoracoidal cartilage.

M. montana Kuhl.—Form of scapula as in *M. major*, but slightly larger than the præcoracoid, which is normal in length.

M. longipes Blgr.—Scapula as in *M. major*.

M. fœc Blgr.—Form of scapula similar to that of *M. major*, with the exception of the distal end of the shaft, the lower corner of which is somewhat produced, making the lower border of the scapula once and a quarter the length of the upper border; lower border of scapula describing an inverted semicircular curve, \cap . *Pars acromialis* with a semicircular upper edge.

Although there is specific differentiation within this complex genus, the form of the scapula is highly characteristic. The equal development of the shaft, the *pars acromialis*, and *pars glenoidalis*, together with the oval central foramen, pierced horizontally, and the highly developed crest of the *pars acromialis*, are characters common to all the species.

HYLIDÆ.

In this family the scapula is usually normal in its proportions, and about equal in length to the præcoracoid. In some instances, however, it is greatly reduced in length, especially the shaft. The cleft between the *pars acromialis* and *pars glenoidalis* is always broad and open, pierced vertically, and visible from without and within as a large oval foramen in the middle of the glenoid cavity. The *pars glenoidalis* is reduced in size, and always shorter than the *pars acromialis*, part of it presumably giving place to the central foramen.

HYLA Laur.

H. maxima Laur.—Scapula normal in its proportions, equal in length to the præcoracoid, and having all the family characteristics already described. Shaft once and a quarter as long as broad at distal end; *pars glenoidalis* separated from coracoid by cartilage; superficial articulation and *fovea acetabulum* very distinct.

Example.

Length of præcoracoid	10 units.
" scapula (upper border).....	10 "
" " shaft	9·1 "
Breadth of " (distal end)	6·4 "
" " (middle)	2·7 "
" <i>pars acromialis</i>	1·8 "
" <i>pars glenoidalis</i>	1·8 "
Length of <i>pars acromialis</i>	2·7 "
" <i>pars glenoidalis</i>	1·8 "
" supra-scapula	11·4 "

In the following species the scapula is as in *H. maxima*:—*H. faber* Wied, *H. albomarginata* Spix, *H. boans* Daud., *H. taurina* Fitz., *H. venulosa* Laur., *H. nigromaculata* Tschudi, *H. dominicensis* Bibron, *H. versicolor* Lec., *H. pulchella* D. & B., *H. arborea* L., *H. macrops* Blgr., *H. cærulea* White, *H. dolichopsis* Cope, *H. aurea* Less., *H. lesueurii* D. & B., *H. nasuta* Gray, *H. gratiosa* Lec.

In *H. lichenata* Gosse and *H. baudini* D. & B., the scapula is a little longer than the præcoracoid.

Although *Hyla* is a very large genus, it will be seen that the scapula is remarkably stable in its proportions. It is not of much use, however, as a diagnostic character, as it is of the form most commonly met with in this family.

NOTOTREMA Gthr.

N. marsupiatum D. & B.—Scapula elongated, once and a quarter as long as præcoracoid, very slender in the middle. Shaft as long as præcoracoid; *pars acromialis* and *pars glenoidalis* as in *Hyla maxima*.

PTERNOHYLA Blgr.

P. fodiens Blgr.—Scapula as in *H. maxima*.

NYCTIMANTIS Blgr.

N. papua Blgr.—Scapula as in *H. maxima*.

AGALYCHNIS Cope.

A. moreletii A. Dum.—Scapula as in *H. maxima*.

PHYLLOMEDUSA Wagl.

P. dacnicolor Cope.—Scapula abnormally developed, about twice as long as præcoracoid, and about twice and a half as long as broad at distal end. Shaft about once and a quarter as long as præcoracoid, very slender, expanding at distal end; *pars acromialis* not in contact with head of præcoracoid; *pars glenoidalis* very much reduced, branching widely from *pars acromialis*; central foramen very large, oval.

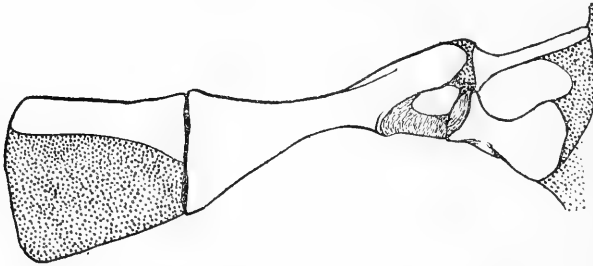
P. bicolor Bodd.—Scapula similar in form to that of *P. dacnicolor*, but even more developed in length, being twice and a quarter the length of the præcoracoid. Shaft once and three-quarters the length of præcoracoid; *pars acromialis* separated from head of præcoracoid on outer surface by acromion cartilage, in contact on inner surface.

Example.

Length of præcoracoid	10 units.
" scapula (lower border).....	23 "
" " (upper ").....	24 "
" " shaft	17 "

Breadth of scapula (distal end).....	10·2 units.
" " (middle).....	2·6 "
" <i>pars acromialis</i>	3·5 "
" <i>pars glenoidalis</i>	1·7 "
" central foramen	2·2 "
Length of " " 	4·4 "
" <i>pars acromialis</i>	3·5 "
" <i>pars glenoidalis</i>	1·7 "
" supra-scapula	14·8 "

Text-figure 9.

Pectoral girdle of *Phyllomedusa bicolor*, $\times 2$; from without.

P. burmeisteri Blgr.—Scapula as in *P. dacnicolor*.

This form of scapula is highly characteristic of the genus *Phyllomedusa*.

TRIPRION Cope.

T. petasatus Cope.—Scapula as in *Hyla maxima*.

BUFONIDÆ.

In this family the scapula is usually normal in its proportions; the *pars glenoidalis* is equally developed to the *pars acromialis*. No important variations occur.

EUEMPHIX Steind.

E. nattereri Steind.—Scapula normal in its proportions; slightly longer than præcoracoid; slender in the middle; similar in shape to that of *Batrachopsis melanopyga*. Dividing cleft between the two *pars* short.

BUFO Laur.

B. vulgaris Laur.—Scapula normal, upper border about as long as præcoracoid, lower border a little longer. Shaft stout, subtriangular; *pars acromialis* somewhat diamond-shaped, with a straight, oblique upper edge; *pars glenoidalis* much depressed, narrower, but equal in length to the *pars acromialis*, from which it branches, forming a Y of which the shafts represent the tail; *pars glenoidalis* widely separated from coracoid by paraglenoid

cartilage; superficial articulation and *fovea acetabulum* strongly marked.

Example.

Length of præcoracoid (greatest).....	10	units.
" scapula (upper border)	10·7	"
" " (lower ")	12·2	"
" " shaft.....	7·9	"
Breadth of " (distal end)	7·9	"
" " (middle)	3·6	"
" <i>pars acromialis</i>	4·3	"
" <i>pars glenoidalis</i>	2·15	"
Length of supra-scapula	12·8	"

In the following species the scapula is like that of *B. vulgaris*:—*B. hamatiticus* Cope, *B. calamita* Laur., *B. viridis* Laur., *B. intermedius* Gthr., *B. lentiginosus* Shaw, *B. marinus* L., *B. crucifer* Wied.

In *B. latifrons* Blgr., *B. tuberosus* Gthr., *B. melanostictus* Schn., *B. claviger* Ptrs., *B. quadriporcatus* Blgr., *B. typhonius* L., and *B. valliceps* Wieg., the scapula is a little longer than the præcoracoid, but of the same form as that of *B. vulgaris*.

In *B. granulosis* Spix the scapula is a little shorter than the præcoracoid.

There is remarkably little variation in this genus, in some species the *pars glenoidalis* is somewhat shorter than in others, and there is slight variation in the length of the shaft.

Example to show Range of Variation in Bufo.

	<i>B. granulosis.</i>	<i>B. melanostictus.</i>
Length of præcoracoid.....	10 units.	10 units.
" scapula (lower border) ..	7·7 "	14·2 "
" " shaft	6·2 "	10 "
Breadth of " (distal end) ...	6·2 "	7·1 "
" " (middle).....	3·3 "	3 "
" <i>pars acromialis</i>	4·6 "	3 "
" <i>pars glenoidalis</i>	3·3 "	3 "
Length of supra-scapula	10·4 "	14·3 "

B. melanostictus has been chosen as an example of the more developed type of scapula, as, being a common Malayan form, it forms an interesting comparison with *B. granulosis* from E. South America.

The equal development of the *pars acromialis* and *pars glenoidalis* in length, together with the fact that the latter is always widely separated from the coracoid by cartilage, distinguishes the scapula of *Bufo* from nearly all other genera of the Arcifera (see text-fig. 1).

RHINOPHRYNUS D. & B.

R. dorsalis D. & B.—Scapula as in *Bufo*.

CYSTIGNATHIDÆ.

In this family the scapula is extremely variable. It may be slender or stoutly formed, shorter than the præcoracoid or abnormally elongated. The range of variation is large as in Hylidæ, and very much greater than in any other families of the Arceifera.

PSEUDIS Laur.

*P. paradoxa** L.—Scapula equal in length to the præcoracoid, rather stout, parallelogrammic in shape; superficially similar in shape to that of *Pelodytes punctatus*. Upper border of shaft bearing a thin straight-edged crest; *pars acromialis* broader than long; *pars glenoidalis* narrow, obtusely pointed, partially separated from *pars acromialis* by a notch forming part of a small oval foramen pierced obliquely.

Example.

Length of præcoracoid	10 units.
" scapula	10 "
" " shaft.....	6·7 "
Breadth of " (distal end).....	6·7 "
" " (middle)	6·7 "
Length of supra-scapula	13·4 "

CALYPTOCEPHALUS D. & B.

C. gayi D. & B.—Scapula normal in its proportions, but large in comparison with the other bones of the pectoral girdle. Longer than præcoracoid.

TELMATOBIVS Wagl.

T. jelskii Ptrs.—In this species all the bones of the pectoral girdle are extremely stout in comparison with their length. Scapula equal to the præcoracoid in length, stout. Shaft squarish; *pars acromialis* and *pars glenoidalis* both well developed, separated proximally by a very small cleft or central foramen.

Example.

Length of præcoracoid	10 units.
" scapula (upper border)	10 "
" " shaft	5·3 "
Breadth of " (distal end).....	6·7 "
" " (middle)	4 "
" <i>pars acromialis</i>	4·7 "
" <i>pars glenoidalis</i>	3·3 "
Length of supra-scapula	12·3 "

ELOSIA Tsch.

E. bufonia Gir.—Scapula equal to the præcoracoid in length, rather slender, but of normal proportions.

* Bones pale green, as in *Rappia chlorostea* E. Blgr.

HYLODES Fitz.

H. raniformis Blgr.—Scapula a little shorter than the præcoracoid, but well developed. *Pars glenoidalis* smaller than *pars acromialis*; dividing cleft short.

H. fleischmanni Boett.—In this species the scapula is subject to slight individual variation. It may be equal to or a little longer than the præcoracoid.

H. lineatus Schn. and *H. martinicensis* Tsch.—The scapula is as in *H. raniformis*.

The scapula in *Hylodes* is somewhat like that in *Hyla* as regards the relative proportions of the shaft, *pars acromialis*, and *pars glenoidalis*. They differ, however, in that the dividing cleft is short in *Hylodes*, forming a very small central foramen instead of a very large one, as in *Hyla*.

CERATOPHRYS Boie.

C. boie Wied.—Scapula greatly developed, once and a half as long as præcoracoid. Distal end of shaft about twice width of proximal end; *pars acromialis* and *pars glenoidalis* normal; dividing cleft short, forming a very small central foramen; a small portion of acromion cartilage exposed between head of præcoracoid and end of *pars acromialis*.

In *C. ornata* Bell and *C. americana* D. & B. the scapula is as in *C. boie*.

Example.

Length of præcoracoid	10 units.
" scapula	15·2 "
" " shaft	11 "
Breadth of " (distal end)	5 "
" " (middle)	2·3 "
Length of supra-scapula	13·7 "

LEPTODACTYLUS Fitz.

L. pentadactylus L.—Scapula equal to or slightly longer than præcoracoid; stoutly formed. Shaft broad, half length of præcoracoid; *pars acromialis* well developed, partially separated from head of præcoracoid by acromion cartilage; *pars glenoidalis* well developed, strongly depressed; dividing cleft short and broad, forming an oval foramen, pierced horizontally, hardly visible from outer view.

L. ocellatus L.—Scapula as in *L. pentadactylus*.

HYLORHINA Bell.

H. silvatica Bell.—Scapula as in *Hyla*.

LIMNODYNASTES Fitz.

L. peronii D. & B.—Scapula well developed, longer than præcoracoid; distal end twice the width at the middle. Shaft as long as præcoracoid; *pars acromialis* somewhat diamond-shaped,

having a \wedge -shaped upper edge; *pars glenoidalis* also well developed; dividing cleft short, forming a small central foramen.

L. dorsalis Gray.—Scapula as in *L. peronii*.

L. ornatus Gray.—Scapula more elongated than in *L. peronii*.

Example.

Length of præcoracoid	10 units.
" scapula	15 "
" " shaft	11.6 "
Breadth of " (distal end)	5 "
" " (middle)	2.5 "
Length of supra-scapula	15 "

CRYPTOTIS Gthr.

C. brevis Gthr.—Scapula equal in length to the præcoracoid; normal in its proportions. Dividing cleft pierced horizontally as in *Megalophrys*.

CHIROLEPTIS Gthr.

C. australis Gray.—Scapula greatly developed, about once and three-quarters length of præcoracoid; slender in the middle. Shaft twice as long as broad at distal end, about once and a quarter length of præcoracoid; *pars acromialis* well developed, subtriangular, similar to that of *Bactrachopsis melanopyga*; *pars glenoidalis* smaller than *pars acromialis*; dividing cleft pierced obliquely.

Example.

Length of præcoracoid	10 units.
" scapula	17 "
" " shaft.....	13 "
Breadth of " (distal end).....	7 "
" " (middle)	2 "
Length of supra-scapula	12(?) "

C. platycephalus Gthr.—Scapula similar in form to that of *C. australis*, but much shorter in proportion.

Example.

Length of præcoracoid	10 units.
" scapula	11.2 "

HELEIOPORUS Gray.

H. albopunctatus Gray.—Scapula abnormally developed; twice and a half as long as præcoracoid; slender in the middle, greatly expanded at distal end, where it is almost the length of the præcoracoid in width. Shaft once and three-quarters length of præcoracoid; *pars acromialis* well developed, completely in contact with crescentic head of præcoracoid; *pars glenoidalis* also in contact with head of præcoracoid, partially separated

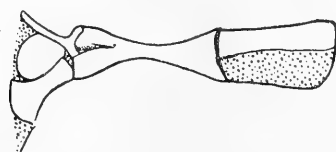
from end of coracoid by cartilage, longer than *pars acromialis*; dividing cleft pierced horizontally, only visible when viewed obliquely.

H. pictus Ptrs.—Scapula as in *H. albopunctatus*.

Example.

Length of præcoracoid	10 units.
" scapula	25 "
" " shaft.....	17.5 "
Breadth of " (distal end)	8.8 "
" " (middle)	2 "
" <i>pars acromialis</i> + <i>pars glenoidalis</i>	8.8 "
Length of supra-scapula	17.7 "

Text-figure 10.



Pectoral girdle of *Heleioporus pictus*, $\times 2$; from within.

The abnormal development of the scapula in this genus is similar to that in *Phyllomedusa* as regards length. In *Phyllomedusa*, however, the *pars glenoidalis* is much smaller than the *pars acromialis*, which is separated from the head of the præcoracoid by acromion cartilage; also the dividing cleft is long and broad, forming a very large central foramen, pierced vertically.

Summary and Conclusion.

These data are sufficient to show that the form of the scapula is remarkably stable within a genus, and that in many instances it is so highly characteristic that a glance at this bone alone suffices to recognize the genus to which the skeleton belongs. This is the case throughout the Pipidæ and Discoglossidæ, and, to a great extent, in other families. In the most recent families, however, there are many genera conforming to one pattern of scapula, which makes the character, in these cases, worthless for diagnostic purposes.

Of the genera which I have studied, the greatest specific variation occurs in *Bufo*; in *Hyla*, which is a very large genus, there is practically none.

Although in many ways the Pelobatid genera resemble *Palæobatrachus*, the Aglossa must be regarded as having the most primitive type of scapula, as in *Pipa*, *Hymenochirus*, and *Xenopus* the proximal end of the bone is entire. In all other genera*

* Genera of the Arcifera.

the *pars acromialis* and *pars glenoidalis* are separated from each other by a cleft, or at least a notch (*Bombinator* and *Pseudis*). This character seems to be of much greater importance than mere size, and corroborates the conclusion of Wolsterstorff, who says* : “*Palæobatrachus* verbindet im Systeme die AGLOSSA mit den ARCIFIRA.”

In spite of generic stability the variation is enormous, particularly in the length of the shaft. *Xenopus*, on the one hand, in which the scapula is absent or represented by the *pars glenoidalis* only, ranging to *Phyllomedusa*, *Ceratophrys*, and *Heleioporus*, in which it is enormously developed, in *Heleioporus* being twice and a half the length of the præcoracoid.

It is astonishing that such a useful bone as the scapula should have been overlooked for so long. The following key is based on this character alone :—

- | | |
|--|--|
| A. Proximal end of scapula entire | PIPIDÆ. |
| B. Proximal end of scapula cleft. | |
| I. Length of scapula $\frac{1}{2}$ or less than $\frac{1}{2}$ length of præcoracoid. | DISCOGLOSSIDÆ. |
| II. Length of scapula more than $\frac{1}{2}$ length of præcoracoid. | |
| a. A large oval foramen pierced vertically in glenoid cavity; <i>pars glenoidalis</i> greatly reduced | HYLIDÆ. |
| b. Foramen, if pierced vertically in glenoid cavity, moderate or small; often represented by a cleft pierced obliquely or horizontally | PELOBATIDÆ.
BUFONIDÆ.
CYSTIGNATHIDÆ. |

I am unable to find reliable family characteristics which differentiate between the Pelobatidæ, the Bufonidæ, and the Cystignathidæ.

* *Op. cit.*

11. Notes on Marine Wood-boring Animals.—II. Crustacea.

By W. T. CALMAN, D.Sc.

(Submitted for Publication by permission of the Trustees of the British Museum.)

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The Crustacea collected for the Committee of the Institution of Civil Engineers include, besides species already known to bore into wood, a number of others, the presence of which in the damaged timber is probably accidental. The possibility, however, that some of these also may prove to be destructive makes it desirable to record their names. The actual wood-boring species in the collection are all well-known, and little of importance is added to our knowledge of their distribution, but the opportunity has been taken to confirm, by direct comparison, the suggested identity of the Indo-Pacific *Spheroma terebrans* with the Atlantic *S. destructor*.

As in the case of the Teredinidæ, the occurrence of European species of wood-boring Crustacea (*Limnoria* and *Chelura*) in Australia and New Zealand has been attributed to introduction by wooden ships. It is true that neither of them, so far as I know, has been recorded as living in ships' timbers, but their appearance in widely-separated localities, while distinct species of the same genera occur at intermediate points (e. g., at Christmas Island, Calman, Ann. Mag. Nat. Hist. (8) v. 1910, p. 181), is suggestive of some such means of transport.

Order ISOPODA.

Sub-order FLABELLIFERA.

SPHEROMA TEREBRANS Spence Bate.

S. terebrans Spence Bate, Ann. Mag. Nat. Hist. (3) xvii. 1866, p. 28, pl. ii. fig. 5; Stebbing, Spolia Zeylanica, ii. 1904, p. 16, pl. iv.; Hansen, Q. J. Micr. Sci. xlix. 1905, p. 116; Stebbing, Ann. S. Afric. Mus. vi. 1908, p. 49; Chilton, N.Z. Journ. Sci. Technol. ii. 1919, p. 12; Calman, Marine Boring Animals, Brit. Mus. (Nat. Hist.) Economic Ser. No. 10, 1919, p. 21, fig. 11; *id.*, Committee on Structures in Sea-water, Inst. Civ. Engineers, 1st Rep. 1920, p. 70, pl. i. fig. 5; Barnard, Ann. S. Afric. Mus. xvii. 1920, p. 358.

S. vastator Spence Bate, Ann. Mag. Nat. Hist. (3) xvii. 1866, p. 28, pl. ii. fig. 4.

S. destructor Richardson, Proc. Biol. Soc. Washington, xi. 1897, p. 105, text-figs.; *id.*, Amer. Nat. xxxiv. 1900, p. 223; *id.*, Proc. U.S. Nat. Mus. xxiii. 1901, p. 534; *id.*, Bull. U.S. Nat. Mus. liv. 1905, p. 282, text-figs.

Locality.—Brisbane, Queensland. Specimens forwarded by Mr. E. A. Cullen, Engineer for Harbours and Rivers. From

Jetties, 5 miles from river entrance in Moreton Bay, in Swamp Mahogany (*Tristania suaveolens*) and Ironbark (*Eucalyptus paniculata*). Many specimens.

Specimens are in the Museum collection from Wyong River, New South Wales, and Brisbane (Prof. Chilton), Travancore (Trivandrum Mus.), Isipingo River, Natal (Durban Mus.), and St. John's River, Palatka, Florida (U.S. Nat. Mus., syntypes of *S. destructor* Richardson).

Remarks.—This species has already been recorded from Brisbane by Prof. Chilton.

Barnard has recently adduced further evidence in favour of Stebbing's view, disputed by Miss Richardson, that the Indo-Pacific species is identical with *S. destructor* Richardson, from Florida. No one, however, has hitherto been able to base this identification on a direct comparison of specimens. By the courtesy of the authorities of the U.S. National Museum, who have presented syntypes of *S. destructor* to the British Museum (Nat. Hist.), I have been able to compare these with specimens from all the other localities mentioned above. I have failed to find any difference that can be regarded as specific. Both Stebbing and Barnard have indicated a certain amount of variation in the tubercles and ridges of the dorsal surface, and this is shown more conspicuously by the specimens now examined. The specimens from Brisbane grow to a greater size (11.5 mm. total length) than the syntypes, and have the tubercles on the sixth and seventh peræon-segments very low; the submedian tubercles on the telsonic segment are distinctly elongated in an antero-posterior direction, and the granulation of the telsonic segment is less close than in the syntypes. The Travancore specimens agree better with the syntypes in their smaller size, generally more prominent tubercles, and closer granulation of the telson, but they differ in having the submedian tubercles of the telson distinctly smaller than those of the lateral pair. The Natal specimen bears a close resemblance to those from Brisbane. I have only been able to observe one character in which the Indo-Pacific specimens agree with one another, while differing from the syntypes. Seven specimens from Wyong River, Brisbane, Travancore, and Natal were found, on dissection, to agree with Stebbing's account in having three large setæ and a small one on the inner plate of the maxillula. Miss Richardson found in her specimens "five strong plumose setæ and occasionally a sixth one that is feeble." The single syntype that I have dissected has five large setæ and a small one on the maxillula of one side, but on its fellow there are six setæ of equal size. In none of the other characters mentioned by Miss Richardson is there any constant difference to be detected*.

* *S. peruvianum* Richardson (Proc. U.S. Nat. Mus. xxviii. 1910, p. 81, text-figs. 3 and 4), found boring in the roots and stems of mangroves on the coast of Peru, is very similar to the species here discussed, but the broadly-rounded terminal segment, the longer antennules and antennæ, and other characters indicated by Miss Richardson may justify its separation. I have seen no specimens.

Hansen has already stated that this species is to be included in the genus *Sphaeroma* as restricted by him. Ovigerous females in the Brisbane collection agree with his definition of the genus in having large overlapping oostegites, while the eggs (and embryos) are contained in internal pouches opening by four pairs of large slits on the sternal surface, as in *S. rugicauda* and *S. serratum*.

A large number (well over a score) of males have been examined, which, from their size (up to 9.5 mm. in length), from the fact that they were found in the same gathering with ovigerous females and from the presence on the last thoracic sternite of a pair of penes, would ordinarily be regarded as adults. Two individuals were dissected and found to have the *vasa deferentia* distended with bundles of filiform spermatozoa. Nevertheless, in no case was there a trace of an *appendix masculina* or even of a marginal thickening on the second pleopods*. Hansen states (op. cit. p. 88) that an *appendix masculina* is present in adult males of all the genera of Sphaeromidae except *Dynamene* and *Ancinella*, but he notes that in the subfamily *Sphaerominae* it "does not appear before the animals are nearly full-grown," while the penes are present at a much earlier stage. His account of *Cymodoce pilosa* (op. cit. p. 89) suggests caution in deciding as to the sexual maturity even of large individuals. Nevertheless, the conclusion seems to be justified that the *appendix masculina* is not developed in *Sphaeroma terebrans*, which in this respect forms an exception among the species of the genus.

Crustacea associated with S. terebrans.—Stebbing has recorded the occurrence of the little Asellotan *Iais pubescens* in association with *S. terebrans* at Ceylon. He had previously given an extended description, with figures, from specimens taken on *Exosphaeroma gigas* at the Falkland Islands (Proc. Zool. Soc. 1900, p. 549, pl. xxxviii.). The collection of *S. terebrans* from Brisbane includes numerous specimens, and that from Natal a solitary young specimen of what is probably the same species. Some of the Brisbane specimens carrying eggs do not exceed 2.24 mm. in length (Stebbing's Falkland specimens reached 2.5 mm.). They have not more than 13-14 segments in the flagellum of the antenna, the uropods are nearly half as long as the abdomen, and the exopod of the uropods is much longer than the peduncle and definitely longer than the endopod.

Specimens found on *Exosphaeroma gigas* from the Auckland Islands differ from these and agree with Stebbing's Falkland Island specimens in having more numerous segments in the flagellum of the antenna (22, while Stebbing records "attaining to 25"), the uropods not more than one-third as long as the telsonic segment, and the exopod of the uropods equal to the

* Barnard notes the absence of the *appendix masculina* in the single male (9 mm. in length) examined by him.

peduncle and shorter than the endopod. The distal segments of the antennules are a good deal less slender than in the Brisbane specimens.

I am unable to perceive any other differences of importance, and, while it might be considered that those enumerated would justify giving a new varietal or even specific name to the Brisbane specimens, I prefer to await further evidence from other localities regarding the range of variation in this widely-distributed species.

Among the Brisbane specimens of *Sphaeroma terebrans* were numbers of another Sphaeromid, apparently belonging to the genus *Exosphaeroma*, but differing from all the described species of that genus. There seems to be no reason for suspecting this species of complicity in the destruction of the timber. The body is more depressed than one would expect to find it in a burrowing animal, and the mouth-parts are much less prominent than they are in *Sphaeroma terebrans*.

Somewhat more suspicious is the case of an Isopod of which a collection was sent from H.M. Dockyard, Simon's Town, by Lieut. L. H. A. Shadwell, R.N.V.R. The specimens were from "Greenheart camber piles, W. yard," and were labelled as *Sphaeroma*. They proved to belong to the species *Parisocladus stimpsoni* (Heller), agreeing closely with Barnard's description and figures (Ann. S. Afric. Mus. x. 1914, p. 399, pl. xxxii. G), and being of the smaller size (male about 7.5 mm. long) which he mentions as characteristic of specimens from the east side of the Cape Peninsula. Here, again, the general form of the body and the disposition of the mouth-parts are not such as to suggest a boring habit. On the other hand, the timber in question must have been attacked by some boring animal, and if *Sphaeroma terebrans* had been present in numbers sufficient to cause visible damage it could hardly have been entirely overlooked by the collector.

The only other animals in this gathering were two specimens of *Cirolana sulcata*. Like its congeners, this species is no doubt predatory and not at all likely to attack wood.

LIMNORIA LIGNORUM (Rathke).

Cymothoa lignorum Rathke, Skrivt. Naturh. Selsk. Kjøbenhavn, v. (1) 1799, p. 101, pl. iii. fig. 14 a-d.

Limnoria terebrans Leach, Edinburgh Encyc. vii. 1814, p. 433; Coldstream, Edinburgh New Philos. Journ. xvi. 1834, p. 316, pl. vi.

Limnoria lignorum White, Pop. Hist. Brit. Crust. 1857, p. 227, pl. xii. fig. 5; Spence Bate and Westwood, Brit. Sessile-eyed Crust. ii. 1868, p. 351, figs.; Harger, Rep. U.S. Comm. Fish. vi. 1880, p. 373, pl. ix. figs. 55-57; Hoek, Verh. K. Akad. Wet. Amsterdam (Tweede Sectie), i. No. 6, 1893, 103 pp., 7 pls.; Sars, Crust. Norway, ii. 1897, p. 76, pl. xxxi.; Chilton, Ann. Mag. Nat. Hist. (8) xiii. 1914, pp. 380 & 448; *id.*, N.Z. Journ. Sci. Technol. ii. 1919, p. 3, figs.; Calman, Marine Boring Animals, Brit. Mus.

(Nat. Hist.) Economic Ser. No. 10, 1919, p. 17; *id.*, Committee on Structures in Sea-water, Inst. Civ. Engineers, 1st Rep. 1920, p. 68, pl. i. fig. 4.

Localities.—Leith. Specimens forwarded by J. Dalgleish Easton, Deputy Superintendent, Port of Leith. From Jetties, in White Pine and Pitch Pine. Many specimens.

Southampton. Specimens forwarded by F. E. Wentworth Shields, Docks Engineer, L. & S.W. Railway. From Outer Dock, in American Elm. Few specimens.

Simon's Town, Cape of Good Hope. Specimens forwarded by Lieut. L. H. A. Shadwell, R.N.V.R., Officer in charge of works, H.M. Dockyard. From creosoted Danzig timber, No. 3 slip. Few specimens.

Auckland, New Zealand. Specimens forwarded by Mr. W. H. Hamer, Engineer to the Auckland Harbour Board. From Totara timber. Many specimens.

Remarks.—As the European *L. lignorum* has already been recorded from S. Africa (Port Elizabeth) and Auckland, the records given above do not extend its known range.

In stating that "in Europe . . . *Limnoria lignorum* seems to be constantly associated with *Chelura terebrans*" Chilton (*l. c.* 1919, p. 6) is repeating a statement frequently made, but certainly erroneous. At Leith, and elsewhere on the east coast of Scotland and England, while *Limnoria* is abundant, there seems to be no record of *Chelura*.

Order AMPHIPODA.

Suborder GAMMARIDEA.

CHELURA TEREBRANS Philippi.

C. terebrans Philippi, Arch. Naturgesch. li. 1839, p. 120, pl. iii. fig. 5; Stebbing, Das Tierreich, xxi., Gammaridea, 1906, p. 693 (with references); Chilton, Ann. Mag. Nat. Hist. (8) xiii. 1914, p. 380; *id.*, N.Z. Journ. Sci. Technol. ii. 1919, p. 6. fig.; Calman, Marine Boring Animals, Brit. Mus. (Nat. Hist.) Economic Ser. No. 10, 1919, p. 20; *id.*, Committee on Structures in Sea-water, Inst. Civ. Engineers, 1st Rep. 1920, p. 71, pl. i. fig. 6.

Localities.—Southampton. Specimens forwarded by F. E. Wentworth Shields, Docks Engineer, L. & S.W. Railway. From Outer Dock, in American Elm. Few specimens.

Simon's Town, Cape of Good Hope. Specimens forwarded by Lieut. L. H. A. Shadwell, R.N.V.R., Officer in charge of works, H.M. Dockyard. From creosoted Danzig timber, No. 3 slip. Many specimens.

Remarks.—This species has been recorded by Chilton (*l. c.*) as destructive in Auckland Harbour, but specimens forwarded from Auckland as *Chelura* proved to be *Corophium contractum* G. M. Thomson, a species, no doubt harmless, also recorded by Chilton.

I learn from Mr. Hamer, however, that this is merely due to a transposition of labels, the *Chelura*, whose identity with the European species is vouched for by Prof. Chilton, being abundant and well known at Auckland.

It appears doubtful whether there is any trustworthy record of *Chelura* occurring apart from *Limnoria*. The gathering from Simon's Town seemed at first sight to consist exclusively of *Chelura*, but on closer examination 13 specimens of *Limnoria* were discovered among more than 300 of the other genus. If these numbers are at all representative of the proportion in which the two species were living in the wood, the great preponderance of *Chelura* is very remarkable. The only previous record of *Chelura* from South Africa appears to be that of Hammersley-Heenan, who found it at Port Elizabeth in 1893 (Trans. S. African Phil. Soc. v. p. 316), and it is noteworthy that no mention is made of its being accompanied there by *Limnoria*.

12. Colour-production in relation to the Coloured Feathers of Birds. By A. MALLOCK, F.R.S., F.Z.S.

[Received February 7, 1921: Read February 22, 1921.]

(Text-figures 1-4.)

The brilliant colouring of many birds and the forms of the feathers on which this colouring appears, present many points of interest both in regard to the means by which the colour-effect is produced, and to the processes of selection which have led to their development.

In the present note I touch only on the physical side of the problems, and hope to give some idea of the many ways in which colour may be produced by the action of white or composite light on matter, and of the effect of the forms of various feathers in modifying the appearances which the more intimate structure of the material produces on the incident light.

If any object appears coloured when viewed in white light, it shows that the matter of which it is composed exercises some selective action on the composite light falling on it, absorbing or transmitting certain colours and reflecting or scattering the remainder. This selection may be of two kinds: namely, a relation between the periods of light of various wave-lengths and the molecular periods of the matter on which it falls, or on a relation between some distance or spacing in the structure of the substance and the wave-lengths themselves.

The first of these relations includes all pigment colours, and the second those which are known as interference effects.

In the following table I have given a list of all the types of colour-production with which I am acquainted, and I believe that these will cover every known case, although the actual dynamics of a large proportion are very doubtful, involving as they do the dynamics and constitution of the molecule.

Colour may be produced by:—

I.

A relation between the periods of waves of light and the molecular periods of the colour-producing matter:

Examples.

Dispersion, <i>i.e.</i> dependence of wave velocity on wave-length.	Prismatic Colours, Rainbows, etc. Powdered glass or other colourless transparent material immersed in a fluid of the same mean refraction index but different dispersive power.
All dyes and pigments, which may be transparent and scatter or transmit waves of certain periods and absorb the remainder.— <i>Or</i> :—	The greater number of coloured solids and fluids.
Reflect certain periods and transmit the remainder.	Aniline colours in crystal or dry films, and many other crystals.

Are opaque and reflect certain periods and absorb the rest.	Opaque pigments such as lead chromate, etc.
Complete opacity may arise either from the absorption of all wave periods or by complete reflection.	Lamp-black. Silver and most white metals.
Fluorescence and Phosphorescence.	

II.

A relation between the wave-lengths of light and the structural dimensions of the matter which appears coloured :

Examples.

Reflection or transmission from or through a striated or laminated structure.	Colours of thin plates. Mother-of-pearl. Lipmann films. Diffraction gratings. Pitted surfaces with pits of uniform depth.
Scattering or transmission of light by particles of sizes comparable with the wave-length, but irregularly distributed.	Red of sunset. Light, seen through vapours or emulsions. Blue sky and the colours of the sea and rivers. Glass coloured with gold. Supernumerary rainbows.

III.

The colours of polarization in most cases depend both on molecular structure and on the linear dimensions (measured along the paths of the rays) of the bodies which exhibit them.

With regard to the first class, little is known concerning the intimate structure of matter. It is a fact, however, that light-waves travel more slowly in solids and liquids than *in vacuo*, and that the velocity is in some unknown way dependent on the wave-length.

In most cases this is best represented by assuming that the ether is, as it were, loaded by matter, while in some others it would appear that the elasticity of the ether is affected. The difference may be exemplified by a stretched string which has a definite period settled by its length, tension, and mass. If the string is loaded, the period is increased by an amount depending on the added load, but an equal increase in period may be produced by relaxing the tension. If the shape of a transparent body is such that the direction of light after passing through it depends on the velocity of the waves in the interior, as for instance in a prism or sphere, the emergent light will appear differently coloured in different directions.

In the case of pigments, it is most probable that the individual molecules have a natural period identical with that of some of the

periods of the incident light, and that the colours which they reflect or transmit are due to resonance.

The actual dimensions, forms, and rigidities of molecules are unknown, but their diameters are apparently of the order of a ten-millionth of a centimetre; and one may inquire what the longest natural period of a sphere $1/10,000,000$ cm. diameter would be if it were as rigid as steel, or, which comes to the same thing, what is its least natural frequency. Without going into the details of the calculation, it may be stated that this least natural frequency is somewhere about 5×10^{12} vibrations per second. All the other natural modes of vibration would have higher frequencies, and there is good reason to suppose that the rigidity of molecules far exceeds the rigidity of the matter formed by their aggregation. The frequency of yellow light is 5×10^{14} vibrations per second. Thus it seems that the natural frequencies of molecules and of visible light-waves are at any rate of the same order.

All these pigmentary and dispersion colours depend on the constitution of the molecule itself. In the second class it is the relation of the size of particles, or on their disposition in space as compared with the wave-length which determines the selective influence of the matter on white or composite light.

The origin of the colouring presented to view as the result of selective action of the structure on wave-length can be fairly well determined by the following tests:—

- (a) Mechanical compression or extension.
- (b) Immersion in various fluids.
- (c) Change of colour with the angle of incidence of the light.

Of these, the compression test is the most decisive; for, if the mechanical distortion of the structure changes or obliterates the colour, it may be assumed that the colour itself depends on some special arrangement of the parts, and not on the molecular properties of the material of which it is built up.

There may be some apparent exceptions, as for instance when a material transmits one colour with less loss than another, so that the predominating colour is dependent on the thickness of the layer through which the light travels (*e. g.* manganese glass or a solution of chlorophyll).

In the circumstances, however, in which this test is applied to organic structures, such as feathers, these exceptions will hardly operate.

The greater part of the colours of feathers have their origin in pigments of the nature of which little is known. Except in one instance, no solvent has been found for them, and the pigments themselves vary much in physical properties. Some are nearly opaque, while others are transparent and transmit the complementary colour. Many, again, polarize the incident light, and this is especially noticeable with transparent yellows. These

form rather brilliant objects when viewed between crossed nicols.

But by far the most brilliant colouring of birds has its origin in interference, that is to some periodic structure in the substance of the feather, where the spacing of the parts is a multiple of the half wave-lengths of the light they reflect. Such is the case among humming-birds, sun-birds, peacocks, birds of paradise, and ducks, to mention only a few instances of what are spoken of as "metallic" colouring.

All these colours disappear when subjected to pressure, and in all cases the colour-producing substance is confined to a very thin layer overlying an intensely opaque black or brown substratum.

The general effect when viewed from a distance depends to a great extent on the form of the surfaces on which the colouring layer is disposed. If these surfaces are planes, the relative positions of the eye and source of light with regard to the feather has to be rather carefully adjusted, in order that any colour may be visible.

When, however, the surfaces are rounded, the range of incidence is much extended, and from almost any point of view some colour appears, although the intensity is lessened, just as a tray of small glass beads will scatter sunlight in all directions although the intensity in any one direction is much less than what would be produced by a plane mirror adjusted to reflect lights in that direction only.

The examples chosen all show distinctive structure peculiar to the orders to which the examples belong.

A feather may be described as consisting of a stem, branches, and leaves (text-fig. 1) (named by zoologists respectively rachis, rami or barbs, and barbules, the latter sometimes as carrying barbicels). It is in the modifications of the leaves that the distinctive features are found.

I will notice these in order.

In all the ornamental feathers of Humming-Birds the branches, but especially those of the gorget, are so bent that their ends are parallel and the colour-bearing surface is on the leaves. A cross-section of the branches and leaves forms a succession of hollows in text-fig. 2 *e*.

The section of the leaves themselves is something like the numeral 7 (text-fig. 4 *c*), and the colour-producing material lies in a thin layer on the upper surface of the leaves, and is nearly a plane, so inclined that the normal makes an angle of about 60° with the branch, but lying in a plane parallel to the latter. (This angle varies in different species.)

To keep the leaves in this position, each barb terminates in a curved plate (text-fig. 4 *d*), which interlocks with the similar plates of the two or three leaves in advance.

Each branch ends in a long bristle (fig. 2 *b*), which, when the plumage is in good order, lies in the trough of the valley formed

by the leaves and branches of the succeeding feather. This bristle is only found in the head- and gorget-feathers. The body-feathers, where coloured, end as shown in text-fig. 2 *c*.

From these arrangements it happens that the best display of colour occurs when the body of the bird is in the nearly vertical position it assumes when hovering.

In the Sun-Bird each leaf has a curious rasp-like shape, and the upper colour-producing surface is in the form of 3 or 4 convex plates, in each of which the virtual image of the sun or other source of light appears as a coloured spot.

The chief peculiarities of the metallic feathers of Birds of Paradise are that the leaves are only developed on one side of the branch, and are so disposed with reference to it as to be parallel to the stem (text-fig. 3 *b*). The upper surface consists of more or less rounded lobes, and the cross-section is shown in text-fig. 3 *c*. This, so far as I have observed, is the rule in all the metallic feathers, whether on the head, wings, or tail.

In the Rifle-Bird, which is a near connection of the Birds of Paradise, the leaves are only developed very slightly on that side of the branch on which, in the true Birds of Paradise, they are absent.

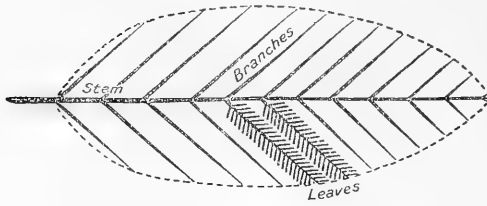
In the Peacock and all other pheasant-like birds, the leaves are of the form shown in text-fig. 4 *a, b*. The cross-section of the leaves is comma-shaped and the whole structure is transversely corrugated. The colour layer lies on the upper surface of the "dot" of the comma, which thus presents a series of rounded knobs to the light, each giving rise to a spot of colour.

In the head-feathers of Ducks the colour is developed on the leaves on both sides of the branch, but in the speculum, on one side only, the uncoloured leaves lying below the coloured part of the adjacent branch and serving to lock the two in position.

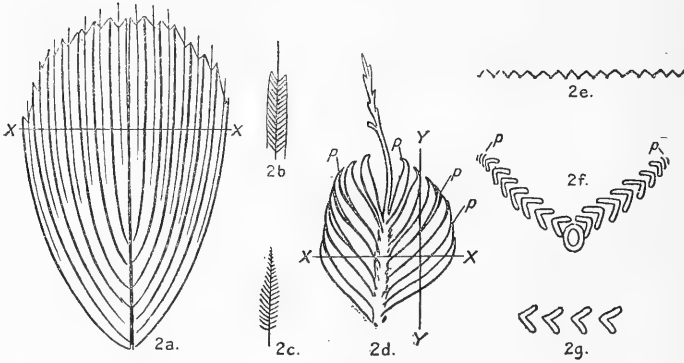
As before stated, all these feather colours disappear when the structure is compressed. For this test I place the feather between a quartz plate and a plano-convex lens of the same material, of a foot radius, these being mounted to fit on the stage of a microscope. The only difficulty in applying this test is to separate a suitable part of the coloured material on which to operate. The result is a conclusive proof that the colours are not due to any form of pigment, and strong evidence that they are due to interference. Most feathers are extremely impermeable to fluids, but in certain cases (the Peacock for instance), when immersion takes place, the colour changes at once to one of a longer wave-length: blue becomes green, green yellow, and so on. Where this happens it is evidence either that the feather is to a certain extent permeable by the fluid used, or, more probably, that the colour-production depends on some quality or grain of the outside surface.

The greater number of the metallic feathers which I have experimented with show no change on immersion in any ordinary

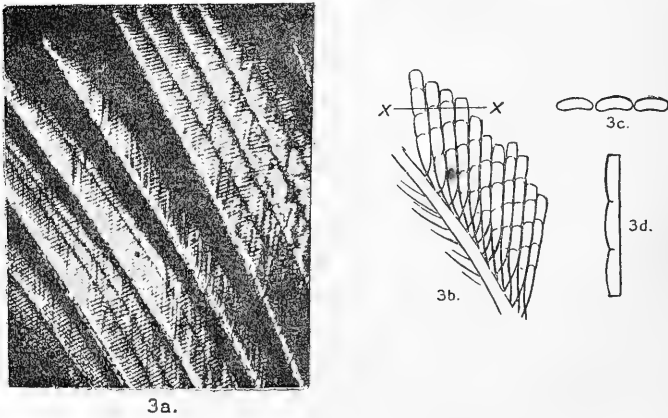
Text-figure 1.*



Text-figure 2.

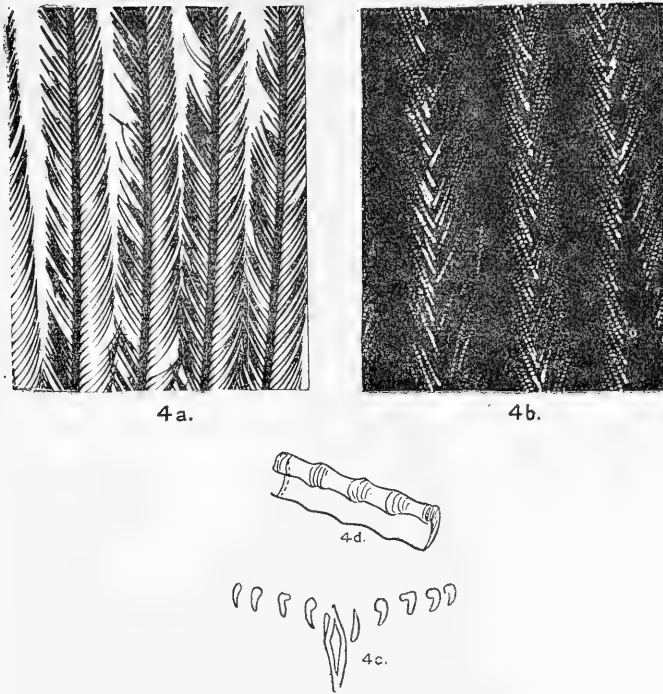


Text-figure 3.



* For description of the figures see next page.

Text-figure 4.



- Fig. 1. Diagrammatic drawing of a Feather, showing Stem, Branches, and Leaves.
- Fig. 2 *a*. Feather from the gorget of Humming-Bird ($\times 20$).
 2 *b*. Termination of single branch of same feather ($\times 30$).
 2 *c*. " " of coloured body-feathers from the same bird ($\times 30$).
 2 *d*. Termination of gorget-feather ($\times 130$), showing the leaves and their prolongations (*p-p*), which serve to keep the former regularly spaced, and the planes of their upper surface inclined at a constant angle to the axis of the branch.
 2 *e*. Cross-section of gorget-feather, parallel to the line *XX* of 2 *a* ($\times 20$).
 2 *f*. Cross-section, parallel to *XX* of 2 *d*, of single branch of the same feather ($\times 130$). Note the sections of the prolongations of the leaves at *p p*.
 2 *g*. Longitudinal section of the same, parallel to *YY* of 2 *d*.
- Fig. 3 *a*. Feather from the wing of King Bird-of-Paradise by reflected light ($\times 40$).
 3 *b*. Part of a single branch of same feather ($\times 130$), showing leaves developed on one side of the branch only.
 3 *c*. Cross-section of leaves, parallel to *XX* in 3 *b* ($\times 220$).
 3 *d*. Longitudinal section of one of the leaves of same feather.
- Fig. 4 *a*. Branches of blue feather from Peacock's neck by transmitted light ($\times 30$).
 4 *b*. The same by reflected light ($\times 40$).
 4 *c*. Cross-section of single branch of same ($\times 130$).
 4 *d*. Part of a single leaf of same, seen in perspective.

fluid (alcohol, xylol, chloroform, oil, etc.), but strong acids in time cause the colours to change towards the red end of the spectrum.

The most penetrative fluid which I have tried is the solution of iodide of mercury in iodide of potassium. This, when concentrated, rapidly destroys the feather substance, but in dilute solution merely penetrates into the interior. The gorget-feathers of the Humming-Bird (from Costa Rica) reflect a brilliant lilac, *i. e.* a mixture of red and blue, but after a few hours' immersion in the iodide solution, the red disappears and the blue changes to a very bright green.

All these metallic colours shift towards the blue as the angle of incidence of the light increases, as do the ordinary colours of thin plates; but this is not a proof that both have the same origin, for many of the aniline colours when in thin dry films show somewhat similar changes depending on the angle of incidence.

Michelson in America has compared the metallic colour of some beetles with those of the anilines, and has given reasons (connected with similarity of the polarization of light reflected by both) for believing that the origin of the colours in the two cases is of the same kind.

The pressure test, however, seems to make this conclusion invalid.

The colours seem to me to be more allied to those of Lipmann films, in which layers of reduced silver are spaced at half wave intervals, and in the case of metallic feathers I believe that one or two layers of optically dense material are the sources of interference.

Although half wave-lengths can be readily resolved by high-power microscopic objectives, it is almost impossible to cut sections thin enough (*viz.* less than $\cdot 00002$ in.) to use with such powers. At least I have cut many hundred sections, but although in some cases a laminated structure seemed to be present, this was due to a diffraction effect, as was evident from the changes in the dimensions of position of the apparent lamina which occurred with the change of focal adjustment.

In the case of the Lipmann films, the layers of reduced silver are readily seen if the sections are expanded by wetting, though I have not been able to resolve them satisfactorily when dry.

13. Fossil Bird-remains collected by Dr. Forsyth Major in Sardinia, Corsica, and Greece. By E. T. NEWTON, F.R.S., F.G.S., F.Z.S.

[Received February 8, 1921 : Read March 22, 1921.]

In the year 1891 Mr. R. Lydekker * gave an account of some Pleistocene Bird-remains which had been collected by Dr. Forsyth Major in Sardinia and Corsica. These remains were from three localities—(1) Tavolara, an island on the N.E. coast of Sardinia; (2) Monte San Giovanni, in the S.W. of the same island; and from (3) Toga, near Bastia, Corsica. From these localities some score of species were recognized more or less definitely as follows:—

(1) *Tavolara*.

Coracias cf. abyssinicus.	
Corvus corone.	
Coccothraustes vulgaris.	
Fringilla cælebs.	
Serinus hortulanus?	
Columba cf. livia.	
Coturnix communis.	
Puffinus cf. fuliginosus.	} Most common.
„ cf. anglorum.	
„ allied to chlororhynchus.	

(2) *Monte San Giovanni*.

Bubo cf. cinerascens.
 Milvus cf. icterus.
 Aquila sp.
 Vultur cf. monachus.
 Pyrrhula europæa.
 Alauda arborea?
 Turdus musicus.
 Hirundo rustica.
 Puffinus cf. fuliginosus.

(3) *Toga, near Bastia*.

Turdus merula.
 Columba cf. livia.
 Aquila sp.

Some years later Dr. Forsyth Major made further explorations of the Pleistocene deposits in the Mediterranean islands, and obtained a large number of Mammalian and other vertebrate remains, not only from the above-named places, but also from several new localities. Among these were many bones of birds, which

* Proc. Zool. Soc. 1891, p. 467.

Dr. Forsyth Major in the year 1908 (just before he left England) submitted to the present writer with a view to their identification. This agreeable task was accomplished some years ago, and the results have been awaiting Dr. Forsyth Major's description of the Mammalia; but, as he is still absent from England, it seems desirable that a brief account of the Avian remains should be published.

Some of these are from the same localities as those described by Mr. R. Lydekker, and, as they include some additional interesting species, these will be first considered.

(1) From Tavolara, N.E. Sardinia, there are in the present series several vertebræ belonging to *Puffinus*, a genus which Mr. Lydekker found so abundant; but besides these I have recognized bones of the Common Swift (*Cypselus apus* Linn.) and Alpine Swift (*C. melba* Linn.), also a small Crake (*Porzana parva*? Scop.) and the Storm-Petrel (*Procellaria pelagica* Linn.).

(2) From the second locality, Monte San Giovanni, there is only one Passerine humerus.

(3) From Toga, near Bastia, I have a nearly perfect humerus of a Chough (*Pyrrhocorax graculus* Linn.), which is distinctly larger than the humerus of the Alpine Chough.

(4) *Grotta di Funtanedu.*

Specimens from this and the following localities were not included in the series sent to Mr. R. Lydekker and alluded to above.

The Grotta di Funtanedu is near Bastia, N.E. Corsica, and is situated 400 metres above sea-level. It has yielded a good number of birds' bones, and some 34 species have been identified; but each of these is represented by only a few bones.

As no account of Avian fossil remains from this cave has hitherto been published, it will be well to give a detailed list of the species recognized:—

PASSERES.

Missel-Thrush. *Turdus viscivorus* Linn.

Song-Thrush (or Redwing). *T. musicus*? Linn.

Fieldfare. *T. pilaris* Linn.

Blackbird. *T. merula* Linn.

*Large Thrush. *Turdus* sp. (? *T. varius* Pallas).

Wheatear. *Saxicola œnanthe* Linn.

Whinchat. *Pratincola rubetra* Linn.

Redstart. *Ruticilla phœnicurus* Linn.

Robin. *Erithacus rubecula* Linn.

Willow-Wren. *Phylloscopus trochilus* Linn.

*Dipper? *Cinclus aquaticus*? Bechst.

Wagtail. *Motacilla lugubris*? Temm.

Titlark. *Anthus pratensis* Linn.

Rock-Pipit? *A. obscurus*? Lath.

- Linnet. *Acanthis cannabina* Linn.
 Chaffinch. *Fringilla caelebs* Linn.
 Starling? *Sturnus*?
 Chough? *Pyrrhocorax graculus*? Linn.
 Jay. *Garrulus glandarius* Linn.
 Jackdaw. *Corvus monedula* Linn.
 Skylark? *Alauda arvensis*? Linn.
 *Shore-Lark? *Otocorys alpestris*? Linn.
- PICARÆ.**
 Swift. *Cypselus apus* Linn.
- STRIGES.**
 Short-eared Owl? *Asio accipitrinus*? Pall.
- ACCIPITRES.**
 Eagle. *Aquila* sp.
 Sparrow-Hawk. *Accipiter nisus* Linn.
 Kestrel. *Falco tinnunculus* Linn.
- ANSERES.**
 Wild Duck? *Anas boscas*? Linn.
- COLUMBÆ.**
 Wood-Pigeon. *Columba palumbus* Linn.
- GALLINÆ.**
 Red-legged Partridge. *Caccabis rufa* Linn.
 Quail. *Coturnix communis* Bonnat.
- FULICARÆ.**
 Crake (small form). *Porzana parva*? Scop.
- LIMICOLÆ.**
 Redshanks? *Totanus calidris*? Linn.
- GAVLÆ.**
 Tern. *Sterna fluviatilis*? Naum.

(5) *Grotta di Brietta.*

This cave is situated in the same locality of N.E. Corsica as Funtanedu, but about 300 metres lower down—that is, about 100 metres above sea-level. From this I have identified bones of Thrush, Blackbird, Wheatear, and *Magpie (*Pica rustica* Scop.), the last-named species being an addition to the fauna of these islands.

(6) *Gradicchia Cave.*

This is another cave near Bastia, which may possibly be prehistoric; but probably even more modern. From it are recognized bones of Blackbird, Crow (or Rook), Fowl, and (it may be) Pheasant.

(7) *Margine Cave.*

The Margine Cave is situated near Nonga, Corsica, and from it remains of only two birds have been identified—the Chough (*Pyrrhocorax graculus* L.) and a Pigeon.

(8) *Grotta del Capo.*

This cave is at Sagro, near Sisio, Cape Corso, N. Corsica, and among the fossil remains Thrush and Blackbird are the only Avian species recognized.

(9) *Monte Santa Cave.*

Monte Santa is near Guisba in N.W. Sardinia, and from this cave we have representatives of two birds—the Red-legged Partridge (*Caccabis rufa* Linn.) and the Woodcock (*Scolopax rusticula* Linn.).

10. *Nesakia, Isle of Cerigo, Greece.*

The remains of four species of birds are recognized among these Grecian island fossils—namely, Blackbird, Rook (?), Pigeon, and Barn-Owl (*Strix flammea* Linn.).

The species mentioned in these notes are without exception living forms; but those marked with a star (*) have not hitherto been recorded from these Mediterranean islands †. Dr. Forsyth Major appears to have no doubt as to the deposits at all the above localities, excepting No. 6, being of Pleistocene age, and doubtless the Mammalian remains which he has collected will justify this opinion; but the Birds, being only referable to modern species, offer no sure grounds for a judgment in this respect. As remarked by Mr. R. Lydekker ‡, many modern species of birds, especially among Passerine forms, are distinguished by their plumage rather than by any osteological differences, and possibly these fossil bones, although like those of modern species, may have been differently clothed in Pleistocene times, and in this way have differed from their descendants of the present day.

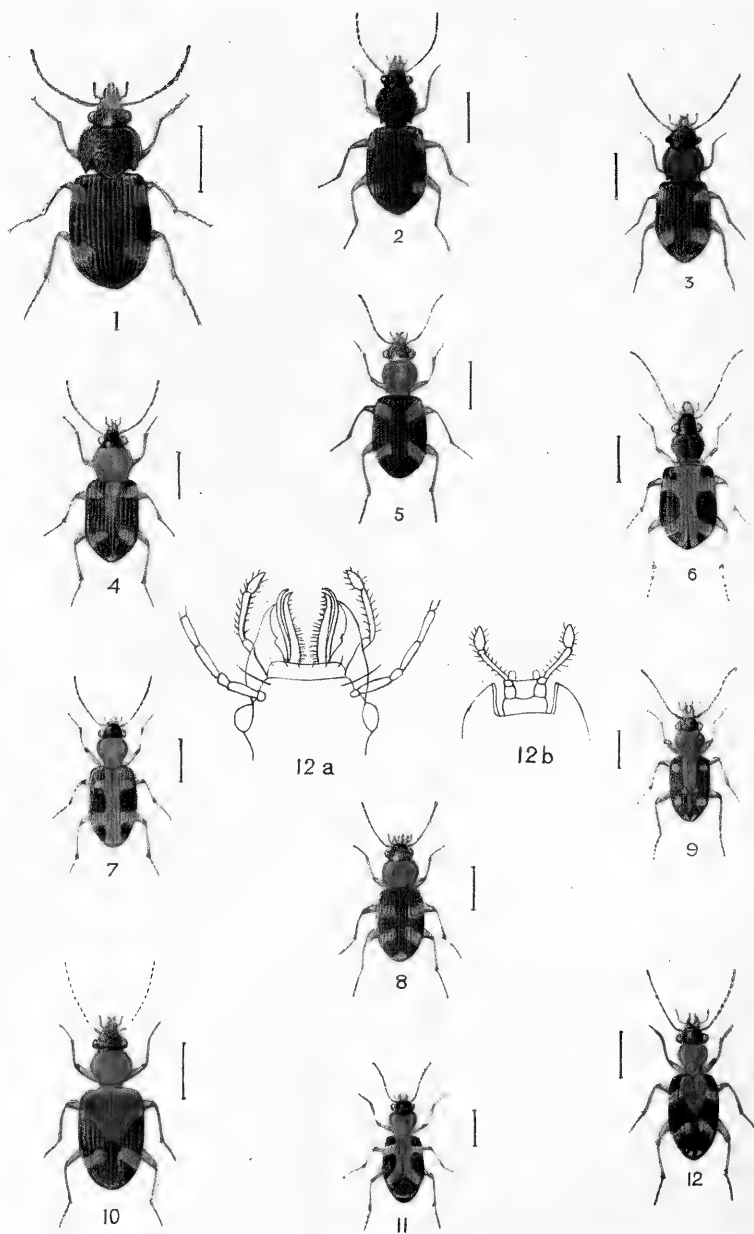
Since these notes were written, I have had the pleasure of seeing the valuable and detailed work of M. M. Boule on the Vertebrate fossils from the Grimaldi Caves §, in which many Birds' bones are beautifully figured and carefully described. As might have been anticipated, these caves of the mainland have yielded a very similar Avian fauna to those of the Mediterranean Islands.

Dr. Forsyth Major's specimens will be deposited at the Natural History Museum, South Kensington.

† See John Whitehead, "Ornithological Notes from Corsica," *Ibis*, 1885, pp. 24-48 and plate.

‡ *Proc. Zool. Soc.* 1891, p. 468.

§ 'Les Grottes de Grimaldi' (Monaco, 1919), Tome i. Fasciculus iv. p. 299.



E. C. Knight, del.

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ORIENTAL SPECIES OF CALLISTOMIMUS.

14. The Oriental Species of the Genus *Callistomimus* (Coleoptera, Carabidæ). By H. E. ANDREWES*.

[Received December 13, 1920: Read March 22, 1921.]

(Plate I.)

Having some new species to describe in this genus, I thought it would be desirable, if it were also possible, to deal in one paper with all the species at present known. I have been fortunate in securing the loan of a number of types, and in receiving permission to see others; in this connexion I have to offer my thanks to Dr. Gahan of the British Museum, Dr. Gestro of Genoa, Dr. W. Lundbeck of Copenhagen, Mr. René Oberthür, Mr. E. Fleutiaux, and Mr. Guy Babault. To Mr. Severin of Brussels my thanks are not less due, for at my request he made an exhaustive search in the Brussels Museum—unfortunately without result—for the types of the two species described by Putzeys.

In 1872 Chaudoir described the genus *Callistomimus* (Bull. Mosc. ii. p. 382), which he differentiated from *Callistus* by the edentate mentum and some other characters. In the following year Bates described a new genus from China under the name of *Pristomachærus* (Trans. Ent. Soc. Lond. p. 323) for an insect (*P. messii*), which was widely different, especially in the form of the prothorax, from any species of the group then known. In describing a number of new species in 1892 (Ann. Mus. Civ. Gen. pp. 303-7), Bates discusses the relationship of the two genera, remarking in conclusion "so that there remains only the prolonged hind angles of the thorax, separated from the base by a deep sinuation, to distinguish *Pristomachærus*."

In examining various species, including some hitherto undescribed, I find a number of links connecting the extreme forms of the prothorax; the difference is one of degree not of kind, and in such species as *Callistomimus coarctatus* Laf. and *C. littoralis* Motch. the hind angles of the prothorax are sharp and the sides of the base distinctly, though only slightly, emarginate. I have endeavoured for some little time past to keep the genera distinct, but I have now seen intermediate forms which render this no longer possible, and I therefore treat *Pristomachærus* as a synonym.

As in *Callistus* the outer maxillary lobe is in one piece. Bates pointed out, when describing *Pristomachærus*, that the maxillæ projected far beyond the mandibles, and this is sometimes the case. In connexion with this, however, there is frequently an optical illusion, which struck me when examining a long series of a new species. Normally the mandibles are tightly closed, and the maxillæ project as long slender shafts in front of them; when the mandibles are opened, it is seen that the relative difference in length of the two organs is considerably less than at first

* Communicated by S. A. NEAVE, B.A., F.Z.S.

sight appeared to be the case. There is also a point to note in connexion with the ligula, which, as in *Callistus*, is said to be bisetose. Actually there are two long setæ placed close together on the middle of the apical margin and directed a little downwards, but there are also some very fine setæ on each side. These latter seem very liable to abrasion, but apparently there are about three such minute hairs on each side of the apical margin.

Chaudoir thought that *Callistus* and its allies were related to *Anichonoderus*, and in this he was followed by Lacordaire. Schaum and G. H. Horn put them near *Chlenius*, and both Bates and Ganglbauer have followed this example. I agree with the latter, but think that the unjointed outer lobe of the maxillæ and the elongate inner one, together with the pubescent palpi necessitate a separate group, in which I follow so good an authority as Bates.

I propose in the following pages to give first of all a brief account of the generic characters, then a catalogue of the species, followed by a dichotomic table, and finally descriptions of the new species, together with additional notes on some of the old ones, where the information afforded by their authors appeared inadequate. In differentiating closely allied species I am aware that it is generally undesirable to rely too much upon colour, but in the insects which I am here considering, especially the smaller ones, the structural characters vary little, and I have been compelled to make use of the colour scheme in my table of species.

GENERIC CHARACTERS.

Ligula dilated and truncate at apex, bisetose but with some additional minute setæ at sides of apex; *paraglossæ* membranous, adnate to near apex, extremities rounded, extending rather beyond ligula. *Mentum* edentate, lobes sharply contracted in front, not much rounded, pointed at apex; epilobes narrow, extending slightly in advance of lobes. *Maxillæ* exceptionally long and narrow, with relatively few bristles on inner margin, especially in upper part, sharply hooked close to apex, outer lobe in one piece. *Palpi* long, slender, setose, pointed at apex, penultimate of labials plurisetose on inner margin. *Mandibles* long, almost edentate, wide at base, slender and very sharp, but hardly hooked, at apex. *Labrum* transverse, generally emarginate, sexsetose at apex, minutely setose at sides. *Clypeus* truncate, a seta not far from front angle on each side. *Eyes* prominent, one supraorbital seta. *Antennæ* thick, setose, densely so from joint 4.

Upper surface densely punctate and setose; hind angles of prothorax usually acute, with a more or less deep emargination between them and middle of base; hind body subpedunculate; elytra 9-striate, with a fairly long scutellary striole between suture and stria 1, base unbordered over first three intervals on each side, sides without sinuation or visible internal fold near

apex; under surface shiny, coarsely but not densely punctate, ventral surface more finely punctate, metepisterna not much longer than wide; legs slender, tarsi setose on upper surface, joint 1 longer than 2 + 3, ♂ front tarsi with three dilated joints, more or less quadrate with rounded angles (as in *Chlœnius*), joint 1 narrowed towards base, densely pilose beneath, claws simple.

CATALOGUE.

- acuticollis (Callistus), Fairm. Ann. Soc. Ent. Fr. 1889, p. 6 = *yunnanus* (Pristomachærus) Maindr. Bull. Soc. Ent. Fr. 1909, p. 275. Yunnan.
belli, sp. n. S. India.
cauliops (Pristomachærus) Bates, Ann. Mus. Civ. Gen. 1892, p. 306. Burma.
ceylonicus Dupuis, Ann. Soc. Ent. Belg. 1913, p. 6. Var. of littoralis, Motch. Ceylon.
chalcocephalus (Panagæus) Wied. Zool. Mag. ii. 1. 1823, p. 57; Chaud. Bull. Mosc. 1861, iv. p. 351; id. Ann. Soc. Ent. Belg. 1878, p. 84; Bates, Scientific Results Sec. Yark. Miss. 1891, p. 4 = *messii* (Pristomachærus) Bates, Trans. Ent. Soc. Lond. 1873, p. 324. S. China, Indo-China, N. India, ? Java.
chlorocephalus (Panagæus) Kollar, Ann. Wien. Mus. i. 1835, p. 335, t. 31. f. 4; Chaud. Bull. Mosc. 1861, iv. p. 351; id. Ann. Soc. Ent. Belg. 1878, p. 84. ? India.
coarctatus (Callistus) Laf. Ann. Soc. Ent. Fr. 1851, p. 230. N. India.
d'abreuï, sp. n. N. and Cent. India.
dicksoni Wat. Ann. Mag. Nat. Hist. (5) xiv. 1884, p. 429; Andr. Trans. Ent. Soc. Lond. 1919, p. 197. Fornosa.
dux, sp. n. Burma.
eucharis (Pristomachærus) Bates, Ann. Mus. Civ. Gen. 1892, p. 305. Burma.
humeralis, var. nov. Var. of modestus Schaum. Indo-China, Burma, N. India.
insularis, var. nov. Var. of modestus Schaum. Java.
jucundus, sp. n. S. India.
lebioides (Pristomachærus) Bates, Ann. Mus. Civ. Gen. 1892, p. 306. Burma.
littoralis (Callistus) Motch. Et. Ent. 1859, p. 33; Bates, Comp. Rend. Soc. Ent. Belg. 1891, p. 327 = *westwoodi* (Callistus) Schaum, Berl. Ent. Zeit. 1863, p. 85. India.
modestus (Callistus) Schaum, Berl. Ent. Zeit. 1863, p. 85; Bates, Trans. Ent. Soc. Lond. 1873, p. 246; id. Ann. Mus. Civ. Gen. 1892, p. 303; Fairm. Ann. Soc. Ent. Fr. 1888, p. 336. Japan, S. China, Indo-China, Burma, N. India.
nair (Pristomachærus) Maindr. Bull. Soc. Ent. Fr. 1909, p. 276. S. India.
nilgirinus, var. nov. Var. of nair Maindr. S. India.
quadricolor (Pristomachærus) Putz. Stett. Ent. Zeit. 1877, p. 101. ? = eucharis Bates. N. India.
quadriguttatus (Pristomachærus) Putz. Stett. Ent. Zeit. 1877, p. 101. ? = chalcocephalus Wied. N. India.
quadriristigma (Pristomachærus) Bates, Ann. Mus. Civ. Gen. 1892, p. 303. Var. of chalcocephalus Wied. Indo-China, Burma.
rubellus (Pristomachærus) Bates, Ann. Mus. Civ. Gen. 1892, p. 305. Burma.
sikkimensis, sp. n. N. India.
subnotatus, sp. n. Cambodia.
saturalis Fleut. Ann. Soc. Ent. Fr. 1887, p. 61, t. 4. f. 2; Bates, Ann. Soc. Ent. Fr. 1889, p. 265. Annam.
venustus, sp. n. Laos.
virescens, sp. n. Burma.
vitalisi, sp. n. Tonkin.

Key to the Species.

- 1 (14). Upper surface black to brassy green (prothorax sometimes reddish), elytra with red or yellow spots (sometimes fasciæ), prothorax closely and coarsely punctate.
- 2 (9). Prothorax green, elytra with red or yellow spots.
- 3 (6). Prothorax half as wide again as long, sides hardly sinuate before hind angles. Length 7.0-7.5 mm.
- 4 (5). Yellow spots on elytra smaller, front one from stria 5 to margin *chalcocephalus* Wied.
- 5 (4). Yellow spots on elytra larger, front one from stria 4 to margin *v. quadristigma* Bates.
- 6 (3). Prothorax not more than a third as wide again as long, sides strongly sinuate before hind angles. Length 5.0-6.0 mm.
- 7 (8). Elytral spots red, front one covering shoulder and extending inwards to stria 5, two minute ones behind on intervals 4 and 6 respectively *subnotatus*, sp. n.
- 8 (7). Elytral spots yellow, front one small, rather behind shoulder, extending inwards to stria 7, hind one small, quadrate, on intervals 6-8, another minute spot on interval 4 *jucundus*, sp. n.
- 9 (2). Prothorax reddish, elytra with yellow fasciæ.
- 10 (13). Prothorax half as wide again as long, elytra coarsely and confluent punctate.
- 11 (12). Prothorax dark red, elytra without sutural red patch; eyes small, very prominent, pedunculate *cauliops* Bates.
- 12 (11). Prothorax light red, elytra with sutural red patch reaching to midway between fasciæ; eyes moderately prominent, not pedunculate *rubellus* Bates.
- 13 (10). Prothorax a third as wide again as long, dark red, elytra moderately and not confluent punctate, without sutural red patch *sikkimensis*, sp. n.
- 14 (1). Upper surface variegated: head metallic green or blue, prothorax red (at least at base), elytra dark (at least on apical half) with two interrupted whitish fasciæ (exceptionally with white spots); prothorax closely but not coarsely punctate.
- 15 (22). Elytra with a red sutural stripe from base to apex, merging in white spot (when present) at apex.
- 16 (17). Prothorax blue with red base, elytra violet-blue, with wide dirty-white fasciæ from sutural stripe to side margins *venustus*, sp. n.
- 17 (16). Prothorax red, elytral fasciæ not reaching margin.
- 18 (19). Shoulders and epipleuræ of elytra coarsely punctate; front fascia hardly reaching externally beyond stria 6 *virescens*, sp. n.
- 19 (18). Shoulders and epipleuræ of elytra not coarsely punctate; front fascia reaching at least to stria 8.
- 20 (21). Elytra moderately convex, front fascia reaching stria 8, hind fascia as wide as front one, oblique *dicksoni* Wat.
- 21 (20). Elytra flat on disk, front fascia reaching stria 9, hind fascia very narrow, bent sharply backwards soon after leaving sutural stripe *suturalis* Fleut.
- 22 (15). Elytra with or without red sutural stripe or scutellary patch; when present, not reaching beyond hind fascia.
- 23 (28). Elytra without red sutural stripe or scutellary patch (though the scutellum itself is red).

- 24 (25). Elytra green, with fairly wide yellow-white fasciæ; prothorax red, with two dark spots on disk, one on each side of median line..... *belli*, sp. n.
- 25 (24). Elytra black with narrow fasciæ, prothorax concolorous.
- 26 (27). Prothorax considerably wider than head, elytra with a small light spot at apex, sides of front fascia tapering inwards..... *acuticollis* Fairm.
- 27 (26). Prothorax very little wider than head, elytra without light spot at apex, front fascia of nearly equal width throughout *lebioides* Bates.
- 28 (23). Elytra with a red sutural stripe or scutellary patch.
- 29 (30). Ground colour of elytra green, each elytron with 4 white spots. Length 4.0 mm. *d'abreui*, sp. n.
- 30 (29). Ground colour of elytra black or very dark blue. Length at least 4.5 mm.
- 31 (36). Elytra with the whole of the basal area red.
- 32 (33). Elytra with red basal area reaching hind fascia, without dark line at margin between shoulders and front fascia, prothorax often blue with base only red *modestus* Schaum.
- 33 (32). Elytra with red basal area not reaching hind fascia, a dark line at margin between shoulders and front fascia.
- 34 (35). Prothorax red, ground colour of elytra dull black. Length 7.0 mm..... *dux*, sp. n.
- 35 (34). Prothorax with base red and apex blue (in varying proportions), ground colour of elytra dark blue, faintly shining. Length 4.5 mm. *v. insularis*, nov.
- 36 (31). Elytra with sutural area only red (to a greater or less width), shoulders always dark.
- 37 (42). Red sutural area on elytra joining hind fascia.
- 38 (39). Elytra half as long again as wide, shoulders not prominent; hind angles of prothorax acute, a distinct emargination between them and middle of base *nair* Maindr.
- 39 (38). Elytra about a fourth as long again as wide, shoulders prominent; hind angles of prothorax right, with only a slight emargination between them and middle of base.
- 40 (41). Elytra with red sutural stripe covering intervals 1-3 at base, 1-2 between fasciæ *littoralis* Motch.
- 41 (40). Elytra with red sutural stripe covering intervals 1-5 at base, tapering to 1-3 at hind fascia ... *v. humeralis*, nov.
- 42 (37). Red sutural area on elytra not joining hind fascia.
- 43 (44). Red sutural area on elytra reaching level of hind fascia, but separated from it *v. ceylonicus* Dup.
- 44 (43). Red sutural area on elytra not or hardly extending behind the front fascia.
- 45 (46). Elytral fasciæ reaching margin, neck red *vitalisi*, sp. n.
- 46 (45). Elytral fasciæ not reaching margin, neck dark.
- 47 (48). Hind angles of prothorax right, quite inconspicuous, a minute indentation between them and middle of base *coarctatus* Laf.
- 48 (47). Hind angles of prothorax acute, a deep emargination between them and middle of base.
- 49 (50). Front elytral fascia covering intervals 5-8, hind one evidently oblique, moderately wide, covering intervals 3-8 *v. nilgirinus*, nov.
- 50 (49). Front elytral fascia covering intervals 4-8, hind one only slightly oblique, narrow, covering intervals 2-8 *eucharis* Bates.

CALLISTOMIMUS CHALCOCEPHALUS Wied. (Plate I. fig. 1.)

Callistomimus messii Bates.do. do. var. *quadristigma* Bates.

Wiedemann's type, which I have recently seen at Copenhagen, was alleged to come from Java and may have done so, though I have seen no other example from the Malay region. He was in the same paper also describing species from Bengal, and I think it possible that his insect came from that locality.

Bates described his *C. messii* from Hong Kong, and *C. quadristigma* from Burma. The former is identical with Wiedemann's species: of the latter, which has rather larger yellow spots on the elytra, Bates says "Probably not more than a local race of" *C. messii*, with which I quite agree.

I have before me specimens of the type form from Hong Kong, and from Tonkin—Than Moi (*R. Vitalis de Salvaza*), of the variety (in addition to cotypes from the Fea collection) specimens from Laos—Vientiane (*R. Vitalis de Salvaza*), Cochin-China—Bien-hoa (*Coll. Fleutiaux*), and Burma—Rangoon (*H. L. Andrewes*); also intermediate forms, as regards the size of the yellow spots, from Burma—Maymyo (*H. L. Andrewes*), Sikkim—Gopaldhara (*H. Stevens*), and Dehra Dun (*Indian Museum* and *Forest Res. Inst.*). An example from Kumaon—W. Almora (*H. G. Champion*) has very small elytral spots, and the upper surface, as in all Indian specimens I have seen, is more strongly punctate than in the China and Burma forms. The example taken by Dr. Stoliczka in the Jhelam Valley (Second Yarkand Mission), and determined by Bates as *C. chalconcephalus*, is now fragmentary, the head and prothorax having disappeared, but the elytra seem to be those of the species under consideration, with the yellow spots well developed. Bates indicates in his paper no feeling of doubt regarding this determination, but he put two marks of interrogation on his label. With such slender Indian material available it seems useless to put names to any of the slightly varying forms.

C. chlorocephalus Kollar has not to my knowledge been identified as yet, and, like Wiedemann's species, it was evidently unknown to Chaudoir. The locality is uncertain, but Kollar thought the specimen probably came from India. The figure is a poor one, but, judging by the hind angles of the prothorax, I think the species will prove to be identical with *chalconcephalus**.

C. quadriguttatus Putz. is probably also the same thing, but I have unfortunately not yet ascertained the whereabouts of Putzeys' types.

CALLISTOMIMUS SIKKIMENSIS, sp. n. (Plate I. fig. 5.)

Length 5.5 mm.

Black. Head metallic green; prothorax red, with a vague dark faintly aneous patch on disk on each side of median line; elytra

* Dr. Holdhaus has kindly compared a specimen of *C. chalconcephalus*, which I sent to him, with Kollar's type in the Vienna Museum, and finds the species to be different. The type is unfortunately a "ruin," so that he cannot send it to me for examination.

with a very faint brassy tinge, each with two interrupted yellow fasciæ; joints 1-3 of antennæ, palpi, and legs flavous; buccal organs, underside of head, epipleuræ of prothorax, and a faint common spot at apex of elytra more or less testaceous.

Head (1.0 mm. wide) convex, moderately and closely punctate, hardly less closely on middle of front than elsewhere, labrum truncate, maxillæ not longer than mandibles; antennæ nearly half the length of body, the 8 apical joints wide, flattened, and quite black. *Prothorax* (1.2 mm. wide) not much wider than long, convex, sides moderately rounded in front, sinuate before hind angles, which are acute, reflexed, and point both outwards and backwards; median line and basal foveæ deep, surface closely and coarsely punctate. *Elytra* (2.10 x 3.0 mm.) ovate, convex, with well marked shoulders, striæ fairly deep and finely punctate, intervals moderately but closely punctate, the punctures hardly confluent; front fascia from stria 3 to margin, transverse, widening a little at margin towards shoulder and tingeing the epipleura with yellow; hind fascia from stria 3 to 9, a little oblique outwards and backwards. Underside shiny, moderately punctate, rather more closely and finely on ventral surface. Practically the whole body is shortly pubescent.

Much smaller than *C. chalconcephalus*; head more finely and more uniformly punctate, eyes less prominent, prothorax red (not æneous), much narrower and more strongly sinuate before hind angles, elytra relatively longer and narrower, more finely punctate, the yellow markings differently shaped.

Sikkim, Gopaldhara (*H. Stevens*), 1 ex. ♂. Mr. Stevens has kindly allowed me to retain the type.

CALLISTOMIMUS SUBNOTATUS, sp. n.

Length 5.75 mm. Width 2.50 mm.

This species bears so strong a likeness to *C. jucundus* m., next described, that I need do no more than point out the characters in which it differs.

Colour (except for elytral markings) identical. *Head* and *prothorax* more coarsely and less closely punctate. *Elytra* more coarsely and confluent punctate, a little more shiny: front spot reddish, larger, elongate, covering the whole shoulder from margin to stria 5 (and including the epipleura), produced backwards along the two outer intervals to very nearly half the length of the elytra; two minute reddish hind spots, one placed on interval 4, as in some examples of *C. jucundus*, the other a little further back on interval 6.

Cambodia, Kompong Keday, April 1914, 1 ex. ♀ (*R. Vitalis de Salvaza*). The type is in the British Museum.

CALLISTOMIMUS JUCUNDUS, sp. n. (Plate I. fig. 2.)

Length 6.0 mm. Width 2.50 mm.

Black. Head æneous, prothorax above and beneath with bluish reflection, elytra with a faint green tinge; mouth-parts

joints 1-3 of antennæ, two spots on each elytron, epipleuræ of elytra adjacent to front spot, and legs testaceous yellow.

Head (1.20 mm. wide) convex, shiny, pubescent, very coarsely punctate; clypeus, neck, and a small foveiform area on middle of front and vertex smooth and polished, eyes prominent. *Prothorax* convex, rather narrow, not much wider than head (with eyes), a third wider than long, sides rounded, sinuate before hind angles, which are acute, reflexed, and directed backwards; median line rather deep; surface closely, coarsely, and confluent punctate, with yellowish pubescence. *Elytra* convex, rather square at shoulder, widest behind middle, nearly twice as wide and two and a half times as long as prothorax, punctate-striate, intervals 2 and 4 a little narrower than the adjacent ones; surface densely punctate (but much less coarsely than prothorax), punctures more or less laterally confluent; front spot small, triangular, behind shoulder, widening from stria 7 to margin, hind spot small, square, at a fourth from apex, covering intervals 6-8. In some examples there is a small additional spot on interval 4, a little in advance of the hind spot. All sterna coarsely, ventral surface more finely punctate, pubescent.

A good deal smaller than *C. quadristigma* Bates, head and prothorax much narrower, the latter darker in colour and less contracted at extremities, elytral puncturation similar, but yellow spots much smaller.

Nilgiri Hills, Ouchterlony Valley, 3500 ft., July, "running among beams on the ground" (*H. L. Andrewes*), 3 ex. ♂ ♀. Bombay: N. Kanara (*T. R. D. Bell*), 2 ex. The type (♂) is in my collection.

CALLISTOMIMUS VENUSTUS, sp. n. (Plate I. fig. 6.)

Length 6.0 mm. Width 2.25 mm.

Black. Mouth-parts (exc. last joint of palpi fuscous), antennal joints 1, 2, and underside of 3, and epipleuræ of elytra (exc. at shoulder) testaceous; head and prothorax blue or blue-green, with red base and side-margins; elytra violet-blue, suture red over intervals 1 and 2, and for basal third over interval 3; two interrupted fasciæ on elytra, apical margin, and legs yellow-white (apex of femora, tibiæ, and tarsal joints fuscous); metasternum and ventral surface (last segment darker) brown.

Head (about 1.0 mm. wide) shiny, a little less convex but more pubescent and punctate than in allied species, the usually smooth space on middle of front with one or two coarse punctures, neck smooth, eyes prominent. *Prothorax* relatively flat, rather small, hardly wider than head with eyes, nearly half as wide again as long, sides rounded in front, contracted behind, and sinuate before hind angles, which are acute and project both laterally and a little backwards; transverse impressions, median line, and basal foveæ all well marked; surface closely and confluent punctate, and pubescent. *Elytra* square at shoulders, nearly parallel, rather flat, twice as wide and three times as long

as prothorax, weakly striate, the whole surface rather dull and finely aciculate-punctate; front fascia at a third from base, not very wide, but widening outwards from stria 3 to margin; hind fascia at a third from apex, of about same width as front one, widening from stria 2 to margin. Underside moderately pubescent, last ventral segment more strongly so and transversely subrugose.

Distinguished from its congeners by its small prothorax, square shoulders, and especially by the fact that the colour of the red scutellary patch extends along the suture to apex.

Laos: Pak Tha, Paklung and Ban Saleun, 16 ex. ♂ ♀ (*R. Vitalis de Salvaza*). The type is in the British Museum.

CALLISTOMIMUS VIRESCENS, sp. n. (Plate I. fig. 7.)

Length 5 mm. Width 2 mm.

Black. Head blue, prothorax red with purplish reflections on upper surface, a sutural stripe on the elytra yellow-red, elytra velvety blue-black with metallic blue-green lustre on shoulders and along sides; two fasciæ on elytra (interrupted by the sutural stripe) and apical margin, joints 1-3 of antennæ, palpi (exc. apex), front margin of labrum, and legs (exc. apex of femora) yellow-white.

Head (about 1.0 mm. wide) convex, shiny, coarsely punctate at sides, smooth and highly polished along median line and on neck; maxillæ as long as mandibles. *Prothorax* very convex, a little transverse, just wider than head, sides bordered and strongly rounded, more contracted behind than in front, hind angles in form of a minute right-angled tooth, with sides of base advancing towards them, median line short but deep; surface coarsely but not very closely punctate, faintly pubescent. *Elytra* punctate-striate, intervals flat, punctate at sides but not evidently so on disk, pubescent, base with a strongly marked border, region of the shoulder irregularly punctate and rugose, epipleuræ coarsely punctate; sutural stripe covering intervals 1 and 2 (more or less), front fascia at a fourth from base, narrow, reaching stria 6, hind fascia at a third from apex, wider, reaching stria 9.

Allied to *C. suturalis* Flt., but a little smaller, hind angles of prothorax less evident, elytra more convex, sutural stripe narrow at apex and lighter in colour, hind fascia much broader, shoulders and sides much more rugosely sculptured. The very coarse puncturation of the elytral epipleuræ at once distinguishes the species from its congeners.

Burma: Tharrawaddy, 2 ex. ♂ ♀ (*G. Q. Corbett*). The type is in my collection.

CALLISTOMIMUS BELLI, sp. n. (Plate I. fig. 8.)

Length 4.25 mm. Width 1.75 mm.

Black. Head dark metallic green with purplish reflections; prothorax brick-red with a small rather faint purplish spot on each side of disk; elytra dark green; mouth-parts, joints 1-3 of

antennæ, underside of head and prothorax (exc. prosternal process and region round front coxæ), epipleuræ of elytra; two interrupted fasciæ on elytra (with a purplish border), a common apical spot and margin, testaceous; legs (exc. apex of femora, which is fuscous) yellow-white.

Head (barely 1.0 mm. wide) shiny, convex, pubescent, coarsely punctate over whole surface (exc. clypeus and labrum), though a little less closely on middle of front, neck smooth, eyes prominent. *Prothorax* moderately convex, rather wider than head, sides rounded and a little sinuate before hind angles, which are acute, slightly reflexed, and directed outwards and backwards; surface densely but not coarsely punctate and covered with a close, dark pubescence. *Elytra* rather ovate, about half as wide again as prothorax, punctate-striate, surface aciculate-punctate and pubescent; interval 2 narrowing towards base and 6 towards apex; front fascia at a third from base, a little wider than in the allied species, extending from the middle of interval 3 to margin, where it widens out both in front and behind, an indentation of the ground colour in front on interval 6; hind fascia oblique (outwards and backwards), extending from stria 2 to margin; apical spot a little larger than in the allied species. Underside moderately punctate and pubescent, prosternal process bordered, last ventral segment transversely substrigose.

Not unlike *C. lebioides* Bates in form, but quite different in coloration. Prothorax less transverse, less coarsely punctate, hind angles much more evident; fasciæ on elytra much wider and extending to margin, an apical white spot (absent in *lebioides*). The species are alike in the absence of a red scutellary patch.

Bombay: North Kanara, Kadra, 11. vii. 1907, 2 ex. ♂ ♀ (*T. R. D. Bell*). The type is in my collection.

CALLISTOMIMUS ACUTICOLLIS Fairm.

CALLISTOMIMUS YUNNANUS Maindr.

Both these species were described from Yunnan, and I have at different times seen the types of both, though I have not been able to compare them. I have before me the type of *yunnanus*, which agrees with Fairmaire's description and with some notes I made on the type of *acuticollis*. I think the species are identical.

I have seen further examples from Djoukoula, Yunnan, in the collection of Mr. H. de Touzalin.

CALLISTOMIMUS D'ABREUI, sp. n. (Plate I. fig. 9.)

Length 4.0 mm. Width 1.5 mm.

Black. Head dark æneous with purplish reflections; prothorax and a scutellary patch red, former with an ill-defined purplish spot on each side of disk; elytra deep green, each with four white spots; mouth-parts, underside of joint 1 and base of joints 1 and 2 of antennæ, epipleuræ, and margin of elytra testaceous, sterna and coxæ reddish, trochanters and femora yellow-white. In the ♂

specimen (type) the tibiae and tarsi are fuscous, in the two ♀ ♀ specimens they are yellow-white.

Head (0.90 mm. wide) shiny, convex, slightly pubescent, coarsely punctate at sides and back, vertex and middle of front smooth and polished, eyes moderately prominent, maxillæ a little longer than mandibles. *Prothorax* narrow, just wider than head, not much wider than long, sides rounded in front, strongly contracted behind, sinuate just before hind angles, which are right; surface closely and coarsely punctate, pubescent. *Elytra* about half as wide again as prothorax, square at shoulder, widest at about middle, punctate-striate, intervals rather convex, the whole surface finely aciculate-punctate, dull viewed from above, but a little shiny when viewed sideways; the red scutellary patch extending half-way to apex, bounded on each side at base by stria 2, but tapering behind; the front white spot, at a fourth from base, extends from interval 4 to margin (it is rounded on intervals 5-7, contracted on 8, and expanded again on 9); the hind spot, also rounded but a little larger, at a fourth from apex, covers intervals 5-7; the two remaining spots are minute, one on interval 3 just behind the end of the scutellary patch, the other at extreme apex. Underside sparsely, ventral surface (exc. at sides) more strongly punctate and pubescent.

India: Central Provinces, Mandla district, Chiriadangra, Nerbudda bank, 7.xii.1916 (*E. A. D'Abreu*), 1 ex. ♂ (type). U.P.: Sitapur, July 1917 (*H. G. Champion*), 1 ex. ♀ (defective) Bihar: Pusa, 1 ex. ♀ — Agric. Res. Inst. Pusa. Mr. D'Abreu has kindly allowed me to keep the type in my collection.

CALLISTOMIMUS MODESTUS Schaum.

Callistomimus amabilis Redt. (*in litt.*) Reis. Novar. ii. 1867, Col. 20.

The species was described from Hongkong, and I have not seen the type; there seems to be no doubt regarding the identification, and, as it is probably the best known species in the genus, I think it unnecessary to prepare a fresh description.

The name *amabilis* was introduced by Redtenbacher, who attributed it to Chaudoir; the latter mentions the name when describing the genus, but attributes it to Redtenbacher. I cannot find that either author published a description, and it seems a pity that it should have got into circulation.

Var. *humeralis*, nov.

Schaum gives no hint of a dark spot on the shoulder, but Bates refers to a small black shoulder-spot on some of the examples taken by Mr. Fea in Burma, one of which is in my collection; the specimen described by Fairmaire from Tonkin is similarly marked. A specimen in the Paris Museum, also from Tonkin, another from Bengal—Sarda (*F. W. Champion*), and other Indian examples in the British Museum, all have this spot more fully developed, and I think the form is worthy of a name.

Var. *insularis*, nov.

Mr. Guy Babault has kindly sent me an example (there being others I understand in his collection) which comes from Java, which has a narrow black longitudinal line behind the shoulder, and in which the two parts of the hind fascia are quite detached from the reddish area in front, so that they appear as transverse whitish spots on a blue-black ground, which covers the apical half of the elytra. In the Brussels Museum there are also three examples of this form labelled "Semarang (*Drescher*)"*; in these the hind fascia is less widely separated from the red area in front.

CALLISTOMIMUS DUX, sp. n. (Plate I. fig. 10.)

Length 7.0 mm. Width 2.60 mm.

Black. Head dark blue, prothorax (above and beneath) dull red with faint purplish reflections, basal two-fifths of elytra brick-red, the coloured area bulging in the middle and reaching to half-way between base and apex, two transverse fasciæ (front one very short, submarginal) and extreme apex yellow-white, joint 1 of antennæ (rest wanting) and legs (exc. apex of femora) testaceous, margin of elytra (exc. just below shoulders) infusate.

Head (2.40 mm. wide) convex, shiny, very coarsely punctate; vertex, middle of front (exc. for one or two punctures), and clypeus smooth, eyes prominent. *Prothorax* (2.60 mm. wide) convex, very transverse, sides strongly rounded, much contracted at extremities, but more so behind than in front, hind angles in the form of a small right-angled tooth, a little in front of apparent base; median line faint, basal foveæ round and deep, surface coarsely and confluent punctate. *Elytra* oval, flat, punctate-striate, intervals nearly flat, finely punctate, (presumably) pubescent; front fascia from stria 5 to 8, merging in colour of basal area, hind one moderately broad, oblique, from stria 1 to 9. Underside moderately and rather coarsely punctate, more finely on ventral surface.

Burma: Prome (*G. Q. Corbett*), 1 ex. ♂. Type in my collection.

The species is so widely different from all others known to me that I have described it with a view to making my note on the Oriental species of the genus as complete as possible. The unique example, however, is defective, especially in regard to the antennæ, tarsi, and buccal organs.

CALLISTOMIMUS NAIR, Maindr., var. *nilgirinus*, nov.

I have in my collection an example of Maindron's species, which I have had the opportunity of comparing with a typical specimen kindly sent to me for examination by Mr. Guy Babault. My specimen agrees almost exactly with Maindron's, which came from Mahé on the Malabar Coast: the only difference I detect is in the elytral fasciæ, which are narrower, the hind one being also

* In reply to an enquiry of mine, Commandant Dupuis writes: "Etiquette de l'envoi reçu du Musée de Sarawak (Bornéo), sans autre précision, mais les insectes provenaient tous, je crois, de récoltes faites dans la région."

less regular in outline and wider near the suture than near the margin. This specimen was taken in the Nilgiri Hills by Mr. H. L. Andrewes, and his note reads "Ouchterlony Valley, December, 3500 ft. Flooded out during irrigation of tea."

A second specimen (σ) was also taken by Mr. Andrewes in the Nilgiri Hills, but I have no note of the exact locality. It is of the same size as *C. nair* and does not seem to differ structurally, but there are distinct differences in the coloration. Joints 5-11 of the antennæ and the front tarsi are brown instead of black; the margin of the elytra is only vaguely reddish, there is only a suggestion of a scutellary red patch, and this does not extend beyond the front fascia; this latter is very small and its sides taper inwards from stria 8 to 4, the hind fascia is rather wider than the front one and extends from stria 8 to 2, neither of the fasciæ reaching the margin. Whether this form will prove to be a local race, or a mere aberration, remains to be seen, and for the present I call it var. *nilgirinus*.

CALLISTOMIMUS LITTORALIS Motch. (Plate I. fig. 11.)

Callistomimus westwoodi Schaum.

Length 4.5 mm. Width 2.0 mm.

Black. Head and front margin of prothorax greenish-blue; rest of prothorax (upper side) and a sutural stripe, bounded at sides by stria 2 and extending backwards to the hind fascia, dull red (the sutural stripe widens to stria 3 at the front fascia); elytra dark blue; two interrupted fasciæ on elytra (exc. on intervals 3, 4 and 9 of hind one, where reddish), apical margin, a common apical spot, and legs (exc. apex of femora and tibiæ fuscous) yellow-white; underside of prothorax, meso- and metasterna, side margins and epipleuræ of elytra, and buccal organs testaceous.

Head (0.8 mm. wide) convex, closely and coarsely punctate, except on neck, clypeus, and middle of front, surface finely rugose, eyes prominent, maxillæ elongate but not really reaching beyond mandibles, labrum emarginate. *Prothorax* (1.10 mm. wide) convex, a little transverse, sides strongly rounded and contracted behind, hind angles small and sharply rectangular, surface moderately but closely punctate and pubescent. *Elytra* (2.75 mm. long) shortly ovate, punctate-striate, pubescent; front fascia at a fourth from base, widening out from sutural line to margin; hind fascia extending obliquely backwards to margin, constricted on stria 4. Underside finely punctate and pubescent.

For a comparison with *C. coarctatus* Laf., see under that species.

I have seen examples from various localities in North, Central and Southern India, but not from Sind. The var. *ceylonicus* Dupuis from Ceylon is apparently a variety of this species and not of *C. coarctatus**.

* I have recently seen a cotype of the variety, which Dr. W. Horn kindly sent to me for examination. It proves as I anticipated to be a var. of *littoralis*.

CALLISTOMIMUS COARCTATUS Laferté. (Plate I. figs. 12, 12 *a*, and 12 *b*.)

Length 5.50-5.75 mm. Width 2.0-2.25 mm.

Black. Head metallic blue; prothorax above (with purplish reflections), and beneath (exc. middle of sternum), a scutellary patch on elytra (tapering rather abruptly at extremity, reaching nearly half-way to apex, and bounded at sides by stria 4), and mouth-parts red; elytra blue-black with faint metallic lustre; two interrupted fasciæ on elytra, apical margin and a common apical spot, palpi (exc. apical joint), underside of joints 1-3 of antennæ, trochanters, femora (exc. apex), upper side of tibiæ (exc. apex), and tarsal joints (exc. apex) yellow-white.

Head (about 1.0 mm. wide) convex, shiny, more or less pubescent, coarsely but not closely punctate, smooth and highly polished on middle of front, vertex, and neck; eyes prominent, maxillæ of approximately same length as mandibles. *Prothorax* (about 1.30 mm. wide) convex, transverse, strongly rounded at sides and contracted behind, sinuate before the sharp—almost acute—hind angles; surface densely and coarsely punctured, pubescent. *Elytra* punctate-striate, intervals moderately punctate, pubescent; front fascia, at a third from base, extending on each side from the sutural red patch at stria 4 to 8; hind fascia, slanting a little backwards from suture towards margin, extending from stria 2 to 9, but not reaching margin. Underside shiny, lightly punctate and pubescent.

Closely allied to *C. littoralis* Metch., but larger. Head less closely punctate, prothorax more transverse and more coarsely punctate, hind angles a little more evident. In *littoralis* the front elytral fascia extends to the margin, and the red sutural patch (which in *coarctatus* stops half-way between the two fasciæ) extends backwards and joins the hind fascia.

The species seems to be confined to the Himalayas. It has been taken in Kumaon by Dr. S. W. Kemp and (in considerable numbers) by Mr. H. G. Champion, in Spiti by Mr. Guy Babault, and in Sikkim by Mr. H. Stevens and Mr. F. H. Gravely. An example from Kurseong is in the collection of Mr. H. de Touzalin.

CALLISTOMIMUS VITALISI, sp. n.

Length 6.5 mm. Width 2.5 mm.

Black. Head (exc. neck) æneous green; upper surface of neck and prothorax (latter with some ill-defined small purplish spots), and a scutellary patch on elytra red; underside of neck and prothorax, joints 1-3 of antennæ, front coxæ and mouth-parts (exc. apical joint of palpi, which is fuscous) testaceous; legs (exc. middle and hind coxæ, and apex of all femora, which are black), two interrupted fasciæ and a common apical spot on elytra, together with margin, yellow-white.

Head (about 1.0 mm. wide), shiny, convex, slightly pubescent, moderately punctate, but smooth on neck, middle of front, and clypeus; eyes prominent, maxillæ hardly longer than mandibles. *Prothorax* (about 1.50 mm. wide), a third as wide again as long, moderately convex, sides gently rounded in front, more strongly

behind, hind angles acute, reflexed, and projecting a little backwards; surface closely and coarsely punctate and pubescent. *Elytra* striate, the striae faintly crenulate, intervals flat, finely punctate and pubescent; red scutellary patch ill-defined, extending about one-third towards apex and to stria 4 at sides; front white fascia at a third from base, narrow, extending on each side from stria 4 to margin, where it widens out towards apex; hind fascia at a third from apex, a little wider than front one, extending from stria 1 to margin, curving a little backwards near margin, but hardly increasing in width. Underside shiny, pubescence faint, a little more evident on ventral surface, sterna coarsely but not closely punctate.

In appearance strongly resembling *C. coarctatus* Laf.; a little larger and less brightly coloured; prothorax wider, less convex, much less contracted at extremities and with more conspicuous hind angles; the hind elytral fascia less oblique, and extending inwards to stria 1 (instead of 2). For Bates this species would have been a *Pristomachus*, on account of the acute and reflexed hind angles of the prothorax.

Tonkin: Hoabinh, 6 ex. ♂ ♀ (*R. Vitalis de Salvaza*). The type is in the British Museum.

CALLISTOMIMUS EUCHARIS Bates.

Putzeys' *C. quadricolor* came from Darjiling, and I do not know where the type is to be found. Bates differentiated his Burmese species from it by the puncturation of the prothorax, apparently the only point of difference which struck him. Mr. H. Stevens has lately sent me from Gopoldhara in Sikkim some specimens which agree exactly with cotypes of *C. eucharis* in my collection, and I think the two species are the same. There must, however, remain some doubt until Putzeys' type is available for examination.

A single defective example in the Brussels Museum, labelled "Central Java, Mt. Oengaran (*A. Koller*)," is evidently a very close ally of this species, but the elytra are a little wider and less deeply striate, the fasciæ being more oblique.

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EXPLANATION OF PLATE I.

Fig. 1.	<i>Callistomimus chulcocephalus</i>	Wied.
2.	"	<i>juvencus</i> Andr.
3.	"	<i>cauliops</i> Bates.
4.	"	<i>rubellus</i> Bates.
5.	"	<i>sikkimensis</i> Andr.
6.	"	<i>venustus</i> Andr.
7.	"	<i>virescens</i> Andr.
8.	"	<i>belli</i> Andr.
9.	"	<i>d'abreui</i> Andr.
10.	"	<i>dux</i> Andr.
11.	"	<i>littoralis</i> Motch.
12.	"	<i>coarctatus</i> Lat.
12 a.	"	" Upper side of head.
12 b.	"	" Lower side of head.

15. On the Molluscan genus *Cochlitoma* and its Anatomy, with Remarks upon the Variation of two closely-allied Forms. By G. C. ROBSON, B.A.*

[Received December 10, 1920; Read March 22, 1921.]

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(Text-figures 1-9.)

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I. INTRODUCTION.

In 1914 Mrs. G. B. Longstaff brought from South Africa to England some living examples of the big land-snails usually referred to the genus *Achatina*. A series of observations was planned by herself and the author upon the habits and later development of these forms. These observations were started early in 1915, and, thanks to the satisfactory way in which the animals acclimatized themselves, have been successfully continued and some interesting results obtained which are given elsewhere (*infra*, p. 379). As certain phases of the behaviour of the two forms represented differed rather sharply and as their specific and generic position was uncertain, an examination of their anatomy was undertaken by the author. The principal object of this paper is to provide additional knowledge of the anatomy of the *Achatininae*; but it also affords an opportunity for discussing how far the individuals of two closely-allied forms agree or differ in all the details of their structure.

The material for this study was presented by Mrs. Longstaff to the Zoological Department of the British Museum (Natural History); and the author is indebted to Mrs. Longstaff, and to Major M. Connolly for information accessory to the study.

The genus *Cochlitoma* was established by Férussac (1821) for a heterogeneous body of forms mostly referable to *Achatina* (s.s.). The name was restricted by Pilsbry (1904) to a small group of the *Achatininae*. Some thirty-five species were enumerated by Pilsbry, and no substantial modification of the genus has been made since. The group is restricted to S.E. and S. Africa though a few forms straggle up the West Coast, and one species is apparently erroneously recorded from Brazil. Our knowledge of the anatomy consists of a very brief description of the late embryo and embryonic shell, shell-lobes, kidney, jaw, and genitalia of *C. zebra*, due

* Communicated by Dr. W. T. CALMAN, F.Z.S

to Semper (1870), a brief description by the same author of *C. granulata* (Krauss), and a short account of some of the internal parts of *C. crawfordi* (Morelet) due to Pilsbry (1904).

II. STRUCTURAL.

1. ANATOMY OF *COCHLITOMA ZEBRA* (Brug.) var. *OBESA*.

Two specimens were available for dissection, both almost fully grown and referable to Pfeiffer's variety *obesa*. They measure 83×47 mm. and 82×47 mm. respectively, and are thus a little shorter than Pfeiffer's type (1854). In the following description the two examples are referred to as z_1 and z_2 respectively.

External Features.

(1) *Shell*.—The conchological status and synonymy has been discussed by Pilsbry (1904). It is necessary, however, to refer in some detail to these features in order to show what relation there is between the variation of external and internal characters.

In Pilsbry's description the *columella* is "arcuate." In z_1 it is perfectly straight and contrasts strikingly with the arcuate form seen in z_2 . In z_1 there is a well-marked callus which is absent in z_2 . The coloration, invariably regarded as an inconstant feature, is markedly different in the two forms. Z_2 agrees with Pilsbry's description, but in z_1 the dark stripes are often twice and thrice the size of the white ones. Both examples have $7\frac{1}{8}$ whorls. The aperture varies. In z_1 it is wider and shorter than that of z_2 , measuring 48×27.5 mm. as compared with 50.5×26 mm.

The sculpture is, as Pilsbry says, granoso-decussate. But in both forms the spiral striæ are weak, so that, as a result, the transverse ribbing is more marked than in the variety *fulgurata*. In z_2 the spiral striation is stronger than in z_1 . This sculpture starts at about half-way round the second whorl in z_1 and three quarters of the way round the second whorl in z_2 . It is continued in both cases to the end of the sixth whorl. A peculiar character seen in the var. *fulgurata* as well, viz. the enlargement of some of the longitudinal bands of granules, is seen in a weak condition in z_1 , but is absent in z_2 . There is, however, in the same position an abrupt enlargement of all the granules.

(2) *Coloration*.—This is more fully dealt with in Mrs. Longstaff's paper.

(3) *Mantle-folds, etc.*—The cervical lobe was thick, narrow, and pointed in z_1 . That of z_2 differed only in being much longer. The posterior lobe is irregular in shape and has two main surfaces, one vertical (between which and the cervical lobe the anal canal runs) and one horizontal. The latter is continuous with the shell-lobe.

(4) *Anus, etc.*—The *anus* and *pneumostome* lie more or less closely together. The latter is interior to and rather below the

former. The *ureter* opens by a wide and non-plicate aperture anteriorly to the anus. In front of the ureter lies a small lobe. A certain amount of distortion made it impossible to compare z_1 and z_2 in this respect.

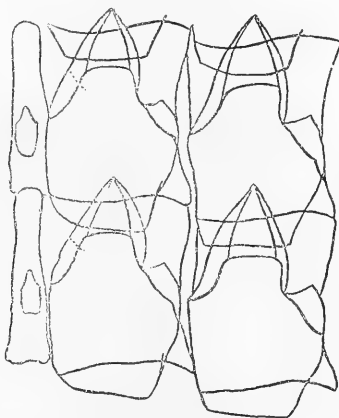
Internal Anatomy.

(1) *Alimentary Canal.*

The jaw was examined only in the case of z_2 , that of z_1 being previously damaged.

Viewed anteriorly the *jaw* is markedly lunate and its antero-dorsal surface is very wide. The interior surface is covered by a fairly dense cuticle which is continued backwards and round the sides and bottom of the mouth. It is more dense dorsally and is continued posteriorly for about 5-6 mm., but is not continued on to the antero-dorsal plate. There is on this cuticle a faint but definite striation. The weak ribbing seen in var. *fulgurata* is represented only by a few irregular faint dark lines which can be seen under a high power.

Text-figure 1.



Cochlitoma zebra var. *obesa*.

Radula; median and admedian teeth. Position of degenerate entocone shown by dotted line.

The *radula*. (Text-fig. 1.)

Formula:— z_1 80. 1. 80. $\times 133$.

z_2 69. 1. 69. $\times 133$.

Another example from the }
Gwatkin collection } 67. 1. 67. $\times 124. \pm 1$.

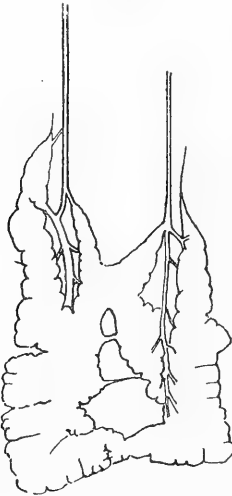
These figures represent maxima.

For the purpose of this study only the median, the first two admedian and the adlateral teeth were compared.

All the specimens examined showed a slender median tooth with simple, rather piriform cusp. In z_2 this is abnormal and irregularly bicuspid. The admedian teeth have large heavily conical mesocones, rather weak ectocones, and degenerate entocones. In z_2 the latter were very meagrely developed. The base of the mesocones is very heavy, broad, and deep. Its inferior edge is usually, but not always, turned upwards and outwards. The adlaterals (e. g., about the fortieth) are bicuspid with low stout mesocones and a very deep narrow basal plate.

The *pharynx*.—The attachment of the pharyngeal muscles is semilunar in shape. It will be more fully discussed under var. *fulgurata*. There is an exceptionally short œsophagus passing

Text-figure 2.

*Cochlitoma zebra* var. *obesa*.

Salivary glands.

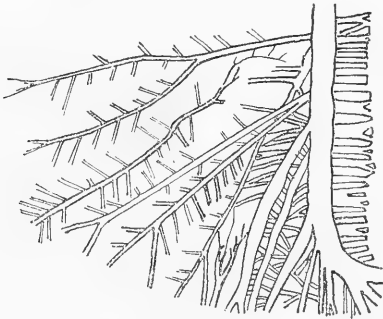
into a *crop* measuring approximately 20 mm. ± 3 . Interiorly the latter exhibits a number of longitudinal folds with transverse secondary connecting ridges, which form a rough trabecular system. In both examples the crop is covered by the salivary glands. The ducts of the latter originate in the usual position. The glands themselves are in both cases asymmetrical, the left being larger than the right. They are joined together in the median line by two organic connections, one anterior, the other posterior. Pilsbry (1919) mentions that the glands of *Achatina schweinfurthii* von Marts. are similarly joined, but only anteriorly. Between z_1 and z_2 are several considerable differences in detail.

The crop is succeeded by a narrow continuation of the œsophagus which fairly rapidly widens into the anterior part of the *stomach*, which is thin-walled and crescentic. At the base of the third whorl this gives off a large reniform, muscular sac which may provisionally be regarded as the representative of the cæcum found in many Prosobranchs, Opisthobranchs, and certain Basommatophora. This structure has been noticed by Wiegmann (1898) in *Achatina panthera*. It is not present in all Stylommatophora, but occurs in *Bulinus (Borus) ovatus* and *proximus* according to Plate (1896). Owing to the fact that the anterior part of the stomach opens close to the pylorus of the intestine, we may fairly assume that the large muscular part does represent the originally smaller cæcum. The muscular portion receives the posterior hepatic duct and is very thick-walled, its inner surface being furnished with characteristic ridges. A more detailed description of these organs is given under var. *fulgurata*.

(2) *Circulatory and Respiratory System.*

As both animals had been dead for some time previous to dissection, it was impossible to make an injection of the circulatory system. This is all the more to be regretted as some

Text-figure 3.



Cochlitoma zebra var. *obesa*.
Anterior end of pulmonary vein.

interesting results might be expected from the study of the elaborate cerebral vascular system noticed when dissecting the circumœsophageal nerve complex. The *pericardium* is under one-third the size of the kidney, a smaller proportion than usual. The *auricle*, as usual, is thin-walled and is attached to the adrenal wall of the pericardium for about one-third of its length. It is irregular in shape, but presents a broad end to the *ventricle*. The latter is of a narrow, ovoid shape and is slightly shorter

than the auricle. Paired auriculo-ventricular valves of a simple nature were found; but apparently there is no aortic valve. The course of the *aorta* was not followed, but its anterior branch was found passing into the pharynx in the usual position; before doing which, it gives off several branches which contribute to the cerebral vascular system referred to above. The *pulmonary vein* (text-fig. 3) is very large. On its left-hand side and particularly towards the anterior end of the pulmonary cavity, it sends out several large branches which become very much concentrated anteriorly. On the left-hand side there were no particularly large vessels. In z_1 the pulmonary vein lies close to the ureter—on an average 5 mm. from it. In the last respect z_2 differed from z_1 , being much further away from the ureter. The latter condition is seen in *Archachatina bicarinata* (Deshayes (1821)) and also apparently in *Limicolaria*. The anterior concentration of large secondary vessels is seen in *Achatina chrysoleuca* (Pilsbry (1904)) and in *Arch. bicarinata*.

(3) *Renal System.*

The kidney measures $58 \times 11-12$ mm. in z_1 and $42 \times 9-10$ mm. in z_2 . Anteriorly it narrows off slightly to an obtuse point. Posteriorly it exhibits a curious diagonal groove on its under surface which separates off a sort of posterior lobe. This occurs in both z_1 and z_2 ; but it is doubtful whether it is of systematic value, though it was absent from both specimens of var. *fulgurata*. Another interesting feature is the presence of a sort of "heel" projecting from the posterior end of the kidney. In both forms this was disposed in prolongation of the main axis of the organ.

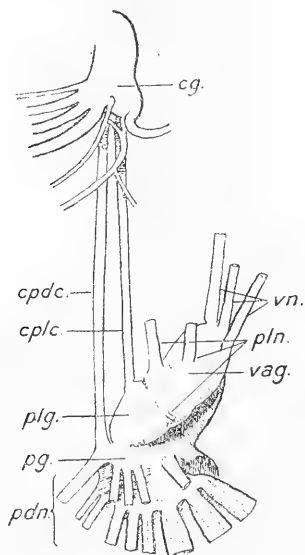
(4) *Nervous System.* (Text-fig. 4.)

General.—In the adult the central nervous system is covered over by a dense layer of connective tissue which involves the main ganglia and roots. This layer, which has been commented upon by previous authors (Nabias (1894)), is exceedingly difficult to dissect away even in young forms, while in most adults it appears to have complete histological union with the surface of the ganglia. In young forms it is less extensively developed, less closely applied to the ganglia and more hyaline. The growth of this sheath involves the anterior aorta and its cerebral branches. It is hoped that a future work may be devoted to the study of this sheath. This much may, however, be stated that, whatever functions it may or may not have acquired in the course of its intimate association with the surface layer of the ganglia, it has certainly developed a great importance as providing additional holdfasts for the muscles of the head and anterior part of the body. For example, the rhinophorial retractors appear to be partly dependent on the postero-lateral extension of this sheath. Interesting analogies are suggested by this structure, particularly on the subject of its function as a

protection for the brain and support for muscles, but they must be deferred to a later date.

The cerebral ganglia are joined by a stout commissure. The several elements of the visceral commissure are very closely united, and on the right side no distinction between abdominal and visceral ganglia could be made out. On the left, the line of demarcation between the visceral and pallial ganglia was fairly plain, that between the visceral and abdominal less plain. There are no pallio-pedal connectives, the centres being closely approximated. The pedal centres are likewise intimately fused to form

Text-figure 4.



Cochlitoma zebra var. *obesa*.

Central nervous system (left moiety).

cpdc. = cerebro-pedal connective. *cplc.* = cerebro-pleural connective. *cg.* = cerebral ganglion. *pg.* = pedal ganglion. *plg.* = pleural ganglion. *vag.* = viscer-abdominal ganglion. *vn.* = visceral nerves. *pln.* = pallial nerves. *pdn.* = pedal nerves.

a single mass, all that indicates an originally separate condition being a faint median ventral furrow. The right side of this complex is larger than the left.

Pedal Nerves.—In counting the number of nerve-roots arising from all ganglia, allowance has to be made for a certain amount of error due to the density of the sheath and the consequent impossibility of being certain that adjacent roots are separate. In z_1 there are eighteen pedal roots on the left and sixteen (three

fused) on the right. In both specimens a grouping of the pedal nerves into two tiers, one above the other, could be made out. The upper tier consists of five roots, one anterior three median (usually fused) and one posterior. Certain of the lower tier roots are separate in origin but enclosed together for the first 2-3 mm. of their length in common sheaths of connective tissue. The arrangement of these differs from side to side and in individuals. In z_2 there were seventeen roots on each side.

Pallial and Visceral Nerves.—In neither example can it be asserted that any nerve arises from the pallial centres. The latter (as defined by the position of the cerebral-pallial connective) is clearly marked off posteriorly from its neighbour and no pallial root arises from it on either side. Pallial nerves arise, however, from the posterior ganglion mass (viscero-abdominal). We can only conclude that fusion of ganglia has gone so far that the slight external divisions are not reflected internally. On the right there is only one pallial nerve, on the left three. There are three main abdominal and visceral nerves arising from the posterior end of the complex. Z_1 and z_2 agree in these particulars.

Cerebral Nerves.—From the cerebral ganglia there arise on each side nine roots in z_1 , eight in z_2 . These consist of three large labial and pharyngeal nerves, two rhinophorial, optic, buccal connectives, and two (one in z_2) of uncertain distribution. There is a certain amount of unimportant difference in the position and distribution of the nerves between z_1 and z_2 . The buccal commissure is symmetrical and the ganglia closely fused. On each side six pharyngeal nerves originate from these ganglia, the origin of which is asymmetrical.

The optic nerve is exceedingly slender and arises a little posterior to the rhinophorial nerve. It enters the sheath of the rhinophore above the latter nerve. In z_2 the base of the rhinophore is innervated by a separate nerve arising just anteriorly to the first mentioned rhinophorial nerve. Amaudrut (1886) refers the innervation of the base of the rhinophores in *Achatina panthera* to a nerve arising from the anterior lobe. There is in *C. zebra* no distinction into three distinct lobes as Amaudrut described for his species, though traces of a fairly distinct lobe corresponding to Amaudrut's "lobe de sensibilité" could be seen in z_2 . Again, there is no fine branch of the rhinophorial nerve as there is in *A. panthera*.

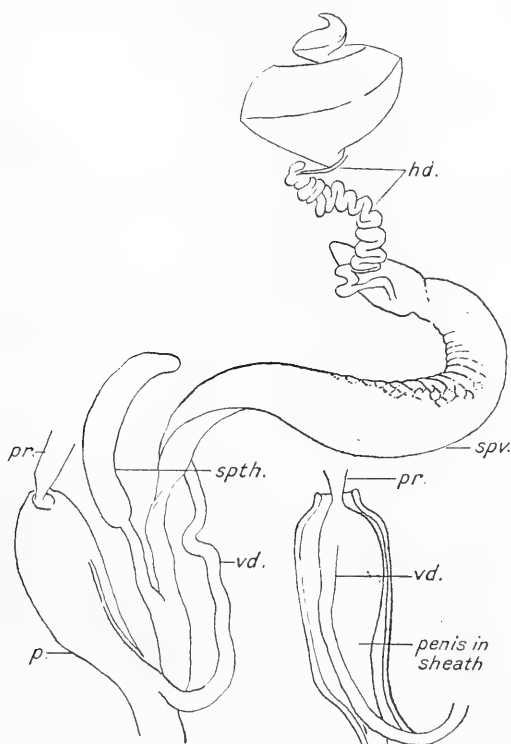
(5) Reproductive System.

Neither specimen dissected was apparently in a state of reproductive activity. The gonad which is situated in the 2-3 whorl, is succeeded by a slender duct which is straight for about 6 mm. and then becomes stouter and more convoluted. In the third whorl this passes into the *spermoviduct*. The male portion of this, as in the Helicidae, forms a sort of gutter incompletely covered by two more or less overlapping ridges. The ducts of the numerous prostatic follicles open into the bottom of

this. The *prostate* invests one side of the spermoviduct over practically its whole length and projects into the lumen of the uterus. The upper end of the latter is much folded, the lower end smooth.

The *vagina* is short (22 mm. in both cases) as compared with the long spermoviduct. The *spermatheca* has a characteristic duct with a broad and stout basal portion narrowing to a short thin

Text-figure 5.

*Cochlitoma zebra* var. *obesa*.

Genitalia. For lettering see text-fig. 9, p. 262.

section which expands to the long, truncheon-shaped spermatheca. The duct measures 17 mm. in z_1 and is longer in z_2 . The latter appears not to have attained its full development, so that the spermatheca may grow at the expense of the duct. The common duct of vagina and spermatheca measures 15.5 mm. in z_2 and only 8 mm. in z_1 .

The *vas deferens* measures 52 mm. in z_2 and 37 mm. in z_1 . It passes to the base of the penis and is inserted into the latter

at a point about two-thirds of the way from its apex downwards. In z_2 the point of insertion is lower down. The penis sheath is *complete*, and the retractor is a branch of the right ocular band.

In the internal structure of the penis there is a marked difference between the two forms. In z_1 the penis fits closely into its sheath. In z_2 the neck of the sheath through which the retractor passes is very much thickened and the retractor passed down it some way before it meets the penis, which is thus shorter than in z_1 .

2. *COCHLITOMA ZEBRA* var. *FULGURATA* (Pfeiffer).

Two specimens were dissected, measuring 115 mm. and 94 mm. These are designated f_1 and f_2 respectively.

External Features.

(1) *Shell*.—The aperture is in both cases more effuse ventrally than in the typical form, and the columella is sinuous in both cases. The sculpture starts in f_1 on whorl $1\frac{1}{2}$ – $1\frac{3}{4}$, in f_2 on whorl $1\frac{3}{4}$ –2. The character of the sculpture was mainly based upon f_2 as f_1 was very much worn. It consists of flattish blister-like decussations of a more delicate texture and quality than in *zebra*. As in var. *obesa* they are crowded at the upper sutures. There is a band formed of enlarged granules running spirally round the upper whorls. In f_2 this is lower down on each whorl than in f_1 . There are eight whorls in each case, and the granules extend as 3–5 sutural rows on to the last but one whorl in f_1 . In f_2 these are only very slightly represented, though the shell is less worn. The character of the colour banding varies a good deal between the two specimens, but it is substantially different from var. *obesa*.

(2) *Coloration*.—A detailed account of this feature will be found in Mrs. Longstaff's paper.

(3) *Mantle-folds, etc.*—The cervical lobe is broad and flat in f_1 , narrow and pointed in f_2 . The posterior lobes are not different from those of var. *obesa*.

The *anus* and *pneumostome* lie very much as they do in var. *obesa* and their general character is the same. A special lobe is found parallel to and below the cervical lobe which more or less screens the urinary aperture as in var. *obesa*.

Internal Anatomy.

(1) *Alimentary Canal.*

The *jaws* agree in both cases. They are flatly lunate when viewed anteriorly. The upper surface is of the same average width all the way round and is rather narrow in proportion to its width. There are faint and irregular signs of broad ribbing and traces of faint striation.

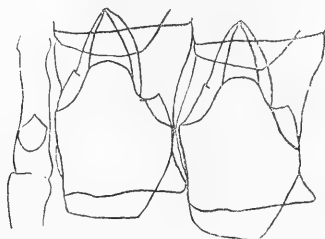
The jaw is at once distinguished from that of var. *obesa* by its narrowness and the parallel edges of its upper plate.

The *radula* (text-fig. 6) has the formula:—

f_1	71.	1.	71.	× 143.
f_2	78.	1.	78.	× 123.

The median tooth is short-cusped and much wider than that of var. *obesa*. The first admedian has a stout but rather low mesocone, a fairly well-developed ectocone, and only the faintest trace of an entocone. It is probable, though not quite certain, that it is less well-developed than in var. *obesa*. The basal plate is uniformly less deep than in the latter, broader and more rectangular. Very little difference can be noticed in the ad-laterals. A curious abnormality was to be observed in f_1 . Commencing at the sixteenth transverse row, a short series of about three rows of teeth is dwarfed and crowded closely together.

Text-figure 6.



Cochlitoma zebra var. *fulgurata*.

Radula; median and admedian teeth.

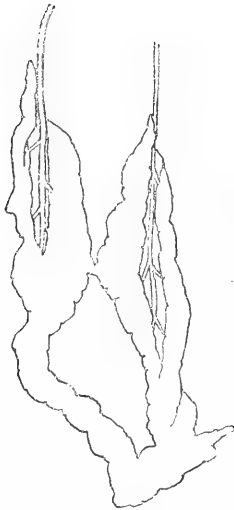
The *pharynx*.—Four main pharyngeal retractors pass through the subcerebral orifice and spread out in a broad fan-shaped fascia which, as in var. *obesa*, has a semi-lunar insertion on the postero-ventral surface of the pharynx. There is a short oesophagus which passes insensibly into the crop. Internally a greater complication of the internal longitudinal folds, a greater frequency of transverse ridges, and a greater general thickness enables us to assume that the crop starts about 10 mm. from the pharynx. Measured from this point the crops of f_1 and f_2 are 39 ± 3 and 26 ± 3 mm. in length respectively.

The *salivary glands* (text-figs. 7 & 8) differ extensively in f_1 and f_2 . In general they correspond to those described above. The crop passes into the anterior part of the *stomach*, in f_1 abruptly, in f_2 gradually. The *stomach* exhibits considerable differences in f_1 and f_2 . Thus in f_1 the shape is piriform and in f_2 irregular. But there is no character which differentiates these forms from var. *obesa*.

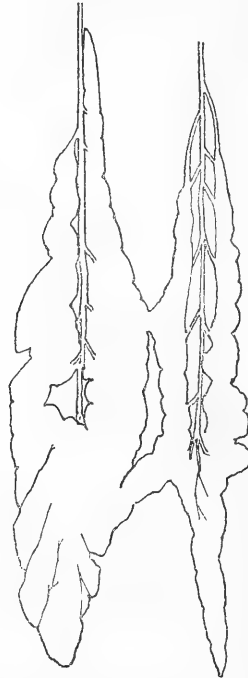
The relation between the anterior and posterior parts of the stomach (or stomach and cæcum) has not been commented upon at any length save in a general way by Wiegmann (1898). The stomach as a whole is bent on itself, and the apex of the bend is

principally occupied by the muscular portion. The floor of the latter shows a distinct ridge which separates the entrance of the fore gut from the intestinal pylorus. The longitudinal muscular folds of the stomach cross this ridge at right angles. In both forms (and in *obesa* as well) the folds begin abruptly on the anterior side of the ridge, cross it and pass down the intestine for a short way. Very characteristic is a strongly developed

Text-figure 7.



Text-figure 8.



Text-fig. 7.—*Cochlitoma zebra* var. *fulgurata*.
Salivary glands (f_2) (semi-diagrammatic).

Text-fig. 8.—*Cochlitoma zebra* var. *fulgurata*.
Salivary glands (f_1) (semi-diagrammatic).

ridge commencing close to the posterior hepatic orifice and running straight down the proximal part of the intestine. Possibly an incomplete or degenerate *typhlosole*, it begins as a thick pillar and gradually diminishes in size. On one side it is bent on itself and accompanied by a smaller narrow ridge, which is separated from it by a narrow space. This space is continued up to the posterior hepatic orifice and round the well-marked angle between the ridge on the floor of the muscular portion and its anterior wall. It passes over on to the anterior side of the ridge and communicates with the anterior hepatic orifice.

In these general features there was no difference between the two varieties or the examples of each.

Neither *intestine* nor *anus* differs from those of var. *obesa*.

(2) *Circulatory and Respiratory System.*

The pericardium is slightly less than half the size of the kidney. In both cases the ventricle is broader and shorter than in *zebra*. The pulmonary vein of f_1 was affected by disease. That of f_2 had its secondary branches more evenly distributed than z_1 and z_2 . As in z_2 the pulmonary vein was a considerable distance from the ureter.

(3) *Renal System.*

The kidney measured:—

f_1	$55 \pm 3 \times 13$ mm.
f_2	$36 \pm 2 \times 14$ mm.

Even with this variation the kidney is in general appearance broader than that of var. *obesa*. There is no posterior groove and the posterior appendage tends to lie *at right angles* to the main axis of the kidney.

(4) *Nervous System.*

The remarks made above (p. 254) about the connective tissue sheath and its general significance are relevant in the case of this variety.

Cerebral Ganglia.—The general shape resembles those of var. *obesa*. The position and origin of the main roots are more or less identical though there are differences of detail. The buccal ganglia are fairly closely approximated in f_2 , but *widely separated by a distinctly differentiated commissure* in f_1 . Each buccal ganglion gives off four antero-lateral and one posterior nerve. As in *zebra*, there are three large labial and pharyngeal nerves. The innermost supplies the lower lip, the next innervates the sides of the mouth and sends a branch to the anterior tentacle (a branch found in *obesa*), while the third gives off lateral and superior labial and a mandibular branch. Behind and above there arises a very slender auditory nerve and behind and above this the rhinophorial nerve.

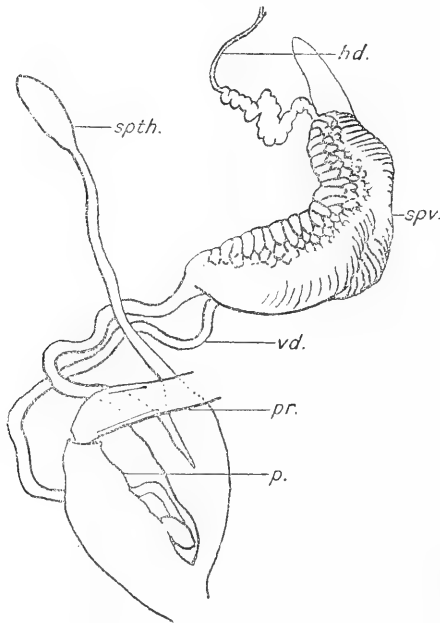
Between this variety and *obesa* the most important differences appear to be the greater apparent differentiation of the "lobule de sensibilité" and the fact that there are only seven nerves aside in this variety.

Pedal Ganglia, etc.—The cerebro-pedal connectives are long and slender. As in var. *obesa* they enter the pedal ganglia in an antero-dorsal position. There is the same tiered arrangement of the pedal nerves, and in f_2 there are seventeen roots aside and probably the same number in f_1 .

There was not nearly so much enclosure of adjacent pedal roots in common sheaths as in var. *obesa*.

Pallial Ganglia, etc.—The cerebro-pallial connectives join the pallial ganglia in exactly the same position in the two varieties, and in this area the arrangement is very similar to that of var. *obesa*. There appears to be no visible distinction between the pallial, visceral, and abdominal ganglia. There is the same asymmetry with regard to the pallial roots, there being three on the left and only one on the right. This asymmetry was observed by Amaudrut in *A. panthera* (1886). The three main abdominal nerves came off a common root in f_2 .

Text-figure 9,

*Cochlitoma zebra* var. *fulgurata*.

Genitalia.

hd. = hermaphrodite duct. *spv.* = spermoviduct. *spth.* = spermatheca.
vd. = vas deferens. *pr.* = penis retractor. *p.* = penis.

(5) *Reproductive System.*

The gonad lies between the second and third whorls. The *hermaphrodite duct*, *spermoviduct*, and *albumen gland* show no difference from those of *obesa*. The *vagina* is long, measuring 27 in f_2 and 34 mm. in f_1 . The *spermatheca* is spatulate in both examples and the duct is long (38 ± 2 in f_1 and 35 ± 2 mm. in f_2). The *vas deferens* measures 56 ± 2 mm. in f_1 and 41 ± 2 mm. in f_2 , and therefore may be regarded as long, though the anomalous

condition seen in var. *obesa* shows that this is not a character to be relied upon. It enters the penis sheath in f_2 half-way down its length. In f_1 its point of insertion is doubtful. With regard to the actual junction of the vas deferens and penis a general approximation is made in f_2 to the condition seen in z_2 . The length of the vagina and the form and proportions of the spermatheca differentiate both examples dissected from var. *obesa*.

III. GENETIC AFFINITIES AND VARIATION OF *COCHLITOMA* *ZEBRA* VAR. *OBESA* AND *FULGURATA*.

The author does not feel justified in altering the position assigned by Connolly (1912) and others to *C. fulgurata* Pfr. as a variety of *C. zebra*. Although it differs from var. *obesa* in certain conchological and anatomical features, conchological intermediates (British Museum, Zool. Dept.) have been found which cannot be disregarded.

It is a commonplace among systematists that between two varieties of a "species" or two "closely allied species" there may be complete agreement in certain respects and difference in others. It is plain, however, that in the case of the two varieties of *C. zebra*, the *individuals* of a variety do not differ from those of a closely allied variety in respect of the *same* characters. Though they may all differ to the same extent from the typical form in respect of, for example, two characters, they do not all show the same degree of difference in their other characters. In the present instance var. *obesa* differs from var. *fulgurata* in having a truncate-shaped spermatheca with a short duct as opposed to a spatulate spermatheca with a long duct, and a shell with narrow brown and white stripes as opposed to broad and jagged stripes of brown and yellow. But one individual of *fulgurata* agreed with *obesa* in having a narrow and pointed cervical lobe, while the other *obesa* had a broad flat one. Of the three forms that agreed in this respect one (z_1) differed from the two *fulgurata* and z_2 in having a straight columella as opposed to a sinuous one. Again, one example of *fulgurata* and one of *obesa* agreed approximately in the length of the vas deferens, while one *fulgurata* agreed with the two *obesa* in the relation of kidney to pericardium and differed from its fellow. Again, the same *obesa* agreed with *fulgurata* (*cf.* above) in respect of the columella, and yet the relationships of the two *obesa* are reversed in respect of the form of the rhachidian tooth of the radula. Two conclusions may be drawn from the above data:—

- (1) That the amount of correlated variation in this case is very slight.
- (2) That the degree of difference or agreement is independent of the type of organ or structure involved; though glandular tissues appear to be more unstable than the others.

The size and possibly the shape of glands, however, are

probably conditioned by the amount of secretion which is usually subject to periodic variation.

The late B. F. Cummings and the present author put forward a suggestion ("X" 1914) that internal structures would probably turn out to be better guides for ordinal and generic characters, while the external structures register specific and varietal differences more readily. There would now be grounds for considering that the internal anatomy is neither more nor less variable than the external structures.

The small amount of correlated variation in these forms, and the irregular fashion in which individuals of a variety agree or differ from those of a closely allied variety, make it very difficult to distinguish the "species" and "varieties" of current taxonomy in this case. The author has come to the same conclusion as Pilsbry (1912), that "a philosophic method of dealing with intra-specific differentiation is one of the greatest needs of systematic zoology." "Species" and "variety" appear to the author, and also apparently to Dr. Pilsbry, to be an association of forms which in their mutual relationship may be singularly unstable and loosely associated. It is not merely a question of the extreme linear or graduated variability with which all naturalists are familiar. In that case species and varieties are equivalent for example to the divisions of time into hours and minutes as convenient, if arbitrary, units. In the present case, however, the large amount of uncorrelated variation between *individuals* of a "variety" leaves a very strong suspicion in the mind that along with linear (or graduated) variability there may exist a radial* tendency of association which cannot be expressed in arbitrary subdivisions. If this impression is substantiated by other evidence it will remain to discover which of the two tendencies corresponds more closely with the results of cytology and genetics. The author is indebted to Professor Duerden for permission to state that certain conclusions arrived at by him in the course of work upon the Ostrich are in line with the facts recorded above.

IV. ON THE CLASSIFICATION OF THE *ACHATININÆ* AND THE POSITION OF THE GENUS *COCHLITOMA*.

Pilsbry (1904) has taken the shell as his basis for arranging the twelve genera of Achatininae, and his first subdivision into two main groups depends upon the presence or absence of sculpture on the embryonic whorls. We cannot, however, disregard the fact that examination of a number of examples in the British Museum collection has made it clear that the sculpture of the embryonic whorls of these forms differs in individuals of the same

* The antithesis between *linear* and *radial* variation used in this connection may be criticized as vague. It is difficult, however, to find two terms which express adequately the fact that an individual of a "species" placed in a series presumed to express descent may, however, exhibit characters which qualify it for a place in another series not necessarily expressing the same line of descent.

species. Thus, in two examples of *Burtoa nilotica* the commencement of the sculpture varied from whorl $2\frac{1}{4}$ to whorl $3\frac{1}{4}$. The result of this is that it is possible to find examples of species placed by Pilsbry in his first group ("embryonic whorls sculptured") with sculpture starting in exactly the same spot as it does in species placed in the second group. For example, in the two examples of *C. zebra* var. *fulgurata* in the British Museum the sculpture starts on whorl $2\frac{1}{4}$, the same position as in an otherwise typical *Burtoa nilotica*. A more serious consequence is that Pilsbry's arrangement cuts right across several other potential arrangements of equal and possibly greater importance. The character of the penis retractor which is either inserted on the diaphragm or on the right ocular bend, that of the penis ring-muscle, whether a complete sheath or annular, and the character of the admedian teeth, whether having three, two, or one cusps, are three out of many characters which might be used as a basis and, if used, would give a different arrangement of the genera and species.

If a classification based upon the *shell* gives (as it certainly does) a different result from that based upon the radular characters, and if the latter yields a different scheme from that based upon the insertion of the penis retractor, it is plain that any classification based upon a single character must be arbitrary*. What is required is a complete knowledge of the variation and mode of inheritance of all the important structures in each genus and a classification based upon the greatest measure of agreement among the various forms.

The anatomy of all the genera and species of this subfamily is not known. It may be, therefore, argued that a provisional arrangement based upon the only organ known in the species, viz. the shell, is justified.

If, however, the object of classification is a correct arrangement expressed in terms of relationship, it would seem best, in cases such as the present, to select from all the available data a combination of the more important characters as a basis and to arrange the species upon it as far as possible, even if some are left vaguely designated as "Achatina." The selection of a character (in this case the shell) that will enable *every* species, whether known completely or not, to be given a definite place, involves the production of a scheme that sooner or later has to be revised, if not abandoned altogether.

With regard to the conchological genus *Cochlitoma* itself, only three species are known anatomically, and of these only the two varieties of *zebra* are known in any detail. But it is very doubtful whether these four forms are referable to the same genus. *C. crawfordi* differs from the others in the remarkable insertion of its penis retractor. *C. granulata*

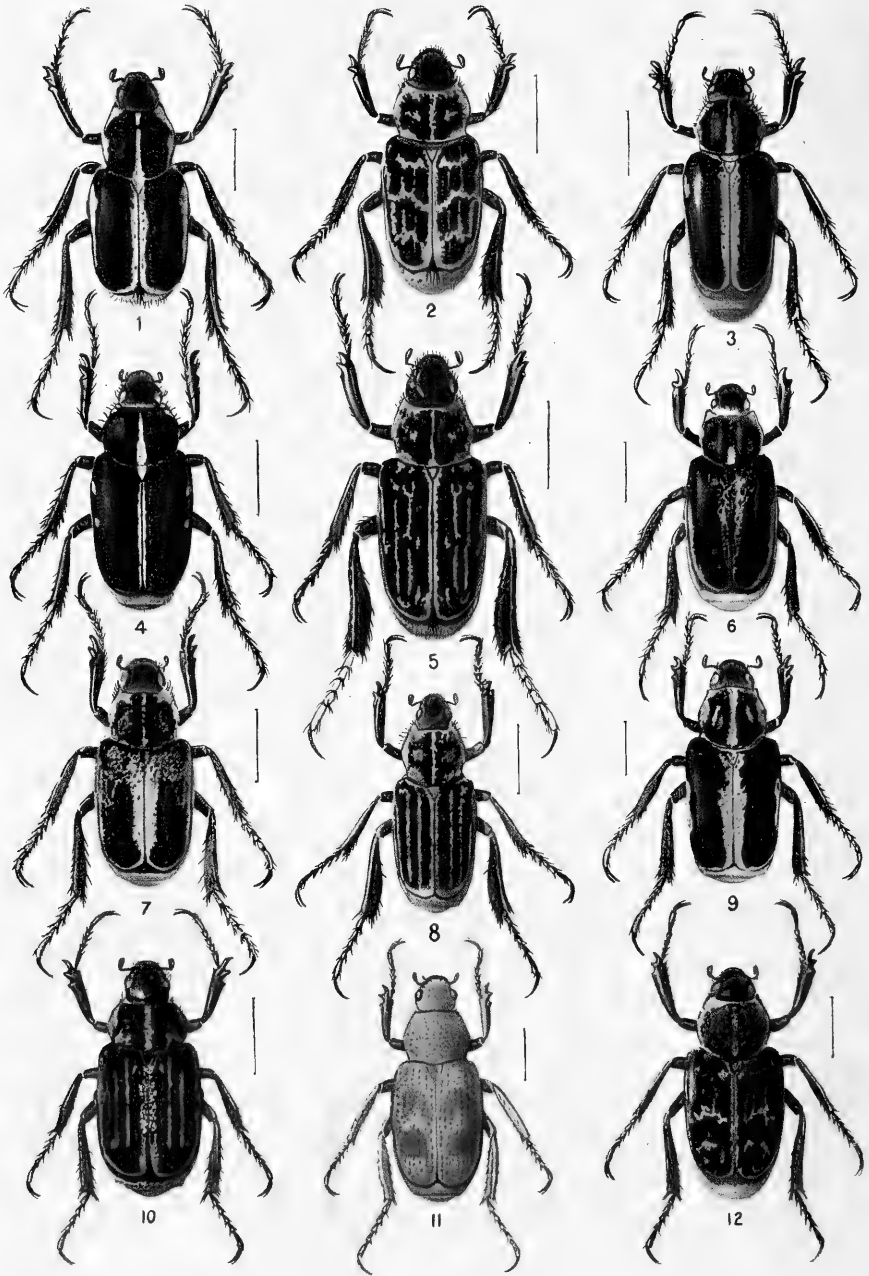
* *Note*.—It is conceivable that intensive study may show that, within a given genus, one organ or structure reflects genetic modifications better than others. But this has yet to be proved.

does not fall into line in the character of its penis sheath. These two forms also appear to be separate from the other forms in respect of the jaw (*v. supra*). Conchologically some of the forms included are indistinguishable from *Achatina* (s.s.). We therefore conclude that the present conception of the genus *Cochlitoma* is unsound. Fresh data are, however, necessary before a final arrangement of the forms involved can be made.

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Terzi, del.

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BETLES OF THE GENUS ECTINOHOPLIA.

16. A Revision of the Melolonthine Beetles of the Genus *Ectinohoplia*. By G. J. ARROW, F.Z.S., F.E.S.

(Plate I.)

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The genus *Hoplia* contains an enormous number of species, often of great beauty but extremely variable and difficult to discriminate. Attempts to divide it into smaller genera have not been very satisfactory, but *Ectinohoplia*, containing a number of Oriental species of moderately large size, distinguished by the propygidium not being covered by the elytra, in addition to the existence (generally) of a tuft of bristles at the extremity of the elytral suture, is fairly well defined. Some of its species, however, have not been referred to it, and others have been described under more than one name. I have therefore attempted a revision of the genus, and the accompanying key to the species includes all those at present known to me as members of it. The striking difference in the coloration of the scales which distinguishes the two sexes of some of the species has hitherto not been noticed. Contrary to the general tendency in insects, the females of some of the species are remarkable for the occurrence of splendid golden, silvery, or iridescent scales, replaced by dull scales in the other sex.

Although differences of this kind are not very unusual, it is almost invariably the male which shows the brighter coloration; and it is therefore interesting to observe in the exceptional instances here brought to notice that the brilliant clothing of the females is almost confined to parts of the body where it is concealed in the ordinary position.

In the male of *E. suturalis* (Plate I. fig. 1) the whole of the scales, of the upper and lower surface alike, are of a uniform pale non-brilliant blue, in striking contrast to the yellow and golden scales of the female (Plate I. fig. 3), in which, however, those of the upper surface are not brilliant, while upon the abdomen they are of the richest gold and pale metallic blue. Under a high power of the microscope the difference is seen to be due to a fundamental difference in the individual scales. The golden scales of the female are deeply pigmented and completely smooth, but the dull blue scales of the male are devoid of pigment and the surface is covered with a dense clothing of fine hairs or hairlike outgrowths, to which the opacity and blue colour are evidently due. A remarkable change is effected by moisture upon the opaque scales, which immediately become metallic and glistening.

E. auriventris Moser has a similar sexual difference, the scales of the lower surface, pygidium, and propygidium being golden in the female and opaque orange-coloured in the male.

In several of the new species here described the females have the median part of the body beneath decorated with beautiful silvery or iridescent scales.

The first to deal with any species of *Ectinohoplia* was Wollaston, who bestowed the name *Hoplia paiva* on specimens taken by Fortune in "N. China." These specimens actually consisted of two species, typical specimens of both of which were bought by the British Museum in 1855 and 1858, labelled "N. China (Shanghai)." Wollaston regarded them as belonging to a single species, but the form which he described as typical, and to which I restrict his name, is that subsequently called *Ectinohoplia variegata* by De Borre, and again described by Reitter as *E. variabilis*, by Fairmaire as *nigrotincta* and *guttaticollis*, and lastly by Moser as *E. tonkinensis*. Wollaston's second form is *E. hispidula* Reitter.

E. suturalis De Borre was re-named *chrysuræ* by Reitter and, again, *luteostriata* by Brenske, while *E. diabolica*, of Reitter, is a dark variety of it. All these names were applied to the female form alone, this being apparently the more numerous sex, for I have seen 46 specimens as compared with 14 males.

I do not know *E. davidis* and *pictipes*, of Fairmaire, *E. huttenbacheri* and *mus*, of Nonfried, or *E. trichota*, of Jakowleff, some of which may not belong to the genus, and these are therefore omitted from the following Table of Species. *E. latesuturata* Fairm., also omitted, belongs to the genus *Hoplia*.

Synoptical Table of the Species.

1 (32). Hind claw entire.	
2 (29). Mesonotum not covered with glistening blue scales.	
3 (22). Not very elongate; hind tibia not much dilated.	
4 (21). Pygidium not brilliant.	
5 (16). Pronotum without tubercles.	
6 (13). Pronotum without close erect setæ.	
7 (12). Pronotum without black patches.	
8 (9). Clypeus straight in front	<i>rufipes</i> Mots.
9 (8). Clypeus evenly rounded.	
10 (11). Hind femora densely scaly	<i>formosana</i> , sp. n.
11 (10). Hind femora not densely scaly	<i>gracilipes</i> Lewis.
12 (7). Pronotum decorated with black patches	<i>paiva</i> Woll.
13 (6). Pronotum clothed with close erect setæ.	
14 (15). Median elytral bar angular	<i>hispidula</i> Reitt.
15 (14). Median elytral bar straight	<i>triplagiata</i> Fairm.
16 (5). Pronotum bearing tubercles above.	
17 (18). Pronotum with two tubercles	<i>simaticollis</i> Moser.
18 (17). Pronotum with four tubercles.	
19 (20). Surface pale	<i>4-tuberculata</i> De Borre.
20 (19). Surface dark	<i>inscripta</i> , sp. n.
21 (4). Pygidium brilliant	<i>indica</i> Moser.
22 (3). Elongate, with dilated hind tibiæ.	
23 (28). Pygidium dull-coloured.	
24 (27). Hind femora dull.	
25 (26). Elytra with three transverse bars	<i>soror</i> , sp. n.
26 (25). Elytra with two transverse bars	<i>latipes</i> , sp. n.
27 (24). Hind femora brilliant	<i>tibialis</i> , sp. n.
28 (23). Pygidium bright-coloured	<i>auriventris</i> Moser.
29 (2). Mesonotum clothed with glistening blue scales.	
30 (31). Pygidium bearing two black spots	<i>oculicauda</i> , sp. n.

31 (30). Pygidium not spotted	<i>suturalis</i> De Borre.
32 (1). Hind claw cleft.	
33 (44). Scutellum small.	
34 (37). Lower surface entirely dull.	
35 (36). Head densely scaly	<i>obducta</i> Mots.
36 (35). Head scarcely scaly	<i>sulphureiventris</i> Redt.
37 (34). Lower surface more or less brilliant.	
38 (43). Pygidium not shining.	
39 (40). Pronotum deeply trisulcate	<i>flavicauda</i> , sp. n.
40 (39). Pronotum feebly trisulcate.	
41 (42). Sutural line green, complete	<i>affinis</i> , sp. n.
42 (41). Sutural line blue, incomplete	<i>nitidiventris</i> , sp. n.
43 (38). Pygidium brilliant.....	<i>nitidicauda</i> , sp. n.
44 (33). Scutellum large	<i>scutellata</i> , sp. n.

ECTINOHOPLIA FORMOSANA, sp. n.

Picea, supra et subtus squamis fulvo-cinereis, aliis pallidioribus interspersis, densissime vestita, capite pedibusque, femoribus posticis exceptis, squamis opalescentibus minus dense tectis; parum elongata, depressa, clypeo nudo, nitido, margine antico semicirculari; pronoto convexo, quam longiori paulo latiori, lateribus medio-leviter angulatis, antice et postice contractis, angulis anticis acutis, posticis obsoletis, scutello minuto; elytris deplanatis, postice separatim rotundatis, ad suturæ finem setis munitis; pedibus gracilibus, tibia antica dentibus tribus approximatis armata, pedum posticorum ungue integro:

♂, fronte squamis rotundatis parum nitidis sat crebre vestito;

♀, fronte setis angustis sat parce vestito, metasterni et abdominis subtus medio squamis argenteis ornato.

Long. 8.5 mm.; lat. max. 4 mm.

Hab. FORMOSA.

This is intermediate between *E. rufipes* Mots. and *E. gracilipes* Lewis, and is closely similar to each. It is rather smaller than *E. rufipes*, and the narrower, more rounded, clypeus will readily distinguish it. From *E. gracilipes* it differs by its more dull-coloured scales, the rather less slender and more densely scaly legs of the male, and the glistening silvery-blue and pink scales at the middle of the metasternum and abdomen of the female. In the latter sex the forehead is clothed with rather scattered narrow opalescent setæ, replaced in the male by more closely-set large round scales.

ECTINOHOPLIA INSCRIPTA, sp. n. (Plate I. fig. 12.)

Nigra, vel fusco-brunnea, antennis pedibusque rufis, femoribus pallidioribus, corpore subtus, propygidio, pygidio, femoribusque posticis dense squamis olivaceis et flavis intermixtis vestitis (sed fœminæ corporis medio et femorum posticorum squamis aureo-viridibus), femoribus anticis et intermediis haud dense aureo-squamosis, fronte parce aureo-squamoso, pronoti lateribus et angulis anticis dense, disco laxè, squamis olivaceis et flavidis ornato, elytrorum marginibus anguste fasciisque tribus undulatis squamis similibus ornatis; parum elongata, capite setoso, clypeo semicirculari, pronoto quam longiori paulo latiori, dorso transverse

4-tuberculato, lateribus arcuatis, medio vix angulatis, angulis anticis acutis, posticis obsolete; scutello sat minuto, acuminato; elytris quam prothorace multo latioribus, deplanatis; pedibus gracilibus, posticorum ungue integro:

♂, tibia antica elongata, minute tridentata;

♀, tibia lata, fortiter tridentata.

Long. 8.5-9.5 mm.; lat. max. 4.5 mm.

Hab. S. CHINA: Fo-kien.

This belongs to the group in which the claw of the hind tarsus is not cleft at the tip. It is a little more slenderly built than most of that group, darker in the colour of the upper surface, without definite pattern upon the thorax and with the elytral pattern reduced. Sometimes, as in *E. obducta* and *suturalis*, the paler scales are entirely wanting above and the surface a uniform blackish brown. As in *E. 4-tuberculata*, the pronotum bears four tubercular elevations in a transverse straight line across the middle, but that species is quite different in its surface, being almost covered by pale scales. In *E. inscripta* these pale scales are of two similar shades intermixed, but they are scattered upon the pronotum and consist upon the elytra of a fine marginal line and three narrow incomplete transverse bands.

ECTINOHOPLIA *SOROR*, sp. n. (Plate I. fig. 2.)

Nigra, corpore subtus, propygidio, pygidio, femorisque postici parte majore dense sulphureo-squamosis, pronoti margine (postice medio interrupto), linea angusta mediana maculaque parva utrinque, scutello, elytrorum margine angusto (basi excepto), fasciis tribus transversis, prima posthumerali recta, secunda mediana, tertia antepicali, biarcuatis, lineisque tribus exiguis longitudinalibus, femoribus anticis et intermediis sat dense, capitis fronte, tibiis, tarsis, femorumque posticorum extremitibus disperse argenteo-cœruleo-squamosis; sat elongata, capite rugoso, clypeo semicirculari; pronoto quam longiori paulo latiori, lateribus medio angulatis, antice et postice valde contractis, angulis anticis acutis, posticis obtusis; scutello minuto; elytris quam prothorace latioribus, dorso deplanato, ad suturam finem longe setosis; pygidio parce setoso; pedibus longissimis, posticorum ungue integro:

♂, tibia antica dentibus tribus minutis, approximatis armatis, posticis compressis, basi excepto valde dilatis, abdomine subtus fortiter curvato.

Long. 11 mm.; lat. max. 5 mm.

Hab. C. CHINA (Fo-kien): Kuatun.

Very closely related to *E. latipes* and with the legs exactly as in that species. It is a little less elongated, and the sides of the prothorax are a little more sharply angulated in the middle. The scaly clothing of the propygidium, pygidium, lower surface, and legs is identical, as well as the yellow pattern of the pronotum. The elytral pattern is almost the same as in *E. variegata* De Borre. There are three well-marked transverse bars, the first

nearly straight, placed just behind the shoulders, and the other two curved and angulated at the suture. The inner, outer, and hind edges are narrowly margined, and there are traces of three slender lines crossing the transverse bars longitudinally.

I know only a single male.

ECTINOHOPLIA LATIPES, sp. n. (Plate I. fig. 5.)

Nigra, corpore subtus, propygidio, pygidio femorisque postici parte majori dense sulphureo-squamosis, pronoti margine (hoc antice et postice medio interrupto), linea mediana angusta maculaque utrinque parva, scutello, elytrorum margine angusto (basi interrupto), lineis longitudinalibus discoidalibus tribus, fasciis duabus transversis, nonnunquam interruptis, internexis, harum antica posthumerali, recta, postica antemediana, ad suturam angulata, leviter arcuata; femoribus anticis et intermediis posticorumque extremitatibus sat dense, capitis fronte, tibiis atque tarsis disperse argenteo-ceruleo-squamosis; elongata, angusta, capite rugoso, subnitido, clypeo semicirculari; pronoto quam longiori parum latiori, lateribus medio angulatis, antice et postice valde contractis, angulis anticis acutis, posticis obsoletis; scutello minuto; elytris quam prothorace latioribus, elongatis, dorso deplanatis, ad suturam finem setis longis instructis; pygidio erecte setoso, pedibus longissimis, posticis crassis, horum ungue integro:

♂, abdomine subtus fortiter curvato, pygidio elongato, tibiis anticis dentibus tribus minutis parum remotis armatis, posticis elongatis, compressis, basi excepto valde dilatatis.

Long. 11-12.5 mm.; lat. max. 5 mm.

Hab. TONKIN: Chapa (*R. Vitalis de Salvaza*—May, June, July), Paklay (Laos) (August).

This is a very slender-bodied species with a pattern similar to that of *E. nitidicauda* and *paiva*. In its undivided hind claw and the metallic scales confined to the head and legs it shows a closer relationship to the latter. The thoracic pattern is almost the same, but the yellow bars upon the elytra, both longitudinal and transverse, are very slender, and only two of the latter, both situated before the middle, are recognizable. The most distinctive feature of the species is found in the very broad hind tibiae, especially in the male. The abdomen in that sex is very strongly arched and the pygidium longer than it is broad.

ECTINOHOPLIA TIBIALIS, sp. n. (Plate I. fig. 8.)

Nigra, corpore subtus, propygidio pygidioque dense sulphureo-squamosis, pronoti linea integra mediana, margine toto (antice et postice excepto), puncto utrinque, scutello elytrorumque margine angusto integro (basi nonnunquam interrupto), lineis tribus tenuibus longitudinalibus fasciaque transversa interrupta paulo post basin pallide viridi-squamosis, femoribus sat dense, tibiis capisque

fronte disperse aureo-viridi-squamosis; valde elongata, angusta, capite rugoso, setoso, clypeo semicirculari, pronoto quam longiori paulo latiori, lateribus medio angulatis, antice et postice valde contractis, angulis anticis acute productis, posticis obtusis; scutello minuto; elytris prothorace vix latioribus, dorso deplanatis; pedibus longissimis, posticorum ungue integro:

♂, abdomine subtus fortiter arcuato, tibiis anticis dentibus duabus parum remotis armatis, tertio obsoleto, tibiis posticis elongatis, compressis, basi excepto valde dilatato.

Long. 9.5 mm.; lat. max. 4 mm.

Hab. ASSAM.

Like *E. latipes*, *soror*, and *auriventris*, this has the hind tibia dilated beyond its base, especially in the male. It is smaller than any of those species, of the narrowly elongate form of the first and almost identical in colouring and pattern, the scales being quite dull, except upon the head and legs, where they are silvery, those of the hind tibia included. The longitudinal lines of pale scales upon the elytra are almost entire, and there is an incomplete transverse band just behind the base. The scales of the tibiæ and tarsi are much narrower than those of *E. latipes*.

A second specimen, a female, apparently belonging to the species, is from the Khasi Hills, but the single male bears no precise locality. In the female the longitudinal lines of the elytra are interrupted in the middle.

ECTINOHOPLIA OCLICAUDA, sp. n. (Plate I. fig. 4.)

Nigra, pronoti angulis anticis extremis lineaque angusta, mediana, scutello toto, elytrorum margine suturali angusto maculisque minutis externis posthumeralibus, corpore subtus pedibusque (his parce) squamis metallico-cæruleis vestitis, abdominis lateribus, propygidio et pygidio læte aureo-squamosis, hoc basi maculis duabus nigris; elongata, capite rugoso, subnitido, nudo, clypeo parum transverso, margine arcuato, pronoto erecte sat longe setoso, quam longiori tertia parte latiori, antice et postice fortiter angustato, angulis anticis acutis, posticis obtusissimis; scutello minuto; elytris dorso deplanatis, postice separatim rotundatis, ad suturæ finem setis munitis; pedibus gracilibus, tibiis anticis dentibus tribus distantibus armatis, tarsorum posticorum ungue integro.

Long. 10 mm.; lat. max. 4-5 mm.

Hab. TONKIN: Chapa (*R. Vitalis de Salvaza*—May, June).

I have seen females only. The male will no doubt be found to be strikingly different, as is the case with the closely-related *E. suturalis* De Borre (Plate I. figs. 1 & 3), of which also the female only has hitherto been described. *E. oculicauda* (female) is similar in shape and pattern to the latter, but the median stripe, instead of being opaque yellow, is brilliant pale blue, like the lower surface, and the beautiful golden or silvery-blue scales of the pygidium are contrasted with a black eye-like spot on each side at the base.

ECTINOHOPLIA FLAVICAUDA, sp. n. (Plate I. fig. 7.)

Nigra, squamis cœruleis et flavidis ornata, capite nigro, pronoti linea mediana duabusque lateralibus obliquis, elytrorum sutura late, lateribus angustius, squamisque sat numerosis interspersis cœruleis, opacis, pedibus, metasterni et abdominis medio squamis cœruleis nitentibus, pronoto angulis anticis, propygidio, pygidio corporisque subtus lateribus squamis sulphureis vestitis; parum elongata, capite rugoso, setoso, vix squamoso, clypeo semicirculari, pronoto parum latiori quam longiori, 4-carinato, carinis externis obliquis, abbreviatis, lateribus medio angulatis, antice et postice valde contractis; elytris pronoto multo latioribus, deplanatis, ad suturæ finem setis longis instructis; pedibus modice gracilibus, posticorum ungue fisso.

Long. 9–10 mm.; lat. max. 5 mm.

Hab. TONKIN: Chapa (*R. Vitalis de Salvaza*—May, June, July).

This resembles *E. sulphureiventris* rather closely, but is smaller, rather shorter, with the pronotum much more deeply channelled along the middle and on each side, so that four distinct carinæ are formed, the two median ones nearly straight and the two outer strongly oblique. These are always black, whilst the depressed parts of the surface contain blue scales. The scutellum is small and may be with or without blue scales. The elytra are shorter and broader than those of *E. sulphureiventris*, with a similar and equally undefined and variable pattern formed by scales of a rather brighter blue colour, which are densest around the scutellum and along the inner and outer margins. The exposed part of the propygidium, the pygidium, and the lower surface of the body are densely covered, as in the Chinese species, with dull sulphur-yellow scales, but the entire median part of the metasternum and abdomen bear instead scales of a beautiful glistening blue, with which the legs are also adorned, but less densely. There is a denuded patch on each side of the metasternum. In the male the front tibiæ are more elongate and the teeth shorter and much closer together than in the female.

ECTINOHOPLIA AFFINIS, sp. n. (Plate I. fig. 9.)

Nigra, squamis pallide viridibus supra ornata, pronoti linea integra mediana margineque laterali, ab angulo postico intus retrorsum producto, scutello, elytrorum margine integro suturali, sæpe cum margine tenui externo connexo, viridibus, corporis subtus lateribus pygidioque dense viridi-squamosis, illius parte mediana argenteo-cœruleo-squamosa; modice elongata, capite rugoso, setoso, vix squamoso, clypeo semicirculari, pronoto longitudine sua parum latiori, trisulcato, lateribus antice et postice contractis, angulis anticis acutis; elytris postice separatim rotundatis, ad suturæ finem setis longis instructis; pedibus modice gracilibus, posticorum ungue fisso.

Long. 7–7.5 mm.; lat. max. 4 mm.

Hab. ASSAM: Khasi Hills; S.W. CHINA: Yunnan.

Of the same size, shape, and general appearance as *E. nitidiventris*, but with the pattern of the upper surface composed of uniform pale green scales. These form a continuous median line from the front margin of the pronotum to the hind margin of the elytra, round which they are continued, and generally unite with a lateral margin extending from the shoulder. There is also a lateral loop of similar scales on each side of the pronotum formed by a rather broad border, continued round the front angle and almost reaching the hind angle, where it remains open. The pygidium and sides of the body beneath are densely covered with similar green scales, and the median part is clothed with silvery-blue scales, also sprinkled thinly over the legs.

ECTINOHOPLIA NITIDIVENTRIS, sp. n. (Plate I. fig. 6.)

Nigra, squamis supra cœruleis, subtus viridibus ornata, capite nigro, pronoti vittis tribus exiguis, elytrorum vitta suturali postice abbreviata squamisque nonnullis posthumeralibus cœruleis, opacis, pedibus, metasterni et abdominis medio squamis argenteo-*viridibus*, pronoti angulis anticis, propygidio, pygidio corporisque subtus lateribus squamis pallide viridibus opacis vestitis; modice elongata, capite rugoso, setoso, vix squamoso, clypeo semicirculari, pronoto longitudine sua parum latiori, trisulcato, lateribus antice et postice contractis, angulis anticis acutis; elytris postice separatim rotundatis, ad suturam finem setis longis instructis; pedibus modice gracilibus, posticorum ungue fisso.

Long. 7.5-8.5 mm.; lat. max. 4 mm.

Hab. ASSAM (Khasi Hills): Shillong, 3000-5000 ft. (*R. E. Turner*—April, May), Gauhati, 1000-3000 ft.

Closely related to *E. flavicauda* and *sulphureiventris*. As in the former, the scales covering the median part of the metasternum and abdomen are extremely brilliant, but of a pale silvery green instead of blue. It is rather more elongate in shape than that species, the elytra being narrower, and the three sulci of the pronotum are less deep. The scales forming the pattern of the upper surface are of the same bright blue colour but are reduced in number. Those in the thoracic grooves are very few except at the base of the median groove, where they form a triangular patch. The scutellum may or may not bear similar blue scales, and the elytra have a rather broad, elongate, indefinite patch upon the suture, beginning at the scutellum but not reaching the hind margins. There are also scattered scales of the same colour at the sides behind each shoulder, usually not extending beyond the middle. The exposed part of the propygidium, the pygidium and the sides of the body beneath, as well as the front angles of the pronotum, are densely covered with scales of a very pale green colour. The front tibiae of the male are more slender than those of the female. Their teeth are less close together than in the male of *E. flavicauda*.

ECTINOHOPLIA NITIDICAUDA, sp. n. (Plate I. fig. 10.)

Nigra, squamis flavis vel fulvis et aureis ornata, capite haud dense aureo-squamoso, clypeo fere denudato, pronoti marginibus anticis et lateralibus, linea angusta mediana vittaque utrinque obliqua, plerumque abbreviata vel disrupta, elytri singuli marginibus (antico excepto) lineisque duabus angustis nonnunquam fasciis tribus transversis interruptis connexis, fulvis vel flavis, pedibus, propygidio, pygidio corporisque subtus medio pallide viridi-aureis, hujus lateribus sulphureis; parum elongata, capite setoso, clypeo subnitido, semicirculari, pronoto sat brevi, medio sulcato, lateribus medio obtuse angulatis, antice valde contractis, angulis anticis acutis, posticis obtusis, elytris prothorace latioribus, haud elongatis, postice separatim rotundatis, ad suturam finem setis longis instructis, pedibus gracilibus, rufis, posticorum ungue fisso.

Long. 9-10 mm.; lat. max. 5 mm.

Hab. TONKIN: Chapa (*R. Vitalis de Salvaza*—June).

Similar to *E. variegata* De Borre and *E. obducta* Mots., but easily distinguished by the brilliant silvery-green scales covering the pygidium and part of the lower surface. The scutellum also is larger. The scales forming the pattern upon the upper surface are generally ochre-coloured, but sometimes pale yellow or of both tints intermixed. The head bears rather scattered golden scales; the pronotum has a narrow median line, a marginal line, which generally includes the front margin but does not extend past the hind angles, and an oblique mark on each side, sometimes extending from the base to the front margin, sometimes abbreviated in front and sometimes reduced to basal and median spots. The scutellum is larger than in the two species just mentioned, and has usually only a few scattered yellow scales. The elytra, in addition to a marginal line not including the base, have each two narrow longitudinal straight lines on the disc extending from the base nearly to the extremity. There may be also fragments of three straight equidistant transverse bars connecting the longitudinal ones. The scales of the propygidium, pygidium, and legs are entirely pale silvery green in both sexes, and those of the whole median part of the metasternum and abdomen in the female. In the male the latter region is covered with dull yellow and brilliant scales intermixed.

ECTINOHOPLIA SCUTELLATA, sp. n. (Plate I. fig. 11.)

Nigra, pedibus antennisque rufis, corpore toto squamis ochraceo-fulvis atque brunneis dense vestito, corpore supra setis minutis erectis nigris sat aequaliter intersperso, pedibus et capite (feminaeque pronoto antice) aureo-squamosis; convexa, clypeo semicirculari, pronoto fere duplo latiori quam longiori, supra haud sulcato, lateribus medio sat fortiter angulatis, antice et postice valde angustato, angulis anticis acutis, posticis obtusis; scutello

magno; elytris postice separatim rotundatis, ad suturæ finem haud fasciculatis; pedibus gracilibus, posteriorum ungue fisso.

Long. 7·5 mm.; lat. max. 3·5 mm.

Hab. TOKIN: Chapa (*R. Vitalis de Salvaza*—June).

I refer this species to *Ectinohoplia* because the propygidium is almost entirely uncovered by the elytra, but the latter are without the usual tuft of bristles at the sutural angles. The nebulous pattern of the elytra is unlike that of any species of *Ectinohoplia* except *E. indica* Moser, but is of a type common to many species of *Hoplia* (e.g. *H. elegantula* White, *aurantiaca* Wat., *aurotincta* Fairm., etc.). The ground-colour is an ochreous yellow, sometimes with a tinge of green, and there are vague markings of a fawn or pale chocolate colour, consisting of a transverse patch on each elytron behind the middle and a paler, less-defined, and narrower arcuate patch before the middle. The scutellum, the outer margins, and a patch at the end of the suture are also generally darker than the general surface. The lower surface is densely clothed with yellow scales, and those of the legs and the clypeus and anterior part of the head are of a pale golden colour. The species is elongate, with the pronotum distinctly transverse but narrower than the elytra, its sides strongly contracted before and behind, the angles well-marked, the front angles acute, the hind obtuse, and the base lobed in the middle. The scutellum is large and the elytra are little flattened. The three teeth of the front tibia are strong and sharp, and not placed close together. The claw of the hind tarsus is cleft. In the female the scales of the median anterior part of the pronotum are metallic, as well as the whole of those upon the head.

EXPLANATION OF PLATE I.

- Fig. 1. *Ectinohoplia suturalis* De Borre, male.
 2. " *soror*, sp. n.
 3. " *suturalis* De Borre, female.
 4. " *oculicauda*, sp. n.
 5. " *latipes*, sp. n.
 6. " *nitidiventris*, sp. n.
 7. " *flavicauda*, sp. n.
 8. " *tibialis*, sp. n.
 9. " *affinis*, sp. n.
 10. " *nitidicauda*, sp. n.
 11. " *scutellata*, sp. n.
 12. " *inscripta*, sp. n.

17. The Comparative Anatomy of the Tongues of the Mammalia.—III. Family 2. Cercopithecidæ: with notes on the comparative physiology of the tongues and stomachs of the Langurs. By CHARLES F. SONNTAG, M.D., F.Z.S., Anatomist to the Society.

[Received January 24, 1921: Read April 5, 1921.]

(Text-figures 16-36.)

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Introduction.

The papers dealing with the tongues of the Cercopithecidæ which have already appeared are divisible into two groups. In the first group are included papers by Mayer (7), Münch (8), Chatin (4), and Tuckerman (11) on the number and arrangement of the vallate papillæ, and the taste-buds. In the second group the papers give short accounts of the entire tongue, as part of the description of the anatomy of the whole animal or its alimentary canal; and the best examples of papers of this kind are Flower's "Lectures on the Organs of Digestion of the Mammalia" (5).

Most of these papers have the defect that they state one form of vallate papillary grouping for each tongue. I found, however, that all the different forms of vallate papillæ occurring throughout the Cercopithecidæ will be found in most species if a sufficient number of examples of each are examined. Consequently, one should qualify each account by a statement that such and such a type occurs in the majority of examples of, say, *Macacus rhesus*, but other types may appear.

The tongues of the Cercopithecidæ possess characters which unite them to the tongues of the Cebidæ, and separate them from those of the Simiidæ. Their vallate papillæ, at least in my one hundred and forty-nine examples, are never arranged in the Y-form, as in most of the Simiidæ, but adopt the triangular, V-arrangement or double-pair type. The orifices of gland ducts

are more numerous than in the Simiidæ, and the lateral organs possess very different characters. In the Simiidæ, as was shown in my last paper (18), the lateral organs consist either of convex bodies on the sides of the tongue, or of fissures and laminae on the dorsum; in the Cercopithecidæ they consist of rows of fissures and laminae on the lateral borders.

In all the Cercopithecidæ the following structures are absent :—

1. Foramen cæcum.
2. Apical gland of Nuhn or Blandin.
3. Lytta.
4. Plicæ fimbriatæ.

The plicæ may, however, be present in the very young animal (see page 291), and disappear as age advances.

The species of different genera have been arranged in groups, according to their external characters; by Pocock and others, but they cannot be so arranged according to the characters of their tongues. I have arranged my species of *Cercopithecus* according to Pocock's grouping, and it will be seen how the lingual structures vary, sometimes considerably, in each of the groups. As regards classification, I will not go farther than state that the members of the Æthiops-group are the only species of *Cercopithecus* in which the vallate papillæ exhibit the double pair type in a pure or unmodified form.

In most tongues the conical and fungiform papillæ exhibit the usual arrangement in clusters and rows of varying degrees of obliquity, and the conical papillæ have the usual distribution according to size; their points, as a rule, have the usual direction. The fungiform papillæ stretch across the entire dorsum or are absent from the centre, thereby forming a dorsal bounding zone.

Genus PRESBYTES (= SEMNOPITHECUS).

THE PURPLE-FACED LANGUR (*P. cephalopterus*).

Habitat: Ceylon.

Measurements.—Total length 3·7 cm.; length of the oral part 3 cm.; length of the pharyngeal part ·7 cm.; width between the lingual attachments of the palato-glossal folds 1·4 cm.; width of the anterior part 1·5 cm.; thickness in the vallate area 1·1 cm.; thickness of the apex ·2 cm.

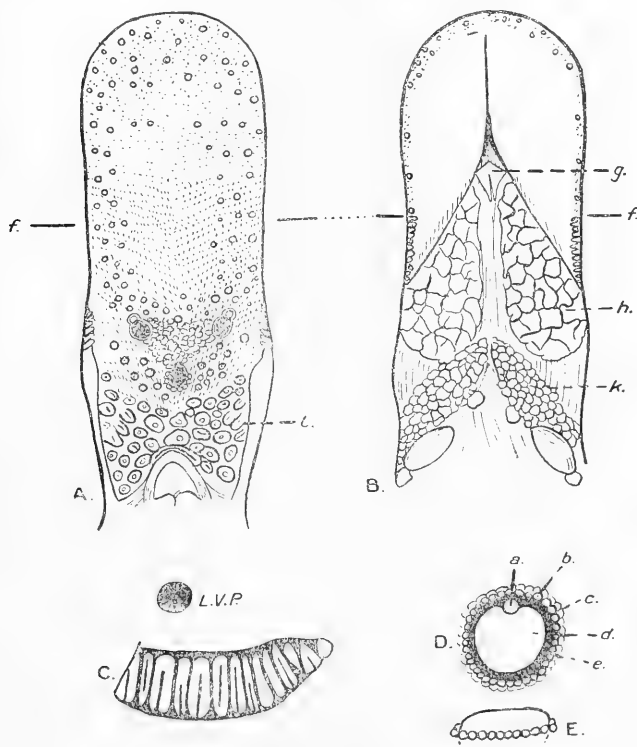
The spatulate tongue has a flat *apex*; the latter is devoid of a notch, and is covered by small conical and fungiform papillæ, but the latter are not numerous. The *lateral borders* are rounded, and have papillæ disposed in the usual manner. The fungiform papillæ thereon are neither numerous nor prominent. They also lodge the lateral organs, which are well-developed, thus agreeing with the description of Boulart and Pilliet (1). The structures mentioned above are absent.

The Circumvallate Papillæ (text-fig. 16 D).

Three prominent, circular, vallate papillæ form an isosceles triangle whose acute vertical angle is directed backwards. All are bluish-black in colour, granular, and have white secondary papillæ at their anterior poles. All the fossæ (text-fig. 16 D, *e*) and vallums are well-marked, and the posterior vallum is coarsely nodulated (text-fig. 16 D, *b* and *c*).

The vallate triangle contains several large conical papillæ, and a large fungiform papilla bisects the base.

Text-figure 16.

The tongue of *Presbytes cephalopterus*.

A. Dorsum ; B. Inferior surface ; C. Lateral organs ; D. and E. Plan and elevation of the posterior vallate papilla (*a*. anterior part ; *d*. main part). Other letters in the text.

The Fungiform Papillæ.

The fungiform papillæ form a dorsal bounding zone on which they have the usual arrangement in clusters and rows, but they have not got the usual distribution according to size. The

posterior rows are close together. All are hemispherical, and their surfaces are smooth or granular.

The Conical Papillæ.

The arrangement, distribution according to size, and course of their points follow the usual type, and the interpapillary dorsum appears as narrow lines.

The Lateral Organs (text-fig. 16 C).

The prominent lateral organs extend over the lateral borders from the dorsum to the inferior surface. The primary sulci are deep, and the laminae, which possess secondary sulci, appear as small rods. Each organ is concave towards the lateral vallate papilla of its own side, for the laminae run in different directions. The lateral vallate papillæ (L.V.P.) are level with the posterior laminae. The anterior laminae run upwards and backwards, the middle laminae are vertical, and the posterior laminae run upwards and forwards. The limits of the organs are shown in text-figs. 16 A, *f* and B, *f*. Each organ is 1 cm. long. The right one has 13 laminae and 14 sulci, and the left one has 13 laminae and 14 sulci. At the anterior end a small fold of mucosa is seen.

The Frenal Lamella (text-fig. 16 B, *g*).

The triangular lamella has a bifid apex. Its crenated edges run postero-laterally as far as the middle of the lateral organs.

The *median ventral* sulcus is shallow and wide, the *frenum* is of moderate length, and the *ventral papillary zone* is narrow.

Glands and Lymphoid Tissue (text-fig. 16 A, *l*).

The whole of the dorsum, behind and at the sides of the vallate triangle, is covered with white circular or oval areas containing round or slit-like orifices. These glands increase in size from before backwards, and their secretions keep the tongue viscid. They are more developed than in the Cercopitheques, Macaques, Mangabeys and Baboons. The viscosity of the tongue remains for a long period, even in preserved specimens.

These large lingual glands are accompanied by an enormous development of the salivary glands (text-fig. 16 B, *h* & *k*).

The lingual and salivary glands of the Langurs form a larger glandular apparatus than in all other Primates. In the case of the lingual glands ocular inspection and microscopic examination must both be employed to estimate their area.

The Physiology of the Lingual Glands and Stomach.

To understand the significance of the great development of the lingual and salivary glands, one must take into account the nature of the diet, the presence or absence of cheek-pouches, the degree of complication of the stomach, and the size of the cæcum.

The LANGURS have no cheek-pouches, large lingual and salivary glands, a complex stomach, and a cæcum of moderate length. They eat leaves almost entirely.

Owen (13) considers that the first part of the stomach replaces the cheek-pouches. I believe his opinion to be correct and would add that the leaves, mixed with the copious secretions of the lingual and salivary glands, lie in the first part of the stomach till insalivation is completed.

The ANTHROPOID APES have no cheek-pouches, a very high development of the basal lingual glands, and a simple stomach. They eat fruits and shoots which are more succulent than the food of the Langurs, and a complex digestive apparatus is not so necessary.

The CERCOPITHEQUES, MACAQUES, BABOONS and MANGABEYS have cheek-pouches, a moderate degree of development of lingual and salivary glands, and a simple stomach. They live on a succulent diet and store food in their cheek-pouches. A little food can be removed from time to time, insalivated thoroughly and swallowed. I would suggest that cheek-pouches are, consequently, part of the digestive apparatus, and not only store-houses.

In the UNGULATA the process of rumination obviates the necessity for largely-developed lingual glands.

The THREE-TOED SLOTH (*Bradypus tridactylus*) resembles the Langurs in the nature of its diet, but the physiology of the tongue and stomach is different. The tongue is mainly mechanical in function, for its gustatory and secretory organs are small. Prehension is its strongest mechanical action. As the stomach contains many hard, almost entire leaves, mastication and insalivation cannot be very complete. Moreover, there are no cheek-pouches to prolong the stay of the food in the buccal area. Consequently, the stomach must soften the leaves for it gets little assistance from the tongue and salivary glands. It also cannot share the process of digestion with the cæcum. The ruminating gutter running through the stomach takes on the regurgitant function of the oesophagus of the Ruminantia.

In the KOALA (*Phascolarctos cinereus*) there are large cheek-pouches, the lingual glands are well-marked, and the salivary glands, especially the parotids, are large. The stomach is simple and the cæcum enormous. The leaves remain long in the buccal area, in virtue of the cheek-pouches, and can be thoroughly moistened and softened. They then pass to the stomach, but the effect of the peculiar gastric gland has not been worked out. The stomach, however, does not play such an important part as in the Langurs and Sloths, for much of its work is taken away by the enormous cæcum.

These remarks indicate that the cheek-pouches are not entirely storehouses, and show how the functions of the different parts are interdependent. They also demonstrate how a diet of leaves requires a complex stomach and small cæcum, or a simple stomach and a large complex cæcum, for its digestion.

THE ENTELLUS LANGUR (*P. entellus*).

Habitat: India.

The tongue differs from that of *P. cephalopterus* in the following respects:—1. It is thicker. 2. The vallate papillæ are smaller and the posterior vallum is more nodulated. 3. The fungiform papillæ are more numerous. 4. The conical papillæ on the base are larger. In other respects the tongues are similar.

In the Capped Langur (*P. pileatus*) the frenal lamella is a broad bilobed plate.

In the Madras Langur (*P. priamus*) the frenal lamella is triangular and bifid, and the apical vallate papilla is small.

Genus COLOBUS.

Flower (5) has briefly described the tongue of the White-thighed Guereza (*C. vellerosus*) as follows:—

“The tongue is long and narrow, with three large circumvallate papillæ forming the corners of a triangle, with the apex directed backwards; close behind each of the large anterior ones is a smaller one of the same form. At the lower part of the frenum is a short, thick, fleshy salivary papilla, constricted at the base, then dilating, and pointed and bifid at the extremity.”

Flower does not describe the condition of the glands on the base of the tongue, but points out that the salivary glands, especially the submaxillaries, are very large, and he gives measurements. As the diet and stomach closely resemble those of the Langurs, and cheek-pouches are absent in the Guerezas, the physiology of the tongue and stomach is similar to those of the former, which I have described on page 280.

The tongues of the members of the genera *Presbytes* and *Colobus*, as will be shown later, differ from those of the other Cercopithecidæ chiefly in the nature of the glands on the base.

Genus CERCOPIITHECUS.

The species are here arranged in the groups described by Pocock (9):—

THE ALBIGULARIS GROUP.

Species examined: *C. preussi*; *C. albigularis*.

PREUSS'S CERCOPIITHEQUE (*C. preussi*).

Habitat: Cameroons.

The conical tongue has the following measurements:—Total length 5·4 cm.; length of the oral part 4·6 cm.; length of the pharyngeal part ·8 cm.; width between the lingual attachments of the palato-glossal folds 2·5 cm.

The *apex* is rounded, and bears many closely-aggregated conical papillæ, and a few small fungiform papillæ. It has no notch. The *lateral borders* are rounded and have the lateral organs at their posterior extremities. The structures mentioned in the introduction are absent.

The Circumvallate Papillæ (text-figs. 17 A & C).

Three papillæ form an equilateral triangle with the apex behind. The two anterior papillæ are smaller than the posterior one, the fossæ are all well-marked, and the vallums appear as clear zones. All are prominent, especially the posterior one, and the surfaces are granular.

Within the vallate triangle there are many large conical papillæ, and a fungiform papilla bisects the base.

Several long sulci and laminae of the lateral organs converge towards the lateral vallate papillæ and end on the outer borders of the vallums. In no other species of *Cercopithecus* is this condition present.

The Fungiform Papillæ.

On the dorsal bounding fungiform zone the papillæ have the usual arrangement, as also on the sides and inferior surface. They are hemispherical or bossed, and the surfaces are smooth or granular. There is no distribution pattern according to size, and the posterior rows are close together. One of them bisects the base of the vallate triangle.

The Conical Papilla.

The papillæ have the usual arrangement in clusters and rows of different degrees of obliquity.

Appearance.—The papillæ of the oral part are dark grey in colour. All of them appear, to the naked eye, like small nodules. Under a pocket lens they appear surrounded by zones of inter-papillary dorsum (text-fig. 17 D), and have bodies of different shapes, with or without processes.

Glands and Lymphoid Nodules.

Small nodules are present on the base, but no duct orifices are visible.

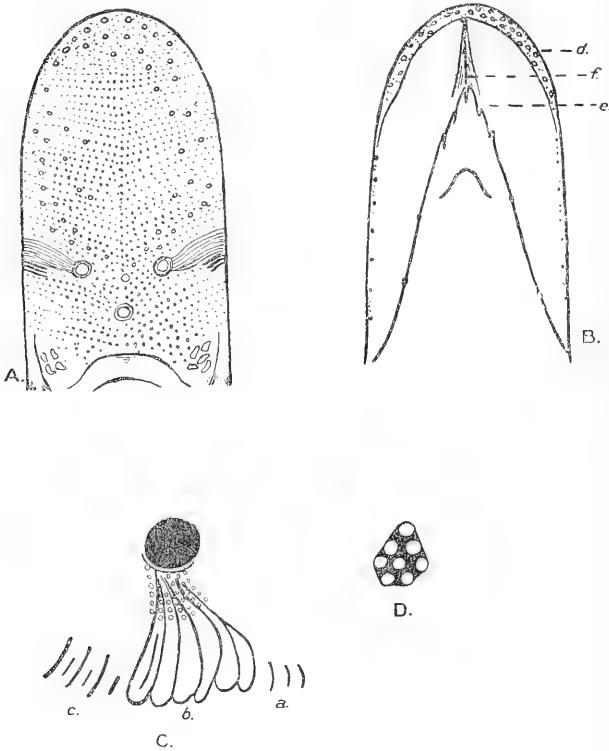
The Lateral Organs (text-fig. 17 C).

The lateral organs begin anteriorly as a number of small ill-defined fissures and laminae (text-fig. 17 C, *a*). These are followed by a series of long tapering laminae and sulci (text-fig. 17 C, *b*) converging towards, and ending on, the vallums of the lateral vallate papillæ, and they are also convex forwards. These are succeeded by a number of laminae separated by sulci which are all parallel to one another (text-fig. 17 C, *c*). Most of the laminae are traversed by secondary sulci. The measurements, etc., are shown as follows:—The right organ is 1.4 cm. long, and has

11 laminæ and 12 sulci. The left organ is 1.4 cm. long, and has 9 laminæ and 10 sulci.

The *ventral papillary zone* (text-fig. 17 B, *d*) is wide anteriorly and narrow posteriorly, and its papillæ have the usual arrangement.

Text-figure 17.



The tongue of *Cercopithecus preussi*.

The Frenal Lamella (text-fig. 17 B, *e*).

The triangular frenal lamella has a bifid apex, and a plain upper surface. Its edges, which extend postero-laterally as far back as the level of the middle of the lateral organs, are fused posteriorly with the under surface of the tongue. They have pointed processes anteriorly and tubercles posteriorly. In no other species of *Cercopithecus* did I find such long, sharp processes.

The *median ventral sulcus* is narrow and deep anteriorly, but widens out posteriorly. It lodges a crest derived from the frenum (text-fig. 17 B, *f*).

In the fresh tongue the vessels on the base were seen, and they

resembled the condition which I have already described and figured for *Macacus* (10).

The outstanding features are, therefore, the great length of some of the laminae of the lateral organs, and the sharp processes on the frenal lamella.

Sykes's Cercopitheque (*C. albipularis*) has an entire, oval, undivided lamella (text-fig. 20 D). Owen (15) described a vallate triangle.

THE MONA GROUP.

Species examined: 1. *C. burnetti* (two examples).

2. *C. mona* (two examples).

I did not observe any pigmented forms in this group.

BURNETT'S CERCOPITHEQUE (*C. burnetti*).

Habitat: West Africa.

When the tongues were examined fresh they did not exhibit the vessels running between the base and the vallate papillae.

Measurements.—Total length 3.2 cm.; length of the oral part 2.5 cm.; length of the pharyngeal part .7 cm.; width between the lingual attachments of the palato-glossal folds 1.5 cm.

The *apex* and *lateral borders* are the same as in *C. preussi*, and the same structures are absent.

The Circumvallate Papillae (text-fig. 18 D).

The vallate triangle has an acute or obtuse vertical angle. It lodges many conical and a few fungiform papillae.

The three papillae, especially the posterior one, are prominent, and the latter appears as if it had been pushed through the vallum, thereby stretching it. All are granular, the fossae are well-marked, and the vallums look like clear zones.

The Fungiform Papillae.

The fungiform papillae are the same as in *C. preussi*, but are more numerous at the sides. None are overlapped by conical papillae.

The Conical Papillae.

The arrangement is similar to that of *C. preussi*. Most of them are cylindrical, and each one is surrounded by a zone of inter-papillary dorsum (text-fig. 18 C). Their surfaces are granular, and there are few points.

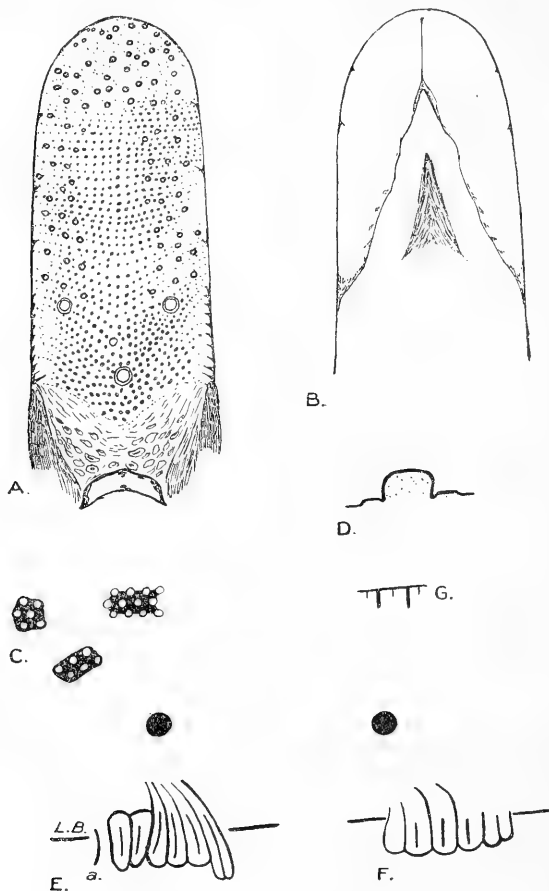
A few *orifices of ducts* are present on the base of the tongue.

The Lateral Organs (text-fig. 18 E, F, & G).

The sulci are narrow, and the laminae lie on both dorsum and lateral borders (L B.) All the sulci and laminae are convex forwards, and secondary grooves traverse the latter. The right organ is .65 cm. long, and has 6 laminae and 7 sulci. The left

organ is .7 cm. long, and has 5 laminæ and 6 sulci. None of them reach near the vallums of the lateral vallate papillæ. False folds of mucosa (*a*) may be present. The laminæ are flat on plan (G).

Text-figure 18.

The tongue of *Cercopithecus burnetti*.

The Frenal Lamella (text-fig. 18 B).

The triangular lamella has an entire apex, and its edges are devoid of tubercles and processes.

The *inferior surface* is otherwise similar to that of *C. preussi*.

When the dorsum is examined by the naked eye it has a finely nodulated surface as in *C. preussi*, and the lens reveals how the interpapillary dorsum forms zones round the conical papillæ (text-fig. 18 C).

THE MONA CERCOPITHEQUE (*C. mona*).

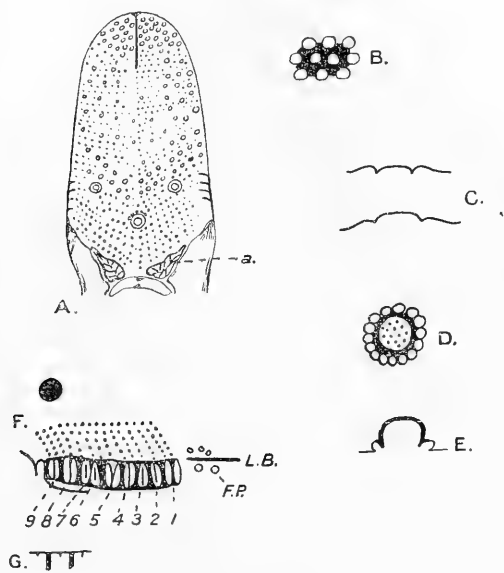
Habitat: West Africa.

The fresh tongues did not reveal the vessels running between the base and the vallate area.

The following *measurements* refer to an adult specimen:—Total length 3.5 cm.; length of the oral part 2.9 cm.; length of the pharyngeal part .6 cm.; width between the lingual attachments of the palato-glossal folds 1.9 cm.

One of my specimens (adult) has an apical notch whence a median sulcus runs back for 1.05 cm., but the young specimen has neither. In other respects, however, the *apex* and *lateral borders* have the same characters, and the lateral parts of the dorsum have the same clusters of fungiform papillæ as in *C. burnetti*.

Text-figure 19.

The tongue of *Cercopithecus mona*.*The Circumvallate Papillæ* (text-fig. 19 C, D, & E).

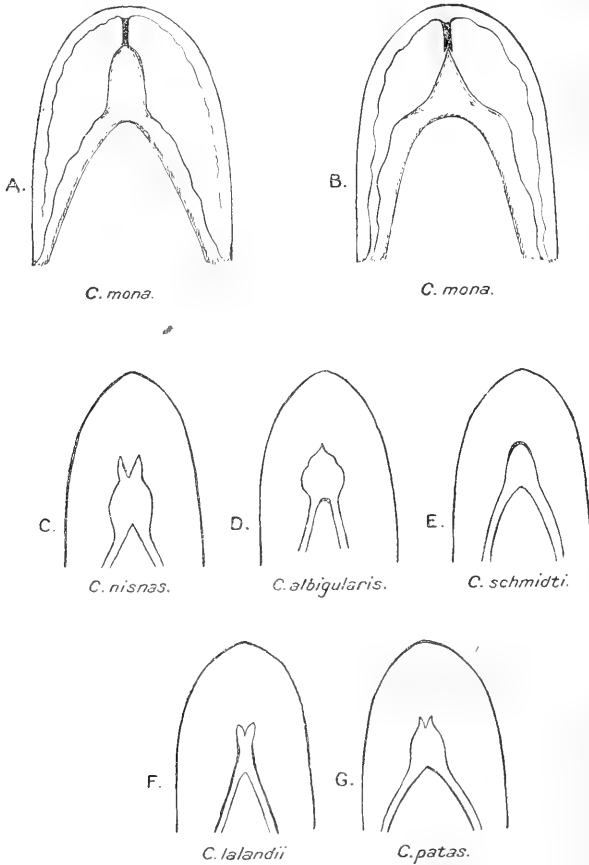
The vallate triangle is isosceles. The three papillæ, especially the posterior one, are prominent as in *C. burnetti*. One tongue has a finely-granular posterior vallum, but the latter is coarsely nodular in my other specimen (text-fig. 19 D). Within the vallate area there are more fungiform papillæ than in *C. burnetti*. The anterior papillæ are oval, but the posterior one is circular,

Münch (8) described a vallate triangle.

The Fungiform Papillæ (text-fig. 19 A & F, F.P.).

On the middle of the oral part of the dorsum the papillæ are small, but those on the lateral parts are large and prominent. The apical cluster contains many large ones. They are hemispherical or umbilicated, and none are overlapped by conical papillæ.

Text-figure 20.



The frenal lamellæ of the Cercopithecues.

The Conical Papillæ.

The conical papillæ have the usual arrangement, but the posterior rows of the oral part of the dorsum are less oblique than in most species of *Cercopithecus*. They are surrounded by zones of interpapillary dorsum (text-fig. 19 B). They also have the usual distribution according to size, and the points run in

the usual directions. The papillary bodies are flat or cylindrical, and the number of points per papilla varies.

Glands and Lymphoid Nodules (text-fig. 19 A, a).

At the sides of the epiglottis there are prominent nodular masses with a few minute orifices of gland-ducts and pits.

The Lateral Organs (text-fig. 19 F & G).

The lateral organs lie on the lateral borders (L.B.) and inferior surface. They consist of short, broad, furrowed laminae separated by short, wide sulci. The laminae do not project (text-fig. 19 G). The right organ is 1.45 cm. long, and has 9 laminae and 10 sulci. The left organ is 1.3 cm. long, and has 7 laminae and 8 sulci.

The Frenal Lamella (text-fig. 20 A & B).

The apex is entire and reaches a point 3 mm. from the apex of the tongue in my adult specimen, and 2 mm. in my young one. It is pointed or rounded. The edges reach as far back as the middle of the lateral organs.

THE PATAS GROUP.

Species examined: *C. patas*; *C. pyrrhonotus*.

THE PATAS CERCOPITHEQUE (*C. patas*).

Habitat: West Africa.

Three specimens were examined, and the following *measurements* refer to the largest one:—Total length 4.8 cm.; length of the oral part 4.3 cm.; length of the pharyngeal part .5 cm.; width between the lingual attachments of the palato-glossal folds 1.9 cm.

In two examples the tongue is yellowish-brown in colour, but in one it is unpigmented. The *apex* and *lateral borders* are similar to those of the preceding forms, except that the apex has a median notch as in *C. mona*. There is no median dorsal sulcus, and the structures mentioned on page 278 are absent.

The Circumvallate Papillae (text-fig. 21 A & F to I).

Three papillary patterns are present in my three examples:—*Specimen No. 1.*—The three vallate papillae form an isosceles triangle with an acute vertical angle. All are prominent, especially the posterior one; they are circular on plan and conical on elevation, the broad ends of the cones projecting beyond the vallums (text-fig. 21 A, H, & F). All have granular surfaces.

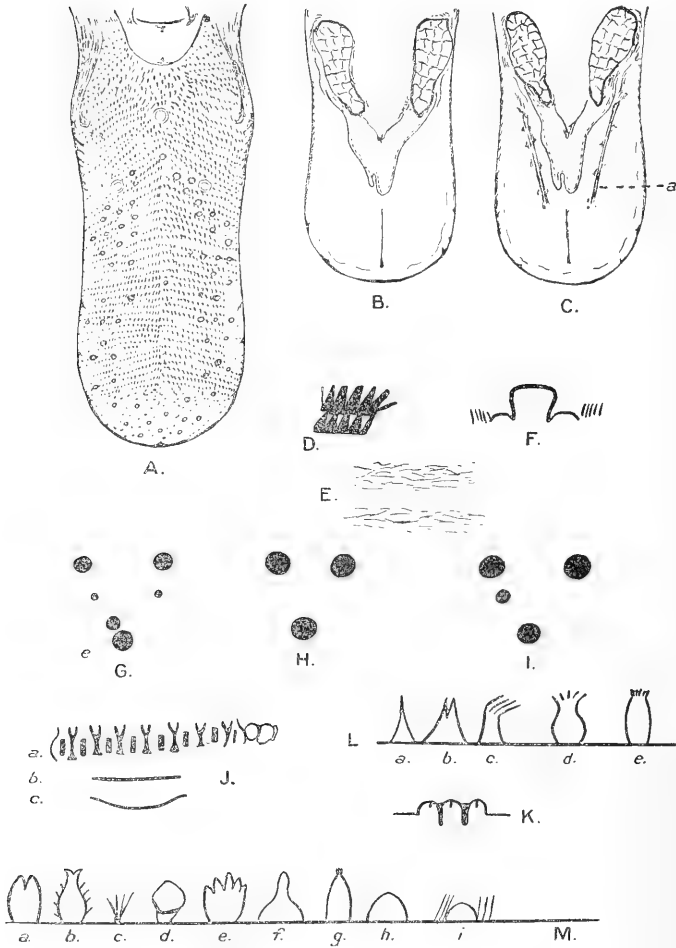
The vallate area contains several prominent fungiform papillae, and is roughened by conical papillae.

Specimen No. 2.—Four vallate papillae form a V. On the left limb, including the posterior papilla, there are three, but the right limb has only two (text-fig. 21 I). The mid left papilla is small.

Specimen No. 3.—Six papillae are arranged in the form of a V, each limb of which has three elements. The most anterior

papilla of each limb is large, and the middle one is small. The left posterior papilla is large, and the right one is small, but both stand on the summit of a common elevation (text-fig. 21 G).

Text-figure 21.



The tongue of *Cercopithecus patas*.

B. Ventral surface of an adult specimen; C. Ventral surface of a young specimen. Other letters in text.

This specimen is an example of a double-pair type greatly modified by the addition of small papillae.

The Fungiform Papillæ.

The fungiform papillæ stretch right across the dorsum, but have the usual arrangement in clusters and rows.

All of them have granular surfaces and are hemispherical, bossed or collared. Those which are included within the vallate area may be mistaken for vallate papillæ, but a careful examination reveals the absence of fossæ and vallums.

There is a variable amount of overlapping or concealment by long conical papillæ (text-fig. 21 M, *i*), especially in the case of the fungiform papillæ within the vallate triangle where the conical papillæ form prominent processes.

The Conical Papillæ (text-fig. 21 L & M).

The conical papillæ have the usual arrangement in clusters and rows, and their disposition according to size takes the usual form. Their points, however, face in all directions.

Most of them are filiform and make the dorsum shaggy, but not to such an extent as in *C. æthiops*. The points form rows, and between them one can see strips of interpapillary dorsum (text-fig. 21 D & E). The number of points to each papilla varies greatly from one to a brushwork.

The Lateral Organs (text-fig. 21 J, *a, b, c,* & K).

The appearance presented by the lateral organs differs greatly from those of *C. preussi* and *C. burnetti*. The sulci are wide, so the laminae, which are small and rounded, appear like a row of small oval bodies. Each lamina is traversed from without inwards by a broad, shallow, secondary sulcus, and a row of conical papillæ runs backwards and inwards across the dorsum from the inner end of each ridge. The measurements, etc., are given as follows:—

<i>Organ.</i>	<i>Length.</i>	<i>Laminae.</i>	<i>Sulci.</i>
Right	1.25 cm.	10	11
Left	1.5 ,,	9	10

The organs may appear as straight rows or curved lines (text-fig. 21 J, *b* & *c*).

The Frenal Lamella (text-fig. 21 B & C; 20 G).

The apex is bifid, and the halves taper from a broad base. The plain edges run postero-laterally to the level of the middle of the lateral organs. The points are rounded or sharp, and may or may not be equal in size.

Plicæ Fimbriatæ (text-fig. 21 B & C *a*).

Plicæ are absent in all my adult specimens, but are present in the young one, so they may disappear as age advances. They begin anteriorly at the level of the apex of the free part of the frenal lamella, and run postero-laterally for 1.8 cm. The mucosa

between them is more smooth and polished than that of the rest of the inferior surface of the tongue.

The *median ventral sulcus* contains a median crest, which, however, is narrow.

THE NISNAS CERCOPITHEQUE (*C. pyrrhonotus*).

Habitat: Sudan.

Mr. Pocock's sketch shows an oval lamella with two apical points (text-fig. 20 G). It is very similar to that of *C. patas*.

THE ÆTHIOPS GROUP.

Species examined: *C. aethiops*; *C. sabæus*; *C. tantalus*;
C. rufoviridis.

The only pigmented specimen observed is my young one of *C. tantalus*.

THE ABYSSINIAN CERCOPITHEQUE (*C. aethiops*).

Habitat: Sudan.

Measurements.—Total length 4.3 cm.; length of the oral part 3.5 cm.; length of the pharyngeal part .8 cm.; greatest width 1.8 cm. These figures refer to the largest of five examples.

The *apex* has no mesial notch, no dorsal sulcus is present, and the structures mentioned on page 278 are absent. The whole dorsum is very rough.

The Circumvallate Papillæ.

Three small plane or umbilicated papillæ are arranged in the form of an isosceles triangle with an acute vertical angle. They are surrounded by prominent conical papillæ which may conceal the fossæ and vallums, or be a little distance from them. The two-pair type of vallate papillæ is rare (1 in 5).

The Fungiform Papillæ.

These stretch right across the dorsum and have the usual arrangement, but many are concealed by the long conical papillæ (text-fig. 22 C). All are hemispherical, smooth and polished, and some have a small central pit.

The Conical Papillæ.

The arrangement cannot be made out easily as their long and numerous points conceal the papillary bodies and interpapillary dorsum. Their distribution according to size is typical, however. All are filiform and have one or more points.

Lymphoid Nodules.

There are many large nodules, and several large duct orifices are visible in some specimens.

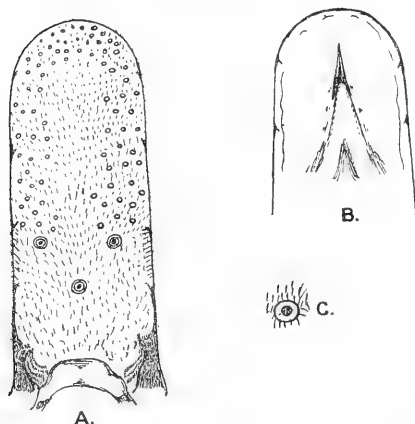
The Lateral Organs.

The sulci are wide, but not to such an extent as in *C. patas*, so the lateral organs appear to be composed of a row of small bodies each of which is furrowed. These are not, however, so prominent as in *C. patas*.

The measurements, etc., are given as follows:—

Organ.	Length.	Ridges.	Sulci.
Right	1.5 cm.	9	10
Left.....	1.2 ,,	8	9

Text-figure 22.

The tongue of *Cercopithecus aethiops*.*The Frenal Lamella* (text-fig. 22 B).

The triangular frenal lamella has an entire apex, and smooth plain edges which are free throughout their entire length.

The Median Ventral Sulcus.

The sulcus is short and opens into a wide triangular space. It lodges a small median crest.

THE GREEN CERCOPITHEQUE (*C. sabæus*).

Habitat: Sierra Leone.

Several authors have described the patterns exhibited by the vallate papillæ. Mayer (7) described four pairs of papillæ, and Münch (8) recorded the two-pair form; he also mentions cases in which there were three papillæ with an additional small papilla on each limb of the V. In six cases I observed the two-pair type.

Measurements of my largest specimen:—Total length 4.9 cm.; length of the oral part 3.9 cm.; length of the pharyngeal part

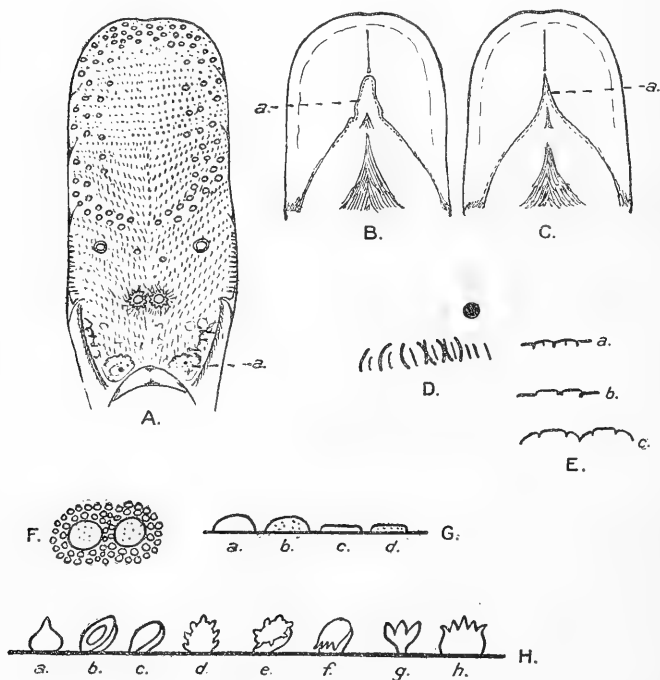
·1 cm.; width between the lingual attachments of the palato-glossal folds 2 cm.

The *apex* has a mesial notch, and it and the *lateral borders* are covered with fungiform papillæ which are more numerous and prominent than in the species already described. The structures mentioned on page 278 are absent.

The Circumvallate Papillæ. (text-fig. 23 E & F).

Four vallate papillæ are arranged in two pairs—anterior and posterior. The former correspond to the lateral papillæ of the triangular type, and the latter occupy the position of the posterior papilla. The posterior papillæ are close together (text-fig. 23 E).

Text-figure 23.



The tongue of *Cercopithecus sabæus*.

The anterior papillæ are surrounded by clear, smooth vallums. The posterior vallums are similar to the anterior ones, or are very prominent and crowded with conical papillæ (text-fig. 23 F).

The vallate area contains many conical and a few fungiform papillæ. The former vary greatly in size, and they were very large in a young specimen which I examined.

The papillæ vary greatly in their degree of projection (text-fig. 23 E).

The Fungiform Papillæ (text-fig. 23 G).

Fungiform papillæ are absent from the centre of the dorsum, and do not form a cluster in front of the vallate papillæ. In this respect the tongue resembles those of *C. preussi*, *C. burnetti*, and *C. mona*, and differs from that of *C. æthiops*. They form, therefore, a papillary zone on which they have the usual arrangement. Some are smooth and glistening, others are granular, and all are hemispherical or cylindrical in shape.

The Conical Papillæ (text-fig. 23 H).

Conical papillæ make the entire dorsum rough, but not to such a degree as in *C. patas* and *C. æthiops*. They have the usual arrangement in clusters and rows, and the direction in which their points run is typical. Between the rows there are strips of interpapillary dorsum.

None of them overlap the fungiform or vallate papillæ.

When they are examined through a lens it is seen how the papillæ vary greatly in shape and appear flattened out. The surface may be plane or excavated (text-fig. 23 H), and one or more processes are present.

The Lateral Organs (text-fig. 23 D).

The lateral organs consist of a series of short laminae and sulci convex forwards. Each ridge is bisected by a longitudinal sulcus. The measurements, laminae, and sulci are shown as follows:—

<i>Organ.</i>	<i>Length.</i>	<i>Laminae.</i>	<i>Sulci.</i>
Right	1·6 cm.	8	9
Left	1·5 „	5	6

The ridges decrease in size from before backwards, and the lateral vallate papillæ are level with the posterior laminae.

Lymphoid Nodules and Glands (text-fig. 23 A, a).

Prominent lymphoid nodules are present on the base of the tongue, and a number of orifices are visible.

The Frenal Lamella (text-figs. 23 B a & C a).

The frenal lamella is triangular and entire or bifid, being divided in the latter (text-fig. 23 B, a) into large left and small right parts. The edges are devoid of processes and tubercles and extend almost to the posterior fissures and laminae of the lateral organs.

The Frenum.

The frenum occupies the whole of the median ventral sulcus as a ridge, and the part stretching from the sulcus to the upper surface of the frenal lamella is very short, as in all Cercopithecidae.

Plicæ fimbriatæ are absent, even in the young specimen. The animal was older, however, than my young *C. patas* in which plicæ are present.

THE TANTALUS CERCOPITHEQUE (*C. tantalus*).

Habitat: Nigeria.

Measurements.—Total length 4.6 cm.; length of the oral part 4 cm.; length of the pharyngeal part .6 cm.; width between the lingual attachments of the palato-glossal folds 2 cm.

The *apex* and *lateral borders* are the same as in *C. sabæus*, and there is no median dorsal sulcus.

The Circumvallate Papillæ.

Four vallate papillæ are arranged in the two-pair type, but the elements of the posterior pair are more widely separated than in *C. sabæus*. The left papillæ are oval and all the others are circular on plan. In some specimens both posterior papillæ are circular (text-fig. 24 K).

The vallums of the anterior pair are clear zones, or have the appearance of nodulated and granular bands (text-fig. 24 C), and those of the posterior papillæ are raised, as in *C. sabæus* (text-fig. 24 D), but are not so thickly crowded with conical papillæ. All the papillæ project beyond the vallums, and they are conical on elevation, with the broad ends free (text-fig. 24 L).

The Fungiform Papillæ (text-fig. 24 E).

The fungiform papillæ are placed on a zone round the anterior two-thirds of the dorsum, and they are arranged thereon in the typical manner. On the lateral borders they form a row of prominent bodies. They have, therefore, the same appearances as in *C. sabæus*.

They are hemispherical, cylindrical or lobulated, and their surfaces are smooth or granular.

The Conical Papillæ (text-fig. 24 F & G).

The conical papillæ have the usual arrangement, the common distribution according to size, and the typical mode of direction of the points. Through the lens they appear very similar to those of *C. sabæus*, but the additional forms are shown in text-fig. 24 F & G. Between the different rows the strips of inter-papillary dorsum are visible.

Lymphoid Follicles.

Several lymphoid follicles and duct orifices can be seen on the base of the tongue.

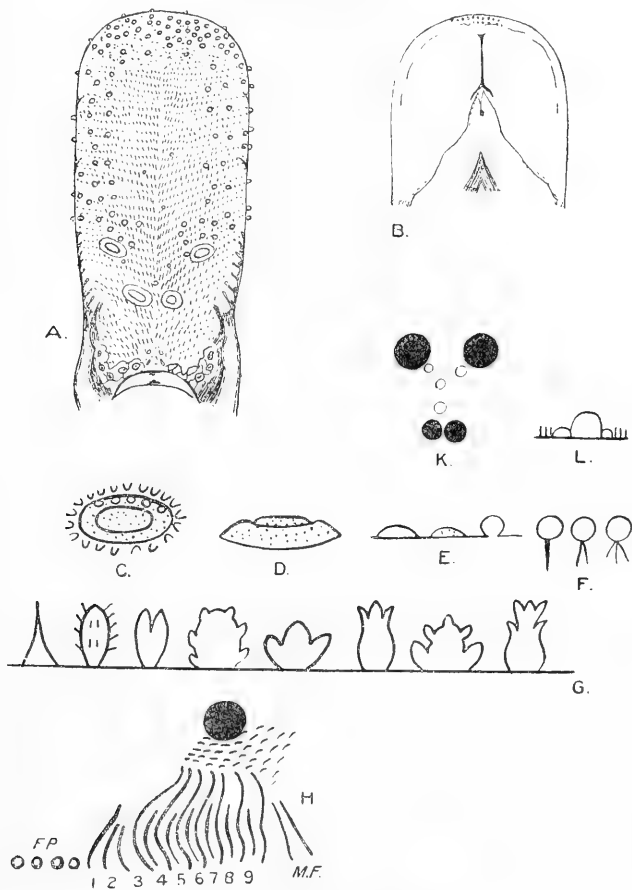
The Lateral Organs (text-fig. 24 H).

The lateral organs resemble those of *C. preussi*. They consist of a series of laminae and sulci running from behind forwards and inwards, and each of the former is traversed by a secondary sulcus. The whole organ diminishes in size from before backwards. Behind them are folds of the mucosa. The laminae do

not touch the lateral vallate papillæ as in *C. preussi*, but are separated from them by a papillary zone.

The measurements, ridges and laminae are shown as follows:—
The right organ is 1 cm. long, and has 5 laminae and 9 sulci.
The left organ is 1.2 cm. long, and has 8 laminae and 6 sulci.
In a second specimen there are 9 laminae and 10 sulci in each organ.

Text-figure 24.

The tongue of *Cercopithecus tantalus*.

The Frenal Lamella.

The triangular frenal lamella has a bifid apex and crenated edges running backwards as far as the lateral organs.

No *plicæ fimbriatæ* are present.

THE MOZAMBIQUE CERCOPITHEQUE (*C. rufoviridis*).

Habitat: Mozambique.

The tongue, which is widest between the anterior limits of the lateral organs, has the following *measurements*:—Total length 4·6 cm.; length of the oral part 3·8 cm.; length of the pharyngeal part ·8 cm.; greatest width 1·8 cm. These figures refer to the larger of two specimens.

The *apex* and *lateral borders* are similar to those of *C. sabaeus* and *C. tantalus*.

The Circumvallate Papillæ.

There are two pairs of vallate papillæ—*anterior* and *posterior*—and the posterior elements are close together. All are circular, prominent and granular, the fossæ are well-marked, but the vallums are not easily distinguishable from the surrounding dorsum. In my second specimen small papillæ lie between the four large ones of the double pair.

The Fungiform Papillæ.

Fungiform papillæ are absent from the centre of the dorsum, so they form a papillary bounding zone. The apical cluster is large, and the oblique posterior rows are close together. The former set contains large papillæ. On the inferior surface the apical papillæ form a prominent cluster, but there is a single row of papillæ posteriorly.

All are hemispherical, smooth and polished, and none are overlapped by conical papillæ.

The Conical Papillæ.

The papillæ have the typical arrangement in rows and clusters. Most of them have cylindrical bodies surrounded by a zone of interpapillary dorsum, and they give the tongue a sago-grain appearance.

The Lateral Organs.

Deep sulci separate short, flat laminae. The right organ is 1 cm. long, and has 7 laminae and 8 sulci. The left organ is 1·2 cm. long, and has 5 laminae and 6 sulci.

A few *orifices of gland ducts and pits* are present on the base of the tongue.

The Frenal Lamella.

The triangular lamella has a bifid apex, and its smooth edges extend back to the anterior limits of the lateral organs.

The *median ventral sulcus* is shallow and triangular.

The Vervet Cercopitheque (*C. pygerythrus* or *lalandii*) has a long, narrow, bifid lamella (text-fig. 20 F).

THE DIANA GROUP.

Tuckerman (11) has described the tongue of *C. diana* and pointed out that it has a vallate triangle. He states that it has no frenal lamella, but does not explain whether the tongue was carefully removed. The lamella is easily cut away unless great care is taken in removing the tongue.

THE PETAURISTA GROUP.

Münch (8) has pointed out that the tongue of *C. petaurista* has a triangular vallate area.

Mr. Pocock's sketch of the tongue of Schmidt's Cercopitheque (*C. schmidti*) has a conical, or oval, undivided frenal lamella (text-fig. 20 E).

Summary of the Tongues of the Species of Cercopithecus.

1. The tongues are conical or spatulate.
2. Apical notches and median dorsal sulci are variable.
3. The foramen cæcum, lytta, and Apical Gland of Blandin are absent.
4. Plicæ fimbriatæ are absent in the adult, but may be present in the young animal, as Deniker described in the Gorilla and Gibbons.
5. The lateral organs appear as flat laminae and sulci, or as rows of oval bodies.
6. The vallate papillæ form a V, T, triangle or double-pair arrangement, and it must be stated that the type described in each species is the commonest in a large series of examples which were examined by me or recorded by others.
7. The frenal lamella has an entire or bifid apex.
8. Fungiform papillæ form a dorsal bounding zone or stretch across the whole dorsum.
9. It is not possible to group the Cercopitheques by the nature of the tongues as one can by their external characters, and I have arranged them in their zoological series to show this. Most of the species in the Æthiops Group have a double-pair of vallate papillæ, but others have the triangular type, and that is as far as one can go.
10. Some examples of *C. patas* and *C. tantalus* are pigmented.

Genus MACACUS.

THE RHESUS MACAQUE (*M. rhesus*).

Habitat: India.

Tuckerman (11) has briefly described the tongue, and most of his account deals with the gustatory papillæ. He has described

a vallate triangle, but I only observed that form once in fifty-eight cases. I give the following *measurements* as those of my largest specimen:—Total length 5·4 cm.; length of the oral part 4·7 cm.; length of the pharyngeal part ·7 cm.; width between the anterior limits of the lateral organs 2·3 cm.

The rounded *apex* and the *lateral borders* are the same as in *C. preussi*, and the structures mentioned on page 278 are also absent.

The Circumvallate Papillæ.

In fifty-eight examples I observed three papillary patterns which are described as follows:—

Specimen No. 1 (type present in fifty-six examples):—There are two pairs of vallate papillæ, and the members of the posterior pair lie close together, but their relative positions differ (text-fig. 25 C, D, G). The fossæ are well-marked, and those of the anterior pair have recesses at their anterior and posterior poles (text-fig. 25 J). The fossæ of the posterior pair have no such recesses. All the vallums are prominent and granular.

Von Ebner has published an illustration of the histology of the posterior papillæ (14).

Within the vallate area there are both conical and fungiform papillæ.

Specimen No. 2 (type observed only in one case):—Three vallate papillæ form an isosceles triangle, the posterior papilla of which is oval. The sides are filled in by ridges of the mucosa. Within the vallate triangle there is a triangle of fungiform papillæ (text-fig. 25 E).

Specimen No. 3 (occurring once):—Five papillæ form a V with the apex behind. The three terminating papillæ are large and prominent, and the middle papillæ of the limbs are small, but prominent. All the fossæ and vallums are well-marked, and the vallate area contains V-shaped rows of fungiform papillæ (text-fig. 25 F).

The Fungiform Papillæ (text-fig. 31 A).

The entire oral part of the dorsum is covered by fungiform papillæ, but these have the usual arrangement in clusters and rows. Occasionally, however, they may be absent from the centre of the dorsum. They are small, but prominent, on the lateral borders, and form a well-marked cluster behind the apex on the inferior surface.

Tuckerman (11) has shown that the apical papillæ have well-developed taste-buds.

The Conical Papillæ (text-fig. 31 B).

The conical papillæ have the usual arrangement, but the close aggregation and mutual compression of the elements somewhat obscure the pattern. They have one or more points which are

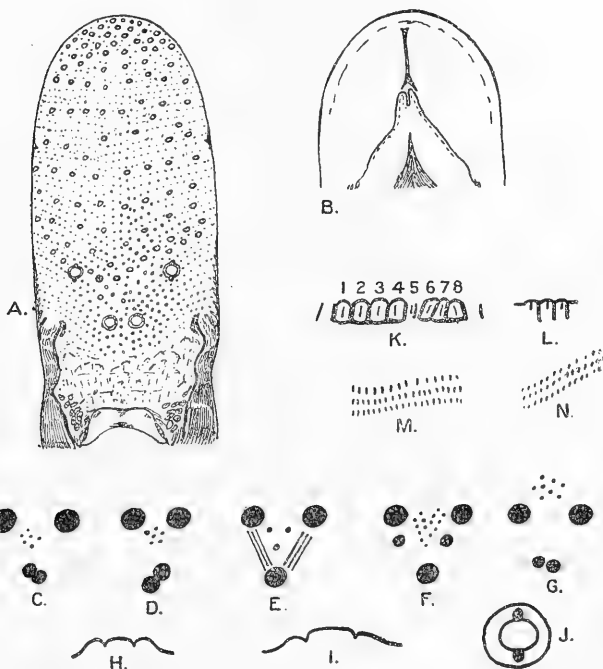
directed in the usual manner. The inter-papillary dorsum forms strips (text-fig. 25 M & N).

On the base of the tongue the *glands and lymphoid nodules* form elevations of different sizes, and a few minute orifices of ducts and pits are present.

The Lateral Organs (text-fig. 25 K & L).

The laminae and sulci are short and either straight or convex forwards. The laminae are mostly traversed by secondary sulci, and the main sulci vary in width. The left organ is 1.1 cm. long,

Text-figure 25.



The tongue of *Macacus rhesus*.

and has 8 laminae and 9 sulci. The right organ is 1.2 cm. long, and has 11 laminae and 12 sulci. At each end of each organ there are small folds of mucosa.

The Frenal Lamella.

The triangular lamella has a bifid apex, and the upper surface of the free part is devoid of sulci. The edges, which extend postero-laterally as far as the anterior limits of the lateral organs, are plain anteriorly and tuberculated posteriorly.

THE COMMON MACAQUE (*M. fascicularis*).

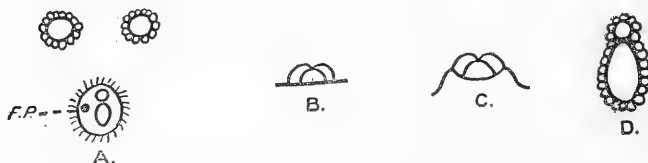
Habitat: Malay States.

Tuckerman (11) has briefly described the tongue, and the following details supplement his account. *Measurements*:— Total length 4.6 cm.; length of the oral part 3.9 cm.; length of the pharyngeal part .7 cm.; width between the anterior extremities of the lateral organs 1.9 cm. These measurements refer to the largest of twelve examples.

The *apex* and *lateral borders* are the same as in *M. rhesus*, and the usual structures are absent.

The variations in the vallate papillæ are not so numerous as in *M. rhesus*, but the fungiform and conical papillæ are very similar. The former are absent from the centre of the oral part of the dorsum in most cases, whereas that is the occasional form in *M. rhesus*.

Text-figure 26.

The circumvallate papillæ of *Macacus fascicularis*.*The Circumvallate Papillæ* (text-fig. 26).

Two types can appear:—1. There are two pairs of papillæ whose appearances, and their variations, resemble those of *M. rhesus*. 2. There is an anterior pair of papillæ, and a posterior cluster of three which stand either on a plane surface or on the summit of an elevation. The vallums consist of one or more rows of nodules, and may contain fungiform papillæ.

A few minute *orifices of ducts and pits* are present on the base of the tongue.

The Lateral Organs.

The short laminae and sulci are arranged in a straight line or in a curve convex downwards. Many of the laminae have small secondary sulci. The right organ is .9 cm. long, and has 6 laminae and 7 sulci. The left organ is .9 cm. long, and has 5 laminae and 6 sulci.

The *frenal lamella* is triangular and has a bifid apex.

THE BONNET MACAQUE (*M. sinicus*).

Habitat: Continental India.

Tongues of Bonnet Macaques differ in size and shape. They may taper from the palato-glossal folds towards both apex and base, or their widest point may be between the anterior

extremities of the lateral organs. My largest specimen belongs to the latter class and has the following *measurements*:—Total length 6.6 cm.; length of the oral part 5.4 cm.; length of the pharyngeal part 1.2 cm.; greatest width 2.4 cm.

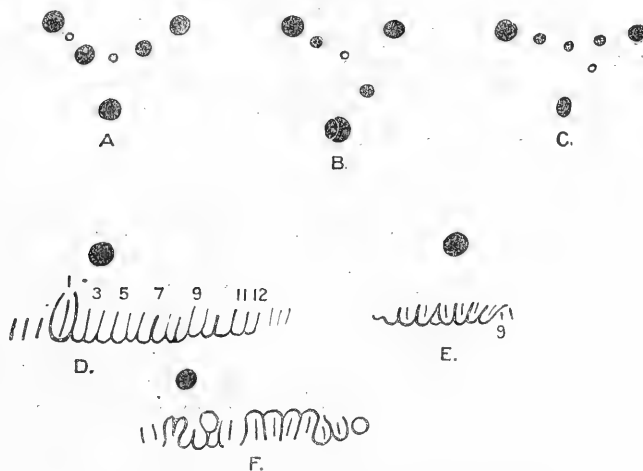
The *apex* is rounded, has no mesial notch, and bears conical and fungiform papillæ, but the latter are neither numerous nor prominent. The fungiform papillæ on the *lateral borders* and *inferior surface* are also insignificant and few in number.

The following structures are absent:—mesial dorsal sulcus, dorsal ridges, foramen cæcum, lytta, and Apical Gland of Blandin or Nuhn.

The Circumvallate Papillæ.

The vallate papillæ are arranged in the form of the letter Y or V, and I subjoin detailed descriptions of the vallate areas of three specimens.

Text-figure 27.



The vallate papillæ and lateral organs of *Macacus sinicus*.

Specimen No. 1:—The vallate papillæ form a V, with the angle posterior. Each limb has two papillæ, so, including the posterior papilla, there are five altogether. Each papilla is circular and prominent, its fossa is well-marked, and its vallum appears as a clear zone. On examination through a lens the papillæ and vallums appear granular. The middle papilla of the right limb is displaced mesially, and there is a fungiform papilla between the two mesial papillæ, so a false appearance of a Y is produced (text-fig. 27 A).

Specimen No. 2:—The papillæ also form a V, but the limbs differ greatly. Those of the left limb are close together, but the mesial papilla of the right limb lies close to the posterior

papilla (text-fig. 27 B). All but the posterior papilla are circular; the fossæ are plain and the vallums appear as clear zones. The posterior papilla is compound, and consists of two elements included within the same fossa. The right element is reniform, and the left one is oval. These two elements may represent a process of fusion of two elements of a posterior pair. If that be the case we may consider a single vallate papilla as the ultimate stage.

Specimen No. 3:—Six papillæ form the letter T. The horizontal limb consists of five elements, and the vertical limb consists of the middle horizontal papilla and one posterior papilla (text-fig. 27 C). All are circular, prominent, and granular.

The Fungiform Papillæ (text-fig. 31 A).

Although fungiform papillæ are scanty in the centre of the dorsum, they cover the entire oral part. They do not form, therefore, a wide dorsal papillary zone, and they have the usual arrangement in clusters and rows.

They are hemispherical or globular, and their edges may be overlapped by conical papillæ.

On the inferior surface they are clustered round the apex, but farther back they form a single chain.

The Conical Papillæ (text-fig. 31 B).

The conical papillæ have the usual arrangement in rows and clusters, and the usual distribution according to size. Those lying between the posterior vallate papillæ are large and well-marked.

They belong to the cylindrical and filiform series and have one or more points.

Lymphoid Tissue and Glands.

The glands and nodules on the base are well-marked, and several small orifices are present in front of the epiglottis.

The Lateral Organs.

The descriptions given below of the lateral organs of three examples correspond respectively to the three specimens whose vallate papillæ have already been described.

Specimen No. 1 (text-fig. 27 D):—A series of short laminae commence on the sides of the tongue, taper on the dorsum and run towards the lateral vallate papillæ, and are separated in the latter situation by wide shallow sulci. Many of the laminae, which are convex forwards, are traversed by secondary sulci. Some of the outer borders are rounded, but others merge into the under surface of the tongue. The right organ is .9 cm. long, and has 13 laminae and 14 sulci. The left organ is 1 cm. long, and has 12 laminae and 13 sulci. At either end there are small folds of mucosa.

Specimen No. 2 (text-fig. 27 E):—The short, rounded, furrowed laminae are separated by wide primary sulci. The right organ is

1·4 cm. long, and has 10 laminae and 11 sulci. The left organ is 1·3 cm. long, and has 9 laminae and 10 sulci.

Specimen No. 3 (text-fig. 27 F):—The laminae and sulci are short and convex forwards, and the latter look like series of short incisions into the lateral borders of the tongue. The right organ is ·8 cm. long, and has 12 laminae and 13 sulci. The left organ is ·7 cm. long, and has 11 laminae and 12 sulci.

The Frenal Lamella.

The frenal lamella is triangular. The apex expands and is either rounded and entire, or pointed and bifid. The edges extend postero-laterally almost to the posterior ends of the lateral organs.

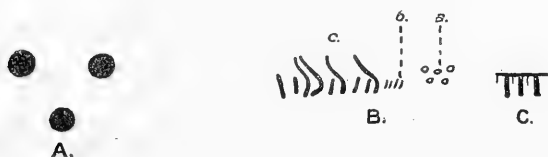
THE TOQUE MACAQUE (*M. pileatus*).

Habitat. Ceylon.

The spatulate tongue has the following *measurements*:—Total length 4·7 cm.; length of the oral part 3·9 cm.; length of the pharyngeal part ·8 cm.; width between the lingual attachments of the palato-glossal folds 1·7 cm.

The *apex* and *lateral borders* are the same as in *M. rhesus*, and the same structures are absent.

Text-figure 28.



The vallate papillae and lateral organs of *Macacus pileatus*.

The Circumvallate Papillae (text-fig. 28 A).

The isosceles vallate triangle has an obtuse vertical angle; the two anterior papillae are small, but the posterior one is large and oval. The fossae are well-marked, and the vallums are clear, prominent zones. Within the vallate triangle there are both conical and fungiform papillae.

The *conical and fungiform papillae* have the usual arrangement, but the latter are large anteriorly and small posteriorly. Large clusters of fungiform papillae are present behind the apex and in front of the lateral organs on the inferior surface.

Few *orifices of gland ducts* are present on the base of the tongue.

The *frenal lamella* has a bifid apex and plain sides.

The Lateral Organs (text-fig. 28 B & C).

The laminae and sulci are all short, and are either straight or

bent with the angles directed forwards. The right organ is 1 cm. long, and has 8 laminae and 9 sulci. The left organ is 1.1 cm. long, and has 9 laminae and 10 sulci. At the anterior extremities are fungiform papillae (*a*) and false folds (*b*), the true laminae and sulci being shown at *c*. The organs are flat on elevation (C).

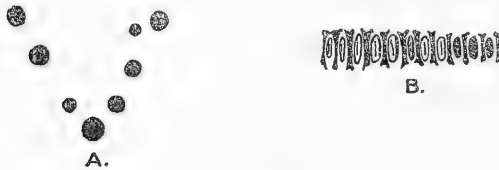
THE PIG-TAILED MACAQUE (*M. nemestrinus*).

Habitat: East Indies and Malay States.

Measurements.—Total length 8.4 cm.; length of the oral part 7.3 cm.; length of the pharyngeal part 1.1 cm.; width between the lingual attachments of the palato-glossal folds 2.7 cm.

The *apex* and *lateral borders* are the same as in *M. rhesus*, and the same structures are absent.

Text-figure 29.



The vallate papillae (A) and lateral organs (B) of *Macacus nemestrinus*.

The Circumvallate Papillae (text-fig. 29 A).

Seven papillae are arranged in the V-type. All are very prominent, the fossae are clearly defined, and the vallums form well-marked zones. In this formation my specimen resembles that of Münch (8), but differs from Mayer's example (7) in which there were four vallate papillae. The vallate area contains both conical and fungiform papillae. In my second specimen the apical papilla is replaced by three papillae deeply sunk within the common fossa. It is unusual to have the three papillae of a cluster deeply recessed; they are usually prominent.

The Fungiform Papillae (text-fig. 31 A).

The distribution is the same as in *M. rhesus*, but they are not so numerous in the centre of the oral part of the dorsum. They are very numerous behind the apex and in front of the vallate area. The ventral apical cluster is also large, but the posterior part of the ventral papillary zone has few papillae.

The Conical Papillae (text-fig. 31 B).

The arrangement of the papillae and inclination of their points take the usual form.

The papillary bodies are flat, conical or cylindrical, and the number of points is variable.

A few minute *orifices of gland ducts and pits* are present.

The Lateral Organs (text-fig. 29 B).

The short, wide sulci, which run forwards and upwards, separate flat, furrowed laminae. The right organ is 1.4 cm. long, and has 11 laminae and 12 sulci. The left organ is 1.2 cm. long, and has 10 laminae and 11 sulci.

The apex of the triangular *frenal lamella* is slightly cleft and rounded.

I have not observed the row of glandular bodies under the tongue described by John Hunter (16).

THE STUMP-TAILED MACAQUE (*M. speciosus*).

Habitat: Burmah.

Measurements.—Total length 5.8 cm.; length of the oral part 4.7 cm.; length of the pharyngeal part 1.1 cm.; greatest width 2.6 cm.

The *apex* has a mesial notch. The *lateral borders* have the usual characters, and the structures mentioned on page 278 are absent.

Text-figure 30.



The vallate papillae and lateral organs of *Macacus speciosus*.

The Circumvallate Papillae (text-fig. 30 A & B).

Four vallate papillae are arranged in the V-type. Including the posterior papilla, the right limb has three elements, but the left one has only two. The left anterior papilla is round and umbilicated, the fossa is clearly marked, and the vallum is flat and granular. The right anterior papilla is oval, granular, and recessed, the fossa is clearly marked, and the vallum appears as a prominent circular band. The posterior papilla is large and prominent; it has a central club-shaped papilla, and is surrounded by a lobulated vallum.

The Fungiform Papillae (text-fig. 31 A).

The fungiform papillae are neither numerous nor prominent, but they stretch right across the dorsum. They have the usual arrangement in clusters and rows. On the lateral borders and inferior surface they are discrete. They are hemispherical or pedunculated, and none are overlapped by conical papillae.

The Conical Papillae (text-fig. 31 B).

Their arrangement and disposition according to size and direction of their points follow the usual plan, and the inter-papillary dorsum appears in the form of strips. There is no great variation in their types.

The Lateral Organs (text-fig. 30 C).

The lateral organs appear as rows of short, furrowed, flat laminae separated by wide sulci. The rows may form a straight line, or be convex downwards. The right organ is 1.7 cm. long, and has 13 laminae and 14 sulci. The left organ is 1.5 cm. long, and has 6 laminae and 7 sulci.

Lymphoid Tissue and Glands.

On the sides of the base there are many small round eminences with central openings, and a few are situated in front of the epiglottis. They are more numerous than in any other *Macacus* tongue which I examined, but they do not occupy such a large proportion of the tongue as in the Langurs.

The Frenal Lamella.

The triangular lamella has a bifid apex, the halves of which taper from a wide base. The edges extend postero-laterally as far as the middle of the lateral organs. The upper surface of the free part is smooth.

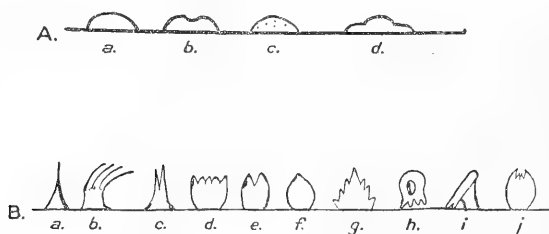
The *ventral papillary border* is narrow and has few papillae, but these have the usual disposition.

The *median ventral sulcus* lodges a triangular crest which is larger than in all other Primates.

THE BARBARY APE (*M. inuus*).

Chatin (4) and Münch (8) have described the tongue of *M. inuus* or *ecaudatus*, and recorded that it has a vallate triangle. The latter examined thirteen tongues of Macaque monkeys and only found the vallate triangle in this species.

Text-figure 31.



The fungiform (A) and conical (B) papillae of the Macaques.

THE PHILIPPINE MACAQUE (*M. philippinensis*).

Mr. R. I. Pocock has lent me the sketch of the frenal lamella which is simply bifid.

The fungiform papillae (text-fig. 31 A) and conical papillae

(text-fig. 31 B) present a uniformity of types, as shown in these figures, in all species.

Summary of the Genus Macacus.

1. The vallate papillæ are arranged in the triangular, V-type, or double-pair formation, and all forms may appear in any species if sufficient examples of each are studied, as shown in the introduction to this paper, and in the description of *Macacus rhesus*.
2. The pharyngeal part of the tongue is relatively larger in the genus *Macacus* than in the genus *Cercopithecus*.
3. The glandular orifices are, in most cases, like pin-holes. They are largest in *Macacus speciosus*.
4. The vallate papillæ may have recesses at their anterior and posterior poles, and in no other genus of the Cercopithecidae did I see these.
5. The frenal lamella is more frequently bifid than entire.

Genus CEROCEBUS.

WHITE-COLLARED MANGABEY (*C. ethiopicus*).

Habitat: West Africa.

Measurements.—Total length 4·8 cm.; length of the oral part 3·6 cm.; length of the pharyngeal part 1·2 cm.; width between the lingual attachments of the palato-glossal folds 2 cm.; thickness in the vallate area ·95 cm.

The *apex* is rounded, has a delicate median notch, and is roughened by closely-set conical and fungiform papillæ, and the fungiform papillæ on the *lateral borders* are prominent and close together. These lateral papillæ are followed by a row of larger oval bodies which compose the lateral organs.

A fine *mesial sulcus* runs along the dorsum.

The Circumvallate Papillæ.

Three large white circular vallate papillæ are arranged in the form of an acute-angled isosceles triangle, with the apex posterior. They offer a marked contrast to the yellow dorsum.

All the papillæ are smooth, polished and glistening, the fossæ are well marked, and the vallums appear as clear flat zones.

The Fungiform Papillæ.

The fungiform papillæ are absent from the centre of the oral part of the dorsum; on the sides they are arranged in clusters and rows in the usual manner.

All are hemispherical, smooth and polished, and there is no overlapping by conical papillæ.

The fungiform area is bounded posteriorly by a V-shaped row of papillæ running backwards and inwards from the anterior extremities of the lateral organs to the middle of the vallate area.

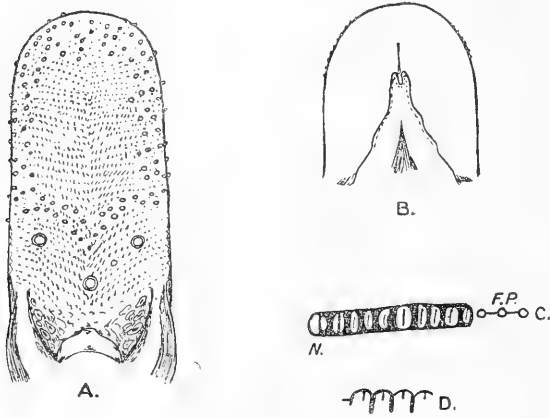
The Conical Papillæ.

The conical papillæ are arranged in the typical form, and the direction of the points takes the usual course. Those on the base are large.

The papillæ have cylindrical, conical or compressed bodies, and have one or more points.

At the insertions of the palato-glossal folds there are clusters of pedunculated papillæ, but histological examination alone reveals whether these are conical or fungiform in type.

Text-figure 32.

The tongue of *Cercocobus athiopicus*.*Lymphoid Follicles and Ducts.*

On the base of the tongue there is on each side a large cluster of lymphoid nodules, and several large ones have orifices of ducts or pits. The two masses are separated by the median glosso-epiglottic fold.

The Lateral Organs (text-fig. 32 C & D).

On each side of the tongue there is a row of laminae and sulci. The latter are short and wide, and the former are small and rounded, so the organs look like rows of beads. The laminae are smooth, furrowed, or crossed by a ridge, and are single or double (text-fig. 32 C, N).

The measurements, laminae, and sulci are shown as follows:—

Organ.	Length.	Laminae.	Sulci.
Right	1 cm.	9	10
Left	1.1 ,,	8	9

The Frenal Lamella.

The apex is bifid, and the edges, which are tuberculated posteriorly, extend as far as the middle of the lateral organs.

The *ventral papillary zone* is widest in front. It has a single row of fungiform papillæ.

The structures mentioned on page 278 are absent.

Münch (8) has shown that the tongue of the Sooty Mangabey (*C. fuliginosus*) has a vallate triangle.

THE WHITE-CROWNED MANGABEY (*C. lunulatus*).

Habitat: West Africa.

Measurements.—Total length 5 cm.; length of the oral part 4.4 cm.; length of the pharyngeal part .6 cm.; width between the lingual attachments of the palato-glossal folds 2.3 cm.

The *apex* is flat and devoid of a notch. It is very closely studded with small fungiform papillæ. The *lateral borders* are more rounded than in *C. æthiopicus*, but their fungiform papillæ are more numerous, smaller, and arranged in more than one row.

The usual structures are absent (see page 278).

Text-figure 33.



The vallate papillæ (A) and lateral organs (B) of *Cercocobus lunulatus*.

The Circumvallate Papillæ (text-fig. 33 A).

Three papillæ form an isosceles triangle with an acute apex, but they are not so large nor prominent as in *C. æthiopicus*. Moreover, they are not thrown into prominence by the contrast between their white colour and pigment of the dorsum, for the tongue is devoid of colour. All are circular and vary in protrusion or retraction, the fossæ are clearly-cut, but the vallums are not prominent.

The Fungiform Papillæ.

The character and distribution are the same as in *C. æthiopicus*, but the papillæ are smaller and more numerous.

All the papillæ are hemispherical, and their surfaces are smooth or granular.

The Conical Papillæ.

Their arrangement and distribution according to size follow the usual plan.

The papillary bodies are cylindrical, irregular or tapering, and

they have one or more points. The interpapillary dorsum appears as streaks.

Glands and Lymphoid Tissue.

The base of the tongue is nodulated, and a few orifices of glands and pits are present, as in *C. æthiopicus*.

The Lateral Organs (text-fig. 33 B).

The lateral organs present a very different appearance to those of *C. æthiopicus*, for they do not look like rows of small oval bodies. They consist of a series of flat, furrowed, laminae separated by wide primary sulci, and those in the centre of the organs are larger than those at the sides. The right organ is 1.1 cm. long, and has 10 laminae and 11 sulci. The left organ is 1.1 cm. long, and has 8 laminae and 9 sulci. One of the right laminae has three furrows (text-fig. 33 B, a).

The Frenal Lamella.

The triangular frenal lamella has a bifid apex, and the plain edges extend back as far as the posterior ends of the lateral organs.

The *ventral papillary zone* maintains an even width, and the *median ventral sulcus* is narrow and deep.

Genus THEROPITHECUS.

Garrod (6) has pointed out that the Gelada Baboon (*T. gelada*) has a triangular vallate area.

Genus PAPIO (= CYNOCEPHALUS).

THE GUINEA BABOON (*P. sphinx*).

Habitat: Africa.

The conical tongue has the following *measurements*:—Total length 6 cm.; length of the oral part 4.6 cm.; length of the pharyngeal part 1.4 cm.; width between the lingual attachments of the palato-glossal folds 2.6 cm.

The rounded *apex* has no notch, and is very thickly clustered with very small fungiform papillae. The *lateral borders* are rounded and possess many fungiform papillae arranged in the usual manner. At their posterior ends the lateral organs are situated.

The Circumvallate Papillae.

Type—double pair.

The two anterior papillae are large, circular, smooth and prominent, the fossae are clearly defined, and the vallums are nodulated. Both posterior papillae, of which the left one is the

larger, are smooth, oval, and contained within well-marked fossæ; both stand on a nodulated elevation (text-fig. 34).

Brücher (3) has figured a tongue with six papillæ arranged in the form of a V.

The Fungiform Papillæ.

The fungiform papillæ form a dorsal bounding zone which is broad, and they have the usual arrangement thereon. They are very numerous and prominent, and, with the exception of a cluster of small ones in the mid-line behind, they increase in size in the usual manner. Those on the lateral borders and inferior surface are also numerous, prominent, and close together.

They are hemispherical or bossed, their surfaces are mostly smooth, and none are overlapped by conical papillæ (text-fig. 35).

The Conical Papillæ (text-fig. 35).

The conical papillæ have the usual distribution and the usual arrangement according to their size and the direction of their points. They have flat or tapering bodies and one or more points. Between them the interpapillary dorsum appears as strips.

At the sides of the base of the tongue there are a few small orifices of glandular ducts and pits.

The Lateral Organs (text-fig. 34).

The lateral organs are confined almost entirely to the lateral borders. They consist of a series of wide sulci separating laminae which are short, traversed by secondary sulci, and more or less rounded. The organs, therefore, look like rows of small oval bodies. The left organ is 1.2 cm. long, and has 9 laminae and 10 sulci. The right organ is 1.3 cm. long, and has 8 laminae and 9 sulci.

The Frenal Lamella (text-fig. 36).

The triangular lamella has a deeply-cleft apex, and the upper surface of the free anterior part is smooth. The edges, which extend postero-laterally as far as the levels of the anterior limits of the lateral organs, bear tubercles and pointed processes anteriorly, and are undulating posteriorly.

The *ventral papillary zone* narrows from before backwards, and is crowded with conical and fungiform papillæ arranged in the usual manner.

The *median ventral sulcus* is narrow and deep throughout its entire length, and a ridge passes into it from the upper surface of the frenal lamella. No *median dorsal sulcus* is present, however, in the fresh tongue.

Mr. R. I. Pocock has lent me a sketch of the frenal lamella in which the apex is divided into two large diverging processes (text-fig. 36).

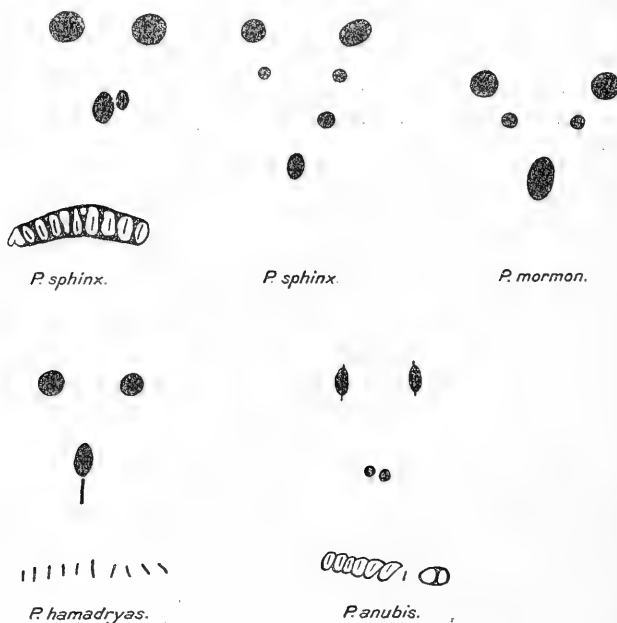
THE ARABIAN BABOON (*P. hamadryas*).

Habitat: Arabia and Abyssinia.

The spatulate tongue has the following *measurements*:—Total length 7.4 cm.; length of the oral part 5.7 cm.; length of the pharyngeal part 1.7 cm.; width between the lingual attachments of the palato-glossal folds 2.6 cm.; width of the anterior third 2.9 cm.

The flat *apex* has no mesial notch, and its papillæ are insignificant. The *lateral borders* are rounded, and their papillæ are also small; their fungiform papillæ are discrete (separate). Running back from the apex for 2.4 cm. there is a deep *mesial dorsal sulcus*.

Text-figure 34.



The tongues of the Baboons.

The upper figures are vallate papillary patterns, and the lower figures of *P. sphinx*, *P. hamadryas*, and *P. anubis* represent lateral organs.

The Circumvallate Papillæ (text-fig. 34).

Four papillæ form a V with a backwardly-directed apex. The left limb consists of three papillæ, including the posterior one, whereas the right limb has two. The posterior papilla is large, oval, smooth and glistening, the fossa is clearly cut and has

a posterior straight prolongation; its vallum is prominent, granular and coarsely nodulated. All the other papillæ are small and circular; their bodies are smooth and polished, their fossæ are sharply cut, and their vallums appear as clear zones. The two small papillæ on the left limb appear to stand on a common vallum.

Within the vallate area there are several large fungiform papillæ which can easily be mistaken for the small anterior vallate papillæ, but the pocket lens reveals how they have neither fossæ nor vallums. The area is also considerably roughened by conical papillæ.

The Fungiform Papillæ (text-fig. 35).

The fungiform papillæ are absent from a small area on the middle of the dorsum, but they have the usual arrangement elsewhere. They are all hemispherical or bossed, and are surrounded, but never concealed, by the conical papillæ.

The ventral apical cluster contains small elements.

The Conical Papillæ (text-fig. 35).

The conical papillæ have the usual arrangement, and the usual direction for their points. They have flat, cylindrical or tapering bodies, and the number of points which each possesses varies. Between the rows the interpapillary dorsum appears as strips. The papillæ on the base are prominent.

Glands and Lymphoid Nodules.

Several prominent elevations are formed on the base by lymphoid nodules, and several orifices are present. These are minute in front of the epiglottis, but there is, on each side of the base of the tongue, a row of prominent round or slit-like orifices stretching along the whole length of the palato-glossal folds. These are more pronounced than in *P. sphinx*.

The Lateral Organs (text-fig. 34).

On each lateral border there is a series of short furrowed laminæ separated by wide sulci. The laminæ do not project, however. Some of the more posterior laminæ appear as oval bodies incised by deep secondary sulci, but these must not be mistaken for glandular pits, from which they are separated by a short interval. The right organ is 1.9 cm. long, and has 11 laminæ and 12 sulci. The left organ is 1.8 cm. long, and has 12 laminæ and 13 sulci.

The Frenal Lamella (text-fig. 36).

The lamella has a rounded, entire, finely crenated apex, and the edges, which are not prominent, extend almost as far back as the middle of the lateral organs.

THE CHACMA BABOON (*P. porcarius*).

Habitat: South Africa.

The tongue is spatulate and has the following *measurements*:— Total length 10·3 cm.; length of the oral part 8·6 cm.; length of the pharyngeal part 1·7 cm.; width between the lingual attachments of the palato-glossal folds 3·2 cm.; width of the anterior third 4 cm.; thickness in the vallate area 2·4 cm.

The *apex* is flat and has a mesial notch whence a mesial dorsal sulcus runs back for 1 cm. It is covered by small conical and fungiform papillæ which are all visible to the naked eye; they are not, however, so prominent as in some species of *Cercopithecus*.

The *lateral borders* are similar to those of the *Cercopithecus* in general both as regards papillæ and lateral organs. The fungiform papillæ are discrete.

The Circumvallate Papillæ.

Three large prominent vallate papillæ form an equilateral triangle (each side = 1·5 cm.) with the apex behind. Within that there is a small vallate V consisting of three very small papillæ on the left limb and two on the right. Münch (8) has described small papillæ as being remnants of an anterior V-row, and Brücher (3) has figured them as connecting the large papillæ in *P. sphinx*, but my specimen is more in support of Münch's views than is Brücher's illustration.

All the large papillæ are circular and have granular surfaces; their fossæ are well-marked, and the vallums appear as white granular rings raised above the level of the rest of the dorsum. The small papillæ are circular and prominent, but their vallums are not raised.

Within the vallate area there are many conical and a few fungiform papillæ which can be mistaken for the small vallate V. To distinguish the latter I have coloured them black in text-fig. 35. In my second specimen five large papillæ form a V.

The Fungiform Papillæ.

Fungiform papillæ cover the whole of the oral part of the dorsum, but are few in number in the centre. They have the usual arrangement in clusters and rows, but the anterior cluster covers a larger area than in any species of *Cercopithecus*; it covers the whole of the anterior third of the tongue. On the lateral borders and inferior surface they form a single row of discrete elements.

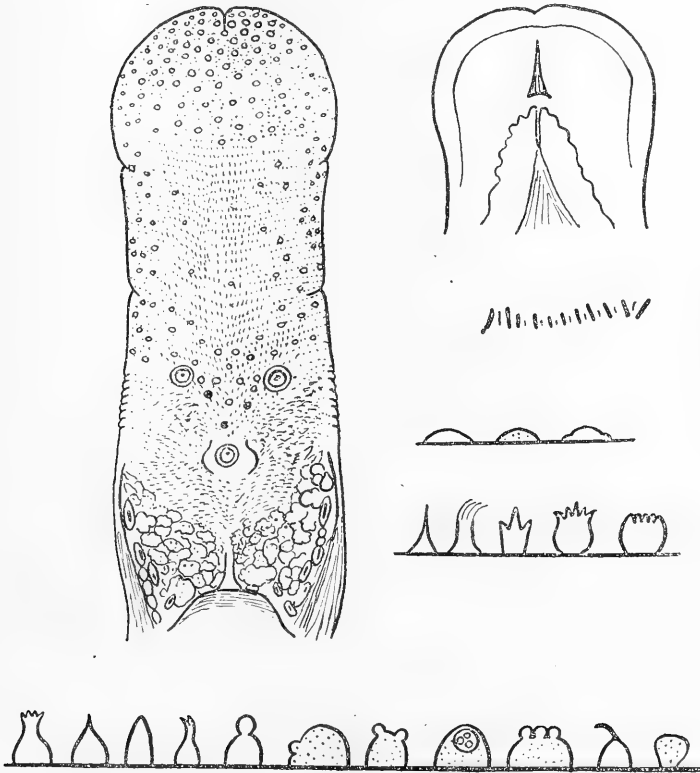
All the papillæ are hemispherical and a few have central bosses. Their surfaces are smooth or granular.

The Conical Papillæ.

The conical papillæ extend back on to the epiglottis. They have the usual arrangement in clusters and rows, but the

directions of the latter are not so clearly marked as in other Cercopitheciadæ. In their type and arrangement, and their enormous development on the base of the tongue, they resemble the conical papillæ of the Gorilla. They differ in the latter respect from the conical papillæ of *P. anubis*. The points of the papillæ are directed backwards, or backwards and inwards in the usual manner.

Text-figure 35.



The dorsum, inferior surface, and lateral organs of *Papio porcarius*, and the fungiform and conical papillæ of the Baboons.

When they are examined through the lens it is seen how they present a large variety of forms which are shown in text-fig. 35.

Behind the apex, on the dorsum, there are many cylindrical and a few filiform papillæ. In the middle third the papillary bodies are flat and scale-like, and their margins are plain or prolonged into a variable number of processes. On a zone lateral and posterior to the large vallate papillæ the conical papillæ are

of medium size; and their bodies are cylindrical, conical or fusiform, and are plain or have processes. Behind the zone and extending on to the epiglottis are large papillæ which are spherical, shield-like or tuberosæ; they may or may not have processes. On the sides and inferior surface the papillæ are small and filiform.

Lymphoid Nodules and Glands.

The base of the tongue has glands and lymphoid nodules of variable size, and large duct orifices are present in rows on the elongated lateral masses. It is difficult, without preparing sections, to determine whether a small nodule is a large papilla or a lymphoid nodule.

The Lateral Organs.

The lateral organs consist of small fissures and laminæ on the lateral borders and dorsum. All the laminæ have small secondary fissures, and the primary or interlaminar sulci are wide. All the fissures of the left organ run from below forwards and upwards, but those of the right lateral organ run forwards, upwards, or backwards. The measurements, laminæ, and sulci are shown as follows:—

<i>Organ.</i>	<i>Length.</i>	<i>Laminæ.</i>	<i>Sulci.</i>
Right	1·9 cm.	11	12
Left	1·8 „	10	11

The Inferior Papillary Zone.

The papillary bounding zone of the inferior surface is wide round the apex, but narrows as it is traced posteriorly. It is, in the former situation, closely dotted by small conical and fungiform papillæ.

Plicæ fimbriatæ are absent in my specimen.

The *mesial sulcus* is shallow and wide.

The *frenum* is long and lax.

The Frenal Lamella.

The lamella is triangular in shape, but the edges sweep round to the bifid apex, and the dividing fissure is deep. The edges also run back to below the middle of the lateral organs and are crenated or bear processes. The upper surface has a mesial longitudinal sulcus from which short, horizontal fissures pass out across the lamella.

THE ANUBIS BABOON (*P. anubis*).

Habitat: West Africa.

Measurements.—Total length 9·2 cm.; length of the oral part 6·6 cm.; length of the pharyngeal part 2·6 cm.; width between the lingual attachments of the palato-glossal folds 3 cm.; width of the anterior third 3·2 cm.

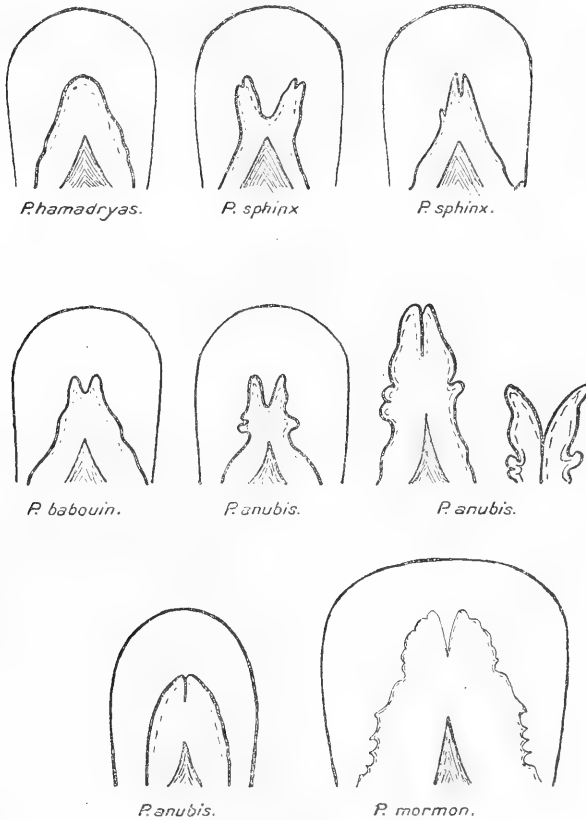
The *apex* has a mesial notch whence a *mesial dorsal sulcus* runs backwards for 2·3 cm. It has many fungiform papillæ.

The structures mentioned on page 278 are absent.

The Circumvallate Papillæ (text-fig. 34).

The vallate area consists of two anterior papillæ, and a mesial cluster of three small papillæ standing on a plane surface. The

Text-figure 36.



The frenal lamellæ of the Baboons*.

anterior papillæ are oval and retracted, the fosse are clearly defined, and the vallums appear as prominent zones. All papillæ are smooth, but the vallums are granular.

* Several of the figures are reproduced from sketches lent to me by Mr. R. I. Pocock.

The Fungiform Papillæ (text-fig. 35).

The fungiform papillæ have the usual arrangement, but the rows are maintained far forwards. They form a dorsal bounding zone on which they are numerous, but they are scanty on the ventral zone.

All are hemispherical, and smooth or granular. None are overlapped by conical papillæ.

The Conical Papillæ (text-fig. 35).

Arrangement.—Behind the apex there is a dense cluster, but behind this the papillæ are all in oblique chains. No transverse rows are present. Between them the interpapillary dorsum appears in the form of strips.

The papillary bodies are flat, conical, cylindrical or tuberoso, and they have one or more processes which are directed in the usual manner. They are not, however, arranged in zones as in *P. porcarius*.

The Lateral Organs (text-fig. 34).

Small rounded lamellæ are separated by wide primary sulci, so the organs look like rows of small oval bodies. They lie entirely on the lateral borders. The right organ is 1.3 cm. long, and has 8 laminae and 9 sulci. The left organ is 1.2 cm. long, and has 10 laminae and 11 sulci.

The Frenal Lamella (text-fig. 36).

The triangular lamella has a rounded apex with a small fissure, but no transverse sulci are present on the upper surface. The edges have small tubercles posteriorly.

A few orifices of ducts and pits are present on the sides of the base.

The *mesial ventral sulcus* has a mesial crest, and the *frenum* is long and lax.

Flower (5) states that there is one posterior vallate papilla, but there may be small ones merging into fungiform papillæ, and the latter are large.

THE MANDRILL (*P. mormon*).

Münch (8) has pointed out how the tongue of *P. mormon* has a well-developed lateral organ.

In the specimen which I examined there are five vallate papillæ in the V-formation. The mesial papilla of each limb is small, the two anterior papillæ are large and round, and the posterior papilla, which is the largest of all, is oval (text-fig. 34).

The left lateral organ has seven laminae and eight sulci, and the right organ, whose ridges are all furrowed, has five laminae and six sulci.

The frenal lamella has a bifid apex, and the edges have long processes (text-fig. 36).

No plicæ fimbriatæ are present.

From the descriptions of different species of *Papio* described above, one can see that plicæ fimbriatæ are absent. Meckel, as reported by Oppel, found traces, however (17). As the mucosa of the under surface of the tongue is sometimes very lax in the Baboons, and thrown into small irregular folds, a false impression of the plicæ may be obtained.

SUMMARY.

1. The tongues of the Cercopithecidæ do not contain many pigmented forms, and those which are coloured vary in the distribution of the pigment. The tongue of *Cercopithecus patas* may be yellow or colourless.

2. The conical and fungiform papillæ, with few exceptions, exhibit the usual type of arrangement. Only in *Cercopithecus æthiops* was it different.

3. The vallate papillæ form a triangle, V, or double pair, but the pattern is not characteristic in any genus.

4. The lateral organs appear as rows of sulci and flat laminae, or as rows of oval or rod-like bodies.

5. The frenal lamella is entire or bifid, even in different examples of the same species, so it is not of value for purposes of classification.

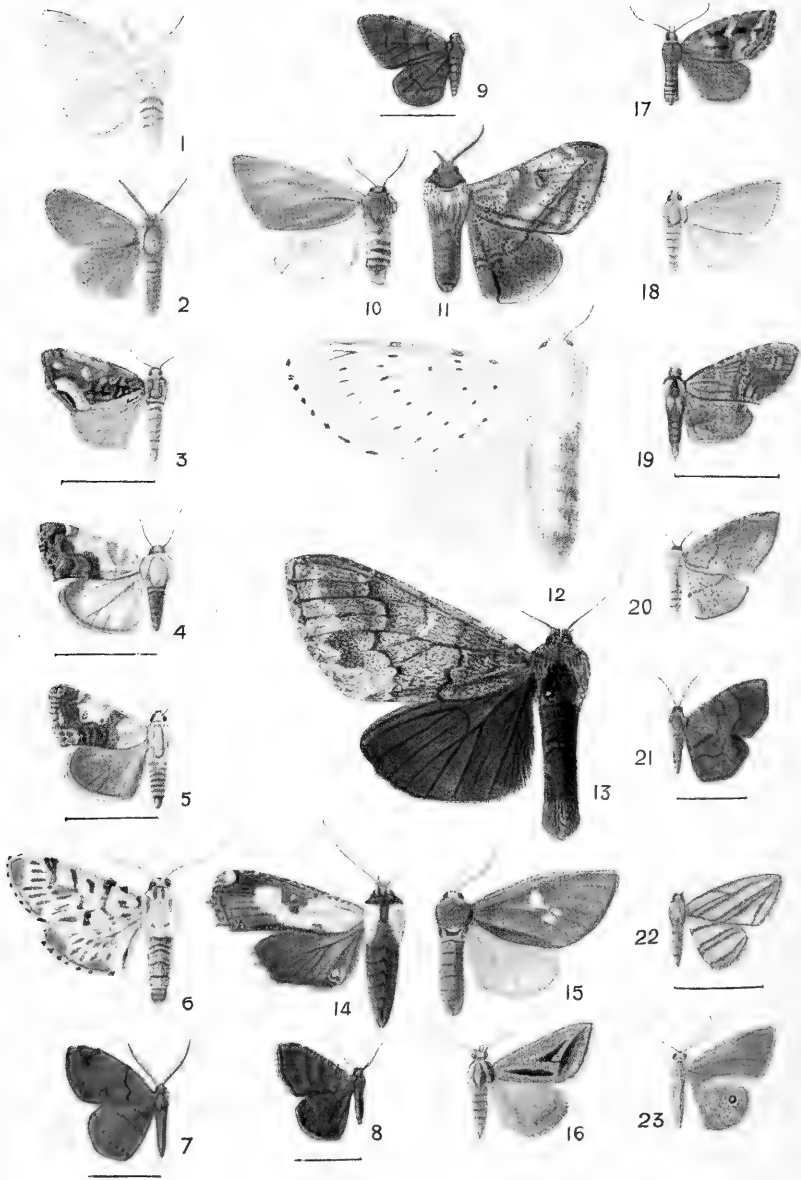
6. The glands on the base of the tongue are largest in the Langurs, in which they occupy a large area. They are not very prominent in the Cercopithecques nor in the Macaques; in the former the duct orifices are larger than in the latter. In the Mangabeys and Baboons they form prominent masses with large orifices on the sides of the base of the tongue. These structures are, therefore, of the greatest value in classifying the tongues of the Cercopithecidæ.

7. Plicæ fimbriatæ, lytta, foramen cæcum, and Apical Gland of Nuhn or Blandin are absent in the adult tongue. Plicæ fimbriatæ may, however, be present in very young tongues.

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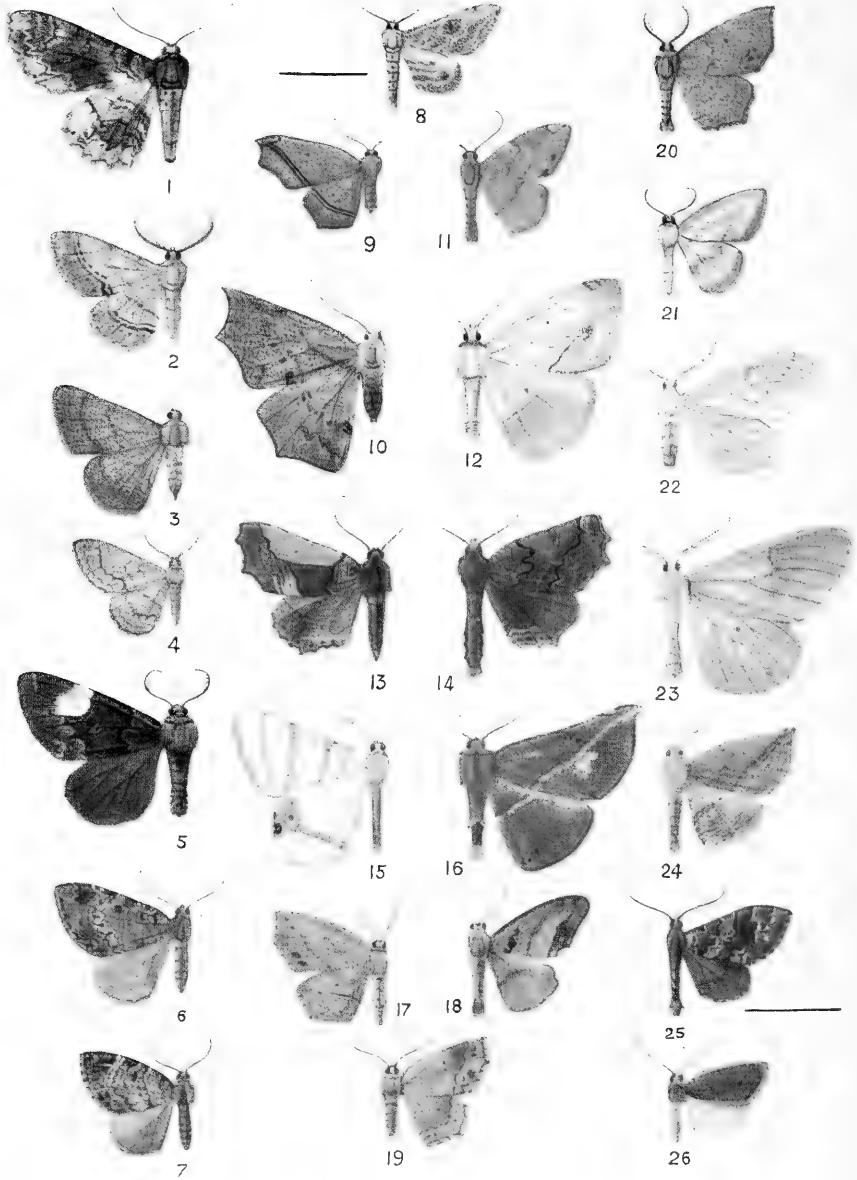
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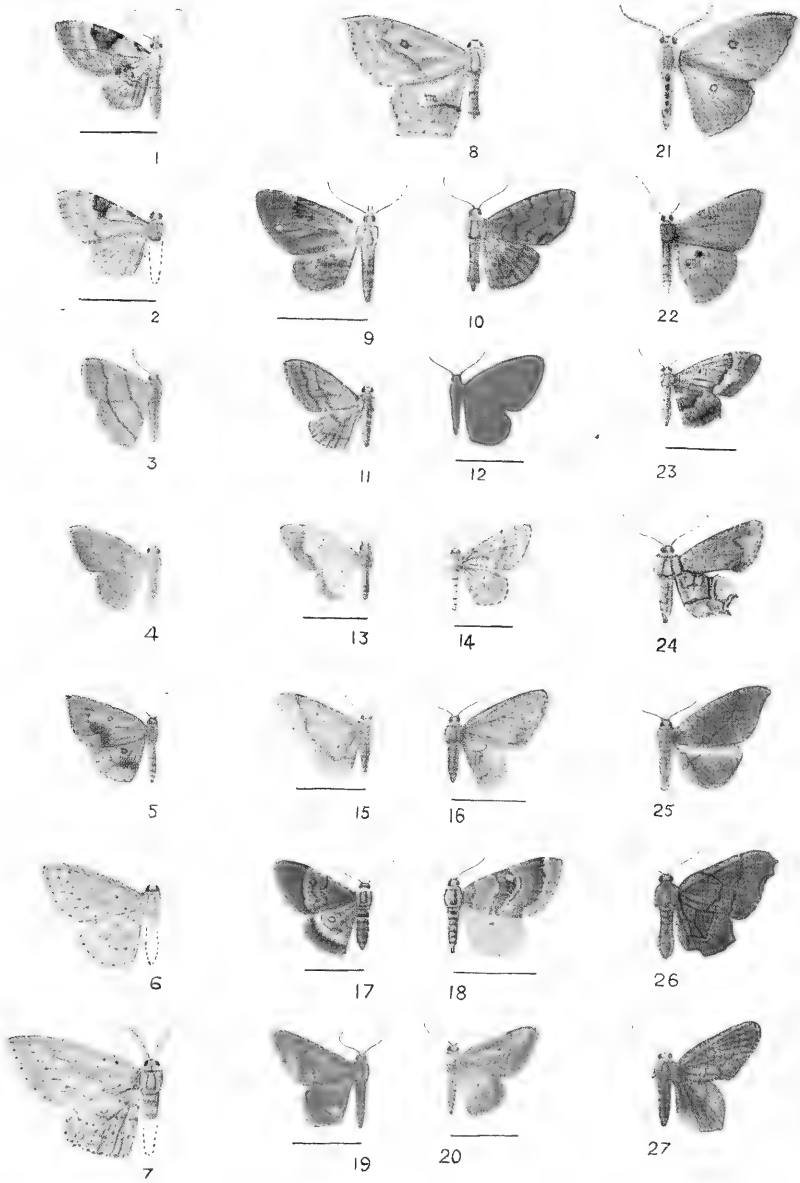
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NEW MOTHS FROM SOUTH EAST BRAZIL.

18. Descriptions of New Moths from South-East Brazil.

By E. DUKINFIELD JONES, F.Z.S., F.E.S.

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(Plates I.-III.*)

Fam. NOCTUIDÆ.

MICTOCHROA PAULATA, sp. n. (Pl. I. fig. 17.)

Female.—Palpi rufous brown; legs brown, the fore and mid tarsi fuscous ringed with ochreous; head and body light brown; anal tuft rufous. Fore wings brownish ochreous, suffused with rufous at base and on medial and terminal areas; dark basal spots on costa, subcostal nervure, and inner margin; a wavy dark antemedial line, dilated on costa and followed by broad whitish band, which includes the orbicular; orbicular whitish, distally defined by black; reniform whitish, incurved and defined proximally and distally by black lunules confluent with a black diffused fascia in cell and beyond it; a fine wavy postmedial line excurved beyond cell, incurved from vein 4 to inner margin, followed by rufous shade; a large fuscous triangular subapical spot on costa containing three white points; a sinuous whitish subterminal line incurved from apex to discal fold, angled inwards on the fold, excurved from discal to submedian fold and bent outwards to tornus; terminal area rufous: a terminal line of fuscous lunules on the interspaces; cilia rufous and fuscous brown. Hind wings brown; cilia with ochreous spots opposite the veins.

Expanse 27 mm.

Hab. São Paulo, S.E. Brazil.

MICTOCHROA PALLIDULA, sp. n. (Pl. I. fig. 18.)

Male.—Palpi and antennæ light brown; body and wings creamy white; abdomen slightly irrorated with light red-brown. Fore wings suffused and lightly irrorated with pale reddish brown; the lines very obscure; antemedial line excurved from costa to submedian fold, then incurved to inner margin; orbicular and reniform creamy white defined by pale reddish brown; indications of medial dark shade; postmedial line sinuous, excurved from costa to vein 2, incurved from 2 to inner margin; termen and cilia concolorous. Hind wings slightly irrorated with pale reddish brown.

Female similar to male.

Expanse: male 21 mm., female 27 mm.

Hab. Castro, Paraná, Brazil.

* For explanation of the Plates see p. 356.

BRYOCODIA PAULINA, sp. n. (Pl. I. fig. 3.)

Female.—Palpi reddish brown; pectus white; legs ochreous brown; frons, head, and antennæ reddish brown; tegulæ ochreous with dark brown bar; thorax ochreous and brown mixed; abdomen ochreous irrorated with fuscous, some fuscous scales on dorsal tufts. Fore wings reddish brown; double dark subbasal lines from costa to median nervure, angled outwards on costa; dark subbasal patches below cell and on inner margin; a dark antemedial line, distinctly marked from vein 1 to median nervure, obscure thence to costa, some rufous before it from 1 to median nervure; a median dark shade on costa, outlined on proximal side by orbicular, a whitish disc below median vein and a prolonged second disc reaching nearly to postmedial line on submedian fold; orbicular large, grey, ringed with white and outlined with fuscous on proximal and distal sides; reniform centre white surrounded with grey, and an outer ring of white outlined with rufous, some dark scales below it; some rufous in cell and on discal fold; postmedial line oblique from costa, excurved beyond cell, sharply angled outwards on vein 6, then incurved to inner margin, followed by a broad white curved fascia with distal projections on veins 3 and 4, a narrow diffused dark line on the white close to the postmedial; a very dark fascia beyond the white from tornus to vein 3; a large brown apical spot with white at the lower end; termen dark brown with rufous line before it; a broad white fascia on inner margin from base to postmedial. Hind wings ochreous suffused with brown.

Expanse 23 mm.

Hab. São Paulo, S.E. Brazil.

TARACHE PARANA, sp. n. (Pl. I. figs. 4, 5.)

Male.—Palpi white, third joint brown; pectus white; frons brown; head, cheeks, tegulæ, patagia, and thorax white; antennæ brown; abdomen dorsally brown, ventrally white, anal tuft luteous. Fore wings white; a bluish-grey basal spot followed by two larger ones on costa and subcostal nervure; two still larger confluent spots on costal and submedian areas and a smaller one below vein 1; a sinuous bluish-grey antemedial band, broad from costa to submedian nervure and narrow thence to inner margin, separated from the above by a narrow white line; a small bluish-grey spot on middle of costa; a minute black spot in cell; a broad dark medial band in and below cell to inner margin, incurved from cell to vein 1 and followed by similarly shaped and broader steel-blue space; an irregular dark fuscous-brown postmedial band followed by steel-blue to near apex; an irregular, broken, rufous-brown subterminal band ending in large fuscous subapical spot on costa; cilia rufous brown and white, a large purple-brown spot above the tornus and at the end of vein 5. Hind wings white; a terminal fuscous-brown suffusion, broad at apex; cilia white with brown band.

Female.—The basal spots as in male; the antemedial dark band confluent with the medial steel-blue space above inner margin; the dark shades on medial area suffused with olivaceous brown. Hind wings fuscous brown, lighter at the base.

Expanse: male 24 mm., female 22 mm.

Hab. Castro, Paraná, Brazil.

ACANTHODICA FRIGIDA, sp. n. (Pl. I. fig. 14.)

Female.—Palpi red-brown, with a fine dark longitudinal streak on outer side; legs red-brown; frons anteriorly red-brown, frontal tufts brown mixed with greenish grey; back of head dark red-brown; antennæ brown; tegulæ light and dark brown mixed, a few scattered white scales; thorax and abdomen red-brown; shoulders and patagia white, a few greenish-grey scales on thorax and inner fringe of patagia. Fore wings light red-brown; base white; a small annulate black basal spot; indications on costa of double subbasal, antemedial, and medial lines; a diffused postmedial line, oblique on costa, bent outwards along vein 11, then strongly excurved and marked by double row of minute dark points on the veins from 7 to 2; a diffused dark subterminal shade; a dark brown fascia on discal fold beyond postmedial; a large irregular white space extends from the base to the postmedial line, extending above subcostal nervure from subbasal to antemedial line, basal half of cell, submedian area to below vein 1, interrupted by brown triangle at one-third from base, continued to postmedial as far as vein 7; distal half of cell brown, containing a small white spot; a large fuscous spot below cell at origin of vein 2; a large semicircular ochreous apical spot defined by fuscous on proximal side; inner margin brown strigulated with dark fuscous; two minute white spots above tornus followed by black points. Hind wings suffused with reddish fuscous; an elongated white spot with black bar across it at tornus.

Expanse 40 mm.

Hab. São Paulo, S.E. Brazil.

PHURYS FASCIATA, sp. n. (Pl. I. fig. 16.)

Male.—Palpi, legs, and antennæ light brown; head and thorax brown mixed with lilacine grey; abdomen ochreous. Fore wings lilacine grey irrorated with brown; costa brown; a broad, dark fuscous streak on submedian interspace from near base to near subterminal dark band; a subterminal dark band from before tornus to apex, evenly incurved on proximal and wavy on distal edge, followed by light brown; a lance-shaped dark streak, with base at origin of vein 3 and point near the dark band at vein 6; a terminal brown shade. Hind wings ochreous white with diffused dark subterminal band.

Expanse 28 mm.

Hab. Castro, Paraná, Brazil.

Fam. NOTODONTIDÆ.

LOBEZA IRRORATA, sp. n. (Pl. I. fig. 13.)

Female.—Palpi fuscous and white; pectus tawny; femora and tibiæ fuscous, tawny, and white; tarsi dark fuscous and white; head and thorax fuscous, tawny, and white; abdomen black, some tawny and white on anal segment, ventral surface fuscous, some tawny hairs on distal ends of segments, anal segment bright tawny. Fore wings white, heavily irrorated with fuscous and tawny; an obscure geminate basal line, distinct on costa; a wavy geminate antemedial line angled outwards on subcostal and median nervures; the basal area dark and heavily suffused with tawny; a slight tawny medial shade; a white discocellular spot; postmedial line well defined, very wavy, dark, diffused, angled outwards on veins 8 and 7, incurved from 6 to 4, angled outwards on 3, thence incurved to inner margin, followed by narrow light shade and a broad fuscous and tawny suffusion to subterminal line; subterminal line very wavy, with double distal projections between veins 2 and 4 and 6 and 8; a dark lunular terminal line; cilia a crenulate line of fuscous and white. Hind wings fuscous; cilia white at ends of veins.

Expanse 72 mm.

Hab. Alto da Serra, Santos.

Fam. MELALOPHIDÆ.

ROSEMA PALLIDA, sp. n. (Pl. I. fig. 10.)

Female.—Palpi, legs, and antennæ ochreous; head green; tegulæ reddish ochreous; thorax green; abdomen ochreous. Fore wings pale green; costa ochreous; a minute white point on discocellulars. Hind wings white. Underside white.

Expanse 38 mm.

Hab. Castro, Paraná, Brazil.

MORESA MONA, sp. n. (Pl. I. fig. 15.)

Female.—Palpi and legs light brown sprinkled with fuscous; frons green; vertex of head and antennæ light brown; tegulæ, patagia, and thorax green; abdomen light buff. Fore wings green; costa ochreous irrorated with fuscous; a large white spot irrorated with fuscous on discocellulars; a smaller similar spot above vein 2, and a still smaller one above vein 3; a minute white point on vein 1 at one-third from base. Hind wings uniform light buff.

Expanse 44 mm.

Hab. Alto da Serra, Santos.

Fam. GEOMETRIDÆ.

Subfam. BOARMIINÆ.

MEROCAUSTA FELINARIA, sp. n. (Pl. I. fig. 20.)

Female.—Palpi: 1st joint ochreous buff, 2nd and 3rd purple-brown; legs ochreous buff speckled with purple-brown; frons anteriorly ochreous buff, posteriorly purple-brown; vertex of head purple-brown; patagia and thorax ochreous; a minute dorsal and two larger subdorsal spots on metathorax; abdomen ochreous speckled with purple-brown. Fore wings ochreous sparsely irrorated with purple-brown, the medial area suffused with light brown extending to termen between veins 6 and 7; a wavy diffused antemedial line angled outwards on median nervure; an obscure postmedial line, wavy from inner margin to vein 6, interrupted between 5 and 7, bent inwards from 7 to costa; a subterminal series of minute dark points; an obscure brown discocellular bar; termen and cilia reddish brown. Hind wings ochreous irrorated with purple-brown; a diffused medial line in continuation of postmedial of fore wings; terminal area slightly suffused with reddish brown.

Expanse 27 mm.

Hab. Castro, Paraná, Brazil.

APLOGOMPHA CASTRARIA, sp. n. (Pl. I. fig. 21.)

Male.—Palpi and legs ochreous mixed with brown; head, thorax, and abdomen purplish brown; antennæ purplish brown, the shaft ringed with ochreous. Fore wings purplish brown suffused with fuscous, the medial area lighter than the rest; dark antemedial, medial, and postmedial bands, the two former nearly straight, the latter evenly excurved; terminal area darkest, especially towards apex; apex lighter; costa crossed by minute ochreous-orange strigulæ; a ferruginous discocellular spot surrounded by dark purple-brown confluent with medial band. Hind wings the same shade as the medial area of fore wings; a rather broad dark antemedial band; a narrow wavy postmedial line strongly excurved between the discal and submedian folds; an obscure subterminal line more clearly indicated on inner margin; apical area dark; termen dark; cilia light purple-brown. Underside bright ochreous orange closely covered with bright purple-brown strigulæ; the bands and lines as on upper side, but much brighter, terminal area with orange strigulated spots at costa, inner margin, and between veins 2 and 4.

Female.—The markings as in the male, but the whole surface of the wings is heavily suffused with fuscous; cilia somewhat reddish. Underside suffused with reddish purple-brown.

Expanse: male 16 mm., female 17 mm.

Hab. Castro, Paraná; São Paulo, S.E. Brazil.

APLOGOMPHA FUMARIA, sp. n. (Pl. I. fig. 8.)

Male.—Palpi ochreous and fuscous; legs ochreous speckled with fuscous; antennæ shaft fuscous ringed with ochreous, pectinations fuscous; thorax and abdomen purplish fuscous. Wings purplish fuscous: fore wings with antemedial, medial, postmedial, and subterminal dark bands; a yellow bar across costa beyond antemedial and four beyond medial (in some specimens there is another bar beyond the postmedial); a ferruginous spot on discocellulars; termen dark fuscous; cilia dark fuscous, tipped with whitish below apex: hind wings, the bars very obscure; a ferruginous discocellular spot surrounded by dark fuscous. Underside: fore wings purple fuscous, suffused with reddish at apex; three bands of ochreous-white strigulæ, the medial one broad and the postmedial narrow; the discocellular spot brighter than on upper side: hind wings similar, but the strigulæ more evenly scattered over the lower half of the wing; discocellular spot as on fore wings.

Expanse 15 mm.

Hab. Castro, Paraná; Araçatuba, São Paulo, Brazil.

APLOGOMPHA SETINARIA, sp. n. (Pl. I. fig. 9.)

Male.—Palpi and legs rufous brown; frons and antennæ dark rufous brown; tegulæ, patagia, thorax, and abdomen purplish grey speckled with darker shade. Fore wings glossy purplish grey; three rather broad sinuous ferruginous lines excurved on upper half and slightly incurved on lower half of wing; a whitish streak before the antemedial on costa; the postmedial with outward points on veins 3, 4, and 6; costa yellow barred with purplish grey; costal area thickly and rest of wing sparsely striated and irrorated with whitish. Hind wings the same shade as the fore wings, a medial and a postmedial line broader and more diffused than on fore wing; the irrorations very much scattered.

Expanse 18 mm.

Hab. Castro, Paraná, Brazil.

APLOGOMPHA YAPONARIA, sp. n. (Pl. I. fig. 7.)

Male.—Head, palpi, pectus, and legs ochreous orange, tarsi suffused with purple-brown; antennæ, shaft light brown ringed with purple, the pectinations purple; thorax and abdomen brownish orange; fore wings bright brownish orange, heavily suffused with fuscous brown on terminal area; fine dark brown strigulæ on costal area; a dark antemedial line broad at costa, narrow on inner margin, bent outwards on median nervure and vein 1; postmedial oblique from costa to vein 7, thence wavy and obscure; an obscure series of subterminal spots; a dark discocellular streak; cilia dark fuscous brown. Hind wings brighter than the fore wings; an obscure antemedial line; a well-defined medial line from inner margin to vein 7 close to

origin; a subterminal line of spots; cilia concolorous excepting at apex where they are fuscous brown. Underside brighter than upper, sparsely irrorated with dark brown; a heavy suffusion of ferruginous brown at apex and tornus; a large triangular ochreous spot on apical suffusion from below vein 5 to above 6, suffused with ferruginous on the veins; a well-defined antemedial line on fore wings, angled outwards on median nervure; a diffused wavy postmedial line on fore wings continued medially across hind wings.

Expanse 18 mm.

Hab. Castro, Paraná, Brazil.

OPHTHALMOPHORA COLUMBARIA, sp. n. (Pl. I. fig. 23.)

Female.—Palpi: 1st joint white, 2nd and 3rd buff; pectus and femora white; tibiæ and tarsi ochreous; frons bright buff; vertex of head and tegulæ white; antennæ ochreous; patagia pale ochreous brown, white on the shoulders; thorax pale ochreous brown; abdomen: first segment ochreous brown at base, then white and posteriorly ochreous; the rest of abdomen ochreous. Fore wings white, heavily suffused with reddish brown; costal area pale ochreous yellow with white below; outer half of inner margin white; cilia pale primrose-yellow. Hind wings white; a very broad band at base the same colour as the fore wings; a white band separating this from the rest of the wing, which is suffused with yellow and thickly irrorated with red-brown; a postmedial line of iridescent gold scales from beyond the cell to tornus, nearly meeting on costa a subterminal line of similar scales; terminal area orange; some scattered metallic scales on inner margin near base; a black spot ringed with white and centred with iridescent metallic scales between veins 6 and 7; cilia pale primrose-yellow.

Expanse 24 mm.

Hab. Castro, Paraná, Brazil.

CALLURAPTERYX PAULARIA, sp. n. (Pl. II. fig. 15.)

Male.—Palpi fawn-colour with white at the ends of the joints; pectus white; legs ochreous; frons fawn; vertex of head white; antennæ light brown; tegulæ, patagia, and thorax white; abdomen fawn. Fore wings white; costa light brown; the lines light brown, straight, expanding on costa, basal narrow, ante- and postmedial geminate, enclosing lighter shade, subterminal narrow, terminal broad; a brown streak on discocellulars; cilia a lighter shade. Hind wings white; a broad postmedial line, geminate, enclosing lighter shade, angled outwards on vein 6 and above vein 7; a narrow subterminal line from before tornus to discal fold; a terminal line from tornus dilating to vein 4, where it suddenly becomes narrow and is bent upwards and changes to pale tawny; apex pale tawny, an irregular metallic silvery-white ring on the tawny from discal fold to near costa, within this ring there is a black spot surrounded by white and with a few metallic scales.

in the centre; a large black terminal spot above vein 6 and a lunular one above 7; cilia pale brown from tornus to vein 4, white from there to apex.

Expanse 38 mm.

Hab. São Paulo, S.E. Brazil.

EARIODES FLAVICILIA, sp. n. (Pl. II. fig. 26.)

Male.—Palpi light brown; legs ochreous, the fore- and mid-tibiæ shaded with fuscous; antennæ brown; frons and vertex of head yellow; back of head, tegulæ, and shoulders yellowish green; patagia green; abdomen pale ochreous, some green at base of dorsum. Fore wings bright yellowish green with a few scattered black scales; costa orange at base, then white with narrow yellow shade below to near apex, where it changes to light brown with bright rufous in place of the yellow; a series of postmedial bright rufous spots on veins 2, 3, and 4; cilia yellow. Hind wings creamy white.

Expanse 23 mm.

Hab. Alto da Serra, Santos

EARIODES BIMACULATA, sp. n.

Female.—Palpi, frons, and antennæ brown; vertex of head and thorax green; tegulæ light brown; abdomen ochreous, dorsally green at base. Fore wings yellowish green; costa white except at base which is yellow, at the apex there is a reddish streak below the white; a large pale purplish-brown lenticular spot irrorated with whitish and red-brown from below vein 2 to above vein 4; a bar of the same colour from inner margin to submedian fold at one-third from base; cilia yellowish white. Hind wings ochreous white. Underside: the lenticular spot on the fore wings is fuscous.

Expanse 28 mm.

Hab. Castro, Paraná, Brazil.

Very close to *E. variomaculata* Warren.

APICIA STRIGULARIA, sp. n. (Pl. II. fig. 24.)

Male.—Palpi ochreous with some brown scales, third joint brown; pectus and legs ochreous; hind femora and tibiæ with fuscous spots, spurs ringed with fuscous; frons light ochreous brown speckled with darker scales; thorax, patagia, and abdomen ochreous irrorated with black. Fore wings pale buff irrorated with black, the basal area suffused with tawny and the terminal area heavily striated with fuscous; sub-basal line represented by a black spot in the cell; an obscure brown antemedial line suffused with whitish, angled outwards in cell and marked by black spots on subcostal and median nervures, on vein 1, and inner margin; a minute black discocellular spot; a postmedial band from middle of inner margin to apex, consisting of a dark line, light shade, dark line, whitish line, and dark line, the second

dark line punctuated on the veins; a dark suffusion at the apex; some strigulæ on inner half of wing from vein 1 to inner margin; termen dark; cilia light at base, dark at tips. Hind wings striated over the whole; a broad medial band similar to post-medial of fore wings; a minute discocellular spot.

Expanse 30 mm.

Hab. Alto da Serra, Santos.

APICIA GEMINIMACULA, sp. n. (Pl. II. fig. 17.)

Male.—Palpi and frons brown; pectus and legs light brown; head, antennæ, and thorax light brown, two black spots on meta-thorax; abdomen light brown, two black distal subdorsal spots on basal segment, the spots confluent on the following segments. Wings light brown irrorated with darker brown and black. Fore wings: antemedial line tawny brown from inner margin to median nervure with dark spot on vein 1 and median, above median invisible except black dot on subcostal nervure; a minute black discocellular spot; postmedial line tawny brown, slightly wavy, dark points on the veins; two large subterminal spots on veins 2 and 3; termen and cilia concolorous, a dark spot at ends of the veins. Hind wings: a broad diffused tawny medial shade; a black discocellular spot; a fine dark postmedial line, diffused on veins, preceded by diffused tawny shade, followed by light shade; a subterminal row of small spots on veins 1-3; termen angled on vein 4; cilia with black spots at ends of veins.

Expanse 25 mm.

Hab. Castro, Paraná, Brazil.

CRATOPTERA FENESTRARIA, sp. n. (Pl. II. fig. 16.)

Male.—Palpi rufous brown; pectus light brown; legs ochreous speckled with black, tarsi ringed with black; frons and head light brown, white between the antennæ; antennæ light brown; tegulæ, patagia, thorax, and abdomen light brown, the latter with a few scattered black scales. Fore wings light ochreous brown, suffused with purplish brown and striated with purplish brown and black strigulæ; antemedial line strongly angled outwards in cell, preceded by white points on costa, on median nervure, and vein 1; a medial dark shade strongly angled outwards below costa and merging into a straight dark band from middle of inner margin to apex followed by narrow tawny and broader whitish shade; a black spot followed by white on costa near apex; a large ochreous semihyaline spot beyond the band from below vein 2 to above 3 with some strigulæ and the veins dark; beyond the spot is a dark diffusion, leaving a light space below apex; a black discocellular spot with a short black fascia above it; cilia dark brown. Hind wings ochreous brown with brown and black strigulæ and suffused with tawny brown on lower part of outer half of wing; an antemedial band of brown, tawny and whitish in continuation of band on fore

wings; a dark medial shade; three black points at tornus on veins 1 and 2 and submedian fold; cilia dark brown.

Expanse 42 mm.

Hab. Alto da Serra, Santos; Castro, Paraná.

TETRAGONODES GEMINARIA, sp. n. (Pl. II. fig. 9.)

Female.—Palpi ochreous, outwardly brown; pectus ochreous; legs ochreous speckled with brown; frons, head, antennæ, thorax, and abdomen light yellowish brown, obscurely strigulated with a darker shade and irrorated with black; a minute black discocellular spot; a very obscure dark medial shade; a geminate postmedial line from costa just before apex, incurved to vein 7, where it is acutely angled outwards, slightly incurved to 6 and thence straight to inner margin one-third from tornus, the inner member rufous brown and the outer dark brown, with whitish between; termen concolorous; cilia dark brown with whitish base. Hind wings ochreous suffused with light brown and irrorated with black, the terminal area with a darker suffusion; a medial geminate line similar to postmedial on fore wings, slightly and evenly excurved; cilia as on fore wings.

Expanse 29 mm.

Hab. Castro, Paraná, Brazil.

BAGODARES CASTRA, sp. n. (Pl. I. fig. 22.)

Female.—Palpi, head, and antennæ reddish brown, a white bar between the antennæ; legs ochreous suffused with reddish brown; tegulæ reddish brown mixed with white; patagia, thorax, and abdomen light brown. Fore wings white; costa light brown irrorated with darker shade; two narrow brown bands from inner margin near the base converging and meeting in the cell, thence a single line to below costa just before apex, where it bends violently inwards to costa; a brown fascia from one-third on costa to join the other band in the cell; two brown bands from middle of inner margin converging and meeting at apex; a subterminal single band meeting the preceding below apex; termen dark brown; cilia light brown. Hind wings: a straight antemedial brown band; two parallel postmedial bands; a subterminal band meeting terminal line at apex; terminal line dark brown; cilia light brown.

Expanse 22 mm.

Hab. Castro, Paraná, Brazil.

POLLA ACUTARIA, sp. n. (Pl. II. fig. 10.)

Female.—Palpi brown, outwardly fuscous; pectus white; legs ochreous speckled with fuscous; frons rufous-brown; head, antennæ, thorax, and patagia light brown mixed with white; abdomen darker brown. Fore wings light brown with fuscous strigulæ; a well-defined dark brown antemedial band from inner margin to cell at origin of vein 2, followed by tawny suffusion;

a diffused tawny postmedial line, fuscous on costa, bent outwards below costa, followed by series of indistinct dark spots diminishing in size from inner margin to vein 4; a pale submarginal band, preceded by indistinct dark spots at tornus and on vein 2; a minute dark discocellular spot; cilia dark brown. Hind wings light brown, heavily strigulated; a subbasal dark brown band forming continuation of antemedial of fore wings; an obscure medial line of spots, indistinct except on inner margin, where there is a large dark spot surrounded by white; a wavy dark subterminal line on lower half of wing, expanding into large patch at tornus; a very minute discocellular spot.

Expanse 39 mm.

Hab. Alto da Serra, Santos.

TROTOGONIA CASTRARIA, sp. n. (Pl. II. fig. 18.)

Male.—Palpi, pectus, and fore- and mid-femora dull orange; legs ochreous; frons rufous; antennæ ochreous orange speckled with purple-brown; tegulæ whitish; patagia bright ochreous, the scales tipped with white; abdomen ochreous, dorsally rufous with some white scales. Fore wings bright ochreous; costa olive-brown; an olive-brown antemedial band between fine whitish lines from subcostal to inner margin; a narrower rufous-brown band, evenly incurved from vein 6 through end of cell to middle of inner margin; a dark brown subterminal band irrorated with a few whitish scales; termen dark brown shading to rufous at apex; the medial area suffused with rufous; subapical area rufous, containing two dark subcostal spots surrounded with whitish; terminal area from vein 5 to tornus heavily suffused with olive-brown, containing ochreous spot below vein 2; cilia dark olive-brown shading to rufous at apex, a white spot above submedian fold. Hind wings bright ochreous slightly irrorated with rufous; a dark antemedial band with some whitish scales slightly incurved from middle of inner margin, obscure on costa; a minute spot at apex below vein 7; cilia bright ochreous except at apex, which is dark olive-brown with a few whitish scales. Underside brighter than upper; fore wings: costal area rufous, terminal area broadly rufous brown with yellow spot below vein 2; hind wings bright ochreous yellow, a rufous spot at apex below vein 7.

Expanse 29 mm.

Hab. Castro, Paraná, Brazil.

NUMIA STRIGULARIA, sp. n. (Pl. II. fig. 11.)

Male.—Palpi dull ochreous yellow, the third joint rufous-brown; legs ochreous yellow speckled with rufous; frons and antennæ rufous brown; thorax and abdomen dull ochreous yellow. Fore wings dull ochreous yellow striated with minute rufous strigulæ which become black on costal edge; a rufous-brown antemedial band, broad at costa and narrowing to inner

margin, angled outwards below costa and preceded by a whitish line; a narrow postmedial band, indistinct except from inner margin to vein 2, followed by some whitish scales; a subapical brown spot on costa containing a few white scales; a subterminal spot on vein 3 and below vein 2; termen and cilia rufous brown. Hind wings ochreous yellow striated with rufous strigulae; a postmedial brown band, broad at costa and narrowing to inner margin, followed by whitish scales; apex rufous brown; cilia ochreous yellow except at apex. Underside: the colours are brighter and the markings more distinct.

Expanse 27 mm.

Hab. Castro, Paraná, Brazil.

CAMPATONEMA, gen. nov.

Palpi upturned, roughly scaled, third joint minute; frons with conical prominence; antennae of male fasciculate; thorax clothed with scales and hairs; patagia fringed with long hairs; abdomen smooth. Fore wings: costa evenly arched; apex rectangular; termen evenly curved; cell more than half the length of the wing; vein 2 from middle of cell, 3 from well before angle, 4 from angle, 5 from middle of discocellulars, 6 from upper angle, 7 from cell close to angle, 8 and 9 stalked from 7, 10 from 7, 11 from cell. Hind wings: cell more than half the length of the wing; termen curved, slightly angled on vein 4; vein 2 from middle of cell, 3 close to angle, 4 from angle, 5 absent, 6 from upper angle, 7 from close to angle.

Type, *C. marginata*.

CAMPATONEMA MARGINATA, sp. n. (Pl. II. fig. 21.)

Male.—Palpi brownish ochreous, 2nd joint with some fuscous scales on outer side; legs, head and antennae brownish ochreous; thorax and abdomen ochreous. Fore wings ochreous sparsely irrorated with ferruginous brown; costa ferruginous brown; termen broadly ferruginous brown at tornus, diminishing to apex; traces of postmedial and subterminal lines, conspicuous on inner margin; inner margin ferruginous brown at tornus; a minute dark discocellular point. Hind wings ochreous, the outer half irrorated with ferruginous brown; a medial band wide at costa and angled outwards above vein 7, narrower on inner margin; termen broadly ferruginous brown.

Expanse 24 mm.

Hab. Alto da Serra, Santos.

OXYDIA PALLIDARIA, sp. n. (Pl. II. fig. 12.)

Male.—Palpi dark brown, the tip of third joint ochreous white; pectus ochreous white; legs light reddish brown spotted and ringed with dark brown; frons ochreous white with two brown vertical streaks; vertex of head light brown with white border;

antennæ dark brown, the basal joint white; tegulæ brown mixed with white; patagia tawny in front, ochreous white behind; thorax ochreous white, two small dark subdorsal spots; abdomen ochreous white irrorated with black. Fore wings ochreous white sparsely irrorated with black; costa tawny; medial shade indicated by tawny mark below costa; a minute black discocellular spot; postmedial line black, evenly incurved from beyond middle of inner margin to near termen above vein 6, where it is bent violently inwards and incurved to costa, the portion above vein 4 is tawny; a large cluster of black irroration beyond the postmedial on vein 3; terminal area darker than the rest of the wing and somewhat suffused with fawn-colour. Hind wings ochreous white sparsely irrorated with black; a minute black discocellular spot; postmedial similar to that of fore wing and continuous with it, vanishing at vein 7; outer half of wing more heavily suffused with fawn-colour; indications of a wavy tawny subterminal line. Underside more heavily irrorated than upper; the postmedial lines diffused black and tawny; minute discocellular spots.

Expanse 38 mm.

Hab. Castro, Paraná, Brazil.

In a second specimen the whole of the outer area of the fore wings beyond a line drawn from tornus to costa a little beyond the cell is heavily irrorated.

ISOCHROMODES ELEGANTARIA, sp. n. (Pl. II. fig. 19.)

Female.—Frons and palpi rufous brown, 3rd joint darker; legs brown; vertex of head and tegulæ light rufous brown; patagia, thorax, and abdomen light ochreous brown. Fore wings light brown slightly irrorated with black; antemedial line light rufous brown, excurved from costa to just before origin of vein 2, slightly incurved to vein 1, then bent inwards to inner margin; a minute black discocellular spot; postmedial line dark rufous brown outwardly shaded by light brown, sinuous, excurved on veins 7 and 4, incurved from 4 to inner margin, dark points on the veins, preceded by rufous-brown shade broad at costa and narrow on inner margin; a wavy ochreous-white subterminal line only visible above vein 5, below 5 the whole area from postmedial to termen is ochreous white on which are three small rufous-brown spots on veins 1 and 2 and the submedian fold, a larger and more distal spot above vein 2; termen dark brown; cilia ochreous white with dark points at the veins. Hind wings light brown, irrorations more numerous than on the fore wings; antemedial line obscure; postmedial rufous brown followed by whitish, slightly wavy, evenly excurved and preceded by a slight rufous-brown suffusion reaching to cell; a subterminal series of obscure diffused rufous-brown spots; termen and cilia as in fore wings.

Expanse 25 mm.

Hab. Alto da Serra, Santos.

AZELINA HANEBARIA, sp. n. (Pl. II. fig. 13.)

Male.—Palpi dark rufous brown, the third joint tipped with ochreous; legs bright creamy ochreous suffused and spotted with purple-brown; head and antennæ rufous brown; patagia and thorax purplish brown; abdomen rufous brown. Fore wings: base lilacine with brown striations; a fine black antemedial line outwardly shaded with dark brown, obliquely excurved from costa to vein 1, where it bends outwards and then makes a minute and violent curve to inner margin; the black line follows the inner margin and connects with the postmedial line, which is slightly excurved from inner margin to submedian fold, then incurved obliquely outwards to vein 4 well beyond the cell, thence almost straight to well before apex; the medial area above the median vein creamy buff slightly irrorated with brown, some reddish-brown suffusion beyond the cell; below the median vein dark purplish brown striated with lilacine; a diffused lilacine subterminal line joining postmedial on costa, the space between postmedial and subterminal creamy buff striated with brown; terminal area suffused with red above vein 2 to apex; termen lilacine; a series of dark subterminal spots between the veins, those above veins 3 and 6 containing ochreous points; cilia dark brown. Hind wings lilacine grey; an obscure pale wavy postmedial line; inner margin golden buff to postmedial, beyond this bright creamy ochreous to tornus and extending to vein 3; black subterminal spots between the veins, the one above vein 6 with ochreous point; cilia brown tipped with white.

Expanse 33 mm.

Hab. Alto da Serra, Santos.

Nearly allied to *A. habenaria* Guenée.

AZELINA CETANA, sp. n. (Pl. II. fig. 14.)

Male.—Palpi light brown, outwardly fuscous, third joint fuscous tipped with light brown; legs light brown heavily irrorated and suffused with fuscous; frons and antennæ reddish brown; vertex of head and tegulæ light brown mixed with ochreous white; patagia reddish brown suffused with fuscous, a few ochreous-white scales; thorax and abdomen red-brown. Fore wings light brown; an indistinct double inner line; a black sinuous antemedial line outwardly shading to red-brown, strongly angled inwards and preceded by ochreous-white spot on vein 1 and median vein; a wavy black postmedial line angled inwards on the veins and strongly excurved on the interspaces, shaded inwardly with brown and followed by ochreous white at costa, preceded by a nearly straight dark shade confluent at costa and at veins 3 and 4; a wavy subterminal line from before apex, to vein 4, where it joins the terminal line, strongly angled inwards on vein 6; a terminal line of spots between the veins; the inner area suffused with violaceous and irrorated and striated with brown; the medial area above the median vein yellowish brown, below the median violaceous; outer area pale olive-green suffused

with brown except the part beyond the subterminal line at apex, where it is violaceous brown; cilia reddish brown. Hind wings suffused with golden brown, lighter on inner margin; a pale postmedial line, obscure on costa and clearly defined on inner margin; a series of subterminal spots between the veins, the three near tornus much larger than the rest. Underside reddish brown slightly irrorated with darker shade and suffused with fuscous on central area; costa crossed with brown strigulae; ochreous white at apex, above tornus, and on discocellulars; a slightly sinuous postmedial line; on the hind wings the postmedial line is wavy, dark, followed by ochreous white.

Expanse 34 mm.

Hab. Alto da Serra, Santos.

NEPHODIA BONITARIA, sp. n. (Pl. II. fig. 22.)

Female.—Palpi light brown, third joint dark; legs, head, antennae, thorax, and abdomen brownish grey; patagia dark brown on shoulders. Wings brownish grey. Fore wings: costa dark brown at base, becoming paler towards apex; a dark diffused antemedial shade, clearly defined on costa; a dark diffused discocellular bar; a narrow postmedial line parallel with termen; cilia dark with darker spots at ends of veins. Hind wings: an indistinct discocellular spot; a diffused postmedial line excurved from costa to vein 3, incurved from 3 to inner margin; cilia with dark spots at ends of veins.

Underside:—Fore wings suffused on costal and terminal areas with broad brown strigulae; postmedial line and discocellular bar as on upper side. Hind wings more heavily suffused with brown strigulae; postmedial as on upper side.

Expanse 34 mm.

Hab. Castro, Paraná, Brazil.

NEPHODIA PAULARIA, sp. n. (Pl. II. fig. 23.)

Male.—Palpi light brown; pectus grey; legs grey suffused with brown; frons, head, and antennae grey; tegulae and patagia suffused with brown; thorax and abdomen grey. Wings grey. Fore wings: costa and outer half of wing suffused with brown; indistinct diffused dark medial shade beyond cell, confluent with postmedial on vein 2; an indistinct diffused dark postmedial shade; a well-defined dark discocellular bar; termen and cilia concolorous. Hind wings: a minute dark discocellular spot; a very faint medial dark shade; terminal area darker than the rest of the wing.

Underside:—Fore wings: costa strigulated with darker brown; a well-defined dark discocellular bar; a well-defined double fuscous postmedial shade. Hind wings evenly strigulated with broad diffused strigulae; a well-defined discocellular spot; dark diffused medial and subterminal shades.

Expanse: male 47 mm., female 48 mm

Hab. São Paulo, S.E. Brazil.

BOARMIA NIGRARIA, sp. n. (Pl. II. fig. 1.)

Female.—Palpi white, some fuscous scales at end of 2nd and 3rd joints; legs ochreous speckled with fuscous, fore tibiæ with large fuscous patches on upper side; fore tarsi ringed with fuscous, mid- and hind-tarsi fuscous; pectus ochreous white; frons fuscous in front and ochreous above; back of head ochreous; antennæ ringed with fuscous and white; tegulæ and patagia fuscous, light brown, and ochreous; thorax fuscous brown and ochreous, a large ochreous-white spot on metathorax with fuscous band across it; abdomen ochreous white irrorated with fuscous, dark subdorsal spots, a wide black dorsal band at base. Fore wings ochreous white heavily suffused with fuscous and black; an obscure dark subbasal line; antemedial line narrow, black, angled outwards on vein 1; an obscure double dark medial shade, distinct on inner margin, where there are a few reddish-brown scales; a discocellular bar of raised bluish-grey scales; postmedial only visible from costa to below vein 5, black, incurved, followed by whitish and then reddish brown; a very wavy whitish subterminal line; terminal area ochreous white with a dark fuscous space irrorated with bluish grey from 4 to 7; veins 2, 3, and 4 black from medial shade to subterminal line; a white space on inner margin from antemedial line to medial shade; termen black; cilia ochreous white with dark central band. Hind wings ochreous white irrorated with fuscous; an antemedial dark shade, double from inner margin to cell, single from cell to costa; a black postmedial line, punctuated on the veins, slightly incurved from costa to discal fold, then more strongly incurved to inner margin; an elliptical bluish-grey discocellular bar surrounded with black; a very wavy white subterminal line; the space between postmedial and subterminal from inner margin to discal fold heavily suffused with fuscous. Underside ochreous white; fore wings slightly strigulated with fuscous brown; a dark diffused discocellular bar; a large fuscous subapical spot; apex ochreous white with two minute terminal spots above 7 and 8; hind wings: diffused fuscous discocellular spot, some dark suffusion on terminal area.

Expanse 44 mm.

Hab. Castro, Paraná, Brazil.

HYMENOMIMA SINUSARIA, sp. n. (Pl. II. figs. 2, 3.)

Male.—Palpi brown; legs ochreous speckled with brown; frons pale reddish brown, a dark bar in front of antennæ; vertex of head brownish ochreous; antennæ brown; tegulæ ochreous mixed with reddish brown; thorax and abdomen ochreous white sparsely irrorated with black; a pair of subdorsal tawny spots irrorated with black on second segment of abdomen. Fore wings ochreous white irrorated with black; costa narrowly tawny; a narrow, tawny, sinuous antemedial line, excurved from costa to

median vein, slightly incurved thence to inner margin; a tawny wavy medial shade; postmedial line narrow, sinuous, excurved from costa to vein 3, incurved thence to inner margin, black on the veins and tawny on the interspaces, followed by a narrow pale line, a broad tawny band and a rather obscure zigzag pale line angled inwards on the veins and outwards on the interspaces; terminal area suffused with pale ferruginous brown; a terminal row of minute black points on the interspaces; cilia brown. Hind wings similar to the fore wings, with the exception that there is no antemedial line. Underside ochreous white more heavily irrorated than upper, outwardly suffused with pale ferruginous brown; a black discocellular spot; a postmedial line of black spots on the veins.

Female.—The wings purplish grey irrorated with black; the lines and suffusions as in male, but darker and duller.

Expanse: male 29 mm., female 31 mm.

Hab. Castro, Paraná, Brazil.

HYMENOMIMA NIVACARIA, sp. n. (Pl. II. fig. 4.)

Male.—Palpi rufous brown; pectus white; legs brown; frons rufous brown, white in front; vertex of head rufous brown mixed with white; antennæ light brown, white at base; tegulae rufous brown; thorax, patagia, and abdomen ochreous with scattered rufous-brown scales. Fore wings ochreous irrorated with rufous brown; edge of costa dark brown: antemedial line light rufous brown, strongly bent inwards in cell; medial line slightly excurved; postmedial line dark rufous brown, excurved, strongly dentate, the points outwards on the veins; an obscure dentate subterminal line; terminal line dark rufous brown; cilia ochreous. Hind wings similar to fore wings, but the lines not so well defined; postmedial angled outwards on vein 4.

Expanse 26 mm.

Hab. Nivac, Matto Grosso, Brazil.

LARENTIOPSIS, gen. nov.

Palpi porrect, short, clothed with scales, third joint minute; frons with a sharp-pointed prominence; antennæ of male bipectinate, the pectinations short and dilated at the ends; tibial spurs short; thorax and patagia clothed with hairs and hair-like scales; a metathoracic dorsal tuft; abdomen smooth, a small dorsal tuft on second segment. Fore wings: costa straight; apex rounded; termen evenly curved, slightly crenulate; vein 2 at two-thirds from base, 3 and 4 from angle, 5 from middle of discocellulars, 6 from upper angle, 7, 8, and 9 stalked from close to angle, 10 and 11 from cell. Hind wings: vein 2 at three-quarters from base, 3 from just before angle, 4 from angle, 5 absent, 6 from upper angle, 7 from close to angle, 8 approximated to cell near base only.

Type, *L. costiplaga*.

LARENTIOPSIS COSTIPLAGA, sp. n. (Pl. II. fig. 5.)

Male.—Palpi and head fuscous grey; pectus white; legs brown suffused with fuscous grey; tegulæ grey; patagia white mixed with olivaceous; thorax dark fuscous grey, the metathoracic tuft olivaceous; abdomen dark fuscous grey. Fore wings fuscous grey heavily suffused and irrorated with black and olivaceous-green scales with iridescent reflection; basal area fuscous grey; antemedial line wavy, black, nearly straight from costa to subcostal nervure, where it is angled inwards, excurved below cell, angled inwards on vein 1, excurved to inner margin, followed by some olivaceous scales above and below vein 1; postmedial wavy, black, angled outwards on the veins; a dark, obscure subterminal line; terminal line black; medial area darker than the rest of the wing; a large white spot on costa beyond cell reaching to vein 4, outwardly striated with black on the costa; an obscure white apical spot heavily suffused with black; a similar spot at termen between veins 1 and 2. Hind wings uniform dull smoky black.

Expanse 39 mm.

Hab. Castro, Paraná, Brazil.

Subfam. LARENTIINÆ.

RHODOMENA SANTARIA, sp. n. (Pl. II. fig. 6.)

Female.—Palpi fuscous brown; pectus luteous; legs brown; head and tegulæ luteous brown; antennæ dark brown; patagia and thorax olive-green and fuscous brown, a metathoracic tuft of black curved scales with metallic lustre; abdomen light brown suffused with greenish. Fore wings luteous olive-green; base fuscous; antemedial line geminate, wavy, slightly excurved through base of cell, very dark on costa, followed by olive-green on which there is a ferruginous-brown band from inner margin to subcostal vein; a geminate dark wavy medial line enclosing darker shade of green, very dark on costa; medial area pale green suffused with luteous except on costa; a black discocellular spot; postmedial wavy, geminate, the outer member denticulate, the points inwards on the veins, enclosing darker shade of green, very dark on costa, followed by a narrow pale line, a diffused dark line and a broad ferruginous-brown band which is confluent with a large black subapical spot and has distal projections above tornus and veins 2 and 3; terminal area suffused with dark olive-green at apex and tornus, leaving a luteous spot below vein 2 and a luteous space from vein 3 to the subapical spot; a terminal row of black lunular spots between the veins; cilia luteous olive-green with dark centre line. Hind wings pale luteous slightly suffused with fuscous on inner margin; an obscure geminate postmedial line, excurved beyond the cell; termen crenulate, black, interrupted at the veins; cilia luteous suffused with fuscous. Underside luteous: fore wings suffused

with pale olive-green at base; a dark olive-green discocellular spot; apex dark olive-green, cut by a fine luteous line from above vein 5 to before apex; a crenulate dark green postmedial line, broad at costa; hind wings: a dark green discocellular spot; a crenulate diffused dark green postmedial line and similar subterminal; a brown terminal suffusion.

Expanse 32 mm.

Hab. Alto da Serra, Santos.

RHODOMENA PAULARIA, sp. n. (Pl. II. fig. 7.)

Female.—Palpi ochreous white, the first joint outwardly black; legs buff heavily suffused with black, the tarsi black ringed with buff; frons lustrous whitish fawn, a large central purple-brown spot; vertex of head pale buff-white with brown central spot; antennæ slightly metallic purple-brown, the basal joint ochreous; tegulæ pale buff-white with a dark brown line; patagia ochreous white, fuscous brown on the shoulder; a large black and brown metathoracic tuft with metallic reflection; abdomen dark ochreous, ringed with tawny and dorsally suffused with black. Fore wings ochreous white heavily suffused with tawny and fuscous brown; a black basal line from costa to vein 1; a dark diffused antemedial line, narrow on inner margin and broad at costa; a dark diffused medial shade, narrow below cell, broad in and above cell, enclosing black discocellular spot and preceded by a narrow whitish shade; a second dark shade before postmedial; postmedial line narrow, denticulate, excurved from vein 2 to 6, thence straight to costa, slightly bent outwards to vein 2, followed by rather broad ochreous white; terminal area heavily suffused with fuscous and brown, the apex very dark; an obscure wavy subterminal line indicated by lilacine scales. Hind wings ochreous suffused with luteous brown; obscure diffused postmedial and subterminal lines; termen brown.

Expanse 27 mm.

Hab. Alto da Serra, Santos.

HYPOLEPIS BELLA, sp. n. (Pl. II. fig. 25.)

Male.—Palpi, pectus, and legs tawny, the latter heavily streaked and suffused with dark reddish brown; frons brown tawny; vertex of head golden tawny; antennæ tawny, the shaft streaked and suffused with brown; tegulæ tawny mixed with golden yellow; patagia outwardly golden brown, inwardly golden yellow; abdomen golden yellow heavily suffused with purplish brown except at base, a dorsal and two sublateral dark spots on first segment, dorsal only on second and third. Fore wings rich golden brown; costa and subcostal vein barred with golden-yellow strigulae, costa almost black on basal half; a silvery-white wavy antemedial line angled outwards on subcostal vein and inwards on vein 1; a silvery-white medial band passing through cell, angled outwards on vein 2, the middle of the band occupied by a narrow band of yellow irrorated with brown, the white

band preceded by an oblique golden-yellow spot in the cell and a dark suffusion in and below cell; a wavy postmedial line straight from costa to vein 7, excurved to 5, excurved to 3, diagonally inwards to 2, below which it makes an **S** and is angled inwardly on vein 1; a broad silvery-white band follows, much dilated at costa, and includes denticulate subterminal line, the points outwards on the veins, the middle of the band is suffused with yellow irrorated with brown; the space between the white bands heavily with dark brown, the suffusion extending to termen between veins 2 and 4 and nearly obliterating the outer white band; terminal line fuscous brown, crenulate; cilia golden yellow interrupted at the veins with fuscous brown. Hind wings golden brown; an obscure diffused dark sinuous postmedial line and discocellular spot; terminal line and cilia as on fore wing.

Expanse 25 mm.

Hab. Alto da Serra, Santos.

PSALIODES AURANTARIA, sp. n. (Pl. III. fig. 18.)

Female.—Palpi white beneath, ochreous above; legs ochreous; antennæ brown; frons dark brown; vertex of head and tegulæ ochreous; patagia and abdomen ochreous irrorated with brown. Fore wings ochreous white; basal area suffused with fuscous; a wavy dark inner line followed by white; central area orange; a broad suffused fuscous medial band preceded and followed by white; a black discocellular spot; an obscure postmedial line followed by broad dark band, fuscous at costa and brown above tornus; terminal line fuscous; terminal area near apex suffused with orange. Hind wings ochreous slightly suffused with orange; a dark discocellular spot.

Expanse 21 mm.

Hab. Alto da Serra, Santos.

EUPITHECIA CUPREARIA, sp. n. (Pl. III. fig. 9.)

Male.—Palpi pale reddish brown; pectus white; legs ochreous brown; head reddish brown; antennæ brown, the shaft ringed with light and dark; tegulæ light brown; thorax and abdomen ochreous white. Fore wings ochreous white, suffused with fuscous on costa and medial area and with coppery brown on outer area; base ochreous white; a dark diffused wavy basal line angled inwards on median vein and outwards on submedian fold; a dark diffused wavy antemedial line angled inwards below costa, outwards on subcostal vein, inwards in cell and outwards on median vein and vein 1; indications of a dark medial shade; a diffused black lunular discocellular spot; postmedial very obscure, preceded by light space on costa; a subterminal line of obscure spots, followed by white spot above vein 3 and a few scattered white scales on the other interspaces; broad dark bars on costa; a fuscous space at tornus. Hind wings ochreous white, the medial area below cell suffused with fuscous, other areas suffused with coppery brown and fuscous; base ochreous white; a round

dark discocellular spot; postmedial line broad, diffused, excurved beyond cell, straight to inner margin, followed by a light band containing a line of diffused coppery spots; a subterminal row of obscure dark spots followed by white spot above vein 3; termen dark; cilia light brown.

Expanse 23 mm.

Hab. Alto da Serra, Santos.

EUPITHECIA MAUVARIA, sp. n. (Pl. III. fig. 1.)

Female.—Palpi, legs, and head grey tinged with light brown; antennæ brown; tegulæ, patagia, and thorax lilacine grey; abdomen greenish grey. Wings lilacine grey. Fore wings: costa dark fuscous at base; antemedial line straight from costa to cell, where it forms a right angle, thence straight to inner margin; medial area, a large dark fuscous patch on costa, outlined with whitish and including a discocellular bar of raised, iridescent scales, a whitish patch on inner margin suffused with fuscous; an obscure pale subterminal line preceded by some greenish-grey suffusions; terminal area suffused with greenish grey. Hind wings: medial area whitish with irregular fuscous diffused lines, including discocellular spot; some greenish-grey suffusions on outer half of wing.

Expanse 20 mm.

Hab. Castro, Paraná, Brazil.

EUPITHECIA AQUANIVARIA, sp. n. (Pl. III. fig. 2.)

Male.—Palpi, frons, head, tegulæ, and patagia white with slight rufous tinge, the latter with anterior fuscous spot; fore legs brown, tarsi ringed with brown; abdomen ochreous white. Wings lustrous greenish grey. Fore wings: base of costa fuscous black; a large medial patch of fuscous black on costa, surrounded by whitish and containing discocellular bar of raised iridescent scales; a whitish dentate subterminal line preceded by minute fuscous spots on the interspaces, those at tornus and costa larger; cilia very long, lustrous grey with diffused greenish fuscous spots on base at the ends of the veins. Hind wings: postmedial and subterminal dentate whitish lines preceded by dark shade, angled outwards on vein 4, thence incurved to inner margin; a minute fuscous discocellular spot.

Female similar.

Expanse: male 16 mm., female 21 mm.

Hab. Castro, Paraná, and Alto da Serra, Santos.

Subfam. STERRHINÆ.

ANISODES BIZARIA, sp. n. (Pl. III. fig. 3.)

Male.—Palpi light rufous brown, whitish beneath; legs, head, antennæ, thorax, and abdomen pale rufous brown. Fore wings pale rufous brown finely striated with darker purplish brown;

a narrow purplish-brown antemedial line angled outwards on subcostal nervure, thence straight to inner margin; a similar postmedial line, slightly sinuous, incurved below costa to vein 6, excurved to below discal fold and straight to inner margin; costa heavily striated with purplish brown on medial and terminal portions; a terminal series of minute lunules between the veins; cilia light reddish brown, some purple at the tornus. Hind wings similar to the fore wings, the lines straight in continuance of those of the fore wings; cilia of inner margin purple.

Expanse 19 mm.

Hab. Alto da Serra, Santos.

ANISODES PARANARIA, sp. n. (Pl. III. fig. 4.)

Female.—Palpi reddish brown above, whitish beneath; legs and head pale ochreous brown; vertex white; antennæ ochreous; thorax, abdomen, and wings ochreous brown. Fore wings irrorated with rufous brown; well-defined ante- and postmedial narrow dark rufous-brown bands; termen and discocellular bar dark rufous brown; cilia ochreous brown. Hind wings similar; discocellular spot elongated, whitish, surrounded by rufous brown.

Expanse 23 mm.

Hab. Castro, Paraná, Brazil.

ANISODES CAROLINA, sp. n. (Pl. III. fig. 5.)

Female.—Palpi pale ochreous brown; legs ochreous brown, the trochanters and femora glistening whitish; head roseate; vertex ochreous white with roseate bar; antennæ ochreous white; tegulæ light rufous brown; patagia with roseate anterior spot; metathorax with some roseate scales; abdomen ochreous brown. Wings ochreous brown, striated with roseate brown, both wings similar; antemedial line represented by fuscous spots on vein 1, median nervure, and cellular fold; postmedial line of diffused fuscous spots on the veins from inner margin to vein 7, preceded by broad fuscous suffusion from inner margin to vein 4; discocellular spot whitish surrounded by fuscous; termen concolorous, with fuscous spots at ends of veins.

Expanse 22 mm.

Hab. Castro, Paraná, Brazil.

ANISODES JAPARIA, sp. n. (Pl. III. fig. 6.)

Female.—Palpi purple-brown above, white beneath, pectus white; legs light ochreous brown; frons white; vertex light brown with purple-brown bar; antennæ light brown; tegulæ purple-brown; patagia, thorax, and abdomen light ochreous brown. Fore wings light ochreous brown irrorated with dark purple-brown; antemedial line represented by fuscous spot on vein 1 and on median and subcostal nervures; a wavy dark

medial shade; a postmedial line of fuscous spots on the veins; a subterminal line of diffused brown spots on the interspaces; a terminal row of fuscous spots on the interspaces; cilia ochreous. Hind wings light ochreous brown; antemedial line represented by spots on vein 1, median nervure, and in cell; a wavy medial dark shade; postmedial, subterminal, and terminal lines as on fore wings; discocellular spot silvery white surrounded by brown.

Expanse 28 mm.

Hab. Castro, Paraná, Brazil.

ANISODES ANTENNARIA, sp. n. (Pl. III. fig. 7.)

Male.—Palpi and legs light ochreous brown, fore femora and tibiæ heavily suffused with purple-brown; frons purple-brown; head, antennæ, tegulæ, and patagia light ochreous brown; thorax spotted with roseate brown; abdomen light ochreous brown with row of roseate dorsal spots. Wings light ochreous brown irrorated with roseate brown. Fore wings: antemedial line wavy, strongly angled outwards in cell, defined by dark spots on median nervure, in cell, on subcostal nervure and above it; a diffused narrow medial shade; a postmedial line of spots on the veins, followed by narrow ochreous brown shade; terminal area suffused with ochreous brown; a terminal row of roseate fuscous spots on the interspaces; discocellular spot surrounded by roseate spots at ends of veins. Hind wings similar; discocellular spots larger.

Expanse 35 mm.

Hab. Castro, Paraná, Brazil.

ANISODES VIGORARIA, sp. n. (Pl. III. fig. 8.)

Female.—Palpi outwardly dark brown, inwardly ochreous white; legs ochreous brown; frons dark brown; head, antennæ, and body ochreous. Fore wings ochreous, irrorated with fuscous; antemedial line wavy, angled outwards in cell, inwards on median nervure, outwards on submedian fold, thence oblique to inner margin; a medial line angled inwards on subcostal, outwards on vein 6, thence straight to lower angle of cell and slightly incurved to before middle of inner margin, followed by narrow dark shade; a diffused postmedial line with dark spots above veins 4-7; an obscure subterminal shade; a terminal line of lunular spots; discocellular spot ochreous, surrounded by orange and fuscous; cilia ochreous. Hind wings similar, the medial shade well defined on inner margin, not reaching costa.

Expanse 36 mm.

Hab. Castro, Paraná, Brazil.

HÆMALIA MANTARIA, sp. n. (Pl. III. fig. 10.)

Female.—Palpi brown; pectus white; legs ochreous brown; frons, vertex, and antennæ dark brown; tegulæ, patagia, and thorax light ochreous brown; abdomen dark brown with large

metallic dorsal spots on first segment. Fore wings ochreous, heavily suffused with ferruginous and irrorated with dark purple metallic scales; costa purple-brown; antemedial, medial, and postmedial lines narrow, wavy, purple-brown; a wavy subterminal line broadly diffused at tornus, on and above vein 4 and at costa; termen dark purple-brown; cilia brown. Hind wings heavily suffused with ferruginous and fuscous and irrorated with dark metallic scales, the lines very obscure.

Expanse 26 mm.

Hab. Castro, Paraná, Brazil.

Near *H. micaceata* Wlk.

HÆMALIA MAGITARIA, sp. n. (Pl. III, fig. 11.)

Female.—Palpi and frons rufous brown; pectus silvery white, iridescent; legs ochreous, iridescent; head and antennæ rufous brown; vertex whitish; tegulæ brown with some iridescent scales; thorax, abdomen, and wings ochreous brown. Fore wings irrorated with darker brown, costa brown, dark at base and lighter at apex; antemedial line very obscure; postmedial slightly excurved beyond cell; subterminal wavy, followed by light shade; terminal area slightly suffused with brown; a fuscous discocellular spot; termen brown; cilia ochreous. Hind wings more heavily irrorated; a medial shade in continuation of postmedial of fore wings, passing on proximal side of discocellular; subterminal line excurved on veins 6-7.

Expanse 20 mm.

Hab. Castro, Paraná, Brazil.

EOIS LUTEARIA, sp. n. (Pl. III, fig. 12.)

Male.—Bright buff with rufous irroration; frons rufous; antennæ brown. Fore wings: antemedial line rufous, excurved across middle of cell; medial line evenly excurved; postmedial excurved, approximating to medial on inner margin, all the lines somewhat diffused, narrow on inner margin and broader at costa; subterminal line much diffused; termen and cilia suffused rufous. Hind wings similar, more heavily suffused; only two conspicuous lines, antemedial and medial.

Expanse 17 mm.

Hab. São Paulo, S.E. Brazil.

PTYCHOPODA TERMINARIA, sp. n. (Pl. III, fig. 13.)

Female.—Palpi and legs ochreous; frons reddish brown; vertex of head white; antennæ ochreous; tegulæ, patagia, and thorax pale reddish brown; abdomen ochreous brown. Fore wings pale ochreous, almost semihyaline; traces of brown antemedial and postmedial lines; a dark discocellular spot; subterminal line wavy diffused dark brown, incurved on submedian fold, nearly straight from vein 2 to costa; terminal area a lighter

shade of brown except at apex which is ochreous; termen and cilia brown. Hind wings pale ochreous; traces of postmedial line; subterminal line dark brown and terminal area a rather lighter shade; cilia brown.

Expanse 15 mm.

Hab. São Paulo, S.E. Brazil.

PTYCHOPODA DELICATARIA sp. n. (Pl. III. fig. 14.)

Male.—Palpi, legs, head, and body light rufous brown; vertex of head and antennæ ochreous white. Wings ochreous slightly irrorated with light brown; the lines light brown, diffused; antemedial excurved in cell; an almost straight medial shade; wavy, slightly dentate postmedial and subterminal lines, the former marked on costa by large fuscous spot; a fuscous discocellular spot; terminal line fuscous, broken at the veins; a lightly defined suffusion just before termen. Hind wings similar, but the inner lines very indistinct.

Expanse 15 mm.

Hab. Castro, Paraná, Brazil.

PTYCHOPODA CAMPINARIA, sp. n. (Pl. III. fig. 15.)

Female.—Palpi, legs, head, and antennæ ochreous brown; vertex of head whitish; tegulæ and patagia ochreous brown with lilacine iridescence; abdomen ochreous brown. Wings pale ochreous brown irrorated with darker brown and irridescent scales; the lines dark brown. Fore wings: antemedial line wavy, strongly excurved in cell; a medial line passing well within the cell; postmedial line well defined, straight from costa to vein 2, incurved on submedian fold; costal and terminal areas lightly suffused with brown; terminal line brown, broken at the veins; a fuscous discocellular spot; cilia long, ochreous. Hind wings: the postmedial line well defined, continuous with that of fore wings. Underside: the postmedial lines well defined.

Expanse 18 mm.

Hab. São Paulo, S.E. Brazil.

PTYCHOPODA LILACARIA, sp. n. (Pl. III. fig. 16.)

Male.—Palpi, legs, and head rufous brown; vertex and antennæ ochreous brown; tegulæ and patagia rufous brown with lilacine iridescence; abdomen dorsally purple-brown, ventrally rufous. Wings ochreous brown with lilacine iridescence. Fore wings: an obscure purple-brown antemedial line, excurved from costa to submedian fold; a well-defined diffused dark medial band; postmedial line wavy, narrow and obscure at inner margin, broader at costa, followed by light shade; terminal area heavily suffused with purple-brown, with light space divided by a fine brown line from vein 3 to apex; a minute fuscous discocellular spot; termen purple-brown with conspicuous spots

below apex; cilia purple-brown. Hind wings: three diffused bands; terminal line of elongated spots; cilia ochreous.

Expanse 20 mm.

Hab. Alto da Serra, Santos.

HYRIA GEMMARIA, sp. n. (Pl. III. fig. 17.)

Male.—Palpi ochreous and purple-brown; legs ochreous, the fore pair suffused with purple-brown on upper side; frons and vertex of head dark purple-brown; antennæ light brown suffused with purple near base; tegulæ white; patagia, thorax, and abdomen light brown with lilacine reflection; a large black spot on first segment of abdomen. Fore wings lilacine grey sparsely irrorated with purplish brown, a strong lilacine reflection; costa pure white from base to postmedial line; indications on costa of a dark medial shade and postmedial line; a luteous white discocellular spot shaded inwardly and outwardly with a few dark scales; a dark purple-brown subterminal line from tornus to two-thirds on costa, slightly and evenly excurved beyond the cell and dilating on costa, followed by lilacine and reddish purple to near termen; termen and cilia bright luteous. Hind wings lilacine grey irrorated with purple-brown; medial dark shade well defined, angled inwards on submedian fold, outwards on median vein and incurved in the cell; postmedial line less distinct; discocellular spot luteous white surrounded with purple; subterminal line parallel with termen and followed by reddish purple; termen and cilia luteous.

Female.—Similar to male, but all the colours more vivid; the medial shade and postmedial line clearly defined on the fore- as well as on the hind wings.

Expanse: male 13 mm., female 15 mm.

Hab. Castro, Paraná, Brazil.

HYRIGONA SANTARIA, sp. n. (Pl. III. fig. 19.)

Male.—Palpi purple-brown; legs light brown, the fore pair suffused with purple-brown; head purple-brown; antennæ light brown ringed with darker shade; tegulæ and thorax light brown; abdomen light brown heavily suffused with purple. Fore wings ochreous suffused with light brown with lilacine reflection and very sparsely irrorated with purple-brown; ante- and postmedial lines indicated by spots on costa; a large purple-brown space with lilacine reflection from just before middle of inner margin to tornus, the inner edge incurved to origin of vein 2, an abrupt outward projection between 3 and 4; this space is bordered by darker diffused lines and crossed vertically by a medial line; a triangular ochreous space with base on vein 3 and apex at tornus; traces of diffused subterminal bands near apex; a black discocellular spot; cilia pale ochreous, a rather large black point opposite end of vein 3; outer half of inner margin strongly lilacine. Hind wings ochreous heavily suffused with purple-brown; a large ochreous space on inner margin just before tornus with tawny shade on inner and upper sides

extending to discocellular spot; a dark purple-brown subterminal spot above vein 3 preceded by ochreous; terminal area from tornus to vein 6 dark lilacine grey; termen from vein 6 to apex ochreous; an ochreous line divides the grey from the purple from apex to subterminal spot above vein 3; cilia ochreous, black points opposite ends of veins.

Expanse 17 mm.

Hab. Alto da Serra, Santos.

HYRIOGONA MONTARIA, sp. n. (Pl. III. fig. 20.)

Male.—Palpi and head purple-brown; legs light brown, the fore pair suffused with purple; antennæ, tegulæ, and patagia light reddish brown; thorax posteriorly purple; abdomen light reddish brown, a few purple scales. Fore wings light reddish brown with lilacine reflection irrorated and suffused with purple-red; costa slightly suffused with dark brown; narrow diffused dark medial and postmedial lines; a dark discocellular spot; a diffused dark purple line from tornus to two-thirds on costa shaded outwardly with purple-red, which expands violently above vein 5 to close to apex; terminal area luteous, angled inwards on vein 5; a terminal row of minute purple points on the ends of the veins; cilia luteous. Hind wings similar to the fore wings, but the subterminal area is much more broadly suffused with purple and the termen narrowly luteous.

Expanse 17 mm.

Hab. Alto da Serra, Santos.

METASIOPSIS PROUTARIA, sp. n. (Pl. II. fig. 8.)

Male.—Palpi brownish ochreous; legs ochreous irrorated with light brown; frons and head rufous brown; vertex ochreous white; antennæ white; tegulæ pale rufous brown; thorax and abdomen ochreous irrorated with brown. Wings ochreous white. Fore-wings: indistinct subbasal, antemedial, and medial rufous-brown bands, the latter enclosing fuscous discocellular spot; postmedial line pale rufous brown, wavy, marked by fuscous spot on costa; terminal area fuscous from tornus to vein 7, the inner edge excavated from 2 to 4, the dark space traversed by wavy pale subterminal line; a terminal line of fuscous lunules on the interspaces, a fine wavy whitish line dividing them from the dark area; cilia ochreous white. Hind wings: medial, postmedial, subterminal, and terminal wavy diffused fuscous brown bands, all of them darker on inner margin.

Expanse 22 mm.

Hab. Castro, Paraná, Brazil.

Subfam. GEOMETRINÆ.

OOSPILA ALTONARIA, sp. n. (Pl. III. fig. 21.)

Male.—Palpi inwardly white, outwardly tawny; pectus white; legs ochreous, fore legs suffused with tawny; frons purple-brown,

a whitish anterior bar; vertex and antennæ shaft white, pectinations ochreous; thorax green; abdomen white; dorsum rosy brown. Wings emerald-green irrorated with darker green scales. Fore wings: costa tawny yellow; a large black discocellular spot with white centre and surrounded with white, the white scales having rosy reflection; termen crenulate, dark purple-brown; cilia rosy brown, white on the interspaces. Hind wings: a smaller discocellular spot. Underside white.

Expanse 32 mm.

Hab. Alto da Serra, Santos.

TACHYCHLORA FLORA, sp. n. (Pl. III. fig. 22.)

Male.—Palpi white; pectus and fore trochanters green; legs ochreous white; frons green, anteriorly white; vertex white; back of head green; antennæ shaft white, pectinations ochreous; abdomen green at base, segments 4 to 6 grey, anal segments white. Fore wings emerald-green; costa white; a minute black discocellular spot; a subterminal line of minute brown spots on the interspaces, the one above the discal fold larger than the rest; cilia white. Hind wings emerald-green; a large antemedial yellow space from vein 1 to subcostal nervure, outwardly nearly covered by a rosy-brown patch inwardly excavated in cell and containing dark discocellular bar; a postmedial series of minute brown spots on the interspaces, the one above discal fold the largest. Underside white, a very conspicuous discocellular bar on hind wings.

Expanse 25 mm.

Hab. Castro, Paraná, Brazil.

Fam. URANIIDÆ.

EPIPLEMA ORNATA, sp. n. (Pl. III. fig. 23.)

Female.—Palpi and frons fuscous brown; legs brown, the fore pair suffused with fuscous, mid- and hind-tarsi ferruginous brown; vertex of head and body greyish brown; antennæ shaft ringed with purplish. Fore wings ochreous grey, the costal area suffused with greyish brown to postmedial line, the suffusion expanding downwards on medial area, forming a triangle with apex at vein 3 defined inwardly by a dark line from cell to postmedial line on vein 2; a fine dark wavy indistinct antemedial line excurved through cell; postmedial line wavy, inwardly ferruginous, outwardly dark, followed by whitish shade; outer area grey with light strigulate suffusion of greyish brown; a fine dark subterminal line and ferruginous suffusion; cilia light brown with dark centre line. Hind wings ochreous grey; antemedial line very dark, slightly wavy, forming a right angle on fold in cell; a medial line parallel with antemedial from inner margin to vein 4, thence slightly diverging to excavation on

costa; the area enclosed between the two lines very dark grey-brown and ferruginous, extending in a rounded projection beyond medial at costa; a wavy dark postmedial line on dark suffusion with some ferruginous brown; cilia ferruginous with dark scattered scales.

Expanse 18 mm.

Hab. Guarujá, Santos.

EPIPLEMA RECTANGULARIA, sp. n. (Pl. III, fig. 24.)

Female.—Palpi, legs, head, antennæ, and tegulæ dark brown; base of antennæ ochreous white in front; thorax and abdomen greyish brown suffused with rufous, base of abdomen dorsally purple-brown. Fore wings ochreous brown suffused with fuscous on upper half and rufous on lower half; obscure traces of an antemedial line angled outwards on subcostal nervure and vein 1; a wavy dark diffused postmedial line bent inwards on discal fold, followed by ochreous streak from inner margin to vein 2; apex creamy white; a dark purplish-brown suffusion at tornus; a subterminal series of black points on the interspaces; cilia ochreous and brown, black points at the veins. Hind wings ochreous heavily suffused with rufous brown on upper half of basal and medial areas; a dark basal line; a dark antemedial line forming a right angle in the cell; postmedial line dark purple-brown from excavation on costa to vein 4 where it forms a right angle straight to inner margin, followed by rufous shade containing a fine strigulate steel-grey line; a dark suffusion on outer area between veins 3 and 6; a dark wavy subterminal line preceded by greyish-brown strigulæ and followed by rufous; a whitish terminal line; apex creamy white with a few dark irrorations; cilia ochreous brown and fuscous.

Expanse 24 mm.

Hab. Castro, Paraná, Brazil.

SACCOPOLOCA STRIGARIA, sp. n. (Pl. III, fig. 25.)

Male.—Palpi, legs, head, and antennæ rufous brown; body light brown. Fore wings light brown striated with purplish brown; some white strigulæ on basal area; inner half of wing darker brown; a ferruginous-brown antemedial line oblique from costa to cell, where it makes a rounded right angle and then runs straight to one-third on inner margin; postmedial line oblique from costa to vein 7, thence straight to middle of inner margin; cilia concolorous. Hind wings light brown, less heavily striated; the basal area darker than the rest of the wing; costal area white excepting at apex; antemedial and medial lines from inner margin to subcostal nervure, the medial being in continuation of postmedial of fore wing.

Expanse 27 mm.

Hab. Castro, Paraná, Brazil.

NEDUSIA CASTRA, sp. n. (Pl. III. fig. 26.)

Male.—Palpi and frons purplish brown; legs light fuscous brown; vertex of head and antennæ brown; patagia light brown; thorax and abdomen purplish brown, the anal tuft golden buff. Fore wings light brown suffused, striated, and irrorated with fuscous brown; a dark wavy medial line strongly excurved through the end of the cell, slightly bent inwards from cell to submedian fold, angled outwards on submedian fold and inwards on vein 1, some white before it in the cell; postmedial line wavy, dark ferruginous brown, slightly incurved from costa to vein 8, excurved from 8 to 2, then bent outwards and downwards to inner margin; terminal area lighter than rest of wing, suffused with darker from inner margin to vein 4; a curved subterminal dark streak between 4 and 7 followed by ferruginous; a dark point between 7 and 8; cilia dark. Hind wings light brown suffused with fuscous brown; the lines dark, parallel, angled outwards above median nervure, the inner preceded and the outer followed by white; medial area dark fuscous brown; cilia dark.

Expanse 28 mm.

Hab. Castro, Paraná, Brazil.

ALAPLENA, gen. nov.

Proboscis short; palpi slightly upturned, evenly scaled, third joint moderate; frons smooth; eyes large, round; antennæ of male simple; thorax clothed with scales; patagia terminating in hairs and long spatulate scales; legs smoothly clothed with scales; spurs moderate, the outer three-fourths of inner; abdomen smooth. Fore wings triangular; costa slightly arched at base and hollowed at middle; apex rounded; termen straight; inner margin slightly excavated before tornus; a small fovea below vein 1c, distorting it and the median nervure, vein 1c becoming obsolete before origin of vein 2; vein 2 from near end of cell; veins 3 and 4 separate from lower angle of cell; vein 5 from just above middle of discocellulars; veins 6 and 7 from upper angle; veins 8-9 and 10-11 stalked from cell. Hind wings: costa highly arched; apex square; termen nearly straight; inner margin folded over on the underside, the fold fringed with long spatulate hair-like scales; on the terminal area of the upper side the scales are raised and minute; the median nervure, submedian veins, and discocellulars aborted, the only veins remaining being 6, 7, and 8; 6 and 7 from subcostal nervure at middle of wing; vein 8 approaches subcostal only at base, where it bends violently towards costa and arched to costa.

Type, *A. castraria*.

ALAPLENA CASTRARIA, sp. n. (Pl. III. fig. 27.)

Male.—Palpi and frons dark rufous brown; legs light brown; vertex of head white; antennæ shaft white; tegulæ, patagia, and

thorax dark rufous brown; abdomen lighter brown. Fore wings light brown suffused and striated with fuscous; a medial ferruginous brown line outwardly shaded with fuscous, straight from inner margin to lower angle of cell, then bent to discocellulars; a whitish spot in the end of the cell; postmedial line sinuous, ferruginous brown inwardly shaded with fuscous, excurved from costa to vein 3, incurved from 3 to 1, followed by broad diffused whitish band; a fuscous-brown subterminal line from apex to vein 3, broad at apex, narrowing to vein 3 and broken at the veins, a narrow whitish shade on inner side; terminal area broadly grey; termen dark; cilia ferruginous. Hind wings light brown suffused with dark ferruginous on basal half above inner margin; terminal area brownish grey; a ferruginous brown antemedial line from costa to subcostal nervure; a medial line straight from before middle of costa to just beyond origin of vein 7, incurved below 7; obscure traces of a fine postmedial line.

Expanse 24 mm.

Hab. Castro, Paraná, Brazil.

FAM. LASIOCAMPIDÆ.

ARTACE REGALIS, sp. n. (Pl. I. fig. 12.)

Male.—Pure white. Palpi outwardly black, inwardly white; fore tibiæ and tarsi black, ringed with white; antennæ rufous brown. Fore wings: subbasal black spots at origin of vein 2 and below costa; antemedial line of black spots on veins 1-2, on median nervure at origin of vein 3, subcostal nervure, vein 11, and costa; a black point on the angles of the cell; a postmedial line of spots from middle of inner margin nearly straight to vein 8, where it bends inwards to costa; a subterminal line of more elongated spots slightly incurved from inner margin to vein 3, thence excurved to vein 10, the spot on costa distally displaced; a subapical row of rather obscure spots above veins 5-8; a terminal row of black spots on the interspaces; cilia white. Hind wings pure white.

Female similar.

Expanse: male 43 mm., female 70 mm.

Hab. Castro, Paraná; Alto da Serra, Santos.

FAM. PEROPHORIDÆ.

PEROPHORA THERMESIA, sp. n. (Pl. I. fig. 11.)

Male.—Palpi dark brown, rufous beneath; legs brown suffused with rufous and irrorated with lilacine white scales tipped with black; frons anteriorly brown, posteriorly rufous; vertex and antennæ reddish brown; tegulæ pale reddish brown with a few black irrorations; thorax light brown suffused with lilacine; abdomen light yellowish brown. Fore wings lilacine irrorated with white scales tipped with black; costa light brown, becoming

darker before apex; a very wavy antemedial line followed by light brown suffusion on medial area; a dark brown postmedial line excurved between costa and vein 8, and abruptly angled outwards below 8, thence straight to inner margin at two-thirds from base, followed by narrow lilacine and a brown suffusion, which is confluent with a dark subterminal shade from discal fold to tornus, a red suffusion beyond the line below apex; two square brown spots on costa at one-third and two-thirds; termen dark brown; cilia tipped with lilacine; a minute hyaline spot at end of cell. Hind wings ochreous lilacine, deeply suffused with reddish brown, the veins on outer half suffused with red; a dark medial line excurved from costa to vein 2, thence straight to inner margin, followed by light shade; a diffused dark subterminal shade; a minute hyaline spot at end of cell; termen brown; cilia lilacine. Underside: fore wings heavily suffused with reddish brown; a dark somewhat diffused postmedial line, oblique from costa to below vein 8, where it is angled outwards, straight to 5, then wavy to inner margin; a red subterminal space from 4 to 8; the veins beyond the cell slightly suffused with red. Hind wings less heavily suffused; a slight red suffusion beyond upper angle of cell; a dark diffused wavy postmedial line.

Expanse 41 mm.

Hab. Alto da Serra, Santos.

Fam. MEGALOPYGIDÆ.

CARAMA INCOLORATA, sp. n. (Pl. I. fig. 2.)

Male.—Grey; palpi, legs, head, and thorax suffused with light brown; antennæ light yellowish brown; abdomen grey ringed with yellowish. Wings satiny grey, rather darker at costa.

Expanse 31 mm.

Hab. Castro, Paraná, Brazil.

NAROPE CINGULATA, sp. n. (Pl. I. fig. 1.)

Male.—Palpi and pectus black; fore legs black with white hairs, mid- and hind-legs white, the tarsi fuscous with white scales on upper side; head very pale primrose yellow; antennæ tawny, the shaft white; thorax pure white; abdomen white with a broad band of orange on each segment. Fore wings pure glossy white; costa narrowly ochreous; antemedial, medial, and postmedial depressions and ridges. Hind wings pure white.

Expanse 30 mm.

Hab. Alto da Serra, Santos.

Fam. THYRIDIDÆ.

RHODONEURA OXYDATA, sp. n. (Pl. I. fig. 19.)

Male.—Palpi light reddish brown, third joint dark; legs ochreous, the fore pair suffused with fuscous; head and antennæ

light reddish brown; tegulæ fuscous brown; patagia anteriorly dark, posteriorly light brown; thorax dark brown; abdomen dark brown, the first segment and a dorsal line on segments 3-5 ochreous; anal tuft ochreous; ventral surface ochreous with dark central suffusion. Fore wings light brown striated with silvery-blue strigulæ; a series of inverted V-shaped marks on costa; a broad reddish medial shade from near tornus to upper angle of cell, with dark suffusion at end of cell; discocellulars circled with silvery blue; a blue circle between veins 2 and 3 at lower angle of cell; two small silvery-buff spots beyond the medial shade between veins 5 and 6; a large spot of the same colour and crossed by brown bar and striations from 5-7 and two triangular spots below 5; a large silvery-buff spot above tornus and some small ones on termen and inner margin; a subterminal series of silvery-blue spots below veins 4, 6, 7, and 8; cilia brown. Hind wings silvery buff heavily suffused with brown and striated with silvery blue; a reddish medial shade most conspicuous above vein 1; a golden suffusion on the submedian fold containing a black spot and some black points beyond; some subterminal black points below the fold; apical area dark brown.

Expanse 25 mm.

Hab. Alto da Serra, Santos.

Fam. PYRALIDÆ.

POLYGRAMMODES EXIMIA, sp. n. (Pl. I. fig. 6.)

Female.—Palpi: 1st joint white, 2nd and 3rd black; legs white, the fore tibiæ tinged with purple and ending in black; tarsi ringed with black; frons white with black at sides; head and antennæ white; tegulæ white with large chocolate central spot; thorax white with large posterior dorsal and two subdorsal chocolate spots; patagia white with central chocolate spot; abdomen white with transverse chocolate bands and short lateral transverse streaks on segments 2, 4, 5, and 6, segment 7 orange, anal tuft white. Wings white. Fore wings: a large basal chocolate spot; three subbasal spots on costa, in cell, and on inner margin; an antemedial chocolate band, broader on costa and angled outwards on median nervure, followed by spot in cell; a medial series of three bars, one on discocellulars, one below vein 2 to submedian fold and one from vein 1 to inner margin; a postmedial bar from costa to vein 5 and series of elongated spots between the veins; a subterminal series of elongated spots from below vein 8 to inner margin, confluent with postmedial series between 1 and 2 and approximate between 3 and 5; a terminal orange band expanding below vein 2 and broad at apex; an orange shade beyond lower angle of cell; cilia white, black at the veins. Hind wings: a medial series of four chocolate spots; a postmedial series of spots above veins 2-5; a subterminal series of elongated spots; a terminal orange band, expanding

below vein 2 and at apex; a slight orange shade beyond lower angle of cell.

Expanse 37 mm.

Hab. Alto da Serra, Santos.

Fam. ZYGENIDÆ.

HARRISINA MEPHISTO, sp. n.

Male.—Black with purple, blue, and green reflection; tegulae red; red lateral patches at base of abdomen almost meeting on dorsum.

Expanse 28 mm.

Hab. Alto da Serra, Santos.

EXPLANATION OF THE PLATES.

PLATE I.

- | | | |
|-------------------------------------|--|---|
| Fig. | | Fig. |
| 1. <i>Narope cingulata</i> . ♂. | | 13. <i>Lobeza irrorata</i> . ♀. |
| 2. <i>Carama incolorata</i> . ♂. | | 14. <i>Acanthodia frigida</i> . ♀. |
| 3. <i>Bryocodia paulina</i> . ♀. | | 15. <i>Moresa mona</i> . ♀. |
| 4. <i>Tarache parana</i> . ♂. | | 16. <i>Phurys fasciata</i> . ♂. |
| 5. " " ♀. | | 17. <i>Mictochroa paulata</i> . ♀. |
| 6. <i>Polygrammodes evimia</i> . ♀. | | 18. " <i>pallidula</i> . ♀. |
| 7. <i>Aplogompha japonaria</i> . ♂. | | 19. <i>Rhodoneura oxydata</i> . ♂. |
| 8. " <i>fumaria</i> . ♂. | | 20. <i>Merocausta felinaria</i> . ♀. |
| 9. " <i>setinaria</i> . ♂. | | 21. <i>Aplogompha castraria</i> . ♂. |
| 10. <i>Rosema pallida</i> . ♀. | | 22. <i>Bagodares castra</i> . ♀. |
| 11. <i>Perophora thermesia</i> . ♂. | | 23. <i>Ophthalmophora columbaria</i> . ♀. |
| 12. <i>Artace regalis</i> . ♀. | | |

PLATE II.

- | | | |
|--|--|--|
| 1. <i>Boarmia nigraria</i> . ♀. | | 14. <i>Azelina cetana</i> . ♂. |
| 2. <i>Hymenomima sinuosaria</i> . ♀. | | 15. <i>Callurapteryx paularia</i> . ♂. |
| 3. " " ♀. | | 16. <i>Cratoptera fenestraria</i> . ♂. |
| 4. " <i>nivacaria</i> . ♂. | | 17. <i>Apicia geminimacula</i> . ♂. |
| 5. <i>Larentiopsis costiplaga</i> . ♂. | | 18. <i>Trotogonia castraria</i> . ♂. |
| 6. <i>Rhodomena santaria</i> . ♀. | | 19. <i>Isochromodes elegantaria</i> . ♀. |
| 7. " <i>paularia</i> . ♀. | | 20. <i>Paracomistis tristaria</i> . ♂. |
| 8. <i>Metasiopsis proutaria</i> . ♂. | | 21. <i>Camptonema marginata</i> . ♂. |
| 9. <i>Tetragonodes geminaria</i> . ♀. | | 22. <i>Nephodia bonitaria</i> . ♀. |
| 10. <i>Polla acutaria</i> . ♀. | | 23. " <i>paularia</i> . ♂. |
| 11. <i>Numia strigularia</i> . ♂. | | 24. <i>Apicia strigularia</i> . ♂. |
| 12. <i>Oxydia pallidaria</i> . ♂. | | 25. <i>Hypolepis bella</i> . ♂. |
| 13. <i>Azelina hanebaria</i> . ♂. | | 26. <i>Eariodes flavicilia</i> . ♂. |

PLATE III.

- | | | |
|---------------------------------------|--|---------------------------------------|
| 1. <i>Eupithecia mauvaria</i> . ♀. | | 15. <i>Ptychopoda campinaria</i> . ♀. |
| 2. " <i>aquanivaria</i> . ♀. | | 16. " <i>tilacaria</i> . ♂. |
| 3. <i>Anisodes bizaria</i> . ♂. | | 17. <i>Hyria gemmaria</i> . ♀. |
| 4. " <i>paranaria</i> . ♀. | | 18. <i>Psaliodes aurantaria</i> . ♀. |
| 5. " <i>carolina</i> . ♀. | | 19. <i>Hyriogona santaria</i> . ♂. |
| 6. " <i>japaria</i> . ♀. | | 20. " <i>montaria</i> . ♂. |
| 7. " <i>antennaria</i> . ♂. | | 21. <i>Oospila altonaria</i> . ♂. |
| 8. " <i>vigoraria</i> . ♀. | | 22. <i>Tachychlora flora</i> . ♂. |
| 9. <i>Eupithecia cuprearia</i> . ♂. | | 23. <i>Epiplema ornata</i> . ♀. |
| 10. <i>Hemalia mantaria</i> . ♀. | | 24. " <i>rectangularia</i> . ♀. |
| 11. " <i>magitaria</i> . ♀. | | 25. <i>Saccoploca strigaria</i> . ♂. |
| 12. <i>Eois lutearia</i> . ♂. | | 26. <i>Nedusia castra</i> . ♂. |
| 13. <i>Ptychopoda terminaria</i> . ♀. | | 27. <i>Ataplana castraria</i> . ♂. |
| 14. " <i>delicataria</i> . ♂. | | |

19. On some new or little-known Acari, mostly Parasitic
in Habit. By STANLEY HIRST, F.Z.S.

(Submitted for Publication by permission of the Trustees of the British Museum.)

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(Text-figures 1-15.)

The present note deals with a miscellaneous series of Mites from various localities, including a number of new Gamasid mites found by Mr. James Waterston in the nasal cavities of Scottish birds, also several new ectoparasites from various sources. *Demodex* is recorded from several new hosts, viz., deer, long-eared bat, mole, and water-rat, three of the species being regarded as new. An interesting pseudoparasite of flies is also described, and a new English jumping-mite (*Speleorchestes*).

Text-figures 1-7 were drawn by Mr. E. J. Engel Terzi, nos. 8-15 by Mr. Percy Highley.

Family G A M A S I D Æ.

RHINONYSSUS CALEDONICUS, sp. n. (Text-fig. 1.)

♀. *Abdomen* not elongated. Hairs on *venter* mostly only slightly thickened at the base, the posterior ones situated just in front of the anus are not dentiform, and there is only one pair in this position. Genito-ventral plate shorter and wider than in *R. neglectus* and *R. waterstoni*. *Legs* of moderate length, those of the first pair apparently sometimes longer than the others. Legs furnished with spinules, but they are minute. Claws of first leg with a distinct short process or denticle dorsally.

Length .92-1.01 mm.

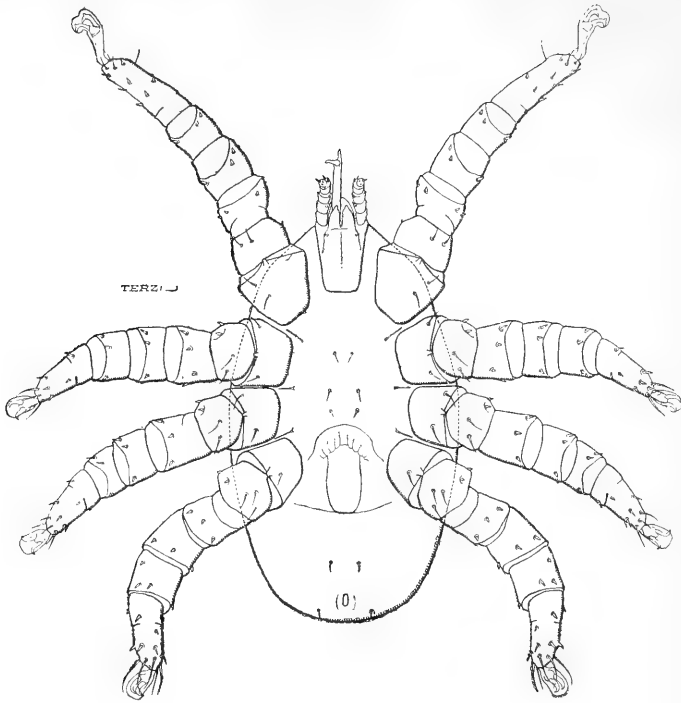
Habitat. Nasal cavities of *Uria grylle* (Black Guillemot), North Mavine, Mainland, Shetland Islands: Gluss Voe (25. ii. 1912), and Gluss Point (17. x. 1912), and Voe, Mainland, Shetland (2. iii. 1912). Specimens collected by James Waterston.

RHINONYSSUS LEVINSENI Trägårdh.

Sommatericola levinseni Trägårdh, Monograph arktisch. Acar. in Römer and Schaudinn's Fauna Arctica, 1905, iv. pp. 28-30, text-figs. 42-47, also pl. i. figs. 1, 3, and 8.

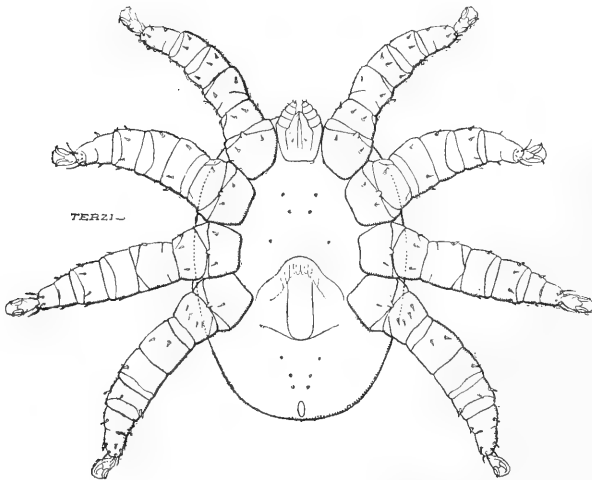
Trägårdh's genus *Sommatericola* must, I think, be regarded as a synonym of *Rhinonyssus* Trouessart. His species *Sommatericola* = *Rhinonyssus levinseni* (from nasal cavities of *Sommateria mollissima*) seems from his description to be closely allied to *R. scoticus*, but he depicts more spinules round the anus than are present in that species, and also shows the lateral spines on the palp as much stronger than in *R. waterstoni*.

Text-figure 1.



Rhinonyssus caledonicus, sp. n., ♀. Ventral view.

Text-figure 2.



Rhinonyssus waterstoni, sp. n., ♀. Ventral view.

RHINONYSSUS WATERSTONI, sp. n. (Text-fig. 2.)

♀. *Abdomen* not elongated. Very minute spinules are present on the *venter* in this species, instead of the hairs that are present in *R. caledonicus*. *Capitulum* short; segments of palp very short, being very much wider than long; tarsal segment very small, the conical tubercle on it well developed. *Legs* not very long, the first pair apparently slightly shorter than the fourth. *Coxæ* with very short spinules or hairlets instead of the fairly long hairs present in *R. caledonicus*. Spines on legs much weaker than in *R. neglectus*. Claw of first leg apparently without any dorsal process.

Length .96 mm.

Habitat. Nasal cavities of the Razorbill (*Alca torda*), Ollaberry, North Mavine, Shetland Islands. Specimens collected by James Waterston (15. xii. 1913).

RHINONYSSUS ECHINIPES, sp. n. (var. of *R. neglectus*?). (Text-figs. 3 & 4.)

♀. *Abdomen* not very elongated in the female sex. There are three pairs of minute denticles or tubercles anteriorly on the *venter*. The three pairs of denticles in front of the anus are much smaller and weaker than in *R. neglectus*. *Capitulum* apparently shorter than in *R. neglectus*. Segments of the palp also shorter; the minute conical tubercle on the tarsus is unusually large in this species. *Legs*. Denticles on posterior *coxæ* weaker than in *R. neglectus* or replaced by hairs with a somewhat thickened base; the other segments of the legs furnished with numerous strong denticles as in *R. neglectus*.

♂. *Abdomen* apparently more elongated (conical) than in the female.

Length, ♂ 1.36 mm., ♀ 1.36 mm.

Habitat. Nasal cavities of Ringed Plover (*Ægialitis hiaticola*), Queyfirth, North Mavine, Shetland Islands (5. i. 1914). Specimens collected by James Waterston.

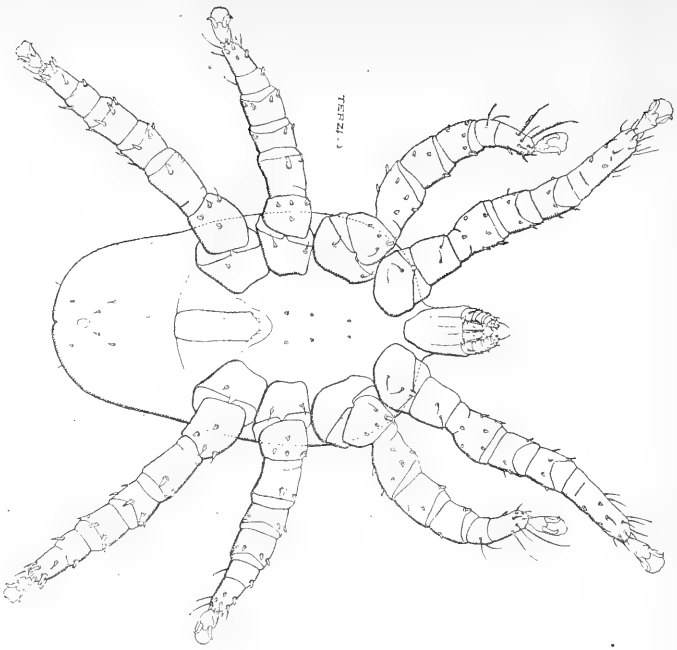
RHINONYSSUS NEGLECTUS, sp. n. (Text-fig. 5.)

♀. *Abdomen* not elongated. Three pairs of strong but short spinules are present anteriorly on the *venter*, and three pairs of very strong spinules (grouped closely together) are placed immediately in front of the anal aperture. *Capitulum* unusually elongated. Palpi with the segments more slender than in *R. echinipes*. *Legs*. First and fourth pairs of legs rather long, being considerably longer than the second and third pairs. Denticles on legs much stronger than in *R. caledonicus* and *R. waterstoni*.

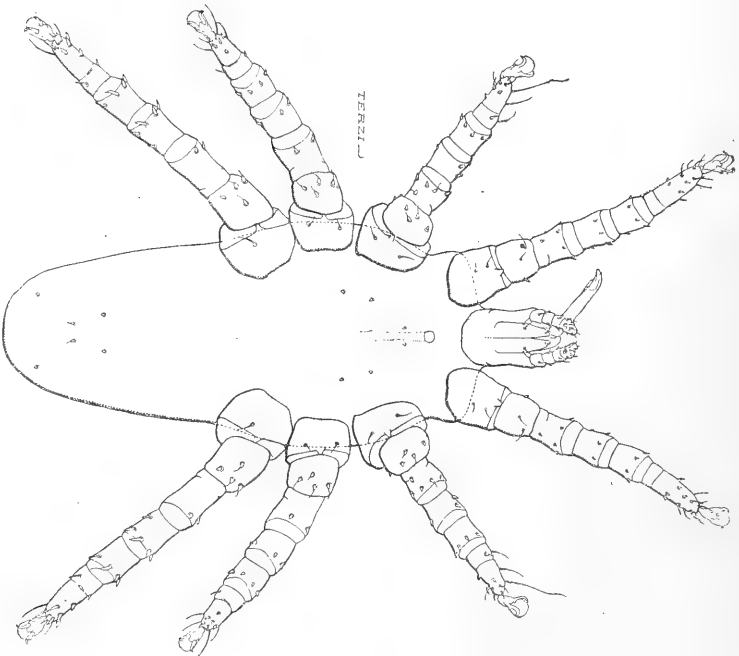
Length 1.36 mm.

Habitat. Nasal cavities of *Tringa striata* (Purple Sandpiper),

Text-figure 3.



Text-figure 4.

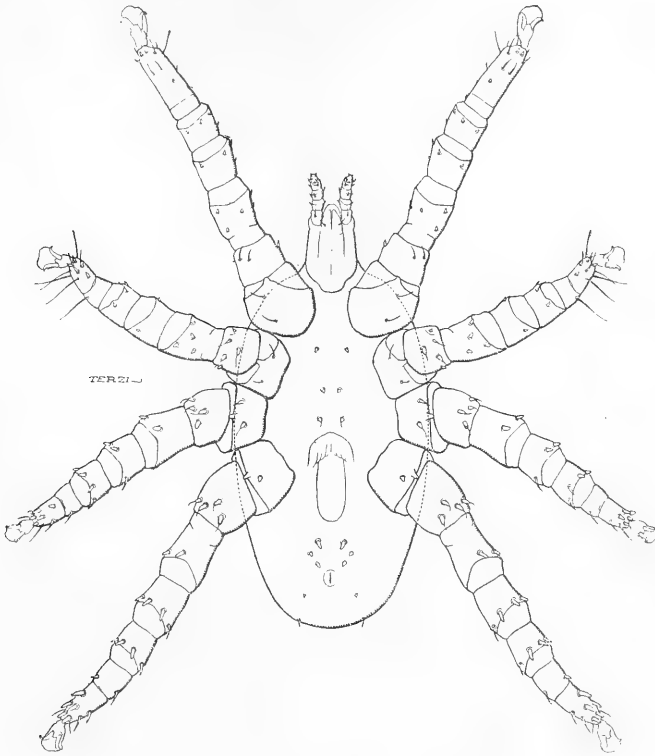


Rhinonyssus echinipes, sp. n., ♀. Ventral view.

Rhinonyssus echinipes, sp. n., ♂. Ventral view.

Yell Sound, Ollaberry, North Mavine, Shetland Islands: Little Roe Island (13. ii. 1913). Specimens collected by James Waterston.

Text-figure 5.



Rhinonyssus neglectus, sp. n., ♀. Ventral view.

RHINONYSSUS CONIVENTRIS Trouessart. (Text-figs. 6 & 7.)

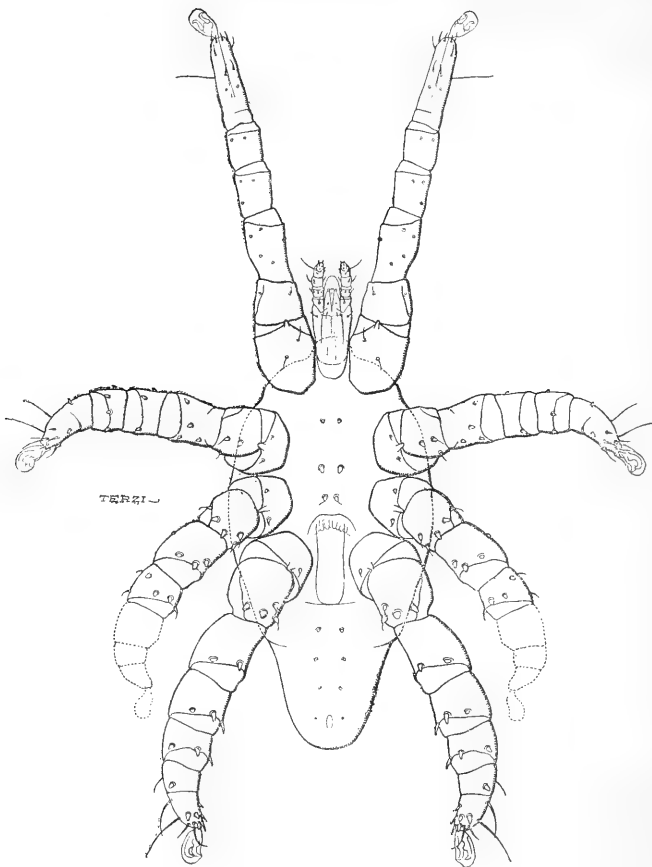
♀. *Abdomen* elongated (conical). Anterior spinules on *venter* similar to those present in *R. neglectus*, etc. There is also a pair of spinules situated not far behind the genito-ventral plate and two pairs of minute spinules or tubercles near the anal orifice. *Legs*. Last pair of legs greatly enlarged and furnished with very strong spinules.

♂. Fourth leg about as long as the first and not much stouter.

Length, ♀, 1.45 mm.

Habitat: Nasal cavities of the Turnstone (*Streptopus interpres*); North Roe, Mainland, Shetland. Specimens collected by James Waterston (27. ii. 1911).

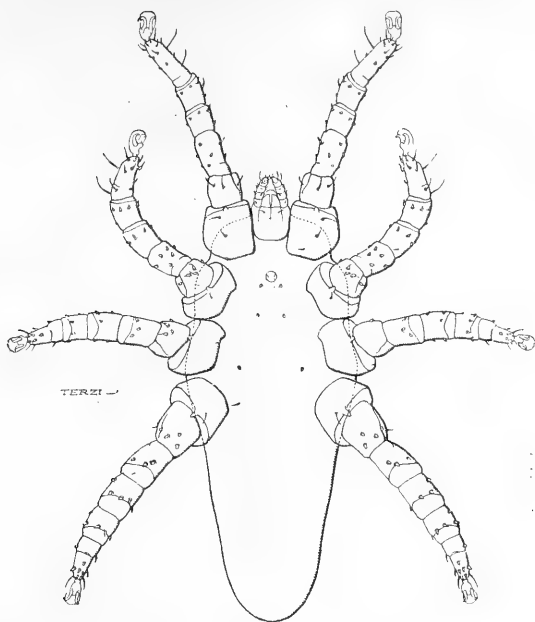
Text-figure 6.

*Rhinonyssus coniventris*, ♀. Ventral view.

LIPONYSSUS BERLESEI, sp. n. (Text-figs. 8 & 9.)

♀. *Body* fairly long oval, and sometimes slightly constricted near the middle (behind the last pair of legs); the abdomen is sometimes rather swollen, and may exceed the width of the anterior part of the body; posterior end with a slight notch. *Dorsal shield* wide anteriorly, but narrowed and coming to a point posteriorly. There are some quite short hairs on the scutum, chiefly placed near the margin, and also a few very minute and inconspicuous hairs in the middle of its surface.

Text-figure 7.

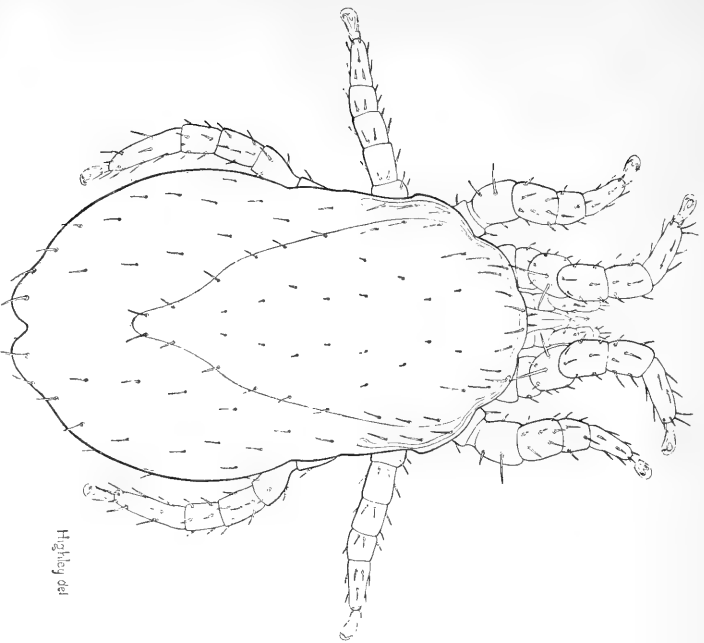
*Rhinonyssus coniventris*, ♂. Ventral view.

Hairs on uncovered part of dorsum not very numerous, and mostly shorter than those on the venter. *Sternal plate* wider than long and with three pairs of long hairs, its anterior margin is not well defined, being continued forwards by transverse linear markings that reach the front end of the body. *Genito-ventral plate* short, of moderate width, and the posterior end is blunt (not pointed). *Anal plate* of the usual pyriform shape, but more elongated than usual. *Peritreme* reaching forwards almost to the level of the middle of the coxa of the first leg. *Legs* normal in appearance, being of moderate length. Second coxa with a long, sharp anterior spine and a very slight rounded spur posteriorly. Third coxa posteriorly with a sharp, well-developed inner spur, and an inconspicuous outer denticle. Tarsus of second leg with a pair of short pointed denticles at the end. The hairs on the legs are shown too strong (spiniform) in the figures of this species. They are more hair-like.

Length (including capitulum) .87–.90, width .36–.44 mm.

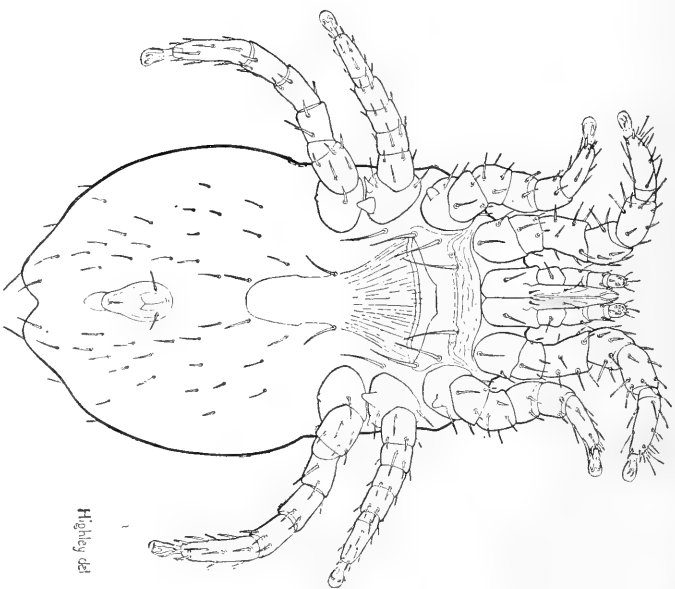
Habitat. Parasitic on *Myospalax scansus*, Shensi, North China; several specimens collected by Capt. H. E. M. Douglas (24. xi. 1908).

Text-figure 8.



Liponyssus bertlesi, sp. n., ♀. Dorsal view.

Text-figure 9.



Liponyssus bertlesi, sp. n., ♀. Ventral view.

LIPONYSSUS SERPENTIIUM Hirst.

This species was described from examples found on a Couper's Snake at the Society's Gardens. I have examined some additional specimens from the Horned Viper (*Vipera cerastes*), also from our Gardens. The first-named host is a Mexican species, whilst the latter is a North African form. This mite has also been found on snakes that have died at the Bronx Zoological Park, N.Y. It is believed that this parasite was introduced with the Malayan Python (*Python reticulatus*), and, whilst it does not harm that host, may leave it and attack American snakes of any kind, giving rise to a kind of blister or eruption under the edge of the scale, causing death. According to Mr. Ditmars, several snakes have been lost from this cause. The above details, relating to the American case, are taken from Mr. P. S. Falshaw's letter accompanying the specimens.

Liponyssus serpentium is easily distinguished from the allied *L. natricis* by the presence of two dorsal shields instead of only one. The genito-ventral plate is ornamented with longitudinal linear markings, as in *L. natricis*.

LIPONYSSUS ARABICUS, sp. n.

♀. There are two plates on the *dorsum* in this species, the posterior being very minute and oval as in *L. serpentium* mihi, but the anterior one is long and wedged-shaped, reaching far backwards, and only separated from the minute posterior plate by a comparatively short space (whereas in *L. serpentium* the two plates are widely separated from one another). Anterior plate furnished with a number of hairs. The minute posterior plate does not bear any hairs. Hairs of body lacking minute off-shoot present in *L. bacoti* mihi. The minute platelets present between the main shields in *L. serpentium* appear to be absent in the new species. Besides the usual fine striations of the integument, there are a number of fairly long, but very fine chitinous (?) linear markings, especially numerous at the sides of the body. *Venter*. Sternal shield trapezoidal in shape, and with two pairs of hairs on its surface. Genito-ventral shield long and narrow. Anal plate pear-shaped; the paired hairs on it shorter than the unpaired one. *Legs*. Coxæ without spurs; the other segments with the usual fairly stiff hairs, but without any strong spines.

Length .73 mm.

Habitat. A single specimen from a lizard (*Agama adramitana*); Ad Dthala, Upper Hushabi, South Arabia.

LIPONYSSUS BURSA Berlese.

During a recent visit to the Natural History Museum, Mr. M. Koidzumi brought me two specimens of a mite found on a Chinese patient at Hôko Tô Island, Formosa. They are referable to the tropical fowl-mite (*Liponyssus bursa* Berlese).

Family LISTROPHORIDÆ:

LISTROPHORUS FRONTALIS, sp. n. (Text-fig. 10 A & B.)

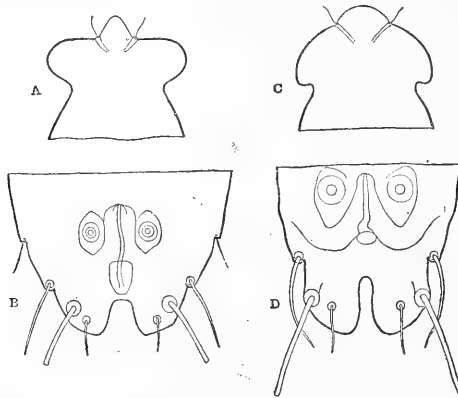
♂. Dorsal (frontal) process of capitulum much more strongly salient than in *L. argentinus*, being fairly long and conical (text-fig. 10 A). Abdominal lobes rather shorter than in *L. argentinus*, and somewhat differently shaped (text-fig. 10 B).

♀. Process of capitulum similar to that in the male.

Length, ♂ 330-345 μ , ♀ 365 μ .

Habitat. Parasitic on the rodent *Orizomys delticola*, from Isla Ella del Delta, Parana.

Text-figure 10.



A. Anterior end of *Listrophorus frontalis*. B. Posterior end of abdomen of male of the same species. C. Anterior end of *Listrophorus argentinus*. D. Posterior end of abdomen of male of this mite.

LISTROPHORUS ARGENTINUS, sp. n. (Text-fig. 10 C & D.)

♂. Dorsal (frontal) process wider than long and rounded in outline (text-fig. 10 C). Abdominal lobes ending in a delicate, almost truncate process, the posterior edge being, however, slightly oblique; the gap between the two lobes long and narrow (text-fig. 10 D).

♀. Capitulum of female very like that of the male.

Length, ♂ 345-360 μ , ♀ 415-450 μ .

Habitat. Argentina; on a rodent (*Scapteromys tomentosus*).

TRICHÆCIUS BREVIPES Can. & Trt.

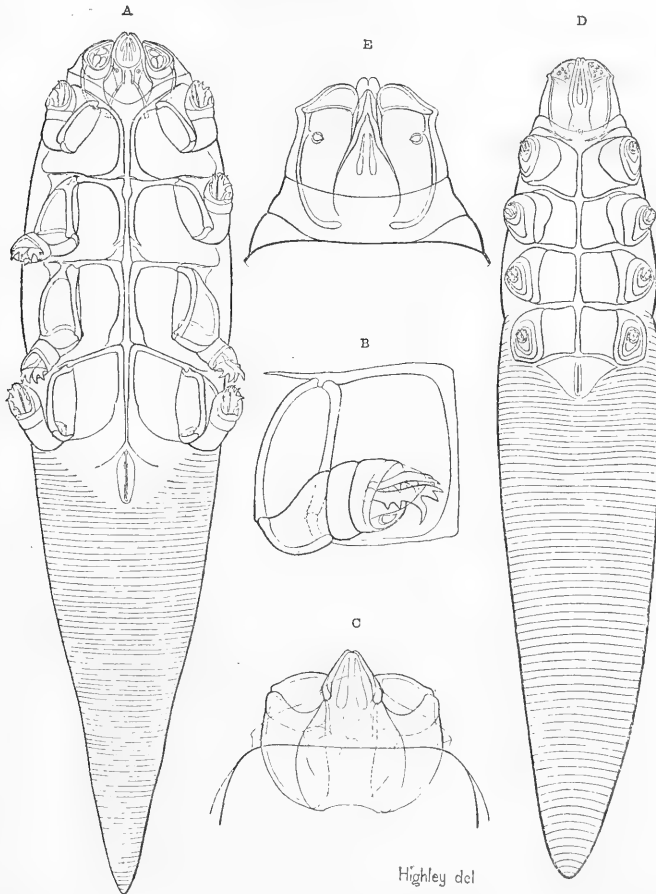
According to Canestrini and Kramer in 'Das Tierreich' (Sarcoptidæ, etc.), this interesting little Listrophorid mite has only been found in Thessaly, and I cannot find a later reference to the species. As a matter of fact, it is not uncommon on English rodents. I have collected numerous specimens off *Evotomys glareolus britannicus* at Exeter, and off *Microtus agrestis* at Barnes, Surrey.

Family DEMODICIDÆ.

DEMODEX CHIROPTERALIS, sp. n. (Text-fig. 11 A, B & C.)

♀. This species differs from the small form of *Demodex* (*D. soricinus*) sometimes present in the skin of the long-eared bat in its much larger size and stronger legs, the latter being

Text-figure 11.



Highley del

A. *Demodex chiropteralis*. Ventral view. B & C. Enlarged view of foot and of capitulum of same. D. *Demodex melesinus*, ♀; ventral view. E. Dorsal view of capitulum of same species.

very strongly chitinised, and furnished with unusually large claws, the genual joint, or articulation, is very pronounced, and the distal half of the limb readily movable. Vulvar opening

elongated. Body wide, the abdomen pointed posteriorly. (Both my specimens of this species are slightly damaged, and it is difficult to give the exact proportions.) Capitulum apparently without any dorsal tubercle or spinule; it is rather like that of a nymph in some respects.

Measurements. Total length 229 μ , length of cephalothorax + capitulum 114–115 μ , of abdomen 115 μ ?; greatest width of cephalothorax 59–61 μ , of abdomen?.

Host. Long-eared bat (*Plecotus auritus*); two specimens collected by the author (October 21st, 1919).

DEMODEX SORICINUS Hirst.

♀. I have found several specimens of a small form of *Demodex* in the skin of long-eared bats, which is very similar to that found in rats and shrew-mice described under the name *soricinus*. The capitulum in these specimens from bats is apparently without any dorsal tubercle or spinule. The body is somewhat differently shaped, the posterior end of the abdomen being blunt (almost rounded), instead of pointed as in typical specimens of the species. Capitulum considerably wider than long. Abdomen a little shorter than cephalothorax + capitulum; body a little more than three times as long as its width.

Measurements. Total length 111–128 μ ; length of cephalothorax + capitulum 63–75 μ , length of abdomen 52–53 μ , width of cephalothorax 33–38 μ , width of abdomen 33–36 μ , of capitulum 18–23 μ , length of capitulum 13–19 μ .

Material. Several specimens from live long-eared bats (*Plecotus auritus*), collected by the author, October 1919.

DEMODEX GLIRICOLENS, sp. n. (var. of *D. arvicola*?). (Text-fig. 12.)

♂. Body varying rather considerably in shape. One specimen is rather narrow and elongated, and about five times as long as wide. Abdomen of this example distinctly longer than the cephalothorax + capitulum. Capitulum rather narrow and fairly elongated (about as long as wide).

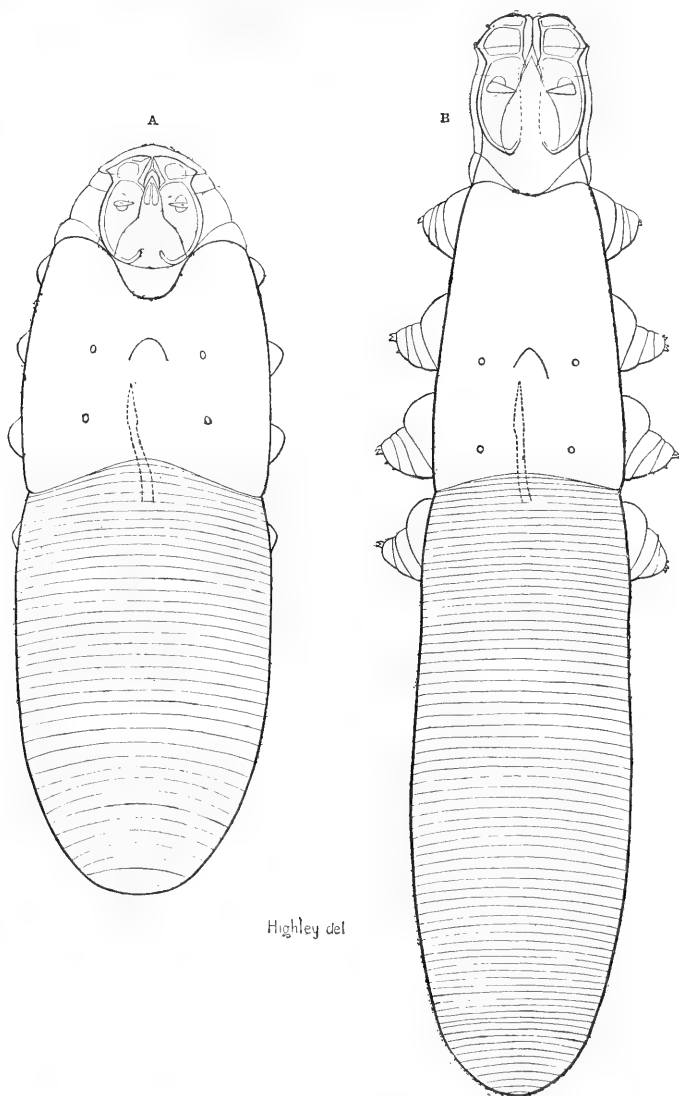
Another specimen is much shorter and comparatively wide, being about three times the width of the cephalothorax. The abdomen is slightly shorter than the united length of cephalothorax and capitulum. Capitulum of this specimen rather wide, being wider than long.

Posterior end of abdomen rounded off in this species. Spinule on dorsal surface of capitulum smaller and more slender than is usually the case in *D. arvicola*.

Genital opening of male situated on the dorsal surface above the interval between the first and second pairs of legs, in this respect resembling *D. erminea*; the opening is, however, very simple, consisting merely of a curved line.

Measurements. Slender example. Total length 144 μ , length of cephalothorax + capitulum 70 μ , of abdomen 74 μ , greatest

Text-figure 12.



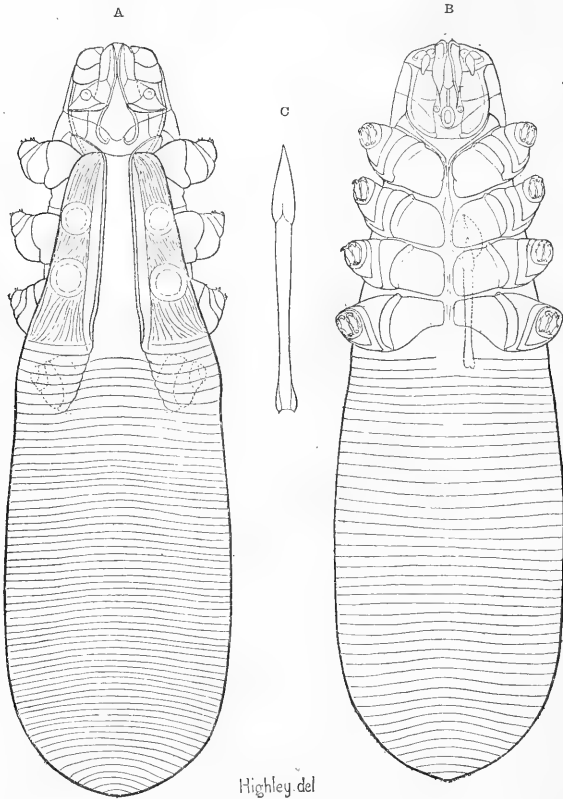
Demodex gliricoles, ♂.

A & B. Dorsal views, showing variation in shape of body

width of cephalothorax $29\ \mu$, of abdomen $30\ \mu$, length of capitulum $18\ \mu$, its width $17\ \mu$. The short wide form measures as follows:—Total length $103\ \mu$, length of cephalothorax + capitulum $56\ \mu$, of abdomen $47\ \mu$, greatest width of cephalothorax $35\ \mu$, of abdomen $36\ \mu$, length of capitulum $15\ \mu$, its width $15\ \mu$.

Host. Water-rat (*Arvicola amphibius*); two male specimens collected by the author from freshly-killed examples of this mammal (July 1919).

Text-figure 13.



Higley del

Demodex talpæ.

A. Dorsal view of female. B. Ventral view of male. C. Penis greatly enlarged.

Note.—The sexual orifice of the male is really dorsal in position and the penis situated in the median line.

DEMODOX TALPÆ, sp. n. (Text-fig. 13.)

♀. Body about four times as long as the width of the cephalothorax. Cephalothorax usually rather narrow in front, becoming a little wider posteriorly. There is a well-defined longitudinal

groove running down the middle of the cephalothorax, which always seems to be present, and is the chief distinguishing feature of the species. This groove is limited laterally by a rather sharp line, which sometimes has the appearance of being double (owing to the depth of the groove). Abdomen sometimes with the sides slightly convex, and it is then distinctly wider than the cephalothorax, in other specimens the abdomen is of fairly uniform width throughout its length; it is a little longer than the cephalothorax. Capitulum fairly elongated, but still it is slightly wider than long. Spinule on its dorsal surface flattened in much the same way as in *D. arvicola*, and pointed distally (internally), the outer angle distinct. The spinule is fairly thick, for under very high magnification a distinct posterior edge can be seen; it is fairly large and wide as compared with the size of the capitulum. One of the little claws or denticles on the ventral surface of the terminal segment of the palp is much longer than the others.

♂. Male very like the female in general appearance and with the dorsal groove well-developed. Body about four times as long as width of cephalothorax, the abdomen being longer than the cephalothorax + capitulum. Male sexual orifice situated on the dorsal surface above the interval between the second and third pairs of legs. Penis quite long and slender.

Measurements. ♀. Total length 128–130 μ ; length of cephalothorax + capitulum 59–62 μ , of abdomen 68–74 μ ; greatest width of cephalothorax 31–34 μ , of abdomen 34–41 μ ; length of capitulum 15–19 μ , its width 19–20 μ . ♂. Total length 126 μ ; length of cephalothorax + capitulum 54 μ , of abdomen 72 μ , of penis 22 μ ; greatest width of cephalothorax 30–33 μ , of abdomen 37 μ ; greatest width of capitulum 21 μ , its length 16 μ .

Material. Several specimens obtained by the author from freshly-killed moles (*Talpa europaea*); May 1919.

DEMODEX BOVIS Stiles.

I have examined specimens apparently referable to this species collected by Dr. E. Brumpt from deer. The material consists of a small piece of skin, preserved in spirit, containing a number of pustules filled with whitish matter and numerous parasites in all stages of development. The material is not very well preserved. The following is a description of the adult specimens:—
♀. Shape very like typical examples of *D. bovis*, the body is from a little more than three times to about three and a half times as long as the cephalothoracic width. Abdomen not quite so sharply pointed as in typical specimens of *D. bovis*; it is nearly always distinctly longer (sometimes considerably longer) than the cephalothorax + capitulum, but occasionally only about the same length. Capitulum wider than long. Spinule on its dorsal surface moderately long and distinctly bent or angular near the distal end.

♂. Male sexual orifice situated well forward on the cephalothorax above the first pair of legs; the minute lobes, etc., round it are exactly as in specimens from cattle. Males are very rare in the slides mounted from the material, and the measurements of the male sex given below are based on very few examples.

Measurements. ♀. Total length 180–238 μ ; length of cephalothorax + capitulum 90–101 μ , of abdomen 90–143 μ ; greatest width of cephalothorax 58–65 μ (rarely 70), of abdomen 53–60 μ .

♂. Total length 199 μ ; length of cephalothorax + capitulum 79 μ , of abdomen 120 μ ; greatest width of cephalothorax 61 μ , of abdomen 64 μ .

Host. Material from a deer (species?) at Chantilly, France (Dr. E. Brumpt).

DEMODEX MELESINUS Hirst. (Text-fig. 11 D & E.)

The *Demodex* of the badger is of unusual interest, for of all the known forms it most closely resembles that present in man (*D. folliculorum*), but is smaller in size and has the capitulum more elongated.

DEMODEX CANIS VAR. ERINACEI Hirst.

Since writing my paper on *Demodex*, I have obtained a number of specimens of this variety from the head of a hedgehog caught by the Museum taxidermist (Mr. A. H. Bishop) at Dymchurch, Kent (3.viii.1919). They are elongated specimens, agreeing fairly well with those on which my description was based. These additional examples measure as follows:—♀. 312–370 μ (a large bent example of this sex probably measures about 400 μ). ♂. 232–292 μ .

Family TROMBIDIIDÆ.

TETRANYCOPSIS HORRIDA C. & F.

This "Red Spider" has not been recorded from England. I have seen an example collected by Mr. K. G. Blair, on hazels at Shoreham, Kent, and during an excursion to that locality I obtained another specimen myself. The species, apparently, is not very abundant, even where it occurs. Numerous specimens of the lime-tree mite (*Tetranychus tiliarium*) occurred on the hazels in this locality.

Genus PSORERGATES.

In some details of structure, the immature stages of the mites of the genus *Psorergates* resemble those of the genus *Demodex*. For instance, the feet of the larval and nymphal stages are incomplete, consisting of an epimeron, shaped almost exactly as in *Demodex*, both its ends being angular and supporting a roughly circular disc-shaped segment, bearing processes or claws furnished with denticles of a similar type to those present in the immature stages of *Demodex*. In spite of the difference in shape

and general appearance, it seems probable that the genera *Psorergates* and *Demodex* are related to one another.

SPELEORCHESTES VENTRIOSUS, sp. n.

♀. This new saltatorial mite differs from *S. poduroides*, mihl in being much stouter in appearance; the abdomen is especially wide (hence the specific name *ventriosus*), being much stouter than in *S. poduroides*. Ovipositor when protruded provided with a basal collar-like structure or sheath as in *S. poduroides*, but it is longer than in that species, its length exceeding the distal part of the ovipositor that projects beyond it (whereas in *S. poduroides* the collar is much shorter than the part of the ovipositor that projects beyond it). Shape of hairs and their distribution much as in *S. poduroides*.

Owing to its rather squat appearance, this new species of *Speleorchestes* somewhat resembles *Nanorchestes*, but the anterior part of the cephalothorax is quite separate and distinct from the posterior portion, not being enclosed by it laterally; posterior part of cephalothorax much narrower than the abdomen and divided from it by a distinct constriction (whilst in *Nanorchestes* the posterior part of the cephalothorax is almost as wide as the abdomen and only separated from it by a slight groove).

Length (including chelicerae) 317 μ ; width of anterior (cephalic) part of cephalothorax 62–67 μ ; width of posterior (thoracic) part of cephalothorax 107–110 μ ; width of abdomen 155–160 μ .

Habitat. Hindhead, Surrey; a number of specimens collected by the author under stones near the path running above the natural hollow known as "the Devil's Punch Bowl" (just below Hindhead Beacon), May 1918.

SPELEORCHESTES PODUROIDES Hirst.

I have added a few more measurements for comparison with those of *S. ventriosus*, sp. n.

Length (including chelicerae) 278–290 μ ; width of anterior (cephalic) part of cephalothorax 58–60 μ ; width of posterior (thoracic) part of cephalothorax 82–85 μ ; width of abdomen 106–115 μ .

Key to British Species of Saltatorial Mites (Genera *Nanorchestes* and *Speleorchestes*).

Body short and wide; anterior part of cephalothorax enclosed laterally by the posterior part	<i>Nanorchestes</i> Tops. & Trouess.
Dorsal hair on chelicera slender and divided into two plumose branches	<i>N. collinus</i> Hirst (Mendip Hills).
Dorsal hair on chelicera rather short, stiff, rod-like, and not divided	<i>N. amphibius</i> Tops. & Trouess. (Littoral species.)
Body more elongated; anterior part of cephalothorax free (not enclosed laterally by posterior part)	<i>Speleorchestes</i> Trgdh.

Body fairly narrow; the part of the ovipositor projecting beyond the collar-like sheath longer than the sheath itself

S. poduroides Hirst
(Malvern Hills.)

Body wider; sheath of ovipositor longer, the part projecting beyond the sheath shorter than the sheath itself.....

S. ventriosus, sp. n.
(Hindhead, Surrey.)

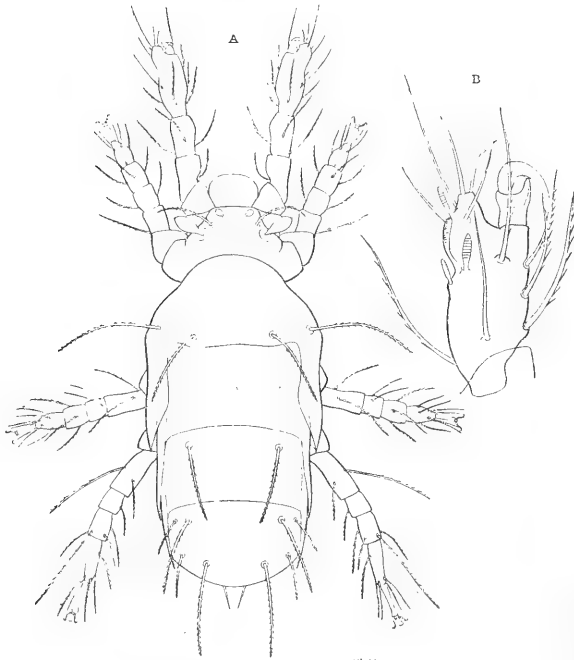
Family TARSONEMIDÆ.

PYGMEPHORUS TARSALIS, sp. n. (Text-fig. 14.)

? *Pigmephorus stercoricola* Berlese, Redia, 1911, vii. p. 184.

♀. Tarsus of first leg ending in a large conical protuberance situated above the claw, which is moderately developed. Striated

Text-figure 14.



Higley del.

Pygmephorus tarsalis, sp. n., ♀.

A. Dorsal view. B. Tarsus of first leg much enlarged.

sensory (so-called olfactory) hairs on first tarsus all slender, and none of them are especially large; the distal one is not very long, being very slender; the two proximal ones are placed close together, they are club-shaped, and one of them is longer than

the other (also slightly longer than the distal one). The remaining (second) sensory hair is prone and closely applied to the segment, and therefore is inconspicuous. Second tarsus with a single striated sensory hair dorsally near the proximal end, and it is comparatively stout. The pair of tiny oval structures situated in front of the pseudostigmata are smaller and further part than in *P. americanus*. Pseudostigmata not rounded off distally (as is the case in *P. spinosus* and *P. pilosus*), but ending in a point. There is only one pair of long hairs on the cephalothorax (instead of three pairs as in *P. americanus*); each hair being situated just in front of, and slightly to the side of, the pseudostigmata. An exceedingly short and inconspicuous hair is also present close to each of these two long hairs. The posterior hair present on the cephalothorax in *P. americanus* is missing in this species from mushrooms. Tarsus of fourth leg with quite long hairs. Hairs on body long and very slightly feathered, the feathering being scarcely visible even under very high magnification (instead of quite distinct as in *P. spinosus* and *P. pilosus*).

Measurements. Total length 217–297 μ ; width 100–132 μ .

Habitat. Numerous specimens from off the top-surface of cultivated mushrooms; received through the kindness of Professor H. Maxwell Lefroy.

PYGMEPHORUS AMERICANUS Banks. (Text-fig. 15.)

Pigmeophorus americanus Banks, Treatise on Acarina, P.U.N. Mus. 1904, xxviii, p. 77, fig. 151 (figured without description).

Pigmeophorus americanus Banks, Proc. Ent. Soc. Washington, vii, p. 139 (1905).

♀. This species is chiefly distinguished from the others of the genus by the position of the little oval structures or accessory stigmata*? (situated on the cephalic segment in front of the pseudostigmata), which are larger than usual and placed quite close together (instead of widely apart as in *P. tarsalis*). Another character is the shape of the pseudostigmata, which are not elongated but short and globular, lacking the slight terminal (apical) point present in *P. tarsalis*.

Two rather long hairs are present on each side of the cephalothorax (instead of one long hair and a very short one as in *P. tarsalis*). There is a third pair of very long hairs on the cephalothorax situated just in front of the posterior margin.

The following details of structure may also be useful:—

Shape of body similar to that of *P. tarsalis*; some specimens appear to be much wider than others (as compared with their length), but this is perhaps merely due to the pressure of the cover-slip. Hairs on body distinctly plumose. First leg stouter

* Oudemans apparently considers these minute paired oval structures to be organs of sense (see Arch. Naturg. 79, Abt. A, Heft 9, p. 113, 1913), but it seems to me to be more probable that they are stigmata, for they appear to be connected with the respiratory tracheæ.

than in *P. tarsalis*, resembling that of *P. aestivus* in this respect. First tarsus produced beyond and above the claw, but apparently not so strongly as in *P. tarsalis*.

Striated sensory ("olfactory") hairs on first tarsus rather similar to those of *P. tarsalis*; they are four in number, all of them being more or less club-shaped; the one situated near the distal end is very short and slender, the next is the largest, being rather stout, close beside it there is another slender but not very short sensory hair, the sensory hair nearest the proximal end of the tarsus is very short and slender. Second tarsus with a short but fairly stout sensory hair near the proximal end; the claws of this leg are distinctly bifid.

There is an unusually stiff bristle on the dorsal surface of the first leg (especially well developed in examples from *Lyperosia irritans* (= *Hæmatobia serrata*)).

Length of body 205-225 μ ; width 110-140 μ .

Habitat. Pseudoparasitic on *Musca domestica* (slides in collection of Laboratoire de Parasitologie, Paris) and *Stomoxys calcitrans* (the specimen from the latter was collected by Dr. J. Burton Cleland, and therefore is presumably Australian in origin). Also numerous specimens (reddish in colour) found on an English specimen of *Lyperosia irritans*.

Prof. T. Harvey Johnston and M. J. Bancroft mention in their paper on the life-histories of *Musca australis* (*M. fergusonii*) and *M. vetustissima* (Proc. Roy. Soc. Queensland, 1920, xxxi. footnote on p. 183) that "These flies may be parasitised by larval mites, a red one probably *Acarus muscarum* Linn., and also a minute whitish species." The latter is probably the species identified as *P. americanus* in the present note.

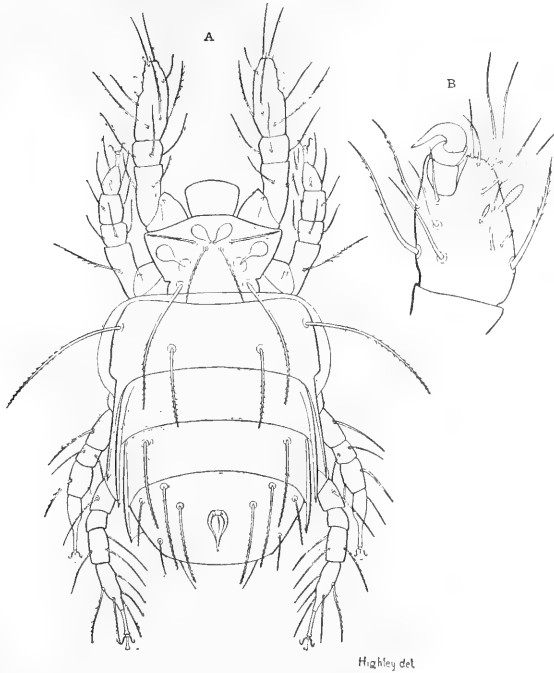
PYGMEPHORUS AMERICANUS VAR. SOCOTRENSIS, VAR. NOV.

♀. Very like the typical *P. americanus* in most respects, but with the sensory (striated) setæ on the tarsi of the first and second legs different in shape, the largest one on the first tarsus being considerably elongated and cylindrical, whereas in *P. americanus* (typical form) it is club-shaped. The sensory seta of the penultimate segment of the second leg differs in a similar manner. The paired oval structures situated near the front of the cephalothorax are placed close together as in *P. americanus*, but are constricted in the middle (perhaps differences like this are merely due to the presence of air or gas in the preparation). Pseudostigmata globular as in *P. americanus*. There is a stiff dorsal bristle on the second free segment of the first leg, much as in *P. americanus*.

Measurements. Total length 210 μ ; width 125 μ .

Hab. *Musca domestica*; Socotra. A single specimen found on a dry example of a fly from that locality.

Text-figure 15.

*Pygmephorus americanus*, ♀.

A. Dorsal view. B. Tarsus of first leg much enlarged.

PYGMEPHORUS SPINOSUS Kramer.

♀. The first tarsus is very characteristic in this species, being much enlarged, the claw also very large and moving against a strong process or spine. There are four striated sensory hairs (the so-called olfactory hairs), a distal pair of fairly long cylindrical ones being placed close together (one of them is slightly stouter than the other), and a proximal pair of very short rather club-shaped ones. Second tarsus with a single sensory hair dorsally, which is not very long but fairly stout, situated near the proximal end of the segment. Pseudostigmata rounded at the distal end. Hairs on body long and more distinctly feathered than in *P. tarsalis*.

Habitat. *Talpa europæa*; England and the Continent.

PYGMEPHORUS PILOSUS Oudemns.

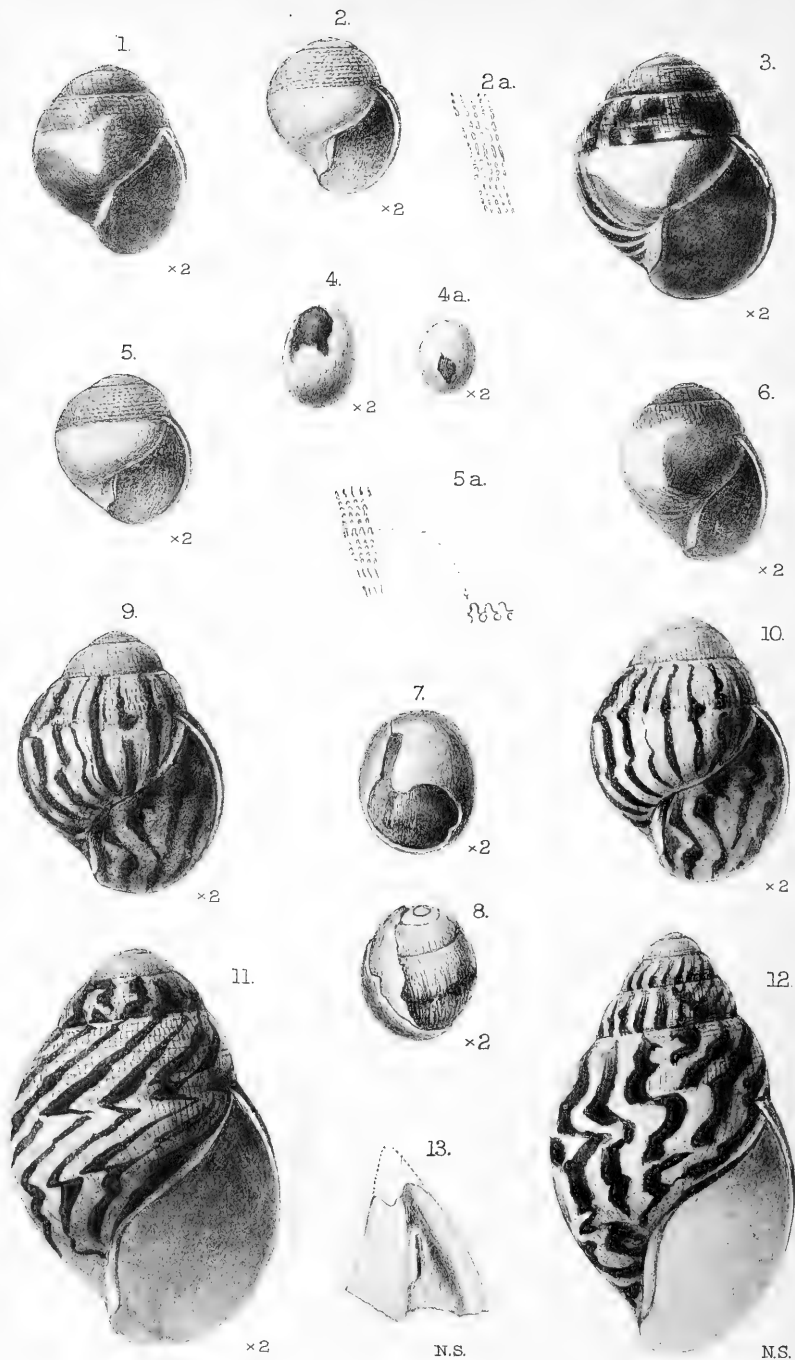
♀. First tarsus not produced nor enlarged. The second striated sensory hair (from the distal end) is much larger and stouter than the others, the first being of moderate length and slender; the two proximal sensory hairs are quite short, one of them is slender but club-shaped, the other very slender, straight, and cylindrical.

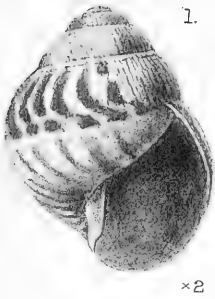
Second tarsus with a rather long spine in the middle of the dorsal surface, and with a short spine and also a short club-shaped sensory hair near the proximal end. Claws of this leg slender and not bifurcated. Pseudostigmata rounded distally (not pointed). Hairs of body and limbs more distinctly feathered than in *P. tarsalis*.

Habitat. *Arvicola agrestis* and *Talpa europæa*, England; several specimens off these hosts.

ACARAPIS, gen. nov.

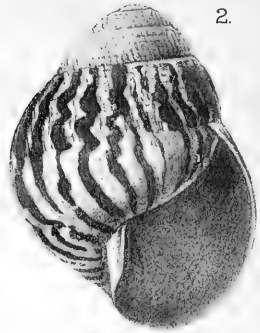
I propose the new generic name *Acarapis* for *Tarsonemus woodi* Rennie, 1921, the principal structural differences between this new genus and *Tarsonemus* being as follows:—Anterior leg of larva of *Acarapis* well-developed and furnished with a pair of claws and a pulvillus, but the second and third legs are very short (almost rudimentary) and without either claws or pulvillus. (In *Tarsonemus* the larval stage has all three pairs of legs well-developed and all end in claws and pulvillus.) The globular pseudostigma always present between the first and second legs in the females of *Tarsonemus* is absent in *Acarapis*. Fourth leg of female shorter and stouter than in *Tarsonemus*, and furnished with a larger number of hairs, resembling *Scutacarus* in this respect.





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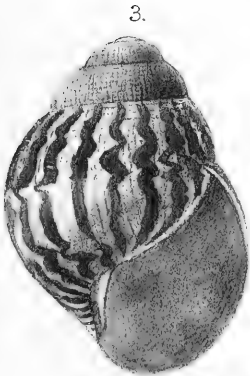
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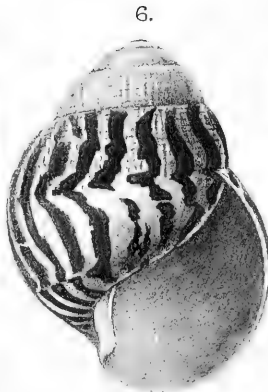
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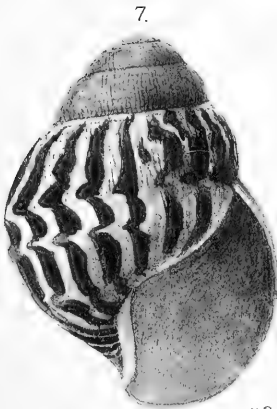
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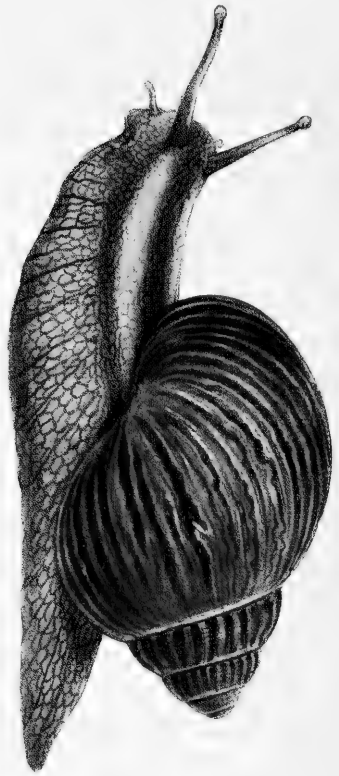
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8.

N.S.

J. Green, del.



1. COCHLITOMA. ZEBRA, VAR. OBESA.
2. COCHLITOMA. ZEBRA, VAR. FULGURATA.

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20. Observations on the Habits of *Cochlitoma zebra*, var. *fulgurata* (Pfeiffer), and *Cochlitoma zebra*, var. *obesa* (Pfeiffer), in Confinement*. By JANE LONGSTAFF, F.L.S., F.G.S.

(Communicated by Lieut.-Colonel RALPH LONGSTAFF, D.S.O., F.Z.S.)

[Received January 24, 1921 : Read April 19, 1921.]

(Plates I.-III. †)

When visiting Cape Colony, during 1914, I obtained six specimens of *Cochlitoma zebra*, var. *obesa*, at Humewood, Port Elizabeth, on March 31st. From these I selected two examples, which I brought home alive in company with a fine specimen of the var. *fulgurata* (the latter was presented to me by Mr. O'Connor, of the "Woods and Forests," who found it at Keiskamma Hoek, about nineteen miles north-west of King William's Town).

On leaving Cape Town, on April 11th, I put all three together in a tin box, which I opened frequently during the voyage, so as to feed them and allow them to crawl about. Upon arrival, on April 28th, I placed them in the conservatory.

In bringing these molluscs to England I had no intention of breeding them, but only surmised they might be of interest for anatomical purposes—therefore I did not keep the two varieties separate; and subsequently there was great mortality among the young through lack of preparation and inexperience.

Broods of original Specimens.

April 29th, 1914.—The smaller example of var. *obesa* had deposited during the night sixteen young molluscs and about thirty eggs; seventeen of the latter were either broken or punctured.

The two varieties were now placed in different pots, with sandy soil, tufts of grass, and varied food-leaves; also the parents were separated from the eggs and young in every case.

May 4th.—The larger specimen of the same variety deposited a dozen or more living young ones and numerous eggs. No fragments of egg-shells were then observed, but the next day I noticed that two of the young were much smaller than the others, and that one of them had a small bit of egg-shell adhering to it—also that there were some pieces of egg-shell lying near them. None of these fragments looked large enough to have contained the biggest of the young, but they might have

* I have followed Major Connolly ('Annals of the South African Museum,' vol. xi. pt. iii. 1912, pp. 204, 205) in regarding these forms as varieties of *Cochlitoma zebra* (Chemnitz).

† For explanation of the Plates, see p. 387.

held the smaller ones. Thus the two latter had evidently hatched from the eggs after they were laid. I did not ascertain the exact numbers at first, as I was afraid of disturbing them, but I now counted seventeen young molluscs and about fifty eggs, many of which were cracked.

May 4th.—I discovered that var. *fulgurata* had deposited two living young ones, which were buried in the soil, without any eggs or fragments of egg-shell associated with them. These died that day when on a visit to the British Museum (Nat. Hist.), where a drawing of one was made.

May 7th.—Var. *fulgurata* laid about seventy eggs near the surface, without any living young molluscs.

May 15th, 16th, 17th, 21st, 22nd, and 25th.—On each of these days an egg hatched, thus there were six young var. *fulgurata* from the eggs laid on the 7th. Some of the other eggs cracked, but with one exception no more molluscs came out.

June 1st.—This one hatched, but the animal died immediately and the shell was cleared out, either by *Agriolimax agrestis* Linn. (which had been introduced, probably on lettuce) or else by its brethren.

September 9th, 11th, and 12th, 1915.—The larger specimen of var. *obesa* was observed to have deposited another brood. On each of these days a single young mollusc appeared on the surface. I then scraped up the soil gently, to the depth of one or one and a half inches, and discovered nine additional young ones. Ten were about the same size, while two were smaller—there were no eggs or fragments of egg-shell.

October 8th.—Two additional young ones were observed with the parent. It is not evident whether these were overlooked before (for young shells, when covered with soil, greatly resemble pebbles), or whether they had been deposited more recently. One was of about the same dimensions as that of the medium size, and the other was about equal to, or rather less than, the smallest of the previous ones.

October 31st, 1916.—This brood was entirely killed by a single specimen of *Arion hortensis*, which I found beside them. Thus they existed little more than a year.

Hibernation and Mortality.

May 7th–July 13th, 1914.—The var. *fulgurata*, after laying eggs, formed an epiphragm and between these dates buried itself. Then it came up at night and ate lettuce, but went below during the day, and continued doing this for about a fortnight, when it remained completely buried till the beginning of October. At this time it rose, and died on November 26th, after having been in confinement eight months.

Winter, 1914–15.—The four young var. *fulgurata*, which alone were living, commenced to hibernate in October and remained below till March 4th. One, however, had protruded its head

and eaten lettuce on February 8th, and then retired again. Only two survived the winter.

November 25th.—The two adult var. *obesa*, as well as the young ones, commenced to hibernate, and they remained more or less, but not continuously, inactive till February 8th, 1915.

May 24th, 1915.—The smaller adult var. *obesa* buried itself, and as it did not rise again I dug it up on July 12th, when I found it was dead, after being from fourteen to sixteen months in confinement.

Winter, 1915-16: October 9th.—The two young var. *fulgurata* hibernated. One came up January 6th, the other on the 29th.

November.—During this month the single adult and the young var. *obesa* buried themselves till January. The former rose on the 20th and remained on the surface till March 2nd, when it died, after about two years in confinement.

Winter, 1916-17.—Two young var. *fulgurata* began hibernating in September, but roused up and ate at the end of February; the weather, however, becoming very cold caused them to go below again till late in March. One died in June, when about three years old.

November.—There were now only six young var. *obesa* living, these began to hibernate during this month. They did not, however, remain continuously below, but came up at different times, though they did not eat. Three died in February and two in March, thus only one specimen remained which belonged to the first brood.

Winter, 1917-18.—The solitary specimen of var. *fulgurata* began hibernating at the end of September and roused up at the end of January. The single example of var. *obesa* was only dormant from December 15th to January 24th.

Winter, 1918-19.—Var. *fulgurata* hibernated from the first week in September till February 22nd. Var. *obesa* from the first week in October till February 21st.

Winter, 1919-20.—Var. *fulgurata* hibernated from September 29th till February, when it came up, but retired again below till the middle of March. Var. *obesa* was buried from October 6th till the middle of March.

The hibernation of the original var. *fulgurata* during our summer may be explained by the fact of that season being dry and cooler in the district whence it came, when it would naturally rest. There being no marked difference between the dry and wet seasons at Port Elizabeth would cause var. *obesa* to be more adaptable. It must be remarked, however, that the young var. *fulgurata* did not follow the example of their parent, but that of var. *obesa*.

The conservatory in which the molluscs lived was heated, and did not fall below 45° F. at night in winter. Nevertheless, they seemed to feel variations in temperature, for there was greater mortality in cold weather, and if they roused up earlier from hibernation during a mild spell they generally went down again

when there was a return of cold. During hibernation they invariably closed the aperture with an epiphragm, which had a slit at the posterior end (Pl. I. fig. 13).

Broods of Progeny.

June 21st, 1918.—As there was only one specimen of each variety living I placed them both together, but they did not appear to like one another at first, for they went as far apart as possible. Later on, however, they became more friendly.

September 16th, 1919.—Several young ones and also some eggs were discovered below the surface, and the adults were separated from them. On the 19th I counted eleven young molluscs, twelve eggs, and three broken bits of egg-shell. On the 26th I found another and still smaller young one, with two bits of egg-shell. It had, therefore, hatched from an egg, but there is no evidence to show whether the whole of those first found had done so. Var. *fulgurata* appeared to have deposited this brood.

July 23rd, 1920.—I scraped up the soil to a depth of about two inches, and discovered fifteen living young molluscs and two dead ones, accompanied by some fragments of egg-shell. The two dead shells were very small, had no coloured markings, and were without any trace of the animals.

August 4th, 6th, and 12th.—Other living ones were found, making nineteen in all, and the eggs numbered between fifty and sixty. It is not clear which variety deposited the young ones. After finding these I actually saw var. *obesa* lay some of the smaller eggs; it is, however, quite possible that var. *fulgurata* may have laid some of the larger ones.

Hibernation.

Winter, 1919-20.—October 6th to the middle of March.

Winter, 1920-21.—Both broods commenced to hibernate the middle of October. During mild spells in January they came up and ate. There were nine living of the first brood and seventeen of the second, all grandchildren of the original specimens.

Summer, 1920.—Var. *fulgurata* was not so active as usual, appeared sickly in August, and finally died on September 22nd at the age of six years and four months.

October 24th.—Var. *obesa* died after being inert several days, when six and a half years old.

Reproduction.

Unfortunately, the cases here described do not afford clear evidence of the length of time elapsing between fertilization and birth. The two original specimens of var. *obesa* travelled together with one of var. *fulgurata* for seventeen days. The former may have fertilized each other, or they may have been fertilized previously by their fellows, or, on the other hand, they may have been impregnated by var. *fulgurata* on the journey. With regard

to the var. *fulgurata*, five or six weeks had elapsed since it had the opportunity of copulation with its own kind, but there is the possibility of its having been crossed with var. *obesa*; fertilization in transit was unlikely as the specimens were tightly packed.

The second brood (September 1915) of the larger specimen of var. *obesa* must have been produced either from the prolonged effect of the previous copulation, or else the mollusc must have been fertilized afresh at least four months before, as that length of time had elapsed since separation from its only fellow. As far as can be judged from the appearance of the animals and shells, cross-breeding does not seem to have taken place. It is, however, a question whether the two broods of the progeny of the original specimens may not be the result of cross-fertilization. The brood of var. *fulgurata* (September 1919) was deposited about two years and three months after the death of the last individual of its own kind, aged three years, and after it had been living with var. *obesa* about fifteen months. The actual parent of the young ones deposited July 1920 is doubtful. If it was var. *obesa*, and fertilized by its own form, three years and four months had elapsed since the death of its last companion, which was then barely three years old. If fertilization was by var. *fulgurata* it may have taken place any time after June 1918. If var. *fulgurata* was the parent, either the effect of the first copulation must have continued or else there must have been crossing with var. *obesa*. The latter variety certainly laid some of the eggs, but it is not evident whether any hatched.

These last two broods are as yet too young to ascertain whether there are signs of cross-breeding. The older one, however, bears most resemblance externally to var. *fulgurata*. In connection with this I would point out that Mr. Darbshire*, in an abstract of Prof. Lang's experiments with *Helix hortensis* and *Helix nemoralis*, quotes an example of one of the snails being fertilized in 1900, which, without further copulation, produced four families in the years 1900, 1901, 1902, and 1903. Dr. Cooke† gives instances of the prolonged effect of a single copulation in *Helix aspersa* and *Arion ater*. In the case of the former the first batch of eggs was laid after the lapse of only four days, and the second the following summer. In the latter a month elapsed, and then this pair of *Arion ater* both laid batches of eggs at intervals during a period of seven weeks. He also quotes from a paper communicated by Mr. J. S. Gaskoin to the Zoological Society in November 1850, to the effect that *Helix lactea* produced young after being isolated four and a half years.

Eggs and Young.

It is of interest to note that these two varieties of *Cochlitoma* have been observed to be at the same time both ovoviviparous

* Jour. Conch. vol. xi, no. 7, 1905, p. 194.

† "Molluscs," Cambridge Nat. Hist. 1895, p. 42.

and oviparous, and also that var. *obesa* had one brood entirely ovoviviparous. A dead specimen of the latter variety, found associated with the living ones, contained a number of dead young shells, with which no eggs were noticed.

Dr. Pilsbry* states that *Cochlitoma* is ovoviviparous, and gives an instance of Semper having found in the uterus of a specimen of *C. zebra* sixty undeveloped eggs with calcareous shells, the largest measuring 6 mm. in length and the smallest 3 mm., together with twenty-five embryos which had crawled out of the egg-shell. Further †, he remarks that Mr. Clapp found young shells of about 8 mm. in diameter inside a specimen of *C. crawfordi* (Morelet), with which there were no traces of calcareous egg-shell.

The dimensions of the eggs of the different broods vary: var. *fulgurata* has the largest eggs—these are preserved in such a manner as to show the structure best. The eggs are calcareous, yellowish in colour, and short-oval or rounded in form. The biggest measure 9 mm. in length by 7.5 mm. in width; the smallest 3.75 mm. in length by 3.25 mm. in width. Inside the outer calcareous shell there is an amber-coloured layer which does not cover the whole of the interior, and which appears to give rise to the embryonic molluscan test. Fully a dozen of the broken eggs of var. *fulgurata* contain the embryo and exhibit a very thin grey layer, more or less calcareous, covering the aperture and the greater part, if not the whole, of the shell. The young shell consists of little more than three whorls, of which the earliest is smooth, pale horn-colour, with the apex slightly sunk; the succeeding whorls have spiral lines crossing the lines of growth and rendering the surface granulated; the brown-coloured markings begin on the last third of the body-whorl, before it leaves the egg, and they form an interrupted spiral band with a few longitudinal brown lines near the aperture. The soft parts of the animal have entirely disappeared from all the eggs. A young shell, released from a broken egg, had a length of 7.5 mm. and width of 8 mm.

The later brood of var. *fulgurata* (offspring of the original specimen) contained fewer eggs but more living young molluscs. I broke one of the twelve eggs, and found it was not so far advanced as some of those of the first brood, as there was only the amber-like layer inside the calcareous shell. The largest measures 8.25 mm. in length by 6.5 mm. in width; the smallest 6.5 mm. in length by 5.5 mm. in width.

One of the biggest eggs of the larger example of var. *obesa* measured 8 mm. in length and 6 mm. in width; one of the smallest, 3 mm. in length and 2.5 mm. in width. The biggest egg of the smaller parent is less, measuring 5.5 mm. in length by 4 mm. in width.

The latest brood, which is probably mixed, contains eggs

* Man. Conch. vol. xvii. ser. 2, p. 77.

† *Ibid.* p. 93.

varying from 7 mm. to 3.75 mm. in length, and from 5.5 mm. to 2.75 mm. in width.

Growth.

The young molluscs of the different broods varied in size and rate of growth; specimens of each of the earlier broods have been figured at intervals to show the latter (Pls. I. & II.). As far as possible the same individual was represented, but when one died another of the same brood was substituted. The rate of growth was not always uniform, and sometimes a smaller specimen surpassed a larger companion. The difference in size was shown in a remarkable manner in the case of the latest brood of var. *fulgurata* (September 1919), which consists of the grandchildren of the specimen originally brought home. Three days after discovery the largest measured 20 mm. in length and 15.5 mm. in width, while a week later the smallest, which was probably hatched from an egg, had a length of 10 mm. and width of 9 mm. On May 4th, 1920, about six weeks after they ceased hibernating the smallest was the same size as before, while the largest had a length of 22 mm. and width of 16.5 mm. There was also another remarkably small one. These two small examples were not long-lived, for the first-mentioned died on May 27th, when it measured 10 mm. in length and 9.5 mm. in width. The second died in October, when it was 13 mm. in length by 10.5 mm. in width. A living companion of average size at this time measured 42 mm. in length and 29 mm. in width. This last, and the rest of the brood, were then commencing to hibernate, so I did not wish to disturb them to make further measurements.

The drawings represent the first broods up to the age of three years and four months, when (September 1917) only one specimen of each form was living. Neither of these had been figured before, and they were then figured with the animals (Pl. III. figs. 1 & 2). At that date this specimen of var. *fulgurata* measured 71 mm. in length and 41 mm. in width; var. *obesa* 57 mm. in length and 39 mm. in width.

In September 1918 var. *fulgurata* measured 81 mm. in length and 46 mm. in width; var. *obesa* 77 mm. in length and 49 mm. in width.

In September 1919 var. *fulgurata* measured 88 mm. in length and 49 mm. in width; var. *obesa* 80 mm. in length and 52 mm. in width. At death var. *fulgurata* had attained a length of 89 mm. and width of 50 mm.; var. *obesa* a length of 80 mm. and width of 52 mm. It must be noted that both grew most between September 1917 and September 1918, and least during the last year of their lives. The increase in all cases was actually made after hibernation, between the months of January and September of each year. Var. *fulgurata* did not attain the length of its parent, which was 107 mm.; but var. *obesa* exceeded the size of its parent (smaller specimen), which only measured 68 mm. in length and 47 mm. in width.

Resemblances and Differences.

In extreme youth the shells of the two varieties greatly resemble one another, but the brown markings, so far as I have observed, appear to commence earlier in var. *fulgurata* than in var. *obesa*. The embryos of the latter form, found inside a dead specimen, do not show them at all, and I have only noticed the faintest trace of them in one embryo. As the molluscs grow older, however, they differ in character and colour of the shell, as well as in the colour of the animal. The specimens of var. *obesa* examined vary somewhat in the spiral angle of the shell, but on the whole it is wider than that of var. *fulgurata*. The shell of var. *obesa* is lighter in colour, being white or yellowish white, while that of var. *fulgurata* is deep horn-colour; both are ornamented by brown, longitudinal, more or less zigzag streaks, which are less closely packed on var. *fulgurata*, and are also broader on the body-whorl. The appearance of the latter is like horn or tortoise-shell, while var. *obesa* is more porcellanous, and is thus similar to the typical *C. zebra*.

The colouring of the animal of var. *fulgurata* is pale greenish or yellowish grey, reticulated with a darker shade, and there are three almost black stripes running down the head, with a banana-yellow stripe on each side of the central one. In var. *obesa* the animal is lead-grey reticulated with a darker shade; it also has three dark stripes, which are not so nearly black as those of var. *fulgurata*, the central stripe is broader, and those on each side are light grey. The fringe and sole are darkest in var. *obesa*.

The eggs of var. *obesa* are proportionately longer than those of var. *fulgurata*, but on the whole they are smaller.

The habits of the two varieties also differ somewhat. Var. *fulgurata* is more nocturnal, moving about and eating most at night, while var. *obesa* moves about during the day as much as at night, and lives more continuously near the surface. The former is more vigorous in its movements, making rapid and deep excavations. It has also been noted that the progeny of the original var. *fulgurata* generally hibernated earlier, seeming to require a longer period of rest. Contrary to its usual custom, the solitary example of this variety lived on the surface during the last summer of its existence, and did not appear to have the energy to move much or to burrow.

Food.

The favourite food of both forms is lettuce, and next to that dandelion and the leaves of the Life Plant (*Bryophyllum calycinum* Sælisb.). They ate the skins of grapes that had been sucked, but could not manage the entire fruit; also banana and the outer leaves of cauliflower, when there was nothing else. They positively disliked cabbage and sprouts, either fresh or cooked. All had a habit of dragging leaves into their burrows, and some-

times the mollusc would remain buried while merely the head was protruded for feeding.

I am greatly indebted to Mr. G. C. Robson for several valuable suggestions, also for affording me every facility when studying specimens under his care.

EXPLANATION OF THE PLATES.

PLATE I.

Cochlitoma zebra, var. *obesa* (Pfeiffer).

- Fig. 1. Brood I. Drawn June 17th, 1914. $\times 2$. Born April 29th, 1914.
 2. Brood II. Drawn shortly after birth, May 4th, 1914. $\times 2$. (Shell lost.)
 2a. Brood II. Sculpture, greatly enlarged.
 3. Brood II. Different specimen, drawn June 17th, 1914. $\times 2$.
 4, 4a. Brood II. Eggs of medium and small size. $\times 2$. Larger one showing inner amber-like layer.

Cochlitoma zebra, var. *fulgurata* (Pfeiffer).

5. Drawn May 4th, 1914, soon after birth. $\times 2$. (Died after visit to the Museum.)
 5a. Sculpture greatly enlarged.
 6. Drawn June 17th, 1914. $\times 2$. Hatched from an egg, May 15th or 17th, 1914.
 7. Egg, laid May 7th, 1914, showing inner amber-like layer. $\times 2$.
 8. Embryo, with egg-shell partly broken away, and showing inner thin calcareous layer, also the brown markings on the last whorl. $\times 2$.
 9. Specimen previously figured June 17th (fig. 6), drawn again July 28th, 1914. $\times 2$.
 10. The same, drawn September 15th, 1914. $\times 2$. (Died immediately afterwards.)
 11. Another shell, drawn April 9th, 1915. $\times 2$.
 12. The same, drawn June 30th, 1916. Nat. size. (Died June 1917.)
 13. Portion of epiphragm, showing slit. $\times 2$.

PLATE II.

Cochlitoma zebra, var. *obesa* (Pfeiffer).

- Fig. 1. Brood I. Same as Pl. I. fig. 1, drawn July 28th, 1914. $\times 2$.
 2. " " " " " " September 15th, 1914. $\times 2$.
 3. " " " " " " April 9th, 1915. $\times 2$.
 4. " " " " " " June 30th, 1916. Nat. size. (Died September 1916.)
 5. Brood II. Same as Pl. I. fig. 3, drawn July 28th, 1914. $\times 2$.
 6. " " " " " " September 15th, 1914. $\times 2$.
 7. " " " " " " April 9th, 1915. $\times 2$.
 8. " " " " " " June 30th, 1916. Nat. size. (Died February 1917.)

PLATE III.

Cochlitoma zebra, var. *obesa* (Pfeiffer).

- Fig. 1. Brood I. Drawn September 5th, 1917. Nat. size. (Not figured previously.)
 Born April 29th, 1914. Died September 1920. Dissected by Mr. G. C. Robson.

Cochlitoma zebra, var. *fulgurata* (Pfeiffer).

2. Drawn September 5th, 1917. Nat. size. (Not figured previously.) Hatched from an egg, between May 15th and 25th, 1914. Died September 1920. Dissected by Mr. G. C. Robson.

All the specimens figured have been given to the British Museum (Nat. Hist.).



21. The External Characters and Classification of the Procyonidæ. By R. I. Pocock, F.R.S.

[Received February 5, 1921 : Read April 19, 1921.]

(Text-figures 1-13.)

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Classification of the Ursidæ, <i>Ailuropoda</i> , <i>Ailurus</i> , and the Procyonidæ	420

Introduction.

To show the wide divergence of opinion on the classification of the genera assigned in the current text-books to the Procyonidæ, it is needless to go to an earlier date than 1869, when Gray published his 'Catalogue of Carnivorous ... Animals.' Using in the main the carnassial teeth, this author divided the Feræ into two suborders, Carnivora and Omnivora, the latter, with the teeth in question non-sectorial, comprising the forms now relegated as a rule to the families Ursidæ and Procyonidæ. Gray, however, admitted six families of Omnivora:—(1) Ursidæ with several genera; (2) Nasuidæ for *Nasua*; (3) Procyonidæ for *Procyon* with two subgenera *Procyon* and *Euprocyon*; (4) Cercoleptidæ for *Cercoleptes* (*Potos*); (5) Bassaridæ for *Bassaris*; (6) Ailuridæ for *Ailurus*.

In the same year, however, Flower (P. Z. S. 1869, pp. 4-37) classified the genera in question into the three families Procyonidæ (*Procyon*, *Bassaris*, *Nasua*, *Cercoleptes*); Ailuridæ (*Ailurus*); and Ursidæ (*Ursus*)*.

In 1872, Gill, whose estimate of the value of characters was far in advance of his time, made a classification which may be described as a combination of Gray's and Flower's (Smiths. Misc. Coll. xi. pp. 58-59, 66-67, 1872). It was as follows:—Fam. Ursidæ (with the genera admitted by Gray); Fam. Æluridæ (*Ælurus*); Fam. Cercoleptidæ (*Cercoleptes*=*Potos*); Fam. Procyonidæ with the subfamilies Nasuinæ (*Nasua*), Procyoninæ (*Procyon*); Fam. Bassarididæ (*Bassaris*).

* This grouping, however, was the same in substance as that proposed by Turner about twenty years earlier (P. Z. S. 1848, p. 86) with the conversion of Turner's subfamilies Ursina, Ailurina, and Procyonina of the family Ursidæ into families of the Arctoidea.

In 1876 (Proc. Acad. Nat. Sci. Philad. pp. 20-23), J. A. Allen described the genus *Bassaricyon* and remarked: "As the species [*B. gabbii*] differs more from either *Nasua* or *Procyon* than the latter do from each other, it seems to form a type quite as well entitled to rank as a subfamily of the Procyonidæ as do either of the others, and may hence be called Bassaricyoninæ."

In 1883 (Encycl. Brit. (9) xv. p. 441), Flower repeated his classification of 1869 with the addition of *Bassaricyon* to the Procyonidæ and of *Ailuropus* to the Ursidæ.

In 1885, Mivart (P. Z. S. 1885, pp. 392-394) adopted Flower's views, with one or two important exceptions. He admitted only two families, the Ursidæ and Procyonidæ, fusing the Ailuridæ with the latter and relegating *Ailuropus* to a place alongside *Ailurus*. His Procyonidæ, therefore, were grouped as follows:— (1) Procyoninæ (*Procyon*, *Nasua*, *Bassaris*, *Bassaricyon*, *Cercoleptes*); (2) Ailurinæ (*Ailurus*, *Ailuropus*). It may be noted that after comparing the dental and cranial characters of *Ailurus* and *Ailuropus*, he summed up by saying "... so that on the whole it appears to me that there is more decided natural affinity between *Ailuropus* and *Ailurus* than between *Ailuropus* and *Ursus*."

Mivart was, I believe, the first author definitely to assign *Ailurus* and *Ailuropus* to the Procyonidæ. Nevertheless, when Flower and Lydekker published their volume on the Mammalia in 1891, they quoted Blanford as the authority for the opinion they adopted that *Ailurus* belongs to that family. *Ailuropus* they retained in the Ursidæ.

Similarly, in their paper upon *Ailuropus*, published in 1901 (Tr. Linn. Soc., Zool. viii. pp. 161-173), Lankester and Lydekker do not appear to have consulted Mivart's paper or to have been acquainted with his views; and the result was that Lydekker put forward a classification of the Procyonidæ identical in every particular with that of Mivart.

Trouessart (Cat. Mamm. Suppl. pp. 183-184, 1904) referred *Ailuropus* and *Ailurus* to the Ursidæ, grouping them in the subfamily Ailurinæ as opposed to the Ursinæ containing the genera of true bears. The Procyonidæ he divided into two subfamilies, the Potosinæ for *Potos* (olim *Cercoleptes*) and the Procyoninæ for *Bassaricyon*, *Bassariscus*, *Nasua*, and *Procyon*. With the substitution of Potosinæ for Cercoleptinæ, this classification is the same as that published by Trouessart in 1898 (Cat. Mamm. i. p. 248).

In 1914, Bardenfleth (Mindeskriфт, etc., for J. Steenstrup's Födsel, Copenhagen, no. xvii. pp. 1-15) reconsidered the question of the affinities of *Ailurus* and *Ailuropoda*, and, deciding that the resemblances between them are purely adaptive, left the former in the Procyonidæ and adopted Flower's view that *Ailuropoda* is an aberrant member of the Ursidæ. The author tabulates in three columns, devoted respectively to *Ailurus*, *Ailuropoda*, and *Ursus*, no fewer than 58 characters by which these genera may

be compared and contrasted, the only character quite inadequately dealt with being the feet, wherein he would have found considerable corroborative evidence supporting his opinion of the Ursine affinities of *Ailuropoda*.

The latest classification was published in 1916 by Hollister (Proc. U.S. Nat. Mus. 49, pp. 141-150), who, following Gray and Gill, separated *Bassariscus* from the rest of the genera, his grouping being as follows:—Fam. 1. Bassariscidæ (*Bassariscus*); Fam. 2. Procyonidæ (*Ailurus*, *Procyon*, *Nasua*, *Nasuella**, *Bassaricyon*, *Potos*). This grouping involves the conclusion that the affinity between *Ailurus* and *Procyon* or *Potos* is greater than the affinity between *Procyon* or *Potos* and *Bassariscus*, a conclusion which, in my opinion, is quite indefensible. With regard also to the affinities of *Potos* and *Bassariscus* with the other genera, I cannot agree with Hollister, whose opinion with regard to the dentition of *Bassariscus* may be contrasted with that of Flower when he wrote in 1869 "*Cercoleptes* [*Potos*] deviates in its dentition from the more typical members of the group far more than *Bassaris* [*Bassariscus*], though in a precisely opposite direction."

From the above-given review it will be evident that there is no sort of unanimity on the three following points:—(1) The position of *Ailuropoda* †. Some authors claim that the genus belongs to the Ursidæ; others place it in the Procyonidæ. (2) The position of *Ailurus* ‡, some authors regarding it as the type of a special family, others, in a majority, placing it in the Procyonidæ. (3) The constitution of the so-called Procyonidæ of America. Every genus has at various times been made the representative of a special family or subfamily. Justification for this course is to be found in the much greater differences that exist between them than between the genera of Felidæ, Canidæ, and other compact families of Carnivora.

This variety of opinions calls for a revision of the questions at issue in the light of other characters than those supplied by the teeth, skull, and skeleton, which have mainly been used. Gray, it is true, employed the feet to a certain extent, but he was compelled to depend very largely upon dried skins, and most authors attach comparatively slight importance to external characters.

During the past few years I have been making sketches of the feet, ears, rhinaria, and other external organs of the Carnivora that have died in the Gardens of the Zoological Society: and the

* To illustrate the differences between *Nasua* and *Nasuella* and justify the creation of the latter, Hollister seems to have selected skulls exhibiting extremes of variation. I have skulls of *Nasua* almost intermediate between the two figures.

† This was the name originally given to the genus by Milne Edwards; but he subsequently changed it to *Ailuropus* because Gray had previously employed the name *Ailuropoda* for a section of the Carnivora comprising the Felidæ, Mustelidæ, and other families. Gray's action, however, did not invalidate the use of *Ailuropoda* in a generic sense. I have, therefore, retained it.

‡ The original spelling of this name is also adhered to in this paper.

present paper is based mainly upon the Procyonidæ examined in the Prosectorium.

The following material has passed through my hands:—

Ailurus fulgens.—Several specimens of both sexes.

Procyon lotor or closely-allied forms.—Several specimens of both sexes.

Nasua nasua (ring-tailed Coati Mondi, with a dark snout and distinctly ringed tail).—Several specimens.

Nasua narica (the white-nosed Coati Mondi, with a white snout and indistinctly ringed tail).—Several specimens.

Bassaricyon sp.—A single specimen, sent on approval by Mr. Cross, the animal dealer, which died on the day of its arrival and had to be returned to the vendor. Of this only the feet and rhinarium were sketched. My observations on this genus have been supplemented by an examination of the dried skins in the British Museum.

The example of this genus dissected by Mr. Beddard (Proc. Zool. Soc. 1900, pp. 661-675) was converted into a skeleton.

Potos caudivolvulus or closely-allied forms.—Several specimens of both sexes.

Bassariscus astutus.—A single immature male preserved in alcohol—probably the specimen whose anatomy was described by Mr. Beddard (Proc. Zool. Soc. 1898, pp. 129-131).

*Jentinkia** *sumichrasti*.—Dried skins in the Natural History Museum. This *Cacomistle* is sometimes admitted as a subgenus of *Bassariscus*. I have provisionally quoted it as a distinct genus, the material available being insufficient to establish the absolute constancy of the differences in the feet observable between *astutus* and *sumichrasti*.

Ailuropoda melanoleuca.—Mounted specimen and skull in the Natural History Museum.

The skulls examined are in the collection of the Zoological Society and in the Natural History Museum.

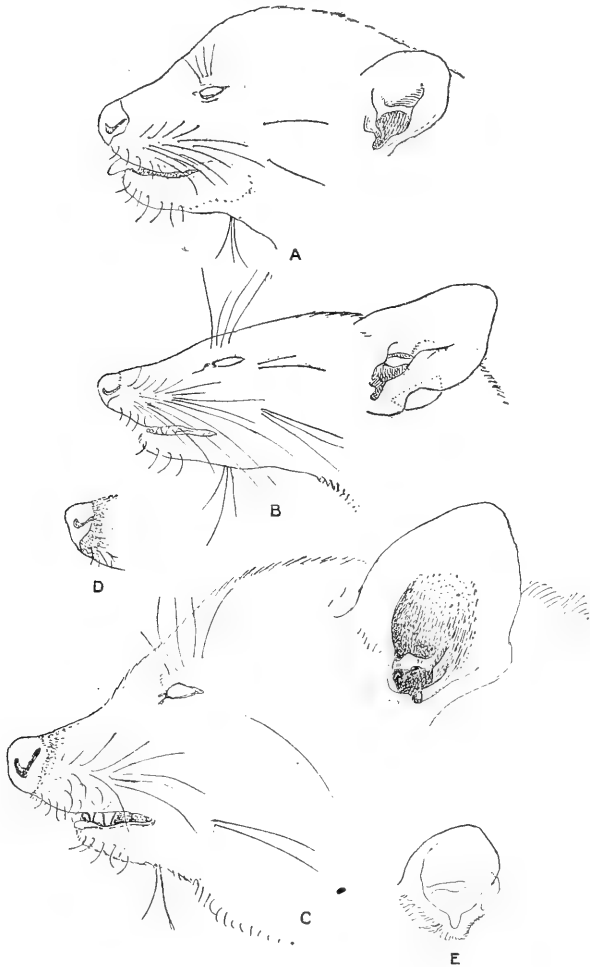
The External Ear.

As recorded by previous authors, the pinna of the ear varies in shape and size, being short and rounded in *Nasua*, *Potos*, and *Bassaricyon*, longer, more pointed, and more expanded in *Procyon*, *Bassariscus*, *Jentinkia*, and *Ailurus*. The cartilages strengthening the base of the ear are simple and normally carnivorous in their arrangement, requiring no special description, especially as they vary in development to a certain extent

* Proposed by Trouessart (Cat. Mamm. Suppl. p. 184, 1904) to replace the pre-occupied name *Wagneria* Jentink (Notes Leyd. Mus. viii. p. 129, 1886) based on the differences between *B. variabilis* [*sumichrasti*] and *astutus* pointed out by Peters (Mon. Ak. Wiss. Berlin, 1874, pp. 704-705).

within generic limits. Much greater interest attaches to the *bursa*. In *Bassariscus* and *Jentinkia* this is developed as in the Canidæ, Felidæ, and some Viverridæ, its posterior half being formed by

Text-figure 1.



- A. Head of *Potos caudivolvulus* (vel *sp. aff.*). ♂ ad. $\times \frac{1}{2}$.
 B. " *Bassariscus astutus*. ♂ immat. $\times \frac{1}{2}$. (From specimen in spirit with ear half closed and hair wet.)
 C. " *Procyon lotor*. ♂ ad. $\times \frac{1}{2}$.
 D. Lateral view of rhinarium of *Bassaricyon* sp.?
 E. Ear of *Bassaricyon alleni*. (Sketched without measurement from dried skin.)

a semicircular flap of integument rising behind the adjacent free edge of the pinna, its anterior rim being deeply emarginate. Judging from dried skins, the bursa of *Jentinkia* is similar to that of *Bassariscus*. I also find it present in dried skins of *Bassaricyon*, but it appears to be less well developed than in *Bassariscus*. The upper portion of the posterior flap arises behind the margin of the pinna, but its lower portion is confluent with it, and its anterior rim is lower and apparently not emarginate. The only other genus in which it is present is *Nasua*, where it has the form of a shallow pouch near the edge of the pinna which bulges slightly at this point. A similar bulge on the ear may be seen in *Procyon*, but in no example examined was there a trace of the pouch, and there is no trace of it in *Potos* or *Ailurus*. There is also no trace of it visible in the mounted example of *Ailuropoda* in the Natural History Museum, and it is absent in all the genera of Ursidæ.

If, as I believe, a well-developed bursa, such as is seen in the Felidæ and Canidæ, is a primitive feature in the Carnivora—and its presence in some of the genera of all the recognised families, except the Ursidæ, suggests that conclusion,—it follows that the ear of *Bassariscus* is the most primitive type in the Procyonidæ. Next comes that of *Bassaricyon*, then of *Nasua* showing stages in its suppression which has been achieved in *Procyon*, *Potos*, and *Ailurus*.

The following table summarises the characters of the ears in the genera examined:—

- | | | |
|-----|--|--------------------------------|
| a. | Bursa retained. | |
| b. | Bursa marginal, at least the upper end of the posterior flap attached behind the adjoining edge of the pinna. | |
| c. | Lower end of posterior flap behind the edge of the pinna; anterior flap emarginate; ears large | <i>Bassariscus, Jentinkia.</i> |
| c'. | Lower end of posterior flap confluent with edge of pinna; anterior flap with low straight edge; ears small | <i>Bassaricyon.</i> |
| b'. | Bursa a shallow pouch in front of posterior edge of pinna.. | <i>Nasua.</i> |
| a'. | Bursa suppressed. | |
| d. | Ears large, expanded, and more or less pointed | <i>Procyon, Ailurus.</i> |
| d'. | Ears small and rounded | <i>Potos.</i> |

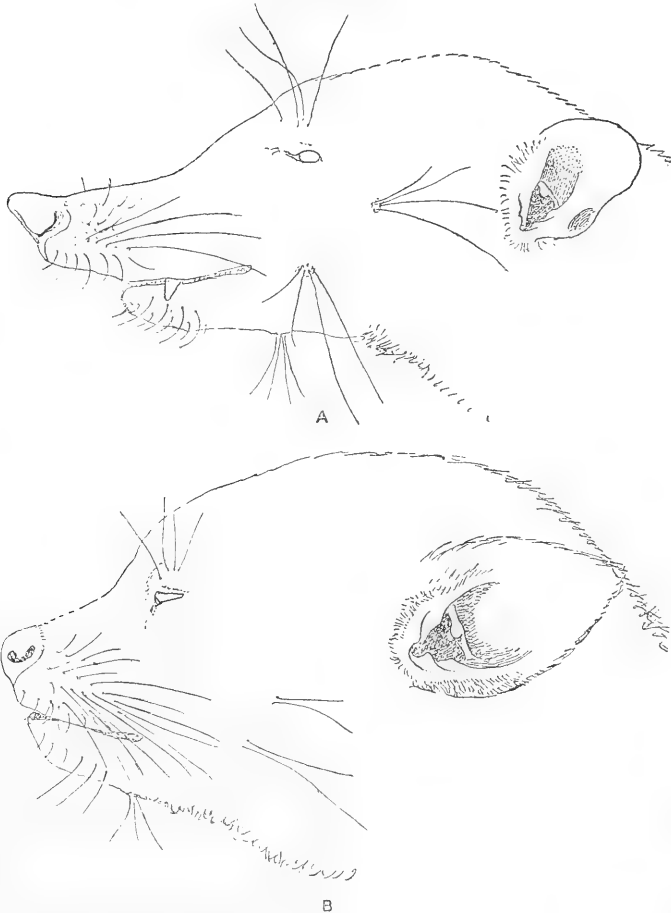
By this table *Ailuropoda* would fall alongside *Potos* under the heading *d'*. In the Ursidæ also no trace of the bursa remains and the ears are always rounded. They may, however, be comparatively large and rounded as in *Selenarctos* * *tibetanus*, or small as in *Helarctos malayanus*.

* Mr. A. de Carl Sowerby has pointed out to me that Heude applied this generic name to this Oriental bear in 1901 (Mém. Hist. Nat. Chinois, v. pt. 1, p. 2). The later name *Arcticonus*, which I gave to it in 1917 (Ann. Mag. Nat. Hist. (8) xx. p. 129), lapses, therefore, as a synonym of *Selenarctos*. My excuse for missing this point is that the then recorder of the Mammalia in the 'Zoological Record' purposely refrained from quoting Heude's work on account of its general worthlessness in his opinion.

Facial Vibrissæ.

Mivart described the facial vibrissæ of *Procyon* as follows:—
 “The whiskers on each side have 5 or 6 bristles grouped together, and there are four sets of such groups. There is also a tuft over the eye, one behind the angle of the jaw, and one under the

Text-figure 2.

A. Head of *Nasua nasua*. ♂ ad. $\times \frac{1}{2}$.B. „ *Ailurus fulgens*. ♂ ad. $\times \frac{1}{2}$.

middle of the chin.” That is quite true; but, in addition, the superior genal tuft is also present, although sometimes it is hard to detect when the normal tuft is reduced to a single vibrissa on

each side. Submental vibrissæ are also present. In this genus, therefore, the tufts of facial vibrissæ are normal for the Carnivora, consisting of mystacials, superciliaries, two tufts of genals, the lower behind the angle of the mouth, the upper below and behind the angle of the eye, submentals, and an unpaired interramal tuft.

I have no notes or sketches of the facial vibrissæ of *Bassaricyon*, but from Beddard's remark that there are five or six long vibrissæ forming the whiskers, three or four upon each cheek and two or three under the chin, I think it may be inferred that this genus falls into line with *Procyon* and *Potos* in having these tactile hairs normally developed.

In *Ailurus* the tufts of vibrissæ are also normal in number and distribution, and the upper genal tuft, represented by one or two vibrissæ, is situated low down on the cheek, only a little above the lower, and is often difficult to detect amongst the normal hairs which thickly clothe this portion of the head.

Similar tufts are present in the genera *Nasua*, *Bassariscus*, and *Potos*, being better developed and consisting of stouter vibrissæ in *Nasua* than in the others. In two examples of *Potos* the upper and lower genals are represented by a single vibrissa each. In *Bassariscus* the upper genal tuft is set high up rather close to the angle of the eye, as is usual in predatory Mustelidæ. In *Potos* and *Nasua* it is lower down the cheek.

In *Ailuropoda* the mystacial vibrissæ are all short and obviously of little import as in the Ursidæ. On the single stuffed specimen examined I was unable to satisfy myself as to the presence of the other tufts.

The Muzzle and Rhinarium.

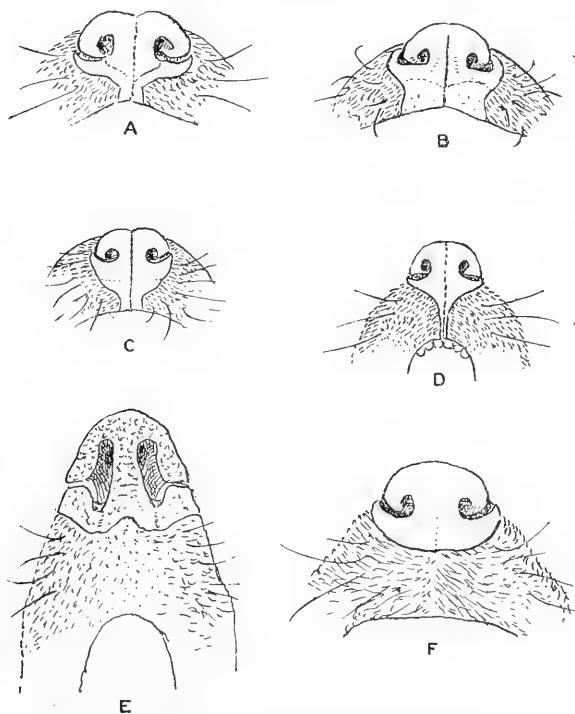
In *Procyon* the snout is moderately lengthened, and projects considerably beyond the lower jaw. The *rhinarium* is large and naked above. In front it has no central groove or, at most, a short indistinct one below. The upper margin is flat or evenly convex, not biconvex, and the width is much greater than the depth, but less than the combined depth of the rhinarium and of the upper lip. There is no trace of a philtrum, the upper lip being continuously, although comparatively scantily, hairy across the middle line, and the inferior edge of the rhinarium transverse in the middle and upcurled laterally. The internarial septum is broad and the infranarial portions moderately deep.

In *Bassariscus astutus* the muzzle is almost as elongated as in *Procyon*, the width of the rhinarium being much less than the combined heights of the rhinarium and of the upper lip; but the lip is cleft by a long narrow philtrum. The rhinarium itself is very like that of some Felidæ and Viverridæ, its upper edge being horizontal, with rounded angles from the anterior aspect and its inferior edge strongly angled mesially, where it passes into the philtrum. The internarial septum is moderately wide and

the infranarial portion comparatively shallow. There is a faint median groove marking the rhinarium from its summit to the bottom of the philtrum.

In *Nasua* the snout is much more elongated and mobile than in *Procyon*, and, as in that genus, the upper lip is entire, the rhinarium showing no trace of philtrum. The rhinarium differs from that of the other genera in certain particulars. Its upper anterior

Text-figure 3.



- A. Rhinarium of *Ailurus fulgens*; front view.
 B. " " *Potos caudivolvulus*; front view.
 C. " " *Bassaricyon* sp. ?; front view.
 D. " " *Bassariscus astutus*; front view.
 E. " " *Nasua nasua*; front view.
 F. " " *Procyon lotor*; front view.

All figures $\times \frac{1}{2}$ approx.

(D, E, F. Drawn with upper lip in same plane as anterior surface of rhinarium.)

margin is strongly produced. Its greatest width in front across the infranarial portions is less than the combined heights of the rhinarium and of the upper lip. The inferior edge is commonly strongly sinuous, owing to the median emargination. The nostrils

instead of being subcircular are markedly elongated from above downwards, and the internarial septum is long and narrow. The infranarial portions are deep, and are defined by a groove from the adjoining central portion, which has no trace of median groove.

To Beddard's description of the rhinarium of *Bassaricyon* as naked and marked with a median groove which also cleaves the upper lip and is visible on the dorsal side, I may add that in the specimen examined by me, the upper edge, when seen from the front, was lightly biconvex, the median groove was well marked and complete, the philtrum was short but barely as wide as the internarial septum, and that the infranarial portion on each side was exceedingly deep and marked with a faint transverse groove, meeting its fellow of the opposite side in the middle line; and that the total width of the rhinarium exceeded the height from the edge of the upper lip to the summit, the snout being short as in *Potos*, and not produced as in *Bassariscus* and *Procyon*.

In *Potos* the snout is not produced or slender, and the rhinarium is remarkable for the great width of the philtrum, which is as wide as or wider than the internarial septum, its sides often diverging below, and the greatest width of the rhinarium exceeds its height from the summit to the edge of the upper lip. The upper edge, seen from the front, is convex or lightly biconvex, the internarial septum is wide, the infranarial portions are very deep, gradually narrowing beneath the slit-like portions of the nostrils laterally. There is a well-marked median groove running from the edge of the lip and sometimes extending on to the upper surface in front, and a faint subhorizontal groove runs inwards beneath the nostril to meet its fellow of the opposite side in the middle line.

In *Ailurus* the snout is not produced, and the upper lip is divided by a short narrow philtrum, much narrower than the internarial septum, and the greatest width of the rhinarium considerably exceeds its height from the summit to the edge of the upper lip. The upper edge is tolerably evenly convex or markedly biconvex, the internarial septum is wide, and the infranarial portions are comparatively shallow, each being marked by a faint groove which extends obliquely downwards and inwards to meet its fellow of the opposite side in the middle line. The median groove is well marked, and extends from the edge of the upper lip often on to the summit of the rhinarium.

So far as it is possible to judge from the mounted specimen of *Ailuropoda*, the rhinarium resembles that of *Ailurus* in all respects, especially in the shortness and narrowness of the philtrum, except that its upper surface is entirely covered with hair. In this respect it differs from that of all the genera of so-called Procyonidæ and Ursidæ.

I was unable to satisfy myself as to the protrusibility of the lips in *Ailuropoda*, although the lower lip, as mounted, is slightly

compressed and pouted in the middle line. The point is not without importance, because all the Ursidæ differ from all the Procyonidæ and from *Ailurus* in having the lips protrusible or capable of being pouted. In the Procyonidæ and *Ailurus* the lips above and below the incisor teeth are comparatively closely adherent to the gums as in normal Carnivora.

By the characters supplied by the snout and rhinarium the genera may be classified as follows:—

- | | |
|--|---------------------|
| <i>a.</i> Snout greatly elongated; upper edge of rhinarium produced beyond the nostrils so that its anterior surface is nearly flat and slopes obliquely downwards and backwards; anterior portion of nostrils vertically elongated, separated by a high, narrow, ungrooved septum, and almost concealed in profile view. Upper lip long and undivided by philtrum | <i>Nasua.</i> |
| <i>a'</i> . Snout not, or only moderately elongated; upper edge of rhinarium not produced, its anterior surface lightly convex, not noticeably receding; anterior portion of nostrils subcircular, separated by a low, broad, generally grooved septum, and visible in profile view. | |
| <i>b.</i> Snout moderately produced; upper lip long so that the width of the rhinarium is less than the combined heights of the rhinarium and upper lip; median groove on rhinarium weak, or indistinct. | |
| <i>c.</i> Upper lip undivided by philtrum; infranarial portion of rhinarium deep and wide, median groove abbreviated or indistinct | <i>Procyon.</i> |
| <i>c'</i> . Upper lip divided by long, narrow, groove-like philtrum; infranarial portion of rhinarium shallow and narrow, median groove complete | <i>Bassariscus.</i> |
| <i>b'</i> . Snout not produced; upper lip short, width of rhinarium exceeding its height from the summit in front to edge of upper lip; median groove strong. | |
| <i>d.</i> Infranarial portion of rhinarium very deep. | |
| <i>e.</i> Philtrum moderately broad | <i>Bassaricyon.</i> |
| <i>e'</i> . Philtrum very broad | <i>Polos.</i> |
| <i>d'</i> . Infranarial portion of rhinarium comparatively shallow and philtrum narrow | <i>Ailurus.</i> |

By this key *Ailuropoda*, so far as it is possible to judge, would fall under heading *d'* alongside *Ailurus*, from which it differs in having the upper surface of the rhinarium covered with hair. The rhinarium is variable in the Ursidæ, being comparatively highly specialised in *Melursus* (Ann. Mag. Nat. Hist. (9) i. pp. 378-379, 1918).

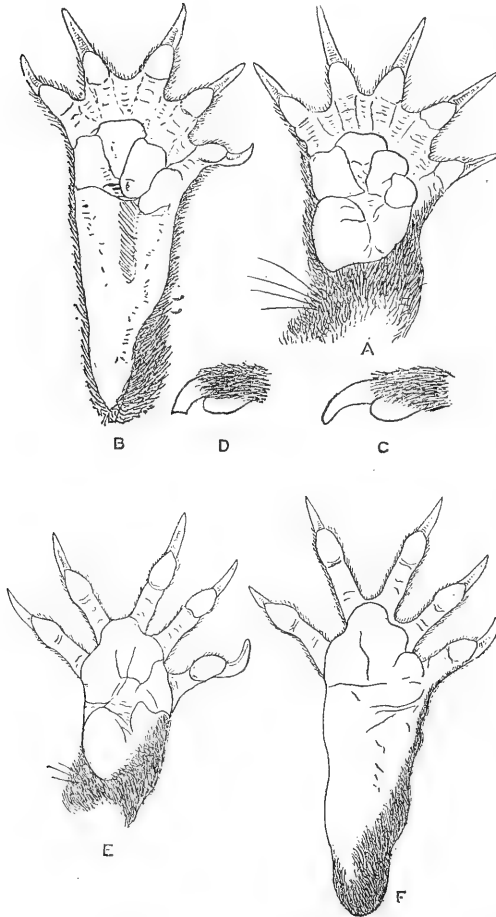
The Feet.

In describing the feet of the American genera, those of *Nasua* may be taken as a standard for comparison.

The claws of the fore foot are long, powerful, blunt and not greatly curved, and the digits are united by web, as described by Mivart, up to the proximal end of the digital pads. The under-side of the digits and of the webs is entirely naked. The plantar pad is broad, moderately well defined and four-lobed. The two conjoined carpal pads, of which the outer is about twice as large as the inner, are together as wide as the plantar pad and

approximately equal to it in area. They are respectively in contact with the inner and outer lobes of the plantar pad; but in the middle line they are separated from it by a depressed area of smooth wrinkled integument. Above the carpal pad on the

Text-figure 4.

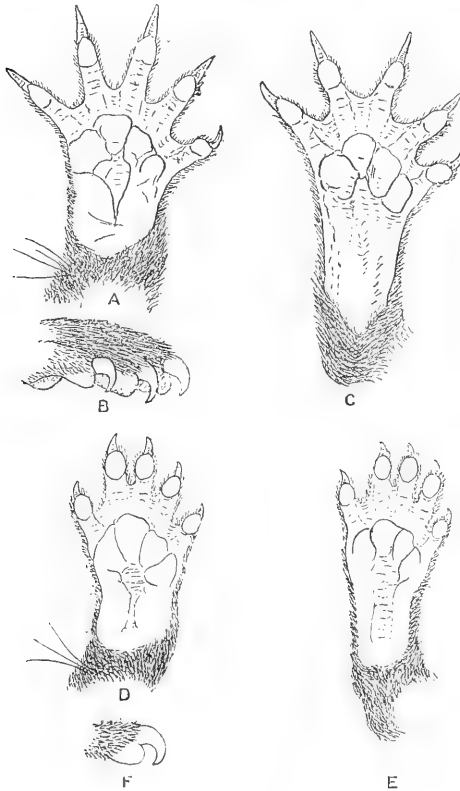


- A. Right fore foot of *Nasua nasua*.
 B. „ hind foot of same.
 C. Claw of fore foot.
 D. „ hind foot.
 E. Right fore foot of *Procyon lotor*.
 F. „ hind foot of same.

$\times \frac{1}{2}$,

ulnar side there is a tuft of carpal vibrissæ. The claws and digits of the hind foot resemble those of the fore foot, except that the claws are somewhat shorter. The plantar pad is four-lobed; and above it the whole of the tarso-metatarsal area is is

Text-figure 5.



- A. Right fore foot of *Potos*.
 B. „ hind foot of same.
 C. Claws and toes of fore foot of same.
 D. Right fore foot of *Bassaricyon* sp.; digits not spread.
 E. „ hind foot of same.
 F. Claw of fore foot of same.

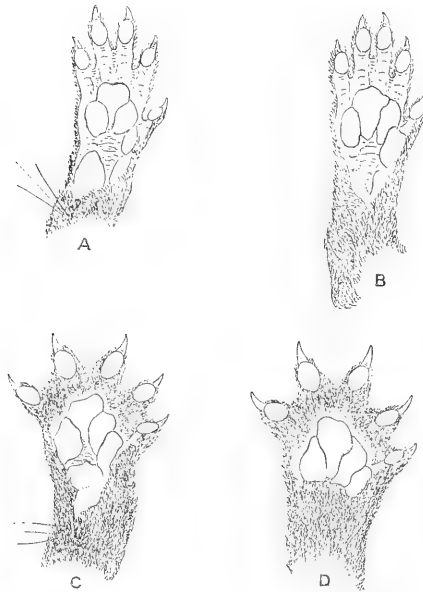
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naked as far back as the tip of the calcaneum, although the proximal third of the naked area is considerably narrower than the distal two-thirds. There are no definite metatarsal pads.

The feet of *Procyon* are a little less robust than those of

Nasua, the pads are less well defined and the claws rather smaller; but the great and essential difference lies in the complete absence of interdigital webbing, the digits being entirely free as far back as the plantar pads. This very rare phenomenon in the Carnivora is paralleled only, so far as I know, in the Crab-eating Mongoose *Atilax*, and in both cases it is probably subservient to delicacy of touch in finding and handling food.

Text-figure 6.



- A. Right fore foot of *Jentinkia sumichrasti*.
 B. „ hind foot of same.
 C. „ fore foot of *Bassariscus astutus*; immat.
 D. „ hind foot of same.

(A, B. Sketched from dried skin.)

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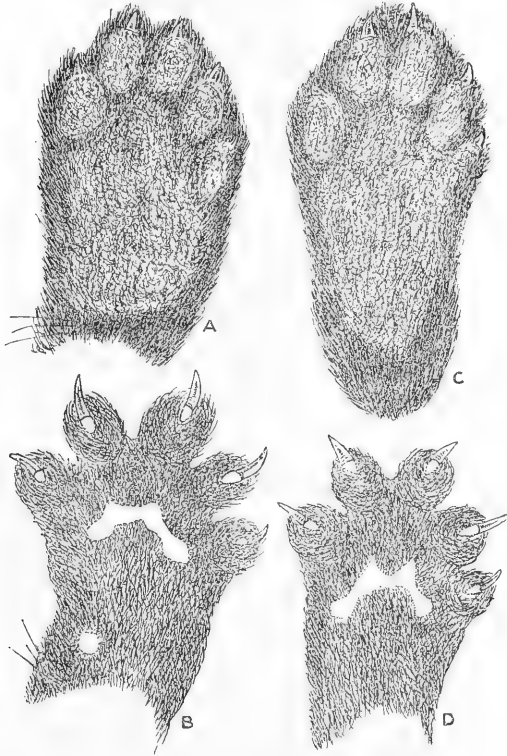
The feet of *Potos** differ from those of *Nasua* in that the claws are shorter, sharper, and more curved; approximately the distal two-thirds of the digits are free from webbing, and, in the hind foot, the lower side of the calcaneum is covered with hair, the hair-covered area corresponding to the narrow naked area in *Nasua*.

* The feet of *Potos* were figured by Kidd to illustrate the development of the sensory ridges on the pads. The feet from which these figures were taken closely resemble those examined by me, but the metatarsal pads seem to have been better developed ('The Sense of Touch in Mammals and Birds,' pp. 24-25, figs. 9 & 10, 1907).

In *Bassaricyon** the feet closely resemble those of *Potos*, the calcaneum being hairy beneath; but the interdigital webs are nearly as well developed as in *Nasua*. The claws are comparatively short and strongly curved and unlike those of *Nasua*.

In *Jentinkia sumichrasti*† the feet are seemingly very like those of *Bassaricyon* in the extent of the interdigital webbing

Text-figure 7.



- A. Right fore foot of *Ailurus fulgens*.
 B. The same with hair cut short and digits spread.
 C. Right hind foot of same.
 D. The same with hair cut short and digits spread.

× $\frac{1}{2}$.

and the length and curvature of the claws, but possibly they are somewhat narrower. The great difference lies in the lower

* Beddard's figure of the fore foot of this genus showing the presence of the carpal vibrissæ agrees closely with my figure of this foot in the example I examined and sketched (see Proc. Zool. Soc. 1900, p. 663).

† I have unfortunately only seen of this species dried skins with the feet shrivelled or stretched. The main features of the pads were discernible, but I could not assure myself of the constancy in shape and size of the naked metatarsal area.

surface of the metatarsus, which is for the most part covered with hair, except for a relatively short, naked, proximally narrowed area just above the plantar pad. In this respect the feet of *Jentinkia* differ from those of the above-mentioned genera.

In *Bassariscus astutus* the feet are short, compact, and somewhat like those of *Genetta*, with short, curved, sharp claws and interdigital webs extending nearly up to the digital pads. They differ from those of all the genera previously described in having the lower side of the digits and of the webs covered with short hair almost as far back as the plantar pads, which are thick and strongly lobed. Also in the fore foot there is a single submedian carpal pad, which is elongated and narrowed proximally and much narrower at its distal end than the plantar pad, with which it is almost in contact. Furthermore, in the hind foot, the metatarsal area is covered with hair right down to the plantar pad.

It is mainly on the strength of the differences observed between the feet of *Bassariscus astutus* and of *Jentinkia sumichrasti*, which by most authors is referred to the genus *Bassariscus*, that I have preserved the genus *Jentinkia*. It is necessary to repeat, however, that I have only seen dried skins of *J. sumichrasti* and only one spirit-preserved example of *B. astutus*. Feet of dried skins of the latter seem, however, to agree with those of that example; but admittedly more material is required.

The feet of *Ailurus* differ from those of the American genera in the complete concealment of all the pads beneath the clothing of long and thick hair which everywhere covers the soles and in the consequent reduction of the pads to apparently functionless vestiges. Separation of the hair reveals vestiges of the pads as areas of naked, somewhat thickened skin, those on the digits being small subtriangular patches behind the base of the claws. The carpal pad is represented by a small subcircular patch remote from the plantar pad; but there is no trace of metatarsal pads. The plantar pads are reduced to transverse recurved areas, expanded at each end towards the base of the first and fifth digits and sending forwards two angular processes, longer on the hind than on the fore foot, approximately in line with the third and fourth digits. A further difference between these pads is that the inner (preaxial) arm is longer than the outer (postaxial) on the fore foot, the converse obtaining on the hind foot. The digits are united by webbing to approximately the same extent as in *Bassariscus*, and the claws are short, curved, and very sharp*.

* This description of the feet agrees in a general way with that published by Flower (P. Z. S. 1869, p. 754). He does not, however, mention the carpal pad, and describes the plantar pad as a "larger, transversely oval, bare space '4' [less than half an inch] across covered by pink soft skin." I assume that he did not trace the details of these pads to their full extent. Mivart would never have described the claws of the Panda as "blunt" if he had ever been scratched by them. The hairs on the soles of the foot of the Panda are a great disadvantage in climbing smooth branches. It is only with considerable difficulty that the animal can slowly ascend a stout branch, stripped of its bark, even when inclined at an angle of 45 degrees. It does so by means of the penetrating power of the sharp claws. It is not easy to suggest a meaning for the hairiness of the feet, since the animal does not live in a region of perennial snow. Possibly, however, it is to obviate slipping on wet branches.

Text-figure 8.



A. Right fore foot of *Ailuropoda melanoleuca*.
 B. „ hind foot of same. (Copied from Milne Edwards's figure.)
 C. „ fore foot of *Euarctos americanus*.
 D. „ hind foot of same.

From the above-given description it is clear that the feet of *Ailurus* differ very materially from those of all the American genera, to which it is supposed by some authors to be tolerably closely allied.

The feet of *Ailuropoda* differ from those of *Ailurus* and of the American genera in being essentially Ursine in three particulars:—(1) The fore and hind feet are approximately equal in length, owing to the shortening of the hind; (2) the five naked digital pads form a slightly curved transverse line, the second and fifth lying respectively alongside the third and fourth, and the first (pollical and hallucal) touching the second when the digits are in contact; (3) the plantar pad is a wide naked transverse cushion, at least twice as wide as long and separated from the digital pads by a short area overgrown with hairs.

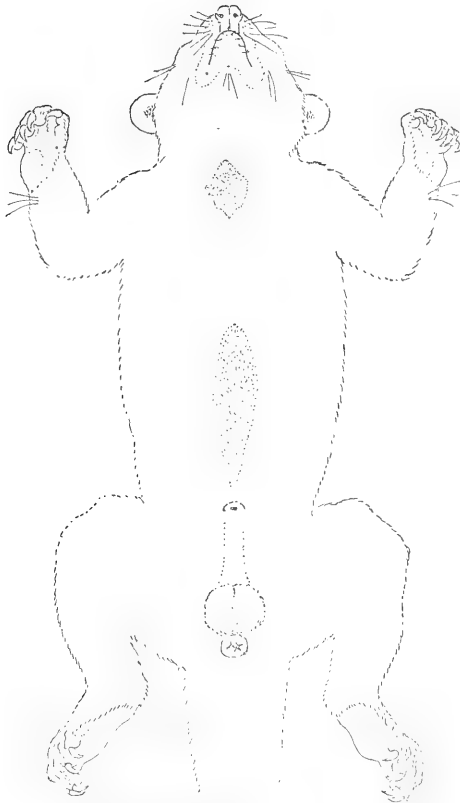
The fore foot further resembles that of *Ursus* and *Euarctos* in possessing a large carpal pad separated from the plantar pad by a long area overgrown with hair; but it differs from the fore foot of all the Ursidæ in the marked preaxial projection of the plantar pad beyond the line of the pollex. This gives additional width to the foot, and is doubtless correlated with the great development of the radio-carpal bone, described by Lankester, which simulates an additional metacarpal. The hind foot differs from that of the typical Ursidæ in that the entire sole is covered thickly with hair from the calcaneum to the plantar pad. It must be remembered, however, in this connection that in *Thalartos* the corresponding portion of the foot is hairy, the metatarsal pad being reduced to a comparatively small lozenge-shaped area. The skeleton of the digits differs from that of the Ursidæ, as Lydekker pointed out, in the presence of a bony hood at the base of the terminal phalange. In the latter particular, as in the remoteness of the carpal pad from the plantar pad, the feet resemble those of *Ailurus*, but they differ therefrom in the large size and exposure of the pads and in the alignment of the extremities of the digits.

Excluding those of *Ailuropoda*, the characters of the feet may be summarized as follows:—

- | | |
|--|---------------------|
| a. Soles of feet entirely and thickly covered with woolly hair concealing the pads, which are reduced in extent and thickness to apparently functionless areas of naked skin; carpal pad a minute naked area remote from the plantar pad | <i>Ailurus.</i> |
| a'. At least the digital, plantar, and carpal pads naked and well developed; carpal pad, or pads, comparatively large and in contact with the plantar pad, or nearly so. | |
| b. Area between digital and plantar pads hairy; carpal pad single, much narrower than plantar pad; metatarsus covered with hair down to plantar pad | <i>Bassariscus.</i> |
| b'. Area between digital and carpal pads naked; carpal pads double, conjointly as wide as plantar pad; at least a small naked area on metatarsus above plantar pad. | |
| c. Naked area of metatarsus reduced to a comparatively small patch, narrowing above | <i>Jentinkia.</i> |
| c'. Naked area of metatarsus extending over the greater part of that area. | |

- d.* Digits entirely free from webbing down to plantar pad ... *Procyon.*
- d'.* Digits united more or less by webbing beyond plantar pad.
- e.* Claws fossorial, long, strong, and blunt; digits fully webbed up to digital pads; calcaneum naked mesially.. *Nasua.*
- e'.* Claws shorter, curved, and sharp; digits less fully webbed; calcaneum covered with hair.
- f.* Digits united by webbing for about two-thirds of their length *Bassaricyon.*
- f'.* Digits united by webbing for about one-third of their length beyond plantar pad *Potos.*

Text-figure 9.



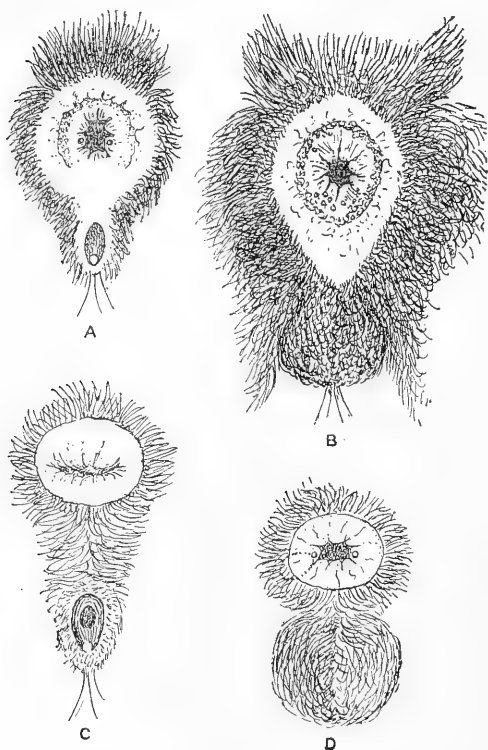
Ventral view of *Potos*, showing the median cutaneous glands, the position of the prepuce, etc.

Cutaneous and Anal Glands.

The only genus, known to me, which has specialized cutaneous glands, apart from those connected with the anus, is *Potos*. In

this genus there are two in the middle ventral line, one anterior and the other posterior. The former consists of a comparatively small patch of skin, scantily covered with short hairs and situated just in front of the anterior end of the sternum; and the latter, which is structurally similar to it, of an elongated tract on the abdomen, extending in the male from a point just in

Text-figure 10.



- A. Anus and vulva of *Ailurus fulgens*.
 B. „ „ scrotum of same.
 C. „ „ vulva of *Procyon lotor*.
 D. „ „ scrotum of same.

(In A and D the orifices of the anal glands are shown; in D the size and position of the gland of the left side is dotted in.)

front of the prepuce, where it is narrowed, over the umbilicus to the posterior end of the sternum. They are similarly placed and equally well developed in the female. These areas are not

sharply circumscribed at the margins, and the glandular portion is composed of well-developed normal skin-glands*.

Potos also has a considerable amount of nearly naked skin on the lower jaw and round the mouth. This, however, does not appear to be especially glandular. Probably the absence of the hair serves to keep the lips and chin clean from such sticky substances as honey, on which the Kinkajou feeds.

In *Procyon*, *Nasua*, and *Potos* the anus, like that of the Ursidæ, Canidæ, and others, opens in the centre of a circular, slightly protuberant area of naked skin, separated by hair from the scrotum or vulva. As Mivart stated, there is a pair of normal anal glands in *Procyon* like those of the Canidæ, but relatively a little smaller. Mivart also states that these glands are present in *Potos*; but I entirely failed to find even a trace of them in two examples, a male and female, the result of my examination confirming Owen's statement that they are absent (Proc. Zool. Soc. 1835, p. 122). Beddard does not appear to have looked for them in *Bassaricyon*. Their presence in *Bassariscus* was recorded by Gervais in the following passage (Voy. de la 'Bonite,' i. p. 19):—"Une petite plaque crypteuse circumanale existe à la terminaison de l'intestin, comme dans les Mangoustes, mais elle est moins grande que dans ces animaux et à sa surface débouchent de même les deux conduits des glandes anales." Although this passage suggests the presence in *Bassariscus* of a circumanal pouch like that of the Mongooses, I am disposed to think Gervais was merely describing the button-like area of naked skin immediately surrounding the anal orifice, such as is seen in *Procyon* or *Nasua*. This supposition is borne out by what he says as to the position of the orifices of the anal glands; and is further supported by the absence of a circumanal pouch in the male example of *Bassariscus* I examined.

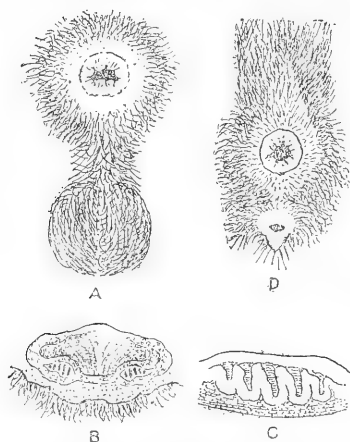
In *Nasua* anal glands are present, but in a much modified form, as Mivart pointed out. When the anus is opened, they appear as a series of four or five parallel slits, each series being set just within the orifice. The slits are the apertures of as many narrow sacs formed by the folding of the anal integument. These glands are quite different from those of any Carnivore known to me, and serve to differentiate *Nasua* tolerably sharply from its allies.

Flower described the anus of the male of *Ailurus*, pointing out the presence of a pair of normal anal glands and of a glandular area round the anal orifice. In the male I examined, the integument round the orifice corresponding to that seen in *Procyon*, for example, is highly glandular, and partially insunk so as to suggest the anal pouch of the Mungotidæ. Round it there is a considerable area of naked skin extending inferiorly to the

* These glands are conveniently placed for rubbing the secretion along the branches of trees to enable Kinkajous to track each other by scent. Although I have never noticed these animals behaving in a way to suggest that that is the function of the glands, I do not doubt that it is so.

scrotum, and from it the glandular central area is somewhat sharply marked off.

Text-figure 11.



- A. Anus and scrotum of *Nasua nasua*.
 B. Anus of *Nasua* opened to show the glands; the upper margin of the anus below.
 C. One of the anal glands of *Nasua* in vertical section, showing the series of pouches opening upwards and the underlying muscle.
 D. Anus and vulva of *Potos*.

The adult female possesses a similar glandular depression round the anus, but the surrounding area of naked skin is not so wide above and laterally, although extending inferiorly to the vulva*.

In an immature female, six months old, the anus is like that of *Procyon*, showing no special development of glands.

The four genera I have examined may be tabulated as follows by their specialized scent-glands:—

- | | |
|---|---|
| <i>a.</i> Anus opening in the centre of a shallow glandular pouch like that of the Mungotidæ; normal anal glands retained | <i>Ailurus.</i> |
| <i>a'.</i> Anus as in ordinary Carnivora †. | |
| <i>b.</i> Anal glands suppressed; two ventral cutaneous glandular areas | <i>Potos.</i> |
| <i>b'.</i> Anal glands retained; no ventral cutaneous glands. | |
| <i>c.</i> A pair of anal glands of the type normal in the Carnivora.. | <i>Procyon</i> and
<i>Bassariscus.</i> |
| <i>c'.</i> Anal glands peculiar, consisting of a series on each side of five shallow slit-like pouches | <i>Nasua.</i> |

* Adults of both sexes of the Panda have the habit, so well known in the Mongooses, of rubbing the secretion of the anal region on the branches or other parts of their cage.

† On the assumption that my interpretation of Gervais' description of the anus of *Bassariscus* is correct.

Nothing is known of *Ailuropoda* with respect to specialized cutaneous or anal glands. The latter are probably present and the former absent. No specialized cutaneous glands have been discovered in the Ursidæ; but the anal glands are present or absent. Owen declared them to be absent, and I failed to find a trace of them in *Ursus arctos*, the type he probably examined. In an example of *Euarctos americanus*, however, I detected the normal pair, though relatively much reduced in size. The anus in this family resembles that of the typical Procyonidæ.

External Genitalia.

In *Procyon*, *Nasua*, *Potos*, and *Bassariscus*, and presumably in *Bassaricyon*, the prepuce is abdominal and far in front of the scrotum, as in the Canidæ, Ursidæ, and Mustelidæ, and the penis, which is supported by a long bone (*baculum*), is susceptible of protrusion from the preputial orifice for the entire length of the bone. The aperture of the urethra is on the ventral side of the bone in some vascular tissue which can be stretched to a certain extent beyond the apex of the bone.

In *Ailurus*, however, as recorded by Flower, the penis is comparatively quite short, the prepuce being close to the scrotum as in the Felidæ and Mungotidæ, although the penis is longer than in those families and structurally resembles that of the genera referred to the Procyonidæ.

Hodgson declared that *Ailurus* has no scrotum; and in the male examined by Flower that sac was represented by a pair of swellings between the anus and prepuce, the testes being internal. But in the male seen by me the testes had descended into the scrotum, which formed a quite distinct swelling below the anus, though not so constricted at the neck as in the examples of *Procyon*, *Nasua*, and *Potos* examined by me*.

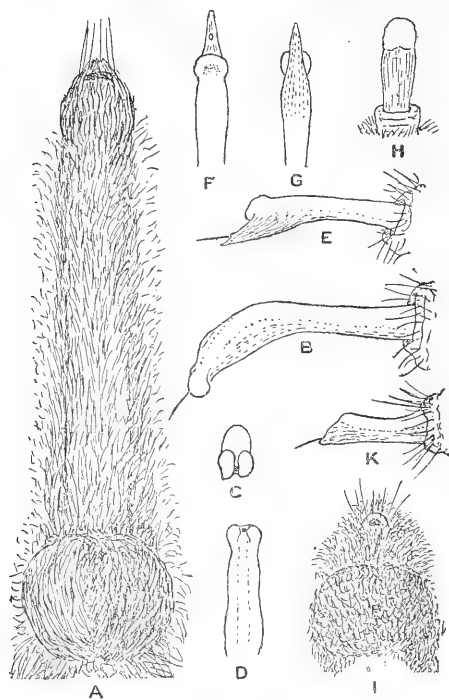
The baculum of *Procyon lotor* has long been known. It was figured by Blainville (Ost. des Mamm., Atlas i., *Subursus*, pl. viii.), and refigured and described by Gilbert (Morph. Jahrb. xviii. p. 818, pl. xxvii. fig. 8, 1892). It is relatively longer than in any other species referred to the Procyonidæ, surpassing 100 mm. along the upper curvature, the distal third of the bone being bent downwards. The apex is expanded both transversely and vertically, and forms a pair of condyle-like lobes separated by a deep notch.

According to Hollister, the baculum of *Procyon cancrivorus* (referred to the subgenus *Euprocyon*) is less curved than in the typical form, *P. lotor*; but the curvature is subject to a great deal of variation in the latter, *i. e.* from an angle of 135° to 90°.

In *Nasua* the baculum, as shown in Blainville's figure (*loc. cit.*),

* It may be added that Flower appeared to be quite unaware of the interest of the fact when he published the discovery of the proximity of the prepuce to the scrotum—a peculiarity in which *Ailurus* differs from all other Arctoid Carnivora.

Text-figure 12.



- A. Ventral view of scrotum and prepuce of *Procyon lotor*, showing the abdominal position of the prepuce.
- B. Lateral view of penis of same partially protruded from prepuce, with bristle thrust into urethral aperture; baculum dotted in.
- C. Anterior view of extremity of penis of same, with urethral orifice between condyles of baculum.
- D. Inferior view of distal portion of penis of same, showing course of urethral canal.
- E. Lateral view of penis of *Nasua nasua* partially protruded; the slack ventral tissue pulled forwards and bristle thrust into urethral aperture.
- F. Upper view of same.
- G. Lower view of same.
- H. „ „ penis of *Potos* partially protruded.
- I. Ventral view of scrotum and prepuce of *Ailurus fulgens*, showing scrotal position of prepuce.
- K. Lateral view of penis of same protruded almost to full extent, with bristle passed into urethral orifice with loose ventral tissue.

All figures except H. $\times \frac{1}{2}$.

is straight or slightly curved and normally* subcylindrical and attenuated, with the apex expanded transversely and somewhat abruptly to a considerable extent. The sides of the expanded portion are rounded, and the distal margin is tolerably evenly truncated or mesially concave, so that the tip is slightly bilobate. The lower surface of the expanded termination is lightly convex; the upper to a corresponding degree concave.

In an adult male of each of the two species examined, namely *Nasua nasua* and *N. narica*, there is a difference in the length of the baculum. In the former species it measures 63 mm., in the latter 77 mm. Possibly this is a specific character †.

The baculum of *Nasuella* is, I believe, unknown.

The baculum of *Bassariscus* was figured by Blainville (Ost. des Mamm., Atlas i., *Mustela*, pl. x.), and described and figured by Gervais (Voy. de la 'Bonite,' i. p. 20, Atlas, pl. iv.). Disregarding the club-shaped base, it is tolerably evenly attenuated up to the apex, which has a simple undivided slightly depressed thickening, like the button on a foil. In the specimen figured by Blainville it was rather strongly upcurled in its basal third, with a slight downward distal curve, and measured about 50 mm. In Gervais' specimen it was straighter and measured the same, which, judging from the figure of the skeleton, was about two-thirds the basal length of the skull. In the young example of *Bassariscus* examined by me—an example in the stage of the tooth change, the milk premolars being still in place—the baculum, resembling in all essential particulars that figured by Gervais, is less than half the basal length of the skull, the latter being 65 mm. and the baculum 30 mm.

The baculum of *Jentinkia sumichrasti* as figured and described by Lönnberg (Anat. Anz. xxxviii. p. 232, fig. 2, 1911) measures 43 mm., is straight and subcylindrical, *i. e.* only gradually narrowed from the distal to the proximal end. The tip is a simple rounded condyle-like thickening; but close behind it, rather on the underside of the baculum, there is a pair of smaller rounded condyle-like tubercles, recalling the similar accessory processes in the baculum of *Potos*, which, however, project upwards and outwards.

As I have elsewhere remarked, the baculum of *Jentinkia* is very like that of the Musteline *Grison*, except that the post-apical processes in the latter are dorsal in direction. The presence of the two tubercles in question distinguishes the baculum of *Jentinkia* from that of *Bassariscus*.

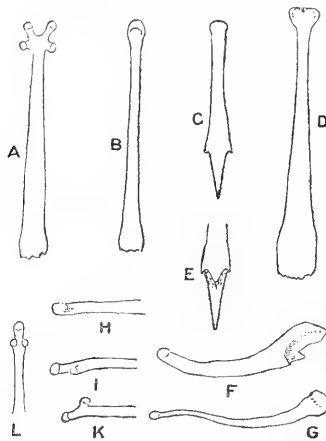
The only account of the baculum of *Bassaricyon* known to me is that of Hollister, who described it as "32 mm. in length,

* In one example of *Nasua nasua* the bone shows an abnormal flattening on the right side.

† In an adult but castrated male of *Nasua nasua* the baculum measures only 52 mm., and is exceedingly slender without any thickening at the proximal end. The penis was correspondingly short as compared with that organ in the entire male. One would perhaps expect the operation in question, if performed early in life, to affect the development of the baculum.

slightly bowed, and much less distinctly bilobed anteriorly than in *Procyon* or *Euprocyon*." I infer from this description that the baculum is of a simple type, resembling somewhat closely that of *Nasua*. I presume the bone was taken from an adult animal. If so, its small size as compared with that of *Potos* and the difference in the formation of the tip are interesting, although there is, of course, no reason to suppose that *Bassaricyon* is in any way nearly related to that genus despite their superficial resemblance in some particulars. In connection with the comparative shortness of the bone, it must be remembered that *Bassaricyon* is the smallest member of the so-called Procyonidæ.

Text-figure 13.



- A. Upper side of baculum of *Potos*.
 B. The same of *Bassariscus astutus* (immat.).
 C. " " *Ailurus fulgens*.
 D. " " *Nasua nasua*.
 E. Proximal end of baculum of *Ailurus* from below.
 F. Lateral view of baculum of the same.
 G. " " " *Bassariscus astutus* (after Blainville).
 H. " " apex of baculum of *Nasua*.
 I. The same of *Jentinkia* (after Lönnberg).
 K. " " *Potos*.
 L. Upper side of tip of baculum of *Jentinkia* (after Lönnberg).

Figs. A, D, H, K $\times \frac{1}{2}$; the rest natural size approximately.

In *Potos* the baculum is somewhat shorter than in *Nasua*, but, as in that genus, it is straight or slightly curved, subcylindrical, and attenuated. The apex differs from that of all the genera referred to the Procyonidæ. It ends in four condyle-like processes, one smaller, directed upwards and outwards on each side, and two at the end separated by a wide and deep notch. The two

bacula of this genus which I possess differ a little in length and in the development of the terminal processes. One measures 65 mm., the other 60 mm. The former is narrower at the base, but slightly thicker at the neck behind the two proximal processes, and these are smaller, a little less salient, and directed slightly less upwards. The baculum is wider across them than across the terminal processes, which project straight forwards and converge slightly at their inner angles, so that the notch between them is a nearly complete oval. In the shorter of the two the proximal processes are larger and the terminal processes diverge slightly from the middle line, so that the width across them is equal to the width across the proximal processes, and the notch between them is wider, and not narrower, at its mouth.

Flower figured and described the baculum of *Ailurus*. Conforming to the size of the penis, it is relatively very short, being only about an inch in length*. Its upper side is markedly concave, owing to the slightly upturned apex and the rather strongly elevated base. Its proximal half is flat below but compressed and carinate above. The tip is a little expanded and truncated, with rounded angles and only very obscurely bilobed, and there is a short median groove on the upper side just behind the tip. The epithet "spatulate" applied by Flower to the tip of the specimen he examined, does not express the shape of the termination of the bone in my example. This bone measures about 23 mm.

By the penis and baculum the genera may be distinguished as follows:—

- a. Penis short, prepuce close to scrotum; baculum short, its apex simple and upturned, its base with a high keel *Ailurus*.
- a'. Penis long, prepuce abdominal; baculum long, not upcurled apically, its base clavate, not strongly keeled.
- b. Baculum ending in four short, radiating condyle-like branches. *Potos*.
- b'. Baculum ending otherwise.
- c. Baculum curved downwards distally, its apex forming two rather deeply cleft condyle-like processes *Procyon*.
- c'. Baculum straight, or nearly so, distally, its apex at most indistinctly bifid.
- d. Baculum with expanded, flattened, subspatulate, indistinctly bifid extremity *Nasua*
(and ? *Bassaricyon*).
- d'. Baculum with rounded apex.
- e. Two small condyle-like processes just behind the apex ... *Jentinkia*.
- e'. No accessory processes behind apex *Bassariscus*.

The length of the penis and the position of the prepuce, two very important points in the classification of the Carnivora, are unknown in *Ailuropoda*. The Ursidæ resemble the typical Procyonidæ in those characters; and in all the species I have examined the baculum is a long, stout, distally tapering bone, with a simple termination.

* That is to say about one-third of the length of the baculum in *Potos*, a smaller animal.

There is very little to say about the external genitalia of the female. In *Procyon* and *Ailurus* the vulva occupies the same relative position as in Canidæ and Ursidæ. In both genera it is an oval or egg-shaped excrescence, with hairy labia surrounding a central pit, the clitoris being a small excrescence near the lower edge of the pit, and above the clitoris is the orifice of the vagina. In *Ailurus* the clitoris contains a small bone; but I have no note of this in *Procyon*. In *Potos* the vulva is relatively a somewhat shorter angular prominence, with the orifice forming a transverse, not a vertical, rima—an adaptation possibly to the width of the tip of the baculum of the male. I found no clitoris within the orifice. Beddard did not describe the vulva in the female example of *Bassaricyon* he examined.

The External Characters as a Guide to Classification.

A review of the above-recorded characters brings to light some interesting facts bearing on the classification of the genera examined.

There is nothing special to say about the vibrissæ except their high development in *Nasua*.

The external ear shows in its variation generic features, but practically no evidence of close intergeneric kinship.

The muzzle and rhinarium also exhibit good generic characters; while the rhinarium of *Nasua* differs markedly in its specialization from that of the rest.

In the case of the feet, however, a marked difference may be noticed between *Ailurus* and the rest. In the latter a gradation may be traced from *Bassariscus* through *Jentinkia* to *Bassaricyon*, from the latter to *Nasua* on the one side and to *Potos* on the other, and from *Potos* to *Procyon*.

Ailurus also stands alone in possessing a specialized glandular area round the anus. The presence of normal anal glands both in *Ailurus* and *Procyon* merely indicates the mutual inheritance of a primitive feature; but the modification of these glands met with in *Nasua* is an acquired differentiating peculiarity, as also is their loss by *Potos*. The latter is also peculiar in the possession of the ventral glands.

Finally, *Ailurus* differs markedly from the rest of the genera in the scrotal position of the prepuce, the shortness of the penis and baculum, and the structure of the base of the baculum itself. The others retain the primitive abdominal position of the prepuce and the large baculum seen in typical Arctoids, all Cynoids, some Æluroids (e. g. *Cryptoprocta*), and the Pinnipedes.

The above-mentioned peculiarities of *Ailurus*, coupled with the better-known peculiarities of the skull and teeth, justify the severance of that genus from the American Procyonidæ as proposed by Gray and upheld by Gill, Turner, and Flower, though

subsequently abandoned by the latter and by most recent authors.

Potos, too, has several peculiarities in its external characters as well as in its skull and teeth; and probably no one will cavil at the adoption of Trouessart's view that it should stand as the representative of a special subfamily of Procyonidæ, namely Potosinæ.

The status of the remaining genera is not so easy to settle. Taking first the older known forms, *Procyon*, *Nasua*, and *Bassariscus*, there does not seem to be evidence of any close affinity between them, a fact clearly perceived by Gray and Gill, although by making *Nasua* and *Procyon* the types of special subfamilies of Procyonidæ, Gill expressed his idea of closer kinship between them than between either of them and *Bassariscus*, which he kept in a family apart. Even quite recently Hollister has adopted the view that *Bassariscus* should rank as a separate family.

The discovery of *Bassaricyon*, since the time of Gray and Gill, does not help matters, since the genus is equally isolated and serves in no respect to affiliate any two of the other three. The four genera, in fact, differ in a large number of characters, to any one of which full generic value would be granted nowadays; and the logical inference to be drawn from this argument is that the sum of the characters demands supergeneric recognition, which should be expressed systematically by elevating the genera to the rank of subfamilies. Further justification for this course may be found in following the present day tendency to grant full generic value to the characters upon which such forms as *Euprocyon*, *Nasuella*, and *Jentinkia* were founded. We shall then have the Procyoninæ, the Nasuinæ, and the Bassariscinæ with two genera each and the Bassaricyoninæ with one.

The Position of Ailuropoda.

The question of the systematic position of *Ailuropoda* cannot be passed by in a paper dealing with the Procyonidæ, since the genus has been referred to that family. Milne Edwards contented himself with pointing out the resemblances between *Ailuropoda* and *Ailurus* on the one hand, and *Ailuropoda* and the Ursidæ on the other. And, so far as I am aware, Mivart was the first author definitely to state the opinion that *Ailuropoda* is more nearly akin to the Procyonidæ, with which it is affiliated through *Ailurus*, than to the Ursidæ; and this opinion found practical expression in the ascription of *Ailuropoda* to the Procyonidæ, under a special subfamily also including *Ailurus*. Mivart's view was adopted, with the support of much additional evidence, by Lankester and Lydekker, and Mivart's classification was independently reached. Finally, Bardenheft attempted to show that Flower was right in classifying *Ailuropoda* in the Ursidæ.

Bardenfleth appears to have been much influenced by Winge's opinion on the homologies of the cusps in *pm.* 4 of the upper jaw, which, admitting its correctness, shows that the structure of the tooth in question lessens the evidence for the affinity between *Ailuropoda* and *Ailurus* and strengthens the evidence for affinity between the former and the Ursidæ. The points are:—(1) The antero-internal cusp of *Ailurus* corresponds to the postero-internal cusp of *Ailuropoda*; (2) the postero-internal cusp of *Ailurus* is unrepresented in *Ailuropoda* and the antero-internal cusp of *Ailuropoda* is unrepresented in *Ailurus*; (3) the postero-internal cusp of *Ailuropoda* corresponds to the postero-internal cusp of the Ursidæ; (4) the antero-external and antero-internal cusps of *Ailuropoda* are unrepresented in the Ursidæ—in other words, *pm.* 4 of the maxilla of the Ursidæ corresponds to the posterior half of the same tooth in *Ailuropoda*, with the further difference that the inner and posterior roots of this tooth in the Ursidæ are, except in abnormal cases, fused. Nevertheless, the resemblances between this tooth in *Ailuropoda* and Ursidæ do not, in my opinion, justify the conclusion that *Ailuropoda* is a member of that family. For, if the tooth in *Ailuropoda* is not Ailurine or Procyonine, it is certainly not Ursine. It is peculiar and stands by itself, so far as living Carnivora are concerned.

Some of the characters cited as of systematic value by Lydekker and Bardenfleth are too inconstant to be of use. Steno's fissure, the cleft between the anterior palatine (incisive) foramina, is cited by Lydekker as diagnostic of the Procyoninæ, restricted to the American genera, which have it, and the Ailurinæ, including *Ailurus* and *Ailuropoda*, which are without it; and Bardenfleth states that it is present in *Ursus* and absent in *Ailurus* and *Ailuropoda*. The actual facts are as follows:—Even in the comparatively small series of skulls belonging to the Zoological Society, I find this fissure present in an example of *Ailurus*, where it is represented by a groove terminating in a foramen which passes up into the nasal passage—a condition which it commonly presents, even within the limits of the genus *Procyon*. As for the Ursidæ, it varies in size from a long cleft to a minute orifice, through which a needle-point can only just be passed.

Lydekker, endorsing Lankester's statement, also draws attention to the "important fact that *Ailurus* and *Ailuropoda* resemble the American Procyonidæ, and thereby differ from all other Carnivora, in the presence of two lobes or cusps on the inner or tubercular portion of the upper carnassial." Even if he had said "some of the American Procyonidæ," the statement would not have been true, because both *Helictis* and *Taxidea*, two of the Mustelidæ, have two cusps on the inner portion of the tooth. Again, "*Ailuropus* approximates to the Raccoon in the absence of postorbital processes of the frontals." This is not true, the frontal postorbital processes being well developed in all the skulls of

Procyon I possess*. Further on we read: "A point of resemblance between *Ursus* † and *Eluropus* is to be found in the circumstance that the maxillary [preorbital] foramen opens on the side of the skull well in advance of the zygomatic root, whereas in *Elurus* and *Procyon* it perforates the zygoma itself." So far as this statement is applied to the Ursidæ, it is contradicted by the Malayan Bear, in which the foramen perforates the zygoma exactly as in *Ailurus* and all the American Procyonidæ. I may also add, in this short-headed species of Ursidæ the zygomatic width of the skull bears to the basal length about the same proportion as in *Ailuropoda*, thus contradicting Lankester's statement that "in all Bears the skull is much longer and narrower both in its facial and cranial regions than in the skull of *Eluropus*." Bardenfleth similarly wrongly contrasts *Eluropus* with *Ursus* when he says of the former "zygomatic arches exceedingly wide" and of the latter "zygomatic arches moderately wide"; and his statements that the basioccipital is broad and the bulla not inflated in *Ursus* are not always true of the species in question. These corrections, however, are of no great moment in settling the degree of kinship between the Ursidæ, *Ailuropoda*, and *Ailurus*—the point at issue between the authors quoted. What they prove is that the resemblances between the genera concerned are closer than either author claimed.

My own opinion about the matter is that Lankester and Lydekker, as Bardenfleth held, overrated the resemblances between *Ailuropoda* and *Ailurus* and underrated the differences; and that Bardenfleth underrated the peculiarities of *Ailuropoda* which distinguish it from the Ursidæ. The attempt to place *Ailuropoda* in the Procyonidæ makes the definition of that family an impossibility. For example, every character used by Lydekker for defining that family has its exception. The same criticism cannot be advanced against its inclusion in the Ursidæ, because in one or two well-marked characters, like the structure of the feet, the length of the tail, and the presence of *m.* 3 in the mandible, *Ailuropoda* and the genera of Ursidæ resemble each other, and differ from *Ailurus* and the American genera assigned to the Procyonidæ. But since the assignment of *Ailuropoda* to the Ursidæ disturbs the homogeneity of that family, which already has some half-dozen well-defined genera, I prefer to regard *Ailuropoda* as the representative of a distinct family. The genus is neither Ursid nor Procyonid, but something distinct from both.

* Bardenfleth also is wrong in stating that *Melursus* is without frontal post-orbital processes.

† Fig. 3, Pl. xix. of Lydekker's paper (Tr. Linn. Soc., Zool. vol. viii.) is part of the skull of an *Ursus*, not of a *Procyon* as labelled.

Dichotomous Classification of the Ursidæ, Ailuropoda, Ailurus, and the Procyonidæ.

Although this method of classifying animals has its disadvantages on account of its deceptive simplicity and its concealment of cross resemblances, it has the convenience, if not admittedly artificial, of presenting clearly the characters relied upon by the author and of expressing his views as to the kinship of the groups concerned.

- a. Feet short and broad, digits subequal, their pads forming a lightly curved line in front of the broad plantar pad. Tail reduced to an anal operculum. *M.* 3 of mandible retained. Carotid foramen situated at posterior end of bulla, close to *foramen lacerum posticum*.
- a'. Cheek teeth comparatively small, especially *pm.* 1-*pm.* 3, which are mostly unicuspid and one-rooted, but *pm.* 1 larger and more persistent than *pm.* 2; upper *pm.* 4 at most tricuspid, its inner root normally fused with the posterior root. Lower *pm.* 4 short, unicuspid. Zygoma arising approximately above the middle of *m.* 2, which is far in advance of the mesopterygoid fossa, the latter preceded by a long edentulous posterior palate. Alisphenoid canal present. External auditory meatus with its floor produced to reach approximately to end of thick mastoid process. Mandible not thickened on inner side of coronoid, which does not conceal *m.* 3 and is comparatively low and but little hooked; angular well developed, condyle and glenoid surface not abnormally wide. Fore foot without long radio-carpal sesamoid etc.* ... **URSIDÆ.**
- a². Cheek teeth excessively developed, except *pm.* 1 of upper jaw, which is minute in maxilla, and absent in mandible; *pm.* 2 of maxilla and *pm.* 2 and *pm.* 3 of mandible tricuspid; *pm.* 3 of maxilla sexcuspid; *pm.* 4 of same, with three large outer and two large inner cusps, its inner root not fused with posterior root; lower *pm.* 4 long, tricuspid. Zygoma arising approximately above middle of *m.* 1; posterior end of *m.* 2 reached or overlapped by anterior end of mesopterygoid fossa; no long edentulous posterior palate. Alisphenoid canal absent. External auditory meatus with its floor abbreviated and falling far short of long compressed mastoid. Mandible thickened on inner side of coronoid, which conceals *m.* 3 and is high and hooked; angular much reduced; condyle and glenoid surface abnormally wide. Fore foot with long radio-carpal sesamoid etc.* **AILUROPODIDÆ.**
- b. Feet comparatively long and slender †, digits unequal, with their pads arranged in a strongly curved line round the comparatively narrow plantar pad. Tail at least long enough to reach the ground. *M.* 3 of mandible suppressed. Carotid foramen on inner side of bulla well in advance of *foramen lacerum posticum*.
- b'. Penis short, prepuce close to scrotum. Pads of feet reduced and functionless, completely concealed by woolly hair; carpal pad remote from plantar pad. Anus in centre of glandular depressed area. *Pm.* 2 and *pm.* 3 of maxilla large and three-rooted; *pm.* 3 quinquecuspid and closely resembling *pm.* 4. Alisphenoid canal present. *Foramen rotundum* minute, lying beneath *for. lac. ant.*, the two separated by a very thin plate of bone and sunk in a common pit; *foramen ovale* elongate. Anterior edge of coronoid inclined forwards **AILURIDÆ.**

* For other skeletal characters distinguishing the Ursidæ and Ailuropodidæ, see the papers by Lankester, Lydekker, and Bardenfleth.

† It is hardly an exaggeration to say that there is no such thing as a plantigrade carnivore. They all run and walk on the digital and plantar pads, whether they are cats, dogs, bears, or badgers. Bears, when standing on their hind legs, and sometimes when walking, place the metatarsal pads on the ground; but generally these pads, like the carpal pads, are raised from the ground in ordinary progression. A naked metatarsal area does not indicate platigradism, as has been supposed.

- ♂. Penis long, prepuce abdominal, remote from scrotum. Feet with digital and plantar pads normally developed and quite naked; carpal pad or pads also well developed and close to the plantar pad. No glandular area round anus. *Pm.* 2 and *pm.* 3 of maxilla comparatively small and one- or two-rooted*; *pm.* 3 unlike *pm.* 4, at most with one main cusp and three minute cusps. Alisphenoid canal absent. *Foramen rotundum* of normal size, well separated from the *for. lac. ant.* and not sunk in a common pit with it; *foramen ovale* rounded. Anterior edge of coronoid inclined backwards PROCYONIDÆ.
- c. Mandible very massive, the rami early fused by a long symphysis, the lower edge straight by the growth posteriorly of a large lamina, sometimes rounded, sometimes angled, beneath the angular process, which is reduced to a small excrescence beneath the condyle †; inner dentary foramen beneath base of anterior edge of coronoid. Palate parallel-sided, as wide in front as behind, depressed behind molars; paroccipitals and mastoids standing away from bulla, which has carotid foramen set forwards much nearer *for. lac. med.* than *for. lac. post.*; molars even when newly cut flat-crowned; *pm.* 1 absent above and below ‡. Tail prehensile. Two ventral cutaneous glands Anal glands aborted *Potosinæ.*
- c'. Mandible slender, the rami separable and with normal symphysis, lower edge arched and inclining upwards without expansion towards angular process, which is well developed and close beneath the condyle; inner dentary foramen about midway between the condyle and the anterior margin of the coronoid. Palate with arcuate sides, wider behind than in front, not depressed behind molars; paroccipitals and mastoids arising close to the bullæ, which have the carotid foramen about equally distant from *for. lac. med.* and *for. lac. post.*, or nearer the latter. Molars cuspidate when newly cut; *pm.* 1 present. Tail not prehensile. No ventral glands. (Anal glands retained in *Bassariscus*, *Procyon* and *Nasua*, unrecorded in *Bassaricyon*.)
- d. Mesopterygoid fossa long, extending to posterior molars; molars and premolars with pointed or blade-like cusps; canines rounded in section, not grooved and not mutually sharpened. Bursa of ear with anterior flap emarginate, posterior flap attached behind edge of pinna. Metatarsus with at most a small naked area above plantar pad; claws short, sharp, curved; digits fully webbed or nearly so. Facial portion of skull and zygoma as under e; hamular in front of foramen ovale; no supplementary foramen behind carotid *Bassariscinæ* §.
- d'. Mesopterygoid fossa short, separated from molars by a long posterior palate. Molars with subequal conical comparatively blunt cusps; canines grooved, mutually sharpened. Bursa absent or reduced, its anterior flap at most very low and not excised. Metatarsus naked beneath.

* Exceptionally in *Procyon*, *pm.* 3 is three-rooted.

† This at all events is, I believe, the correct interpretation of this region of the mandible.

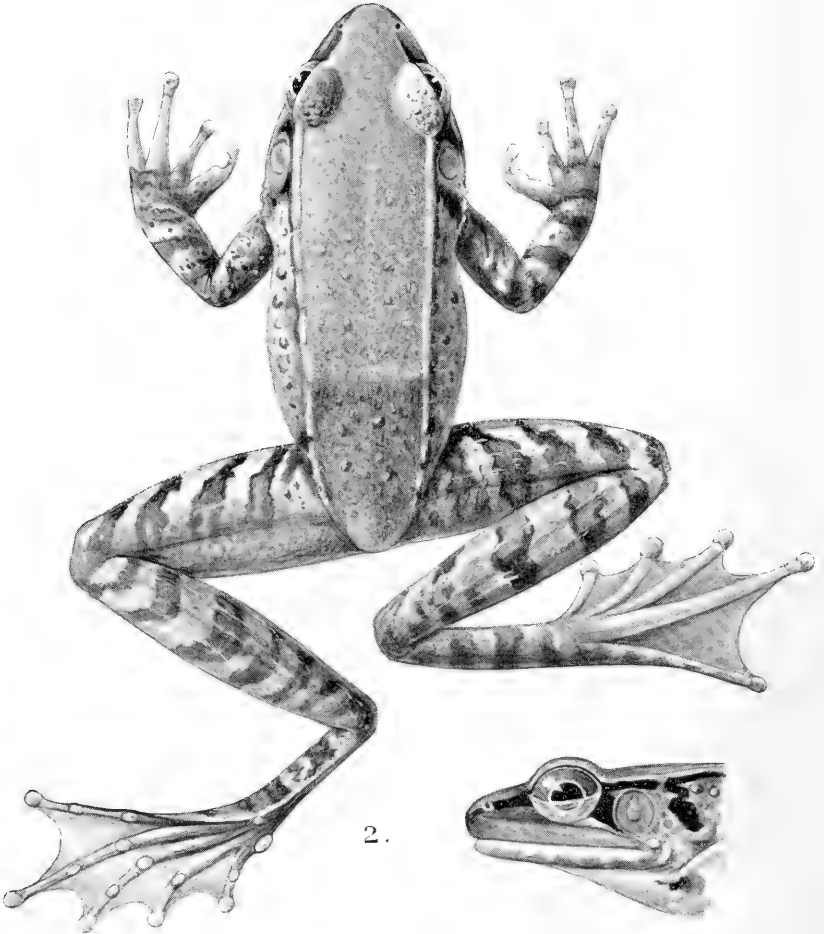
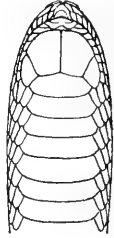
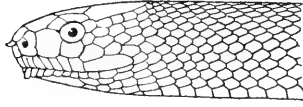
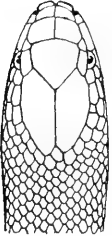
‡ Huet figures a mandible with it present on the right side.

§ Hollister gave full family rank to this group, because "The *Cacomistles* (*Bassariscus*), while exhibiting many of the characters of the *Procyonidæ*, differs so greatly in the nature of all the teeth that it seems impossible to retain them in the family. The dog-like premolars and molars, the rounded canines, and the evident though small secondary lobes on the incisors . . . all show unmistakable characters of the teeth of the *Canidæ*." Nevertheless, by a series of comparatively simple changes, the teeth of *Bassariscus* can be derived from those of such a *Procyonid* as *Nasua*, for example, or *vice versa*, and the secondary grooves and lobes on the incisors are not always more marked in *Bassariscus* than they are in *Potos*, and the grooves are often traceable in other genera. The teeth of all the genera attest the extreme plasticity of those organs. (See above, p. 418.)

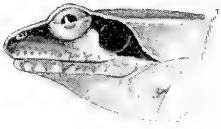
- e. Skull with muzzle short, not compressed above, preorbital foramen close to anterior rim of orbit, which is above *pm. 3* or *pm. 4*; inferior edge of anterior nares normally formed; canines only moderately sharp in front; posterior root of zygoma not abnormally expanded; typically no supplementary foramen on inner side of bulla between carotid and *foramen lacerum posticum*. Upper edge of rhinarium not produced, its anterior surface convex, with normal nostrils and wide septum.
- f. Mastoid small, not bigger than paroccipital and hardly surpassing auditory orifice; carotid foramen not behind middle of bulla; *foramen ovale* well behind tip of hamular; ridges of posterior palate marginal. Claws short, sharp, much curved; digits webbed for two-thirds of their length. Snout not produced; upper lip divided by wide philtrum. Bursa retained and marginal *Bassaricyoninae*.
- f'. Mastoid large, larger than paroccipital and projecting far beyond auditory orifice; carotid foramen behind middle of bulla; *foramen ovale* not behind tip of hamular; ridges invading lower surface of posterior palate. Claws longer, blunter, and less curved; digits entirely free from webbing. Snout produced, upper lip undivided, no philtrum. Two normal anal glands. Bursa absent *Procyoninae*.
- e'. Skull with muzzle elongate and compressed above; preorbital foramen remote from orbit, the anterior rim of which is above *m'*; inferior edge of anterior nares thickened and produced; glenoid portion of zygoma much extended antero-posteriorly; a very distinct supplementary foramen between carotid and *foramen lacerum posticum*. Upper edge of rhinarium produced, its anterior surface nearly flat, with vertically elongated nostrils and narrow septum. Digits with powerful claws, fully webbed. Anal glands a series of small pockets on each side. Mastoid as under *f*; palate as under *f'*; position of carotid foramen and *f. ovale* intermediate. Bursa retained but not marginal *Nasulinae*.



1.



2.



1.



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22. New or Little-known Reptiles and Batrachians from Southern Annam (Indo-China). By MALCOLM A. SMITH, M.R.C.S., L.R.C.P., F.Z.S.
(Plates I.-II. and Text-figures 1-2.)

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The collection of Reptiles and Batrachians of which this paper is the subject was made in Southern Annam, chiefly on the Langbian Plateau, in March, April, and May, 1917. I was fortunate in having as my companion on the trip Mr. C. Boden Kloss, of the Selangor Museum, Federated Malay States, and as he was able to remain on in the country for several weeks after I had left, was the means of adding many valuable specimens to my collection.

The famous Plateau had long attracted us, as zoologically it was almost unknown; and as, owing to the war, we were unable to obtain home leave, of which we were badly in need, we decided to take advantage of a short holiday and visit this region. The enterprise of the French Government, too, in building a sanatorium at a high elevation, and in constructing fine roads up to it, rendered the plateau easily accessible, so that little time was wasted in travelling.

Our expectations of rich material were fully justified. The report on the birds by Messrs. Robinson and Kloss has already appeared in 'The Ibis' (July 1919), and a good account of the general conditions on the plateau has been given there by Mr. Kloss. It is unnecessary for me to repeat his remarks here, but for convenience I have recapitulated the camps at which collections were made. Starting from the sea-coast at Four Cham, we gradually made our way up into the hills, our final camp being underneath the Langbian peaks at 2000 metres elevation.

I was accompanied by two trained native assistants. Altogether about 700 specimens were obtained. Many more of the common

forms could have been taken, but with a good series in hand, and the difficulties in transporting heavy collecting-tanks about the country, it was necessary to place some limit upon what was caught.

The number of snakes obtained was not great, and most of these were caught after the rains had commenced in the middle of April. Mountain-streams abounded everywhere, and frogs, chiefly of the genus *Rana*, were plentiful. A fine series of *Rhacophorus* and *Ixalus* were also taken. During the day these tree-frogs were seldom seen. Their small size and fine protective colouration rendering them almost invisible among the bushes in which they lived. Their shrill cries by night, however, guided one quickly to them, and by means of a lantern they were easily found and taken.

Perhaps the two most interesting discoveries of the trip were a new genus of snake, allied to *Xenodermus*, and a new species of the degraded skink, *Dibamus*. A new form of *Gymnodactylus peguensis* was obtained on the plateau, but, with the exception of the common house-geckoes and the equally common *Phyllodactylus siamensis*, the family Geckonidæ was remarkable for its absence. The same can be said of *Tropidophorus*, a single specimen only being obtained, although in search of frogs the collectors were daily working along streams. Three new forms of *Rana* and two of *Megalophrys* are also described in this paper. Want of time has prevented me, for the present, from completing my examination of the *Rhacophorus*, the *Ixalus*, and the smaller species of *Lygosoma*.

On the whole, the Reptilian and Batrachian fauna of the plateau, so far as my examination extends, approximates most nearly to that of the hills of Siam and Southern Burma and the higher hills of the Malay Peninsula. A few species only are related to those of more northern origin.

Types of all the species here described have been presented to the British Museum of Natural History.

Finally, I wish to express my thanks to Mr. G. A. Boulenger, F.R.S., for his valuable help in several difficult determinations.

The following localities were collected in:—

Tour Cham, on the sea-coast (lat. 12° N.).

Daban, in the foot-hills at 200 metres altitude. Dry, deciduous jungle, but fairly dense.

Sui Kat and *Dran*, localities about 6 kilometres apart in the hills, at 1000 metres elevation. Chiefly evergreen jungle, with some useful small swamps.

Dalat, *Camly*, *Le Bosquet*, *Arbre Broyé*, localities on the plateau at 1200 to 1800 metres. The country at the two first-named camps was chiefly open pine-forests, but at the two last dense evergreen jungle was met with.

Langbian peaks, 2000 metres. Mixed forest, some pine, more oak.

FIMBRIOS, gen. nov. (Pl. I. fig. 1.)

Teeth subequal, 30-32 in each maxillary; head not very distinct from neck, covered with large shields; eye small, with round pupil; loreal very large, touching the eye, nostril in the anterior part of a large nasal; body slender, scales elliptical, keeled, juxtaposed anteriorly, feebly imbricate posteriorly, those of the outer row larger than the others; ventrals large, rounded; tail rather short, subcaudals single.

Allied to *Xenodermus* Reinhardt.

FIMBRIOS KLOSSI, sp. n.*

Nostril in the anterior part of a large, concave nasal; rostral triangular, concave, not visible above; internasals much smaller than the præfrontals and separated from the rostral by a horizontal ridge of the skin; frontal as broad as long, longer than its distance to the end of the snout, much shorter than the parietals; supraocular very small and narrow; præocular small, just touching the frontal; a large square loreal in contact with the eye; two postoculars and a subocular; temporals small, 3+4; 9 or 10 supralabials, the first 5 very small, with strongly raised edges, the last one much elongated; no mental; 12 infralabials, the first 7 very small and with their edges raised like the supralabials, 1st and 2nd pairs in contact with each other; a pair of very large chin-shields.

28 to 30 scales round the anterior part of the body, 30 to 32 round the middle; ventrals 162 to 167; anal 1; subcaudals 43 to 58.

Dark grey above, yellowish (in life white) below, the edges of the posterior ventrals and subcaudals tinged with grey.

Three specimens obtained at Dalat and Camly at 1500 metres. Measurements of the type series in mm. :—

Author's No.	Total length.	Tail.	Ventrals.	Subcaudals..
2144 ♀	395	50	166	43
2145 ♂	345	68	162	57
2143 ♂	310	60	167	58

These remarkable snakes were caught beneath fallen timber. They were quiet and gentle in their movements, and made no attempt to bite when handled. I kept one alive for a few days in the hopes of learning something of its habits, but difficulties of transport prevented my doing this as long as I should have wished.

ZAMENIS MOI, sp. n.†

Maxillary teeth 18; eye moderately large; rostral considerably broader than deep; internasals shorter than the præfrontals;

* Named after Mr. C. Boden Kloss, to whom I am indebted for two of the three specimens.

† Named after the Moi people, the aboriginal inhabitants of the country in which it was found.

frontal $1\frac{1}{4}$ times as long as broad, longer than its distance to the end of the snout, shorter than the parietals; loreal twice as long as high; one pre- and two post-oculars; no subocular; temporals 1+2; 8 supralabials, 4th and 5th touching the eye; 6 infralabials, 4th very large; 4 infralabials in contact with the anterior chin-shields, which are as long as the posterior; posterior chin-shields in contact anteriorly. Scales in 15 rows throughout, entirely smooth; ventrals, rounded, 168; anals 2; subcaudals 103 pairs.

Olive-greenish above, with indistinct, narrow, pale, dark-edged cross-bars on the posterior part of the body and tail. Below yellowish, speckled with grey on the posterior two-thirds; a dark median streak between the subcaudals.

Total length 1000 mm., tail 290.

Allied to *Z. korros* Schleg.

A single male specimen collected at Dran (1000 metres) by Mr. Boden Kloss in May 1917. Author's number, 2153.

TROPIDONOTUS JOHANNIS Blgr.

Ann. & Mag. Nat. Hist. (8) ii. 244, Sept. 1908.

Ten examples from the Plateau differ from typical *johannis* only in the supralabial shields. Two of them have 8 on one side, 9 on the other; all the rest have 9. From *T. modestus* Günther, which it resembles very closely, it differs in the fewer caudal shields and in the colouration of the belly.

Variation in my series:—Scales 19–17, ventrals 149–159, caudals 83–98. Five out of the ten specimens have the tail more or less docked. Largest: total length 640 mm., tail 185 (♂).

Colour. Brown above, with small black spots, and a series of small yellow ones also present in most. Labials with black sutures, and a yellow streak from the last labial to meet its fellow on the nape. Belly yellowish white, with a black spot at the outer side of each ventral.

COLUBER OXYCEPHALUS Boie.

Bouleng., Rept. Malay Pen. p. 143 (1912).

1 ex. from Daban. Scales 23, 23, 15. V. 245. C. 130. Total length 1880 mm., tail 480. Green above, yellowish below, tail pale reddish-buff (in spirits).

DENDRELAPHIS SUBOCULARIS Blgr.

Cat. Sn. B. M. ii. p. 89 (1894).

1 ex., Dran. Scales 15, 15, 11. V. 165. C. 98. 8 supralabials.

CALAMARIA PAVIMENTATA D. & B.

Cat. Sn. B. M. ii. p. 348 (1894).

Var. UNIFORMIS, nov.

Differs from the present known forms in its distinctive colouration.

Olive-brown above, uniform (no longitudinal lines or collar), below yellowish-white, with a median line along the tail and usually another down the belly. Labials yellow.

10 examples examined. Variation: ♂. V. 143-149; C. 30-34. ♀. V. 166, 167; C. 18, 19.

Type locality, Langbian peaks at 2000 metres.

Type series, Author's Nos. 2135, 2136, 2137, and 2139.

TRIMERESURUS MONTICOLA Günther.

Lachesis monticola, Cat. Sn. B. M. iii. p. 548 (1896).

1 ex. The specimen differs from the recognized description in having all the subcaudal shields single, and in having only two rows of scales between the eye and the labials. Wall, however, records one from the Chin Hills (Journ. Bombay N. H. S. xx. p. 775), in which the subcaudals are irregularly single and paired, and I find in the British Museum an example in which there are only two rows of suboculars. For the present, therefore, I regard my specimen as *T. monticola*. Scales 21, 15. Anal 1. V. 132. C. 38. Six scales between the supraoculars.

GYMNODACTYLUS PEGUENSIS and subsp.

G. peguensis, Bouleng. Rept. Malay Pen. p. 36 (1912).

Two specimens of a *Gymnodactylus* obtained at Camly agree well in characters with the typical form of *G. peguensis*, but differ distinctly in colouration. Both are males, and in both the tails are missing, and it is possible, with more complete material for examination, that the present diagnosis will be found incorrect. I refer them here to *G. peguensis*, and at the same time take the opportunity to describe another colour race which I have obtained in Eastern Siam.

The three forms may be described as follows:—

GYMNODACTYLUS PEGUENSIS, forma typica. (Text-fig. 1, A.)

7-8 præanal pores; 9-11 upper and 7-9 lower labials; two series of (6-8) large round spots on the back, or with the spots confluent transversely. Head in the adult with large rounded spots.

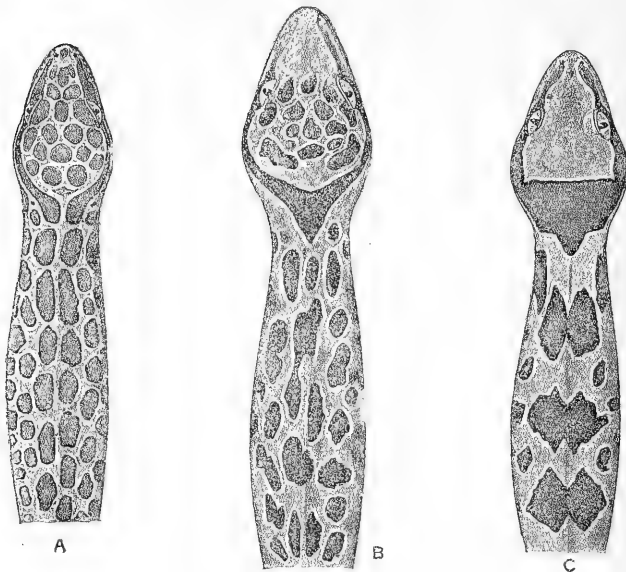
Type locality, Palon, Pegu. Has been found also in other parts of Pegu and in Peninsular Siam as far north as Nakon Sri Tamarat.

Var. *ANGULARIS*, nov. (Text-fig. 1, C.)

10-11 upper and 9-10 lower labials; two series of (4) large angular spots connected mesially. Head in the adult with indistinct angular spots.

Habitat. Dong Rek Mts., Eastern Siam.

Text-figure 1.

*Gymnodactylus peguensis.*A. Forma typica. B. *irregularis*. C. *angularis*.

Measurements of specimens known, in mm.:—

		Head & body.	Tail.	Arm.	Leg.
5364. Lat Bua Kao, Korat (Type).	♀	68	80	27	32
2028. Pak Jong	♀	65	70	25	32
2029. Hin Lap	juv.	34	35	13	17

Var. *IRREGULARIS*, nov. (Text-fig. 1, B.)

5-7 prænal pores; 8-9 upper and 8-9 lower labials; small angular spots not arranged in any very marked pattern; head with well-marked angular spots.

Habitat. Langbian Plateau.

		Head & body.	Arm.	Leg.
4875. Camly (Type).....	♂	79	28	36
4876. " "	♂	80	29	37

CALOTES MICROLEPIS Blgr.

Fauna Brit. India, p. 134 (1890).

1 ex., Camly. The specimen, a ♀, agrees well with the type in the British Museum. It has 70 scales round the middle of

the body. Head and body, 80 mm.; tail, 180. Brown above, finely speckled with black and yellow. Below whitish, speckled. Black lines radiating from the eyes.

The characters given by Boulenger (Rept. Malay Pen. p. 70) to separate this form from *floweri*, namely narrower head and more compressed tail, will not stand the test of my specimens. I have examined two examples of *floweri* from Chantabun, in addition to the two in the Museum. They have from 50-55 scales round the middle of the body.

I separate *microlepis* as having more scales, 65-70, round the body, smaller ventrals and smaller tympanum; it is possible that *floweri* is only a Southern form of this species.

I have examined pregnant females of both forms. The eggs are oval.

CALOTES MYSTACEUS D. & B.

F. B. I. p. 138 (1890).

Specimens obtained at Saigon and on the Langbian Plateau lack the three chocolate spots on the back which appear to characterize the form found west of the Mekong River. Enough, however, is not yet known of this handsome lizard in Burma to name races definitely. The plateau is a considerable extension eastwards of its known habitat.

LIOLEPIS BELLIANA Gray.

Bouleng., Rept. Malay Pen. p. 73 (1912).

Var. ANNAMENSIS, nov.

When collecting upon the sea-coast at Tour Cham, before ascending the Plateau, our attention was attracted by the marked difference in colour between the form of *L. belliana* which we observed there, and the one which we knew so well from Siam and the Malay Peninsula. The vivid orange bars upon the flanks of the typical form were replaced by bands of pure white.

A detailed examination of the specimens obtained showed further that, in the number of femoral pores, and in the size of the scales behind the tibia, they differed from the typical form. I distinguish the two as follows:—

Forma typica.

13-20, usually 15-18, femoral pores.

7-13, ,, 8-10, scales across the back of the middle of the tibia.

Flank with orange and black bars alternating.

Hab. Burma, Siam, Malay Peninsula and Archipelago, and S. China*.

* Amundale has shown (Rec. Ind. Mus. vii. p. 90, Feb. 1912) that the occurrence of this lizard in S. India is incorrect.

Var. ANNAMENSIS, nov.

19-26 femoral pores.

14-22, usually 17-20, post-tibial scales.

Flanks with black and white bars alternating.

Hab. Coast of S. Annam.*Specimens examined.*

Forma typica :—

	Femoral pores.	Tibial scales.
Tavoy	15—15	9
"	16—18	10
"	13—14	9
Penang	15—16	9
Perak	20—20	9
Jalor, Patani.....	17—17	9—10
" "	16—18	10
Tenasserim	16	12
Mergui	15	9
Burma	20—20	13
Siam	16—16	9
" (Koh Samui)	16—17	8
" (Koh Lak)	16—17	9
" "	16—16	10
Hainan	16—16	9
China.....	18	9
"	14—16	11

Var. *annamensis* :—

	Femoral pores.	Tibial scales.
2468. Tour Cham	♂. 26—26	16
2469. " "	♂. 24—24	16
2470. " "	♀. 24—25	18
2471. " "	♀. 21—22	17
2472. " "	22—21	19
2473. " "	♂. 23—24	20
2474. " "	21—22	22
2475. " "	♂. 24—24	16
2477. " "	20—20	18
2478. " "	♂. 24—24	19
2479. " "	♂. 23—24	17
2482. " "	20—21	14
2483. " "	♀. 21—21	17
2481. Cap St. Jacques	19—20	12
2480. " "	22—22	18

Types from Tour Cham. Type series, Author's Nos. 2473, 2475, 2480, 2481, 2482, and 2483.

LYGOSOMA STELLATUM Blgr.

Bouleng., Rept. Malay Pen. p. 87 (1912).

1 ex., Dalat. Before known only from two specimens, the types in the British Museum, from the Larut Hills, Perak. My example differs in that the prefrontals just miss contact, and the black spots on the neck and shoulders are arranged to form a broad vertebral band.

LYGOSOMA CORPULENTUM, sp. n.

Section *Riopa*. Distance between end of snout and arm twice in distance between axil and groin. Limbs well developed, short, pentadactyl, widely separated when adpressed. Snout obtuse, eyelids scaly, supranasals in contact behind rostral; frontonasals forming a good suture with frontal; prefrontals small; frontal broader than the supraocular, longer than the frontoparietal and interparietal together; parietals in suture behind the interparietal; 4 supraoculars; 2 loreals, posterior longest; 7 supralabials, 6th subocular; temporals small and scale-like; ear-opening small, subcircular, about half the size of the eye-opening, without projecting lobules; a large azygos postmental; 36 smooth scales round the middle of the body; præanals slightly enlarged; digits short, compressed, 4th toe a little longer than the 3rd, 12-13 keeled lamellæ inferiorly.

Head and body, 170; tail, 150 mm.

Colour in life. Light chocolate-brown above, mingled with yellowish on the flanks; lips, sides of neck, and throat yellow. Belly brownish-white. Labial shields edged black.

A single specimen obtained at Dalat. Author's No. 2128. Closely allied to *L. bamfyldii* Bartlett, from Borneo, Sumatra, and the Malay Peninsula, from which it differs in the absence of lobules to the ear-opening, number of scales round the body, colour of the head, and size.

DIBAMUS MONTANUS, sp. n. (Text-fig. 2.)

Snout covered with 7 more or less complete shields; a high, narrow rostral, well visible above; a pair of prefrontals, separated

Text-figure 2.



Dibamus montanis. Side and upper view of head.

from the 1st labial by a suture running backwards from the nostril, but fused with the labial anteriorly, the nostril thus

lying between the 1st labial and præfrontal; a long 2nd labial*. Other head-shields as in *D. argenteus* Taylor and *D. nova-guineæ* D. & B., viz. an enlarged frontal and a larger interparietal, an ocular and an enlarged scale behind the 2nd labial on either side. Mental narrow, trapezoid, with a pair of long infralabials.

24-26 scales round the middle of the body, scales imbricate and subequal. Præanals enlarged. Light chocolate-brown above, paler below.

Types, ♂ & ♀. Author's Nos. 4864, 4865. From Le Bosquet. Measurements of specimens in mm. :—

		<i>Le Bosquet.</i>		
		Total length.	Tail.	Diameter, mid-body.
♂ . 4865	.....	145	23	5
♀ . 4864	.....	145	21	5
		<i>Daban.</i>		
♀ . 2609	.....	112	?	3
♂ . 2608	.....	115	20	3
♀ . 5365	.....	70	11	2.5
♀ . 5366	.....	86	16	2.5
♀ . 5367	.....	65	12	2

In the length of the tail (which from this table appears to be comparatively longer in the young than in the adult) *D. montanus* resembles *D. argenteus* from the Philippines. From it also, as well as from *D. nova-guineæ*, it differs in the greater differentiation of the shields of the snout.

RANA MILLETI, sp. n. (Pl. II. fig. 2.)

Vomerine teeth in oblique series, commencing from the anterior borders of the choanæ and extending beyond their posterior borders, the distance between them equal to their distance from the choanæ. Head a little longer than broad, snout obtusely pointed, projecting beyond the mouth, longer than the eye; canthus rostralis distinct; loreal region slightly oblique, strongly concave; nostril distinctly nearer the tip of the snout than the eye; distance between the nostrils greater than the interorbital width, which is equal to or a little greater than the upper eyelid; tympanum very distinct, $\frac{2}{3}$ - $\frac{3}{4}$ the diameter of the eye, and $2\frac{1}{2}$ -3 times its distance from the eye.

Fingers rather long, 1st longer than 2nd; tips with small but distinct discs, which may bear a feeble groove separating the upper from the lower surfaces; subarticular tubercles large and prominent; discs of the toes larger than those of the fingers, and with a distinct groove separating the surfaces; toes $\frac{1}{3}$ webbed; outer metatarsals separated nearly to the base; subarticular

* In the two adult examples from Le Bosquet (1200 metres) the shields are as described, but in five juveniles from Daban (200 metres) the sutures are feebly evident or entirely absent.

tubercles prominent; no tarsal fold; inner metatarsal tubercle $2\frac{1}{2}$ –3 times in length of inner toe; a small, prominent rounded outer tubercle; tibio-tarsal articulation reaching to the tip of the snout or not quite so far; tibia $1\frac{3}{4}$ – $1\frac{5}{8}$ in distance from snout to vent; heels overlap when the limbs are folded at right angles to the body.

Skin of the back finely granular; a prominent and fairly broad dorso-lateral fold from the eye to the hip.

Yellowish-brown or greyish-brown above, sometimes with indistinct darker markings; sides of the head dark brown; limbs with indistinct dark bars; below yellowish.

Males without vocal sacs, with a large, flat, humeral gland, and a small pad on the first finger.

Allied to *R. adenopleura* Blgr., from Formosa, from which it differs in the more slender habit, less extensive webbing to the feet, the web not reaching the discs of any of the toes, and in colouration.

Eggs pigmented, the vitelline sphere measuring 2 mm. in diameter.

Type locality, Dalat. Numerous specimens were obtained in the type locality, from the Langbian peaks, and from Dran.

I have named this frog after Monsieur Millet, Conservator of Forests to the French Government, who gave us every help possible while travelling upon the Plateau.

Measurements of type series in mm.

Author's Nos.	5119	5128	5129	2571	2600	2602	4818	5103	5107	5176
Snout to vent..	48	47	47	45	46	37	36	36	37	29
Head	16	17	16	16	17	14.5	14	14	14	14
Width of head	15	16	15	15	16	13	12.5	12.5	13.5	14
Snout	7	7	7	7	8	6	6	6	6	6
Eye	5	5	5	5	5	4.5	4.5	4	4	4
Interorbital ...	4.5	4	4	5	5	3.5	3.5	3	4	4
Tympanum ...	4	4	4	4	4	3.5	3.5	3.4	4	3.5
Arm	29	27	28	27	27	22	21	23	22	24
Leg	85	79	79	81	81	64	64	62	63	67
Tibia	27	25	27	27	26	20	20	20	20	21
Foot	27	25	25	26	26	20	20	20	20	21
	♀	♀	♀	♀	♀	♂	♂	♂	♂	♂
	Dalat.	Dalat.	Dalat.	Dran.	Dalat.	Dalat.	Dran.	Dran.	Dran.	Lang Bian.

RANA NIGROVITTATA Blyth.

Boulenger, Rec. Ind. Mus. xx. p. 144, June 1920.

Boulenger's Monograph on the Asiatic *Ranae* omits any statement of localities, or measurements of specimens of this species. It is known from Southern Burma to the Man Son Mts., Tonkin. On the hills in Northern Siam it is very common, and I obtained specimens on the plateau at Sui Kat, Dran, and Dalat. Boulenger further describes the male as having internal vocal vesicles, but I have many specimens in which the skin of the

throat is pigmented, and sufficiently differentiated, to entitle the sacs to be called external.

In general appearance *R. nigrovittata* very closely resembles *R. mortenseni* from S.E. Siam. *R. mortenseni*, however, has no groove at all to the finger discs, grows to a larger size, and the male has internal vocal sacs. Adult males cannot be confused, but immature specimens or females could be mistaken. *R. mortenseni* appears to be confined to the Island of Chang. The specimens identified by Boulenger as having been obtained in the Karin Hills (N. Siam), Monograph, No. 5 & 6, p. 136, should, I feel sure, be referred to *nigrovittata*. The tadpole also, as originally described by me under *nigrovittata*, should stand as correct.

I give measurements of some specimens in the British Museum which I have examined.

	Byngyi Mts., Burma.		Mergui.	Klong Bang Lai, P. Siam.			Me Wang, P. Siam.		Langbian Plateau.	Man Son Mts., Tonkin.	
Snout to vent	49	50	49	52	42	44	54	46	56	49	42
Head	19	19	17	18	14	16	18	16	18	17	16
Width of head.....	18	19	16.5	17	14	15	18	17	18	17	16
Snout	8	8	7	8	6	6.5	7	6.5	7	7	6
Eye	5.5	5.5	6.5	6	4.5	5	6	5	6	5	4.5
Tympanum	4	4	4	4	3	2.5	4	3.5	4	3.5	3.5
Arm	28	29	28	28	27	28	30	23	32	30	28
Leg	82	84	80	85	70	76	84	73	85	84	75
Tibia	26	23	27	27	22	25	27	22	27	25	24
Foot	26	28	25	25	21	22	27	22	26	25	24

RANA SAUTERI Boulenger.

Rec. Ind. Mus. xx. p. 143, June 1920.

Var. JOHNSI, nov.* (Pl. II. fig. 1.)

Eleven specimens of a frog from the Plateau differ sufficiently from *R. sauteri* Boulenger, from Formosa, to be entitled to racial distinction. I have compared them with types in the British Museum, and separate them on the following grounds:—

More pointed snout, longer leg, tibio-tarsal articulation to well beyond the snout, very prominent glandular dorso-lateral fold, and smaller size.

In other points also, Boulenger's description, drawn up from four females, shows small variations, and I therefore describe my specimens in detail.

Vomerine teeth in oblique groups between the choanæ and extending beyond their posterior borders, as far from the choanæ as from each other, or a little farther.

Head as long as, or a little longer than broad, depressed; snout obtusely pointed, projecting beyond the mouth, longer than

* Named after Mr. Johns, British Consul in Saigon at the time of our visit, and who was of the greatest assistance to us in arranging many details of our expedition.

the eye; distance between the nostrils considerably greater than the interorbital width, which is equal to the upper eyelid; tympanum very distinct, $\frac{2}{3}$ - $\frac{3}{4}$ the diameter of the eye, which is 3-4 times as long as its distance from the latter.

Fingers moderate, the tips swollen into very small discs which do not bear a groove; 1st longer than 2nd; subarticular tubercles large and prominent.

Hind limb long and slender, the tibio-tarsal articulation reaching far beyond the snout; heels strongly overlapping when the limbs are folded at right angles to the body; tibia 5-6 times as long as broad, $1\frac{1}{3}$ - $1\frac{1}{2}$ times in length from snout to vent, longer than the foot. Toes with small discs, more developed than those of the fingers, and bearing a groove separating the upper from the lower surfaces; web reaching to the disc of the 5th toe and to the 3rd on its outer side, last two phalanges of 4th free. Outer metatarsals separated nearly to their base; no tarsal fold; subarticular tubercles strongly developed; inner metatarsal tubercle oval, prominent, $\frac{1}{3}$ - $\frac{1}{4}$ length of inner toe; a very small round, distinct tubercle at the base of the 4th toe.

Skin smooth or very finely granulate, a few enlarged scattered tubercles on the back, a \wedge -shaped glandular fold between the shoulders, and short oblique folds crossing the thighs and tibiae; a narrow, prominent, dorso-lateral fold from the eye to the hip, and two short folds from behind the tympanum enclosing a triangular black patch.

Greyish-brown above, uniform or faintly mottled with darker; a well-defined, rich, dark brown patch from the eye to the shoulder, enclosing the tympanum; snout below the canthus rostralis darkish; limbs with narrow dark cross-bars; a brown streak along the back of the arm and another along the front of the tibia. Below whitish, the chest and throat speckled with grey.

Males with internal vocal sacs, and a brown nuptial prominence on the 1st finger.

Types from Sui Kat. Type series, Author's Nos. 2638, 2639, 2640, 2641, 2644, 2657.

Measurements in mm.

Author's Nos.	5031	2657	2642	2639	2640	2641	5087	2638	2644	2645	2457
Snout to vent.	45	43	42	43	40	50	43	42	42	41	40
Head	15	14	14	14	13	16	15	15	14	13	13
Width of head	14	14.5	14.5	14	12	15	14	14	14	13	12.5
Snout	6	6.5	6	6	5.5	7	6.5	6.5	6.5	6	6
Eye	4.5	4.5	4.5	4.5	4	5.5	5	4.5	4.5	4.5	4.5
Interorbital ..	3.5	3	3	3	3	4	3.5	3	3.5	3	3
Tympanum ..	3.5	3.5	3	3	3.5	3.5	3.5	3	3.5	3	3
Arm	26	25	25	25	25	29	26	24	25	23	22
Leg	87	81	84	82	77	100	81	78	81	77	75
Tibia	28	27	27	27	26	34	28	27	27	26	25
Foot	26	25	25	25	23	30	25	25	25	23	22
	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀	♀

RANA MONTIVAGA, sp. n. (Pl. I. fig. 2.)

Vomerine teeth in short oblique groups between the choanæ, and extending beyond their posterior margins. Head broader than long; snout rounded, scarcely projecting beyond the mouth, longer than the eye; canthus rostralis strong; loreal region oblique, deeply concave; nostril a little nearer the tip of the snout than the eye; distance between the nostrils greater than the interorbital width, which is equal to the width of the upper eyelid; tympanum very distinct, about half the diameter of the eye, $1\frac{1}{2}$ - $2\frac{1}{2}$ times its distance from the latter.

Fingers moderate, terminating in small discs which bear a groove separating the upper from the lower surface; 1st a little longer than the 2nd; subarticular tubercles large and prominent. Hind limb long and shapely; tibio-tarsal articulation reaching to far beyond the snout; heels strongly overlapping when the limbs are folded at right angles to the body; tibia $1\frac{1}{2}$ - $1\frac{2}{3}$ times in length of head and body, much longer than the foot. Toes with well-developed discs, which are larger than those of the fingers and bear a strongly-marked groove; web reaching to, and including a portion of the discs of all the toes, but in the case of the 4th it is continued on as a narrow fringe from the 2nd phalanx; outer metatarsals separated nearly to the base, subarticular tubercles large and prominent; a feeble tarsal fold; inner metatarsal tubercle oval, $2\frac{1}{2}$ times in length of inner toe; no outer tubercle.

Skin above granular, with larger tubercles; a narrow, prominent, dorso-lateral fold from the upper eyelid to the hip, strongest in front, sometimes broken up. Lower parts smooth.

Yellowish-brown or greyish-brown above, usually with indistinct blackish markings; sides of the head darker; limbs with dark cross-bands. Below yellowish-white, usually powdered with brown on the throat and chest.

Males smaller than females, with internal vocal sacs.

Types from Dalat, Langbian Plateau, at 1500 metres.

Allied to *R. varians* Blgr., from Celebes and the Philippine Islands; from which it differs in the stouter habit, broader

Measurements of type series in mm.

Author's Nos. ...	5124	5123	5126	2572	5013	4826	2529	2530	4829	5022
Snout to vent ...	48	48	48	46	48	75	72	71	66	58
Head.....	17	16	18	16	17	25	23	24	22	21
Width of head...	18	18	17.5	16	17	26	25	26	24	20.5
Snout	6.5	7.5	7	7	7	10	11	11	10	9
Eye	6.5	6.5	6	6	6	8	8	9	8	7.5
Interorbital	5	5	5	4	4	6	6	7	6	6
Tympanum	4	4	4	3	3	4.5	5.5	5	5	4.5
Arm	28	30	30	28	31	43	44	47	40	34
Leg	98	94	95	93	96	140	135	138	138	111
Tibia.....	32	32	32	30	31	44	45	45	42	39
Foot	30	28	29	27	27	37	41	37	38	34
	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀

head, shorter and more rounded snout, and absence of external metatarsal tubercles.

This frog was common on the Plateau, and numerous specimens were obtained at between 1500 and 2000 metres elevation.

RANA GRAMINEA Boulenger.

P. Z. S. 1899, p. 958, pl. lxvii. fig. 1; id., Rec. Ind. Mus. xx. p. 204, June 1920.

Boulenger's description was drawn up from male specimens only. A fine series from the Plateau shows that the females are much larger than the males, some of them being twice as large. The specimens differ from the types in the snout being longer than the eye, and in the nostrils being distinctly nearer the tip of the snout than the eye. Females have a proportionately smaller tympanum than males.

Colour. Above bright green to dark olive, or greyish-brown, uniform or with large darkish spots. Below white, uniform or powdered with grey. Females usually light greyish-brown above, seldom bright green, and conspicuously spotted on the back and limbs.

This frog was common on the Plateau at all elevations above 1500 metres.

Measurements of *R. graminea* in mm.

Author's Nos....	2515	2513	2518	2526	2647	2506	2509	2510	2648	2649
Snout to vent ...	58	53	56	45	40	105	101	89	79	72
Head	22	20	20	17	15	35	34	29	27	25
Width of head...	20	18	18	16	14.5	35	35	32	27	25
Snout	10	9	9	7	6.5	17	16	14	13	11
Eye	9	7	7	5.5	5.5	11	11	10.5	8	8
Interorbital	4.5	4.5	4.5	4	3.5	9	9	8	8	6
Tympanum	4.5	4	4.5	3.5	4	6	5	4.5	4	4
Arm	35	34	34	31	30	66	66	60	52	49
Leg	96	94	94	85	76	190	190	168	150	150
Tibia.....	32	32	30	29	25	65	65	59	52	53
Foot	28	28	27	24	22	54	54	46	46	44
	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀

MICROHYLA PICTA Schlegel.

Verh. Nat. Ges. Basel, xiii. 1901, p. 151, fig.

Known from a single specimen in the Basel Museum.

Dr. Roux has kindly compared one of my specimens with it, and considers them to be identical. In general characters *M. picta* agrees so closely with *M. rubra* from India that, were it not for the distinctive colouration of the two forms and their geographical distribution, it would be difficult to separate them. Comparing my specimens with examples of *M. rubra* in the British Museum, I find the following differences:—Snout (of *picta*) a little more obtuse, tibio-tarsal articulation reaching to posterior border of eye, web of toes slightly fuller.

Colour. Greyish or yellowish above, with a large dark white-edged mark on the back, commencing between the eyes and diverging about the middle into two arms which run to the groin. Dark markings along the sides parallel to it, and often a second \wedge over the sacral region. Limbs with dark bars. Below yellowish, the males with blackened throats.

M. picta is found in Cochin China (type locality unknown), *M. rubra* in India and Assam.

I found this little frog one night in April at Cap St. Jacques, where it was breeding in the ditches beside the road, not far from the sea. We were attracted by the strident voices of the males, and without difficulty captured large numbers.

BUFO GALEATUS Günther.

Rept. Brit. India, p. 421 (1864).

B. galeatus was described by Günther from a single specimen obtained by Mouhot in Cambodia. A series of eight specimens obtained at Dran in April enables me to enlarge his original diagnosis, and I take this opportunity to re-describe the species.

Canthus rostralis with strong bony ridges, which are continued backwards more or less distinctly over the supraorbital and parietal regions. A thick, arched, elevated orbito-tympanic ridge, separated by a slight depression from the parotid gland, which is about as long as the bony ridge; snout short, blunt; tympanum very distinct, two-thirds diameter of eye. 1st finger distinctly longer than 2nd; toes one-third to nearly half webbed; two well-marked metatarsal tubercles, the inner nearly twice as large as the outer; no tarsal fold; tibio-tarsal articulation reaching to tympanum in male, not so far in female. Upper parts with prominent warts, which become spiny on the flanks; lower parts coarsely granular; parotids prominent, elongate, about as long as the orbito-tympanic ridge.

Reddish or greyish-brown above, with dark marblings on the back, the limbs with dark bars; bars upon the lips. Dirty yellow or whitish below, more or less distinctly spotted with black.

Males considerably smaller than females and with black nuptial asperities on the inner two fingers.

Measurements in mm.

Author's Nos.	2426	2427	2428	2492	2132	2592	Type
Snout to vent.....	85	70	61	62	50	43	63
Snout to ant. border } of tympanum }	23	17	17	17	13	11	16
Width of head	35	27	25	24	18	15	27
Fore limb	56	44	40	45	36	33	42
Hind limb	99	81	72	83	67	59	82
Tibia	32	26	24	27	22	19	25
Foot.....	32	25	23	25	20	18	24

MEGALOPHRYS INTERMEDIUS, sp. n.

A form intermediate between *M. carinense* and *M. feci*, differing from the latter in the web between the toes, and from the former in the more posterior position of the vomerine teeth, and from both in several other small points.

Tongue feebly nicked behind. Vomerine teeth present in two widely-separated groups just behind the level of the choanæ. Head large and depressed, $1\frac{3}{4}$ -2 times as broad as long; snout rounded, hardly as long as the eye, not projecting beyond the lower jaw; canthus rostralis very distinct; loreal region slightly oblique, feebly concave; nostril equidistant from the eye and the snout; interorbital space $1\frac{1}{2}$ times to nearly twice as broad as the upper eyelid; tympanum hidden. Fingers short, with feebly swollen tips, 1st and 2nd about two-thirds length of 3rd; no sub-articular tubercles; metacarpal tubercles very indistinct; toes with feebly swollen tips one-third to one-half webbed, the web extending as a fringe along either side; no subarticular tubercles; a large oval, flat, inner metatarsal tubercle; tibio-tarsal articulation reaching to nearly, or quite, the commissure of the jaw; tibia one-third to two-fifths in length of head and body; foot longer than the head. Upper eyelid with conical tubercles, one of which is enlarged to form a short horn; an oblique glandular fold on the back parallel with the supratemporal fold usually present; more or less distinct oblique folds across the limbs, throat finely granulate, belly nearly smooth.

Colour in life. Above bronze or dark coppery, the head and fore part of the body, outside the dorsal glandular fold, usually lighter. Back usually with indistinct light and dark markings; arms and legs with dark cross-bands; a dark patch over the region of the tympanum and dark bars below the eye. Below dark brown to bronze, paler on the belly. Dorsal fold and tubercles on the flanks black on their inferior aspect, light

Measurements of type series in mm.

Author's Nos.	2070	2073	2075	2078	2067	2086	2074	2085	2076	2084	2083
Snout to vent	92	94	103	92	94	97	99	103	86	63	43
Head (to occiput)...	27	25	26	25	25	25	25	28	23	18	14
Width of head.....	50	46	49	47	48	46	48	51	44	30	22
Length of snout ...	12	12	13	12	12	12	12	12	11	9	6.5
Diam. of eye.....	9	9	9	9	8	9	8	10	8.5	5	5
Interorb. width ...	13	13	13	12	13	12	13	12	12	9	7
Fore limb.....	52	51	50	48	54	52	54	58	50	32	23
Hand.....	25	25	24	24	24	24	26	27	23	16	12
Hind limb } (to artic.) }	114	116	110	114	115	115	115	118	100	69	50
Tibia.....	36	39	36	36	36	35	36	37	32	22	15
Foot	37	39	35	36	38	38	38	42	32	22	17
	♀	♂	♂	♂	♂	♂		♂	♂	♀	♀

superiorly. Young with paler (yellowish) head and shoulders, and with the markings more clearly defined.

21 specimens examined.

This fine *Megalophrys* was common on the Plateau above 1500 metres, and the loud, harsh croakings of the males could be heard at all times of the day and night. It was by means of their call that most of them were discovered and finally tracked down to their hiding-place in some deep crevice between the rocks or boulders of the streams in which they lived.

MEGALOPHRYS HASSELTII Tschudi.

Bouleng., Fauna Malay Pen. p. 282 (1912).

Var. PULLUS, nov.

Differs from the typical form in the longer and more prominent metatarsal tubercle (at least twice as long as broad), longer leg (to tympanum), smaller size, and in colouration. Toes $\frac{1}{3}$ webbed.

Dark grey above, sometimes with indistinct darker markings. Limbs with alternate dark and light cross-bars. Below whitish or brownish. Upper half of iris (in life) scarlet.

Type locality, Arbre Broyé. Also found at Camly.

Altogether 20 specimens were obtained, which I have been able to compare with some 20 examples of the typical form from Siam and the Malay Peninsula.

Measurements of type series in mm.

Author's Nos.....	2093	2101	2108	2091	2103	2090	2105	5192
Snout to vent	49	44	52	45	44	45	44	49
Head.....	17	15	18	15	15	16	15	17
Width of head	21	19	22	20	19	19	18	21
Interorbital.....	6	5	7	5.5	5	5.5	5.5	5.5
Arm	30	27	38	27	29	28	29	34
Hand	12	10	13	10	10	10	10	12
Leg	56	50	62	51	52	51	50	56
Tibia.....	17	15	18	15	15	15	15	17
Foot	17	16	18	15	15	15	15	17
	♀	♀	♀	♂	♂	♂	♂	♂

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. *Fimbrios klossi*.
- 2. *Rana montivaga*. (Nat. size.)

PLATE II.

- Fig. 1. *Rana sauteri* var. *johnsi*. (Nat. size.)
- 2. *Rana milleti*. (Nat. size.)

EXHIBITIONS AND NOTICES.

March 8th, 1921.

Sir S. F. HARMER, K.B.E., F.R.S., Vice-President,
in the Chair.

In the absence of the donor, Dr. R. W. SHUFELDT, C.M.Z.S., three photographs of the last of the Passenger-Pigeons (*Ectopistes migratorius*) presented by him to the Society, were exhibited by Dr. P. CHALMERS MITCHELL, C.B.E., F.R.S., who read the following notes from Dr. Shufeldt:—"The specimen was a female which

Text-figure 1.

Passenger-Pigeon (*Ectopistes migratorius*).

died in the Zoological Gardens of Cincinnati in September 1913, where she had lived in captivity for a number of years with

others of the same species. From time to time these others died, until only the female remained—the sole living representative of the endless millions that originally were to be found in the United States.

“When the dead specimen came to the United States National Museum, I posed it in three different positions, that anterior, posterior, and lateral views of the body might be photographed. New York State, when I was a boy, had annually in its avifauna its millions of these pigeons (*Ectopistes migratorius*), and they were slaughtered there every season, as they were all over the country and in all the States.”

Mr. R. I. Pocock, F.R.S., F.Z.S., exhibited, and made remarks upon, the skull of a Sumatran Tiger.

On behalf of Messrs. Gerrard & Sons, Mr. R. I. Pocock exhibited, and made remarks upon, a Cheetah skin from Tanganyika Territory, showing an interesting modification in the arrangement of the markings on various parts of the coat.

March 22nd, 1921.

Sir S. F. HARMER, K.B.E., F.R.S., Vice-President,
in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the month of February 1921:—

The registered additions to the Society's Menagerie during the month of February were 143 in number. Of these 50 were acquired by presentation, 53 were deposited, 36 were purchased, and 4 were born in the Menagerie.

The following may be specially mentioned:—

1 Nylghau (*Boselaphus tragocamelus*), ♂, from India, deposited by H.G. The Duke of Bedford, K.G., F.R.S., on February 24th.

2 Capybaras (*Hydrochaerus hydrochaerus*), from S. America, deposited on February 5th.

1 Collared Peccary (*Tayassu tajaçu*), from S. America, purchased on February 10th.

2 Pied Starlings (*Spreo bicolor*), from South Africa, new to the Collection, purchased on February 15th.

A collection of 20 Pheasants and 17 Peafowl, presented on February 21st by the Hon. Nathaniel Charles Rothschild, F.Z.S.

April 5th, 1921.

Prof. E. W. MACBRIDE, D.Sc., LL.D., F.R.S., Vice-President,
in the Chair.

Dr. P. CHALMERS MITCHELL, C.B.E., F.R.S., Secretary of the Society, exhibited, and made remarks upon, a series of lantern-slides of a Baby Chimpanzee born in the New York Zoological Park.

Sir S. F. HARMER, K.B.E., F.R.S., exhibited, and made remarks upon, a photograph of Elephant Twins.

Mr. E. G. BOULENGER, F.Z.S., exhibited, and made remarks upon, the following Reptiles and Batrachians:—a young specimen of *Testudo nigra*, *Monopeltis capensis*, *Siphonops annulatus*, and *Phryniciscus nigricans*.

Miss L. E. CHEESMAN, F.E.S., exhibited, and made remarks upon, a nest of *Anapha venata* (Lepidoptera).

April 19th, 1921.

Sir S. F. HARMER, K.B.E., F.R.S., Vice-President,
in the Chair.

The SECRETARY read the following Report on the Additions to the Society's Menagerie during the month of March 1921:—

The registered additions to the Society's Menagerie during the month of March were 276 in number. Of these 73 were acquired by presentation, 34 were deposited, 153 were purchased, 7 were received in exchange, and 9 were born in the Menagerie.

The following may be specially mentioned:—

3 Wapiti (*Cervus canadensis occidentalis*), ♂ ♀ ♀, from Vancouver, presented by the Govt. of British Columbia through the Game Preservation Board on March 30th.

1 Persian Gazelle (*Gazella subgutturosa*), ♂, from Mesopotamia, presented by Maj.-Gen. Sir Percy Cox, K.C.M.G. on March 29th.

1 Bennett's Gazelle (*Gazella bennetti*), ♀, from Feluja, Mesopotamia, presented by Major Chadwick on March 29th.

1 Black Wallaby (*Macropus ualabatus*), from New South Wales, presented by H.R.H. The Prince of Wales, K.G., on March 4th.

1 Scarlet-breasted Sunbird (*Cinnyris gutturalis*), from Durban, South Africa, new to the Collection, presented by Harold Millar, C.M.Z.S., on March 18th.

1 Southern Tree-Snake (*Dryophis dispar*), from India, new to the Collection, presented by A. P. Kinloch, on March 26th.

Mr. R. H. BURNE, M.A., F.Z.S., exhibited, and made remarks upon, a series of mounted specimens of young Flat Fish, demonstrating various stages in the transference of the left eye to the right side of the head.

Dr. P. CHALMERS MITCHELL, C.B.E., F.R.S., read the following extract from a letter he had received from Mr. E. H. Bean, Director of the Washington Park, Milwaukee, Wis., U.S.A., describing the successful rearing of a Polar Bear Cub:—"Our cub was born December the 2nd, 1919. I am quite sure the period of gestation was eight months. I removed the female bear in September. She was placed in a smaller compartment of our bear den, alone. The sleeping den is small, about 6x8 ft. The outside enclosure was also small, with a bathing tank in same. The mother bear bathed regularly up to about three weeks before the cub was delivered. We attempted to give her bedding prior to the birth of the cub, but she always put it outside and preferred the bare boards to sleep upon. She stopped eating about three days before the cub came. About nine o'clock in the morning, December the 2nd, I passed her cage, detected a strange sound, which at first I thought to be a stray cat, but upon investigation, found to be coming from the polar bear cage. It happened to be twelve below zero that morning, and the den door faced the north, from which direction a very stiff wind was blowing. The mother bear had her back to the opening, and it seemed as though she had the baby cuddled up against her abdomen, and covered it as best she could with her great paws. I called the keeper, and he took a bale of straw on the rocks above the den door and gradually dropped a few handfuls down. I watched to see the effect it would have upon the mother bear. She did not seem to be disturbed at all, just raised her head up, looked around, and then settled back. We continued until we had shaken up two bales of straw, pushing same well up into the mouth of the den. During the night she took all of this straw inside, and at intervals of a few days we continued until she had seven bales of straw. It was very interesting to note her ability to determine approaching storms. When a storm was on the way, she would pack the opening from the inside, just leaving a

small vent at the top. When mild weather was on, she would take her paws and pat the straw down until the opening was practically full size. She left the nest at the end of seven days for food and drink, and continued to do so until along in April, when she permitted the baby to come out. The nest was so constructed that it resembled a large wicker basket. For a few weeks the baby would crawl out and look over the side, but mother was always there to discourage any attempt on the baby's part to leave the nest.

"We have four adult polar bears that came to us direct from Bergen, Norway, in 1912. I have accustomed them to what might be considered a peculiar diet for this class of animals. We feed them on bread, apples, carrots, boiled rice, dried stock-fish, a mess of fresh fish seldom, and no meat whatever. They get a pan of cod-liver oil now and then, grass of all kinds during the summer months, also dog biscuits. The adult bears have a sleeping den on the hillside 8×47 ft. deep and 7 high, and an outside enclosure 50×60 ft., containing ledges, grottos, etc., also a bathing tank 15 ft. wide, 30 ft. long, and 8 ft. 5 inches deep. The bears bathe continuously, and are one of our main attractions in the collection.

"We used every precaution not to disturb our mother bear. The day that she was out for food I peeped into her nest, and this baby was about as large as a full-grown guinea-pig, fully furred, and with two little black eyes like beads. I could not determine when it had opened its eyes. It is a wonderful cub, only had one sick spell, and that lasted only for a few hours."

Mr. C. DAVIES SHERBORN, F.Z.S., exhibited a coin of the Saka Dynasty (Punjab Region) of King Arzes (Ayasa), showing the so-called "maneless lion" of Asia, about B.C. 30. This coin belongs to the Bactrian Series, and is inscribed in Greek on one side and in Pali on the other.

Mr. F. MARTIN DUNCAN, F.Z.S., exhibited, and made remarks upon, a series of lantern-slides of a remarkable nest of the Wasp (*Vespa germanica*).

Mr. D. SETH-SMITH exhibited a series of skins of the Australian Budgerigar (*Melopsittacus undulatus*), showing the various colour-varieties that have been produced in captivity. He remarked that the species was apparently first imported alive in Europe by John Gould in 1840, since when not only had it been freely brought home, but it had bred in captivity so readily that now it might be said to be a domesticated species, and, like other domesticated species, certain colour-varieties had been produced. There

was the well-established yellow variety, the rarer blue variety, and a so-called olive variety, and recently a nearly pure white bird (which was shown) had been bred by Mr. H. D. Astley.

These varieties were produced by the elimination or partial elimination of the two primary pigments, yellow and black, which were present in the normally-coloured green bird. The yellow variety showed entire lack of black pigment, the blue variety was entirely lacking in yellow pigment, the blue colour being produced by a combination of black pigment and prismatic feather structure.

The olive variety Mr. Seth-Smith was unable to show, but it appeared to be a case in which both yellow and black pigments were weak, while the unique white specimen was an instance of the elimination of both the black and yellow pigments.

Major E. E. AUSTEN, D.S.O., F.Z.S., drew attention to an apparent change of habitat on the part of the Common Cricket (*Gryllus domesticus*), and described a recent visit he had paid to a large refuse dump where he had observed the Crickets in considerable numbers.

ZOOLOGICAL SOCIETY OF LONDON.

THIS Society was founded in 1826 by Sir STAMFORD RAFFLES, Mr. J. SABINE, Mr. N. A. VIGORS, and other eminent Naturalists, for the advancement of Zoology and Animal Physiology, and for the introduction of new and curious subjects of the Animal Kingdom, and was incorporated by Royal Charter in 1829.

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The Society consists of Fellows, and Honorary, Foreign, and Corresponding Members, elected according to the By-Laws. It carries out the objects of its foundation by means of its collection of living animals, by its Library, and by its Scientific Publications.

The Office of the Society, Regent's Park, N.W.8, where all communications should be sent, addressed to "The Secretary," is open from Ten till Five, except on Saturdays, when it closes at ONE P.M.

The Library, under the superintendence of Mr. F. Martin Duncan, F.Z.S., F.R.M.S. is open daily (except Sunday) from Ten A.M. till Five P.M.; on Saturdays, Ten A.M. till One P.M.

The Library is closed from Good Friday to Easter Monday, and upon all other Bank Holidays. It is also closed annually for cleaning purposes during the whole month of September.

The Meetings of the Society for General Business are held in the Meeting Room at the Society's Office on the third Wednesday of the month at 4.30 P.M. except in September and October.

The Meetings for Scientific Business are held in the Meeting Room at the Society's Office fortnightly on Tuesdays, except in July, August, September, and December and January, at half-past Five o'clock P.M.

The Anniversary Meeting is held on the 29th of April, or the nearest convenient day, at Four P.M.

The Society's Gardens are open daily from Nine o'clock until Sunset. Mr. R. I. Pocock, F.R.S., F.L.S., is the resident Superintendent and Curator of Mammals, Mr. D. Seth-Smith is Curator of Birds and Inspector of Works, Mr. E. G. Boulenger is Curator of Reptiles, Miss L. E. Cheesman, F.E.S., is Curator of Insects. Applications for anatomical material or facilities for work in the Prosectorium should be addressed to Dr. R. T. Leiper, Director of the Society's Prosectorium.

TERMS FOR THE ADMISSION OF FELLOWS.

FELLOWS pay an Admission Fee of £5, and an Annual Contribution of £3, due on the 1st of January, and payable in advance, or a Composition of £45 in lieu thereof; the whole payment, including the Admission Fee, being £50.

No person can become a FELLOW until the Admission Fee and first Annual Subscription have been paid, or the annual payments have been compounded for.

FELLOWS elected in November and December are not liable for the Subscription for the year in which they are elected.

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FELLOWS have Personal Admission to the Gardens upon signing their names in the book at the entrance gate, and may introduce Two Companions daily.

The WIFE or HUSBAND of a FELLOW can exercise these privileges in the absence of the Fellow.

Until further notice, FELLOWS will receive 40 undated Green Cards, available on any Sunday or week-day up to the end of February of the year following the year of issue, and 20 White Cards available on any week-day up to the same date. Twenty of the Green Cards may be exchanged for a book containing two Orders for each Sunday in the year. Twenty White Cards may be exchanged for a book of dated Week-day Orders, each Order available for any day during the week except Sunday. Special children's tickets are no longer issued, but the Green and White Cards are perforated, and each half is valid for a Child under twelve years of age. It is particularly requested that Fellows *will sign every ticket* before it goes out of their possession. Unsigned tickets are not valid.

FELLOWS are not allowed to pass in friends on their written order or on presentation of their visiting cards.

FELLOWS have the privilege of receiving the Society's ordinary Publications issued during the year upon payment of the additional Subscription of One Guinea. This Subscription is due upon the 1st of January, and must be paid before the day of the Anniversary Meeting, after which the privilege lapses. FELLOWS are likewise entitled to purchase these Publications at 25 per cent. less than the price charged to the public. A further reduction of 25 per cent. is also made upon all purchases of Publications issued prior to 1881, if above the value of Five Pounds.

FELLOWS also have the privilege of subscribing to the Annual Volume of 'The Zoological Record,' which gives a list of the Works and Publications relating to Zoology in each year, for the sum of One Pound Ten Shillings. Separate divisions of volumes 39 onwards can also be supplied. Full particulars of these publications can be had on application to the Secretary.

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Any FELLOW who intends to be absent from the United Kingdom during the space of at least one year, may, upon giving to the Secretary notice in *writing*, have his or her name placed upon the "dormant list," and will then be called upon to pay an annual subscription of £1 only during such absence, but after three years must make a further application to be retained on that list.

Any FELLOW, having paid all fees due to the Society, is at liberty to withdraw his or her name upon giving notice in *writing* to the Secretary.

Ladies or Gentlemen wishing to become Fellows of the Society are requested to communicate with "The Secretary."

P. CHALMERS MITCHELL,

Secretary

Regent's Park, London, N.W. 8.
June, 1921.

MEETINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON

FOR

SCIENTIFIC BUSINESS.

1921.

TUESDAY, JUNE	7.
„ OCTOBER	18.
„ NOVEMBER	8 and 22.

The Chair will be taken at half-past Five o'clock precisely.

ZOOLOGICAL SOCIETY OF LONDON.

LIST OF PUBLICATIONS.

THE scientific publications of the Zoological Society of London are of two kinds—"Proceedings," published in an octavo form, and "Transactions," in quarto.

According to the present arrangements, the "Proceedings" contain not only notices of all business transacted at the scientific meetings, but also all the papers read at such meetings and recommended to be published in the "Proceedings" by the Committee of Publication. A large number of coloured plates and engravings are issued in the volumes of the "Proceedings," to illustrate the new or otherwise remarkable species of animals described therein. Amongst such illustrations, figures of the new or rare species acquired in a living state for the Society's Gardens are often given.

The "Proceedings" for each year are issued in four parts, paged consecutively, during the months of March, June, September, and December. From January 1901 they have been issued as two half-yearly volumes, indexed separately.

An "Abstract of the Proceedings" is published by the Society on the Tuesday following the date of the Scientific Meeting to which it refers. It is issued along with the "Proceedings," free of extra charge, to all Fellows who subscribe to the Publications, but it may be obtained on the day of publication at the price of Sixpence, or, if desired, sent post free for the sum of Six Shillings per annum, payable in advance.

The "Transactions" contain such of the communications made to the Scientific Meetings of the Society as, on account of the nature of the plates required to illustrate them, are better adapted for publication in the quarto form. They are issued at irregular intervals.

Fellows and Corresponding Members, upon payment of a Subscription of One Guinea *before* the day of the Anniversary Meeting, are entitled to receive the Society's Publications for the year. They are likewise entitled to purchase the Publications of the Society at 25 per cent. less than the price charged to the Public. A further reduction of 25 per cent. is made upon purchases of Publications issued prior to 1881, if they exceed the value of Five Pounds.

Fellows also have the privilege of subscribing to the Zoological Record for a sum of One Pound Ten Shillings (which includes cost of delivery), payable on the 1st of July in each year; but this privilege is forfeited unless the subscription be paid *before* the 1st of December following.

The following is a complete list of the publications of the Society already issued.

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In consequence of a re-arrangement of the stock of the 'Transactions,' the Society is now able to offer for sale, at the reduced price of £30, sets of Vols. V.-XVI. inclusive, and separate papers, of which a list can be supplied, at about one-fourth their published price.

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CATALOGUE OF THE LIBRARY of the Zoological Society of London (Fifth Edition.) 8vo. 1902. Cloth, 6s.

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THE HOUSE-FLY CAMPAIGN. 3rd Edn. Illustrated. 8vo. 1916. 3d.

PRACTICAL ADVICE ON THE FLY QUESTION. 8vo. 1915. 2d.

ZOOLOGICAL RECORD.—Vol. 55, containing literature relating chiefly to the year 1918, was published in November 1920. Vol. 56, for the year 1919, is being prepared as usual.

P. CHALMERS MITCHELL,

Secretary.

Regent's Park, London, N.W. 8.
June, 1921.

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The 'Proceedings' for the year are issued in *four* parts, paged consecutively, so that the complete reference is now P. Z. S. 1921, p. . . . The Distribution is usually as follows:—

Part	I.	issued in	March.
"	II.	"	June.
"	III.	"	September.
"	IV.	"	December.

'Proceedings,' 1920, Parts I. & II. (pp. 1-194), were published together on July 21st, 1920. Part III. on September 15th, 1920. Part IV. on January 15th, 1921.

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„	IV.	„	December.

'Proceedings,' 1921, Part I. (pp. 1-186), was published on April 2nd, 1921.

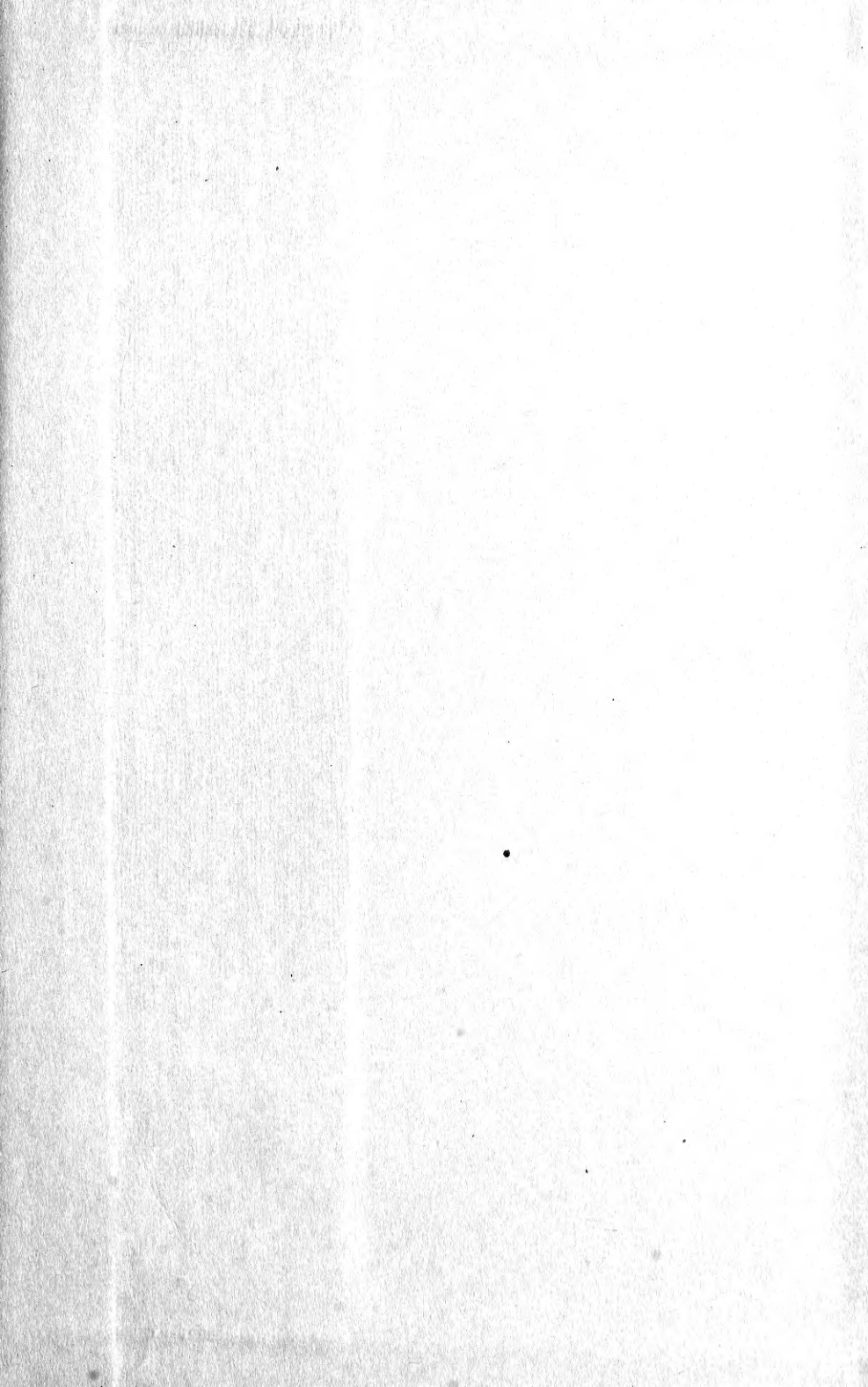
The Abstracts of the 'Proceedings,' Nos. 213-216, are contained in this Part.

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The dates of Publication of 'Transactions,' 1833-1869, will be found in the 'Proceedings' for 1913, page 814.

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