

RECORDS

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INDIAN MUSEUM

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XV

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LAND LEECHES IN THE "FAUNA OF BRITISH INDIA".—SOME CORRECTIONS.

By J. PERCY MOORE, *Philadelphia*.

A season spent in India in the study of land leeches (Haemadipsinae) has afforded an opportunity of correcting or modifying a number of statements made in the account of this group in the volume on Hirudinea in the "Fauna of British India" series. When this account was prepared the author had never seen one of these creatures alive, much less in its native habitat, and all matter relating to their lives and habits was built of compilation and inference. Recent personal experience, though limited, has given first-hand knowledge of the conditions under which these interesting animals occur and has cleared up some hitherto obscure points in their life-histories and behaviour.

It is not intended to attempt here any general or complete summary of the results of these investigations, but it does seem desirable to present to Indian readers in a form that will have about the same publicity as the original some corrections that are required now.

So far as systematics are concerned the earlier conclusions are generally confirmed. The only important change that seems indicated is that *Haemadipsa zeylanica cochiniensis* should be considered a full species instead of a subspecies. Two new colour forms of the *zeylanica* type were discovered, the final determination of the status of which must await morphological study and it is possible that the two colour-pattern types of *H. montana* may require separation. These questions will receive full treatment later.

One of the most intricate problems concerning these leeches relates to their local distribution and the physical and biological factors determining it. One who has not visited the Himalayan foothills and lower ranges can have little conception of the topographical and meteorological complexities which they present. This gives them the greatest possible interest to the student of ecology and distribution but anything like a complete understanding must involve an experience extending over several years. Here will be considered only very broadly the general distribution of the four principal species found in the Darjeeling District and Sikkim, concerning which somewhat erroneous conclusions were stated. There is nothing to be added to the accounts of the other species.

The common small grass leech (*H. zeylanica montivindicis*, p. 267) has a wide altitudinal range, according to my personal observations from 800 to 11,200 feet, those at the higher elevations being generally darker in colour. While most characteristic of open or partially open grass and pasture lands they live equally in jungle which, no doubt, was their original habitat. The vertical range of the other species is much more restricted. *H. montana* (p. 269) is generally encountered on forest grazing grounds and along pony trails and cattle paths in the misty zone between 6,000 and 8,000 feet. It is a jungle species not found on open

grass lands. Like *H. ornata*, which may be considered as replacing it at lower altitudes, it is a characteristically bush-climbing species. Hooker refers to a large yellow-brown solitary leech as abundant below 3,000 feet. In the "Fauna" volume this was identified without hesitation as *H. sylvestris* (p. 283). During my own explorations this species was very rarely met with in the Darjeeling District and only in the lower parts of the Teesta and Balasan Valleys, and near Siliguri. It therefore seems much more probable that the large solitary leech encountered by Hooker was more often *H. ornata* (p. 289), which is generally distributed throughout this region below 3,000 feet.

In considering the abundance of leeches reference was made (p. 244, *et seq.*) to the accounts of several observers which now seem to me to represent these annelids as far more numerous than they actually are. Certainly I had been led thereby to a picture very different from that actually found. When a scientific observer like Dr. Hooker uses such language as incredible profusion, it produces an impression of numbers too great to count or even to estimate fairly. And similar terms are used by many other observers. Throughout my stay of 11 months I continually hoped to find leech populations of a density to meet my expectations. Every locality within reach where leeches were reputed to be excessively abundant was visited but invariably my hopes were dashed. Without intending to mislead, it is very easy to get and to give an exaggerated impression of the numbers of such animals. The activity of their exploratory and looping movements and the rapidity with which they concentrate on one's feet, combined with the repugnance which most persons feel toward them, all tend to lead to over estimates. These affect both the extent of their distribution and their abundance at particular spots. Land leeches are found by no means everywhere in jungle, forest or grass land but chiefly in local aggregations or colonies. Such areas of concentration may be only a few feet or yards in diameter or they may cover acres, especially of forest grazing lands. Elsewhere one may proceed often for several miles along a seemingly favourable jungle trail and meet with scarcely a leech. The first impression that one gets on finding a populous leech colony is of larger numbers than actual counts justify. If one quickly marks out a square foot or yard and, taking proper precautions to insure reasonable accuracy, captures and counts all of the leeches that appear on that area in a fixed time (say 2 minutes) the results prove surprisingly low. Many such counts were made and rarely did they exceed 6 or 8 leeches per square foot. But if one remained standing on such a spot for 10 or even 5 minutes the number of leeches on the square foot including one's feet would often be tripled or quadrupled. Only during July when the Southwest Monsoon was well advanced and young leeches were hatching in large numbers were these figures much exceeded. Under such circumstances as many as 14 to 20 per square feet were counted in a few cases, and owing to the small size of the young leeches some might have been overlooked. The figures given are maximum figures for selected square feet. Only rarely would several contiguous feet yield so many. If larger areas or if scattered square feet taken at random over a considerable area were counted the average number would fall much lower. On many feet none would appear, others would yield only one. On

100 square feet scattered at random over an acre of good leech ground the average was 1.8. On this ground there were spots where the leeches were concentrated in such numbers as to give the impression of great abundance, but the largest number counted on one square foot was 13 and in places one might walk 50 paces quite unmolested. The question arises whether the season of my observations, coming in a year of somewhat abnormal weather conditions, might not have been one of reduced number of leeches. Of course I lack the perspective to form a judgment myself. But this question was put to a number of planters, forest men and other permanent residents of the hills. The answers were conflicting. Some thought that the leeches were present in normal, others in reduced, numbers. I should be very glad to receive data on this point from any readers.

There has been much speculation but little observation on the disappearance of leeches during the dry season. In the "Fauna" account (p. 251) after summarizing the several suggested explanations and the available evidence bearing thereon, I was inclined to accept tentatively a limited migration as explaining the facts. Later observations partially confirm this view. There is, however, some difference in the habits of the several species, doubtless determined by the diverse conditions of their environments. *H. sylvestris*, the large 3-lined species of the plains, can be found throughout the year. In every month of the dry season, from November to April inclusive, I had no difficulty in finding many large fed individuals lying at the surface of the ground under tiles, bricks, sticks, etc., on air dry soil. However, they had left the open fields where they are found during the rains and were congregated at low spots often in the vicinity of a tank or ditch, where a little water or wet mud might remain and generally in the shade of jungle growth, mango groves, or other trees. Small and medium-sized leeches also were found during the winter and spring associated in small numbers with the large ones but mostly hidden at the roots of grasses or under fallen leaves, sticks, etc., along shaded roadside ditches and cattle paths and often in the vicinity of permanent water. Unlike the large fed leeches, which were in a semi-dormant condition, the unfed leeches were active and could be tempted to come into the open, particularly in the early morning when the grass was still moist with dew. After the coming of the rains few of the largest sized leeches could be found. They had deserted their winter resorts and were scarce elsewhere. But medium-sized and small leeches were generally distributed over the fields and in the jungle and by the end of July their number was largely augmented by newly hatched young from $\frac{1}{2}$ to $\frac{3}{4}$ inches long. It seems evident that with this species there is a slight movement to sheltered spots at the beginning of the dry season and a wider dispersal to the open during the rains.

With *H. z. montivindicis*, the little mountain leech of the eastern Himalayas, with a vertical range of at least 10,500 feet, the habits appear to differ somewhat with the elevation. In the lower part of the misty zone, with its high humidity and mild climate, active individuals may be found at all seasons, although they are much less evident during the dry season. I rarely found resting individuals and those found were invariably fed leeches hidden under stones and not buried in the soil.

Above and below the misty zone the seasonal wax and wane in abundance of the leeches is very marked, as is well known. During May and June, 1931 there was abundant evidence to show that the active leeches were mostly concentrated in the ravines and gulleys and along the *jhoras* and nullahs and that with the early rains they were spreading over the neighbouring grass lands and drier jungle. The evidence for this movement was found not only in counts on successive days of the number of leeches on the same measured and marked areas, but even more directly by tracing the movements of marked leeches from the gulleys, where they were liberated for many yards out into the open but not in the other direction. Unfortunately no such crucial observations were made at the close of the rainy season to determine if a reverse movement into and down the gulleys was in progress. There seems to be a seasonal local movement, chiefly altitudinal, but there is no direct evidence that this extends to any considerable distance.

In describing the functions of the caudal sucker stress was laid upon its use as a vacuum disk and prehensile organ (p. 248). A third means of adhesion is the stickiness of the mucous, which applies not only to the suckers but to all parts of the body surface. This is noticeable especially when a leech is moving over a surface, as of glass, not actually wet, when the mucous reaches a consistency making it very effective as an adhesive, at times even to the point of hampering the movements of the leech.

Not a few persons, including even some scientific observers, have attributed to land leeches not only great agility but even the ability to actually jump. Impressed by the competency of the testimony I was led to partially accept it (p. 248), having particularly in mind the power of certain earthworms (like *Pheretima*) to flex the body with such violence that they are thrown clear of the ground. Careful attention was paid to this, with the result that I saw not the slightest evidence that these leeches are capable of any activity that by any stretch of the meaning of the word could be described as a jump. They do reach far out from their places of attachment and transfer themselves to a passerby with such rapidity that a careless observer might think that they had projected themselves. The bush-climbing leeches (*H. ornata* and *H. montana*) will frequently abruptly loosen their hold on a leaf or twig and drop to the ground or on to a passing animal, and the ground leeches will similarly drop from grass stems on to one's foot. Such performances have no doubt been mistaken for leaping. I now fully agree with Whitman that the several species of land leeches that have come under my observation are incapable of leaping in any proper sense.

In the account of *H. sylvestris* it is stated that this species enters streams and Mr. G. Mackrell is quoted (p. 283) that they swim well. Many futile efforts were made to induce individuals of this species to swim and experimental studies on the motor mechanism were made, the conclusion being that the land leeches not only do not swim but that they have lost the effective swimming reflexes.

Concerning the ability or even the attempt of land leeches to gnaw through a pasteboard box as quoted from Green (p. 264) I am quite sceptical. Most probably the hole which he describes was the work of a mouse. My leeches were offered many opportunities to show such

powers, of which they never took advantage. They will discover and force a way through an astonishingly small orifice which they may enlarge by muscular pressure and in the case of textiles sometimes by cutting one or two obstructing threads, but I have seen nothing more. My cultures were kept in wide-mouthed vessels with one to three thicknesses of closely woven cloth tied securely over the top. During my early experience several times on coming into the laboratory in the morning large holes were found cut through these covers and the leeches gone. Recalling Green's statement this was at first attributed to the leeches themselves. It was soon discovered, however, that the building was overrun with mice which were the real culprits. When suitable precautions were taken there was no further trouble.

There is a very widespread belief in India that most land leeches never secure a meal of blood, failing which they subsist on plant juices. While my limited experience makes me unwilling to deny that they ever imbibe plant juices no affirmative evidence has been found and it is practically certain that they do not do so habitually. This statement is based upon the examination of the stomachs of hundreds of leeches fresh from the jungle, which in no case contained anything resembling plant juices, and upon unsuccessful attempts to induce hungry leeches to imbibe the juices of highly vascular plants found in their habitats, of various fruits (oranges, peaches, mangoes, grapes, raisins) and sugar water.

In considering the origin of land leeches I was led to quote with approval a manuscript note of Prof. Whitman (p. 251) in which he suggests that the elevation and drainage of the Siwalik lake-beds was the occasion of the evolution of the true land leeches from their aquatic ancestors. While this subject must necessarily remain speculative my observations on the mode of life of both aquatic and land leeches in India incline me to believe that a more immediate explanation is at least as probable.

Any naturalist visiting India must be impressed by the tremendous influence of the monsoons on the character and rhythm of life. The outstanding biological fact is the adaptation of practically all life—both plant and animal, including human—to the stress of the alternation of well defined wet and dry seasons. Human social and economic customs have been adjusted thereto, as have the habits of most animals and plants. In general the dry season is one of comparative growth, rest and inactivity; the wet season one of reproduction, development, growth and general quickening. Practically all animals dependent upon a plentiful supply of water have a dry season rest period.

The habits of the aquatic blood-sucking leeches of India, the putative progenitors of the land leeches, conform to these principles. The species of *Hirudinaria*, *Hirudo*, etc. during the season of rains spread out into the paddy and jute fields and other flooded or irrigated areas. After the cessation of the rains many of them follow the receding waters back through the main nullahs to rivers or tanks or swamps where there is permanent water. Large numbers, however, remain in smaller ponds and pools which later become nearly, or quite dry. In such places, under logs or in the last remaining mud, these leeches may often be found aggregated in large numbers. In ordinary seasons, when the mud does not become dried completely for too long a period or where the aggrega-

tions are very large, most of these leeches are likely to survive. Probably there is a selection of those best fitted to survive dry conditions which one would expect to become rigid in times of severe drought. Thus the regular seasonal changes and the adjustment of aquatic leeches to them offer recurring conditions that are favourable to the evolution of terrestrial forms.

Another fact of interest in this connection is the frequency with which aquatic leeches are carried by their hosts well away from the water.. It is a common sight to see buffaloes leaving the water bearing on their skins a number of feeding *Hirudinaria manillensis* or *Hirudo birmanica*. Those that are sated usually drop off at the water's edge but those only partially gorged will continue their meal and may be carried a considerable distance before they drop off and seek shelter. I have been told that elephants similarly often carry leeches on the thin protected skin of the axilla, groin, and behind the ears for long distances from the water in which they originated. In general it may be said that the aquatic blood-sucking leeches of India are better adapted to an amphibious mode of life and a periodical shortage of water than are those of western countries. It seems possible that the true land leeches may have evolved through the operation of everyday factors without the necessity of any distance and far-reaching geological changes.

No evidence was found that any mimetic relation exists between land leeches and land planarians of similar colour pattern (p. 254). Indeed the evidence all points against it.

A REVISION OF THE GENUS *COELICCIA* (ORDER *ODONATA*).

By F. F. LAIDLAW.

(Plates I—III.)

INTRODUCTION.

In this paper I have attempted to give a sufficient description of all the species of *Coeliccia* known to me, and at the same time to arrange them into groups which will indicate as far as possible their relationships to one another.

I have been fortunate in the opportunities provided for examining a very large proportion of the species, nevertheless this account is still incomplete.

I have to acknowledge with my best thanks material from the following sources.—The British, United States National, Indian, Raffles and Sarawak Museums and from the private collections of Mr. E. B. Williamson, the late Dr. F. Ris, Mr. N. M. A. Lieftinck and specimens from Captain Alleyne collected in the Shan States.

Professor C. Kennedy has given me valuable help in studying the genital structures of the males of several species and lastly Lt.-Col. F. C. Fraser has generously allowed me to incorporate in this paper descriptions of new species in his own collection and has further devoted time and trouble to the preparation of plates and figures which largely enhance the value of the paper.

In discussing characters of venation, I have employed the Comstock-Needham notation as this has been employed in former descriptions of species, and thus facilitates comparisons.

GENERAL ACCOUNT OF THE GENUS *Coeliccia*.

Definition of the genus.—A genus belonging to the subfamily Platytneminae in which the medio-anal link is as a rule strongly angulated; the quadrangle of the hindwing always a little longer than that of the forewing, and the anal side of the quadrangle in both cases, longer than the costal side, generally markedly so. The outer side is thus more oblique than the inner and this is correlated with the condition of the medio-anal link. The sector *Rs* arises at or shortly distad the vein descending from the nodus (referred to hereafter as the *subnodus*), whilst the sector *Miii* arises from or proximad the same vein, the position of these two sectors relative to the subnodus serving as a character for defining groups of species within the genus. The wings relatively narrow and their petiolation ceasing at or a little proximad the nervure *Ac*, that is to say, the vein *Ab* arises at or immediately proximad the level of *Ac*. The latter lies at a point halfway between the levels of the two antenodal nervures in all species; between the distal end of quadrangle and the subnodus 2 to 4 cells (referred to hereafter as “discal cells”). Pterostigma usually somewhat inflated and covering from 1 to 2 cells.

Antennae with the two basal joints subequal and together equal in length to the third joint which is however more slender; legs with long ciliae; abdomen long and slender. Genitalia differing in the species. Larval characters unknown.

Genotype.—*C. membranipes* (Ramb.).

Taxonomy.—*Coeliccia* agrees with certain genera of the Platycneminae, and differs from all the others in having a strongly angled medio-anal link.

The genera with which it agrees are *Calicnemis*, *Indocnemis* and *Leptocnemis*. To the last it is very closely allied, in fact the two were not originally separated by de Selys.

The species of *Leptocnemis* are found only in the Seychells Is., and I think we may take this distribution as arguing a very high antiquity for both genera.

The two others, *Calicnemis* and *Indocnemis* are both found in occupation of the same territory as *Coeliccia*, but are both of them restricted to a smaller area.

Though it is not altogether easy to separate them on characters which are not sexual, they have a distinct "facies".

Calicnemis is a more robust insect with a relatively shorter abdomen, and with a different style of colouring; the wings are relatively a little broader, and the venation shows a curious and rather extreme tendency to individual variation amounting to a condition which can be spoken of as freak venation in not a few cases. Further the position of *Ac* relative to *Ab*, much more distal than in any species of *Coeliccia*, save in individuals of *C. chromothorax*, serves to distinguish the two genera.

Indocnemis on the other hand resembles *Coeliccia* in its proportions, but is a larger insect with more dense venation. The wings are relatively long and slender, as in *Coeliccia*, but have the same degree of petiolation as is found in *Calicnemis*. It shows little or no elaboration of the colour pattern of the synthorax, and like *Calicnemis*, has, in the female, a simple hind-margin to the prothorax.

It is not possible to say, on present knowledge, that any one of these genera is ancestral to the others.

It is convenient to arrange the species of *Coeliccia* in three groups, using a venational character for the purpose, and I believe that this arrangement is a natural one.

Group 1.—*bimaculata*.

Rs arising at the subnodus, *Miii* proximal to it.

Group 2.—*didmya*.

Rs arising distal to the subnodus, *Miii* proximal to it.

This group is largely confined to the mainland of tropical Asia, but examples occur in the islands of Formosa and Hainan, and the Philippines.

Group 3.—*membranipes*.

Rs arises distal to the subnodus, *Miii* from it.

This group is massed in the Malay Peninsula and the great Sunda Islands, with an outlying species in the Philippines.

Unfortunately there is a tendency to a considerable amount of individual variation in the point of origin of these sectors, and it is well, where possible, to determine their most usual position in any given species. This I have not always been able to do, and consequently in a few cases the position of a species in one or other group must be regarded as arbitrary, though supported to some extent by other characters.

The genotype is *C. membranipes*, described by Rambur in 1842 (*Ins. Nevrop.* p. 240). He referred the species to *Platycnemis*. The genus was defined by Selys in 1863 (*Syn. Agr.*) as a subgenus of *Platycnemis* and named by him *Trichocnemis*; the latter name was however preoccupied, and Kirby in 1890, in his Catalogue, proposed the name *Coeliccia* for the genus. The latter author listed five species but at the present time the genus has swollen to some twenty-five named species.

Sexual characters.

1. Colouration.

Like other genera of the *Platycneminae*, *Coeliccia* has a type of colouring of the synthorax which shows a wide departure from that of other subfamilies.

It is unfortunately impossible to trace the evolutionary history of the development of the colour pattern at present. All that can be attempted here is a very imperfect sketch.

It seems feasible to derive the various colour-patterns of the synthorax from a (theoretic) primitive type in which the dorsum of the synthorax had two pale bands on either side of the middle line (*c.f.* certain *Epallaginae*).

By the fusing or suppression of parts or of the whole of these lines, it is possible to plot out in a somewhat diagrammatic fashion, a scheme which indicates how the adult pattern of the male of any species has been arrived at. A difficulty arises in that in the case of the female the pattern is as a rule different from that of the male, and does not necessarily show a lesser degree of suppression of one or other of the original elements, though as the females of at least many of the species show a greater resemblance to one another than do the males, one is not unnaturally inclined to think that they must be more primitive in this respect.

It must be noted further that the two presumed primitive pale bands are to be regarded as being wider anteriorly and somewhat suddenly constricted just before their middles.

Taking then such a species as *didyma*, one may regard the pattern of the dorsum of the synthorax of the adult male as consisting of the fused lower ends of the two bands, which form the larger anterior spot; whilst a vestige of the upper end of the outer band remains as the small upper spot. That this view is in part at least correct is I think demonstrated by the appearance seen in the young male in which a complete outer band is continued up from the anterior spot.

Similarly also in *renifera*, but of course in this species the upper part of the outer band is completely suppressed in the adult, though here again it is to be seen in the young male.

In the females of these species the inner band is completely gone, whilst the outer band, of even width throughout, is retained.

In *erici* and *albicauda* a similar condition is found, and likewise in *cyanomelas*.

The pattern of *scutellum* and of *loringae* has probably developed on similar lines, but in the case of the former the female is unknown.

Slight modifications of the same general plan, *i.e.*, the fusion of the lower half of the two presumed original lines with loss of the upper part of the inner line in part or altogether, and some modification of the upper part of the outer line would give the pattern found in such forms as *macrostigma*, *nigrohamata*, *flavostriata*, *campioni*; in these the condition of the females is either similar to that of such a species as *didyma*, or in some cases females, whose exact identity is a little doubtful, show an approximation to the condition found in the male.

The cases of *chromothorax* and *poungyi* may be explained by supposing that in the males the two lines have fused for their whole length, so producing the large colour-spot which so strikingly characterizes them. In them again the female has retained only the outer stripe.

On the other hand, in the case of *flavicauda* the female shows a colour pattern identical with that of the male, and one that is very similar to that of (say) the male of *didyma*.

In a number of species both sexes have retained only the outer stripe, such are *membranipes*, and *loogali*.

The only known sex of *vacca* and *dinoceras* show this arrangement.

Lastly in the case of *fraseri* the males appear to have lost both stripes or to have retained the inner stripe only, as have also the young females, whilst the very adult female has almost lost the stripe altogether. In the closely allied *bimaculata* the male has an anterior spot apparently derived chiefly from the lower end of the inner stripe, the female is much as in *fraseri*.

C. pyriformis is not sufficiently known to me.

2. Penile organ.

In all species examined the shaft is devoid of spines; the inner and terminal lobes are well developed; the third segment cannot be said to show any form definitely characteristic of the genus.

One series of species has the terminal lobe deeply cleft and ending in a pair of long whip-like processes, which vary in length and slimness according to species. This series includes the following:—*C. fraseri*, *flavicauda*, *bimaculata*, *erici*, *didyma* and *chromothorax*.

It is to be noted in passing, that the structure of the organ in *Indocnemis orang* is very similar to that of members of this series.

In a second series of species the terminal segment is not deeply bifid, but may terminate in a hood-like process, thus resembling to some extent the condition found in *Calicnemis*. This hood-like process may itself bear paired appendages, usually much shorter than the processes

of the first series. The members of this second series are as follows :—*C. loogali*, *lieftincki*, *campioni*, *flavostriata* and *dinoceras*.

In the following, the third segment carries a short median process, which is perched on the apex of the basal part of the segment, and from under it there arises a pair of short horn-like projections.—*C. nigrohamata*, *membranipes* and *albicauda*.

A study of the penile structures does not appear to furnish any clue to the relationships of the species beyond that in a general way it supports the evidence furnished by the venation and by other characters as to such relationship.

3. Female prothorax.

This structure shows some of the most interesting features in the morphology of the genus.

In several genera, the Platycneminae have an elaboration of the hinder margin of the prothorax of the female, a character which is shared by the Protoneurinae, though the elaboration is by no means identical in the two subfamilies.

In the case of *Coelliccia* the margin in question presents in general the following characters.

The middle of the margin carries a projection usually of small size and triangular shape, projecting dorsally. On either side of this projection, the margin is more or less deeply incised or notched, and on either side of each notch there is a lateral lobe or projection which I refer to hereafter as the "lappel"

The degree of development of these processes varies of course with the species, and it is entirely absent in the male. In the male of a single species only is there any comparable structure, and in that species, *dinoceras*, the prothoracic horns are not homologous with the processes of females of the genus.

In the female of the new species *vacca* the median process is bifid, in all others, so far as I know, it is simple.

Another point worth mention is that, in the genera most nearly related, the posterior margin is simple (*Calicnemis*, *Indocnemis*).

This does not exhaust the interest of the prothorax in the females of the genus. In certain of them, apparently only in members of the group *membranipes*, the middle lobe of this structure carries on either side a lateral spur which rises close behind the junction of the anterior and median lobes. This spur or horn is particularly well developed in *campioni*, but can be distinguished also in females allied to *nigrohamata*. I do not know of anything like it in any other Zygopterous genus.

Presumably it functions as a "point d'appui" for the anal appendages of the male during copulation.

The arrangement of the species adopted is as follows :—

Group 1.—*bimaculata*.

Rs arises from subnodus, *Miii* proximal to it; 2 discal cells in all wings.

Coelliccia bimaculata Laidlaw.

Coelliccia fraseri, sp. nov.

Coelliccia vacca, sp. nov.

Group 2.—*didyma*. *Rs* arises distal to subnodus, *Miii* proximal to it.

3 discal cells in all wings.

Coeliccia didyma didyma Selys.

Coeliccia didyma loringae, subsp. nov.

Coeliccia renifera Selys.

Coeliccia erici Laidlaw.

Coeliccia chromothorax (Selys).

Coeliccia scutellum, sp. nov.

Coeliccia brachysticta Ris.

Coeliccia poungyi Fraser.

Coeliccia pyriformis, sp. nov.

2 discal cells in hindwing, 2 to 3 in the fore.

Coeliccia loogali, sp. nov.

Coeliccia flavicauda Ris.

Coeliccia cyanomelas Ris.

Group 3.—*membranipes*. *Rs* arises distal to subnodus, *Miii* from it.

3 discal cells in all wings.

Coeliccia membranipes (Ramb).

Coeliccia lieftincki, sp. nov.

Coeliccia dinoceras Laidlaw.

Coeliccia flavostriata Laidlaw.

Coeliccia campioni Laidlaw.

Coeliccia nigrohamata Laidlaw.

Coeliccia macrostigma Laidlaw.

Coeliccia octogesima Selys.

Coeliccia borneensis Selys.

2 discal cells in all wings.

C. albicauda Forster.

This account is necessarily incomplete as I have not been able to examine specimens of *octogesima* and *borneensis*, both of which require re-examination.

Quite recently I have received examples of what I take to be a new species from Malaya, a description of this being now in the press. Lastly N. Pendlebury has sent me several specimens from Kina Balu, taken by him at an altitude of 5,000 ft. These too seem to belong to an undescribed species.

The synonymy involved is unimportant save in the case of *C. chromothorax* Selys, which was described by its author as a *Calicnemis*, and in the case of the name *Trichocnemis* which, as has already been noted, was preoccupied. A list of the literature and references consulted is appended.

A. Group **bimaculata**.

Coeliccia bimaculata Laidlaw.

(Plate III, figs. 12, 17.)

Material examined: 3 males and 2 females, Tura, Garo Hills, Assam. Type in the Indian Museum.

Length of abdomen ♂ 36 mm. Hindwing 22.5 mm.

„ „ ♀ 35 mm. „ 22.75 mm.

Venation.—Quadrangle of forewing $\frac{3}{4}$ length of that of hindwing. Costal side of quadrangle of forewing $\frac{3}{4}$ length of anal side, of hindwing more nearly equal. *Miii* rises before subnodus, *Rs* at subnodus. *Ab* rises at level of *Ac*; 2 discal cells in all wings.

Postnodals, fore-wings 20, hindwing 18. Pterostigma small, covering scarcely more than one cell, its inner margin more oblique than outer, no deeper than the cell immediately following it, black.

In all the wings examined (24) the number of discal cells is constant. In one female the origin of *Rs* and *Miii* is closely approximated on all four wings, and on one wing both lie before the subnodus. In all the other wings *Rs* and *Miii* are well separated at their origins.

Type ♂ (Sub-adult).

Head: dorsal surfaces black, except the bases of the mandibles, genae, anteclypeus and a pair of small post-ocular transverse spots, which are yellowish-white.

Prothorax: entirely black on dorsum, ventrally yellowish-white.

Synthorax: dorsum black, with a pair of elongate-oval spots of pale blue, lying close against the mid-dorsal carina, and extending along it for nearly its anterior half. Sides pale blue with a black line along the second lateral suture. Ventral surfaces pale.

Abdomen: dorsally very dark brown, tending to black on segments 2 and 8, 9, 10, as well as at the joints. Segments 1-7 whitish-yellow ventrally, 1-2 also with yellow at the sides, whilst 4-7 have small ventro-lateral spots of the same colour apically.

Legs: whitish-yellow, femoral and tibial ridges, joints and ciliae black.

Anal appendages: white or yellowish-white, upper pair club-shaped pointed apically, somewhat excavated internally, each with a very minute, conical black-tipped projection. Lower pair rather longer, slender, together in shape like a pair of pincers.

(A young male has the ninth and tenth segments milky-white, the former with a small black triangle at its base dorsally, as in the type which also is immature.)

♀ (adult). Colouring as in the male with the following differences:—

Prothorax: middle lobe yellowish-white, with a very fine line of black mid-dorsally, joining the black anterior and posterior lobes.

Synthorax: dorsum with oval anterior markings smaller than in the male, narrowing suddenly at their upper ends, continued thence as a very narrow stripe almost to the level of the ante-alar sinus.

Abdomen: pale markings on sides of first and second segments more extensive than in male. Distal two-thirds of 8 milky-white, 9 and 10 black.

A younger female has the stripes on the dorsum of the synthorax of nearly equal width throughout. The black line on the second lateral suture is very narrow and incomplete below. Segments 8, 9, 10 of abdomen entirely white.

Penis: terminal lobe prominent. Inner fold of second segment well developed. Third segment consists of a pair of long whip-like processes, conjoined at their bases.

Female prothorax: median process of hind-margin has the shape of a small isosceles triangle, the two lappels lie close to it on either side and are slightly smaller than it.

***Coelliccia fraseri*, sp. nov.**

(Pl. I, figs. 15, 22 ; Pl. II, figs. 9, 10 ; Pl. III, fig. 8.)

Material examined: 7 ♂♂ Shillong, Assam. May-July, 1923 (one of these is the type). 2 ♀♀ Same data (one is the allotype).

All collected by Bainbrigge-Fletcher. At present in my collection; the types will be deposited in the British Museum.

Length of abdomen ♂ 36 mm., of hind-wing 24 mm.

„ „ ♀ 35 mm., „ 24 mm.

Venation: quadrangle of fore-wing about $\frac{3}{4}$ length of that of hind-wing. Costal side of quadrangle of fore-wing about $\frac{3}{4}$ length of anal side; *Miii* rises before subnodus, *Rs* at subnodus; 2 discal cells on all wings; *Ab* rises definitely before level of *Ac*. Postnodals, fore-wing 15-18, hind-wing 15. Pterostigma covering one cell, its outer margin slightly more oblique than its inner, not deeper than the cells immediately following and preceding it; gray-brown with fine pale margin.

The number of discal cells is constant in all the wings. In 20 per cent. of the thirty-six wings examined *Rs* rises after instead of at the subnodus.

Type ♂ (Adult).

Head: black, upper lip and post-clypeus with slight metallic lustre. Genae, bases of mandibles and ante-clypeus bluish-white as are a pair of small, linear, postocular spots. Apex of pedicle of antennae white.

Prothorax: dorsum black, sides dull yellow, this colour encroaching on the black of the dorsum in the middle lobe.

Synthorax: dorsum black, with a very fine blue line tapering posteriorly on either side of the mid-dorsal carina and not quite reaching the ante-alar sinus. Sides bluish with a complete black band along the second lateral suture.

Abdomen: black generally, sides of segments 1-2-3 blue or pale yellow. Distal half of 9 and all 10 dull ochre.

Legs: yellow, margins of femora, tarsi and ciliae black.

Anal appendages: brownish yellow, lower pair longer and darker than upper, the latter club-shaped, each with a blunt internal projection near its apex, and a smaller spine-like process a little basal to this.

♂ (younger): similar to this but with the following differences:—yellow of genae and ante-clypeus continuous across frons; a narrow line of yellow runs from eye to eye across the head at the level of anterior ocellus. The dorsum of middle lobe of prothorax with only a very narrow line of black mid-dorsally; dorsal thoracic stripe yellow, black line of second lateral suture of synthorax incomplete below. Small pale basal spots laterally on segments 3-6 of abdomen, segments 9-10 wholly yellow.

♀ (allotype, not fully mature): colour exactly as the young male, with the addition of a pale apical lateral spot on segment 8 of abdomen.

Penis : terminal lobe large, apparently rugose. Inner fold of second segment well developed. Third segment consisting of a pair of long spirally coiled whip-like processes, conjoined at the base.

Female prothorax : hinder margin simple, exactly as in male.

Closely allied in colour and in structure of penis to *bimaculata*.

***Coelliccia vacca*, sp. nov.**

Material examined : 1 ♀ (*type*) from above Tura, Garo Hills, Assam, 3,000-3,900 ft., July-August 1917, coll. S. Kemp.

Type No. 7965/HI in the Indian Museum.

Female (male unknown). Abdomen 36 mm. Hindwing 25 mm.

Venation : quadrangle of forewing perceptibly shorter than that of hindwing ; costal side of quadrangle of forewing and hindwing, at least $\frac{5}{6}$ the length of anal side ; *Ab* arises at level of *Ac* ; *Rs* arises at level of subnodus, *Miii* proximal to it ; 2 discal cells in all wings ; post-nodal nervures 19 in forewing, 17 in the hind ; pterostigma black, covering about $1\frac{1}{2}$ cells, its inner and outer margins oblique, parallel, scarcely deeper than the cells following and preceding it.

♀ (Adult).

Head : black, except genae, anteclypeus, bases of mandibles, a pair of small spots running out and forward on either side of the ocelli and a pair of small postocular spots, all pale yellowish-white.

Prothorax : primrose yellow, broadly marked with black on dorsum.



TEXT-FIG. 1.—*a*. Right lateral view of prothorax of *Coelliccia vacca*, ♂. *b*. Dorsal view of same.

Synthorax : dorsum black, with a narrow antehumeral stripe of pale blue on either side, just internal to the humeral suture. Sides pale blue, with a narrow black oblique stripe along the second lateral suture incomplete below.

Abdomen : brownish-black above, yellowish-brown below, this paler colour extending up the sides of the eighth segment near its apex so as to be visible from above as a pair of apical yellow spots. Basal half of dorsum of segment 9 also marked with yellow.

Legs : yellowish-white, posterior surfaces of femora, anterior mark on lower half of femora, anterior ridges of tibiae, joints and ciliae black.

Female prothorax : posterior lobe very remarkable, the median projection large and bifid, its terminal horns project forward resembling the horns of a cow (hence the specific name), the lappels are quite

isolated from the median part and project backward on either side as a small triangular process.

♂ Unknown to me.

Venationally this species belongs to the same group as *bimaculata* and *fraseri*; in colour pattern of the synthorax and in structure of the posterior margin of the prothorax it stands alone; and the latter character is so striking that I have no hesitation in naming the species from a single specimen.

B. Group *didyma*.

Coelicia didyma (Selys).

(Pl. I, fig. 24; Pl. III, fig. 6.)

Material examined: 1 ♂ Burma (coll. E. B. Williamson), 2 ♂, 4 ♀ Simla and Cachar, Assam.

Length of abdomen ♂ 40 mm., of hindwing 25 mm.

 " " ♀ 36 mm., " 25 mm.

Venation: quadrangle of hindwing longer than that of forewing in the ratio of 6:5; costal side of quadrangle of forewing $\frac{3}{4}$ the length of anal side, of the hindwing $\frac{4}{5}$; *Ab* arises just before *Ac*; *Rs* and *Miii* on either side of subnodus; discal cells numbering 3 in all wings; pterostigma black, covering nearly 2 cells, deeper than cells preceding and following it; 18 postnodal nervures in forewing, 16 in the hind.

One specimen, a male from Cachar, Assam, has in all four wings only 2 discal cells but it is in all other respects identical with typical specimens. Another from Simla has 3 in the forewing, 2 in the hind.

♂ (Adult).

Head: black, anteclypeus, genae and small cuneiform postocular spots pale blue.

Prothorax: black above, with a large blue spot on either side of middle lobe; ventral surfaces pale whitish-yellow.

Synthorax: dorsum black, on either side of the middle line a large oblong-oval mark of blue extending about halfway up the dorsum; just in front of the antecular sinus on either side is a smaller blue spot, wedge-shaped, or, in very mature specimens, reduced to a mere point. Sides of thorax blue with a narrow oblique black stripe along the second lateral suture.

Abdomen: black; first segment extensively marked with blue, restricting the black to a dorsal triangle, with its base anterior; second segment marked with blue at the sides; segments 3-7 with minute, paired lunules of blue situated basally on the dorsum, the ventral surface of these segments brownish-yellow; distal two-thirds of 9 and the whole of 10 blue.

Legs: yellowish-white with black lines on anterior and posterior surfaces of femora, and on anterior surfaces of tibiae; tarsi, joints and ciliae black.

Anal appendages: upper pair black, blue on dorsum, slender with pointed apices and a ventral spur tipped with blue (or white), and a smaller basal spur directed ventrally also. Lower pair slightly shorter, stouter, blue.

Young males have a yellowish band running across the vertex from eye to eye, crossing the anterior ocellus. The small upper pair of spots on the dorsum of the synthorax are continued forward as a complete line to meet the large anterior spots on their outer sides, the minute upper spots of the adult thus evidently being vestiges of the dorsal stripe of the female. The blue of the adult is replaced everywhere by yellowish-white.

♀ (Adult). Colouring as in young male but with blue instead of whitish yellow, and without the large anterior spots of the synthorax.

Penis : internal and terminal folds well developed. Third segment deeply and roundly cleft, its apex terminating in a pair of long curving processes which arch back over the second segment on either side.

Posterior margin of female prothorax : median lobe well developed, viewed from above it has the shape of an equilateral triangle, and seen in profile, it shows as a small dorsally directed process ; lateral processes small.

This is perhaps the most widely spread of all species, its range extending from Simla to the north of the Malay Peninsula.

***Coeliccia loringae*, sp. nov.**

(Pl. I, fig. 12 ; Pl. II, figs. 7, 8 ; Pl. III, fig. 3.)

Material examined : several ♂♂ from Gokteik, Upper Shan States, Burma, June and July ; 1 ♀ from the same locality, coll. Col. F. Wall, received from F. C. Fraser.

Type male in Laidlaw collection, *paratype* in Fraser collection, *paratypes* in Br. Museum collection.

Male. Length of abdomen 43 mm. Hindwing 27 mm.

Venation : quadrangle of forewing about three-fourths the length of that of hindwing ; costal side of quadrangle of forewing about three-fourths the length of anal side, of hind-wing about four-fifths ; *Ab* arises barely before the level of *Ac* ; *Rs* and *Miii* one on either side of subnodus, or *Miii* at the subnodus ; 3 discal cells in all wings ; 20 post-nodals in forewings, 19 in the hind ; pterostigma rather large, covering 1 to 1½ cells, deeper than the cells immediately preceding it, with inner and outer margins parallel.

Head : black, bases of mandibles, genae, anteclypeus and lateral part of frons blue ; occiput with elongate pyriform blue or yellow post-ocular spots.

Prothorax : black with a large blue spot on either side of middle lobe.

Synthorax : black on the dorsum, with a large blue spot on either side of the middle line which extends a trifle more than half way up the dorsum, pyriform in outline, the broad rounded end anterior, the tapering end bifid on the outer side. At the upper end of dorsum a small oblong oval blue spot well separated from the lower larger spot ; laterally blue with a narrow oblique black line along the second lateral suture.

Abdomen : black marked with blue.—dorsum of segment 1 black ; sides of segment 2 broadly blue ; 3 to 7 with subapical blue spots ventrolaterally ; on 3 to 6 these show from above as sub-apical lunules ;

a similar subbasal marking on the same segments ; distal third of segment 8 and the whole of 9 blue ; 10 blue with a large black apical marking, trilobate in shape, the middle lobe extending as far as base of segment.

Legs : bluish-white, coxae of the same colour : posterior surface of femora, anterior surface of tibiae, tarsi, ciliae and articulations black.

Anal appendages : bluish-white, identical in appearance with those of *C. didyma*.

Penis : identical to that of *C. didyma*.

Female : Abdomen 41 mm. Hindwing 27 mm.

Differs in several respects from the male—labrum bright ochreous, its base narrowly black ; postclypeus black with a rounded yellow spot on each side ; bases of mandibles and genae bright yellow ; isolated spots on vertex (usually present in the male on the ocellar space) are replaced by a continuous transverse stripe, very sinuous and traversing vertex between the ocelli ; postocular spots always yellow ; eyes bordered with yellow beneath.

Prothorax : black, broadly yellow at the sides and beneath ; posterior lobe reduced to a small median tongue-like process directed straight back.

Thorax : black marked with bright yellow as follows—a very narrow antehumeral stripe on each side of dorsum and a tiny upper humeral spot ; the sides and beneath all yellow save for the narrow black lateral stripe seen in the male.

Legs : yellow marked as in the male, but tibiae, trochanters and coxae entirely yellow.

Wings : with *Rs* and *Miii* arising close together, one on either side of the subnodus ; postnodals 17 to 20 in number.

Abdomen : black on dorsum with a bright yellow stripe extending the whole length of side ; segment 3 with a pair of subdorsal spots confluent with this yellow stripe ; segment 1 broadly yellow marked with a broad triangular dorsal black spot ; segments 2 to 6 with the middorsal carina finely yellow ; segment 8 with nearly its apical half bright ochreous, the extreme apical border bearing a small triangular black spot ; segments 9 and 10 entirely yellow.

Very closely allied to *C. didyma* from which it is distinguished by the following characters—Dorsal thoracic spots differing in shape and very constant in this ; subapical blue annules on abdomen very conspicuous ; segment 8 with its apical third or half blue ; nodal index higher ; in most specimens examined *Rs* and *Miii* arise together from the subnodus or *Rs* rarely a shade proximal to it, thus differing from the origins of these nervures in *C. didyma*. Apart from this however, the similarity of the anal appendages and shape of penis rather point to subspecific value.

***Coelicia renifera* (Selys).**

(Pl. I, figs. 9, 26 ; Pl. II, figs. 11, 12 ; Pl. III, fig. 9.)

Material examined : 2 males and 1 female, Pashok, 2,000 ft., Darjeeling District. Coll. F. H. Gravely.

Type in Selysian collection.

Length of abdomen ♂ 44 mm. Hindwing 27.5—28.5 mm.

„ „ ♀ 40 mm. „ 27.5 mm.

♂ (Adult).

Venation : quadrangle of hindwing longer than that of forewing in the ratio 5 : 4. Costal side of quadrangle, of forewing about $\frac{3}{4}$ length of anal side, of hindwing about $\frac{4}{5}$; *Ab* rises distinctly before level of *Ac*; *Rs* and *Miii* rise one on either side of subnodus; 3 discal cells in all wings. Pterostigma black; proximal and distal sides parallel, oblique, covering about $1\frac{1}{2}$ cells, deeper than cells immediately preceding and following. Postnodals—, forewing 20-21, hindwing 20.

Head : black, genae, anteclypeus and cuneiform postocular markings, blue.

Prothorax : dorsum entirely black, sides broadly blue.

Synthorax : dorsum black, with a pair of large oval or slightly reniform marks of pale blue on either side of the middle line, extending from near the anterior margin to half-way up the dorsum. Sides and under-surfaces black, the side with a large subquadrate blue mark divided into two by a black line running along the second lateral suture.

Abdomen : entirely black, second segment with white markings below, segments 3-6 with paired, apical, subventral spots oblong in shape, white or pale blue in colour, 9-10 with minute lateral spots of the same colour.

Legs : white, or bluish-white, ciliae and tarsi black, femora and tibiae heavily lined with black.

Anal appendages : white, upper pair shorter than lower, rather club-shaped with a stout ventral spur beyond the middle of their length. Lower pair incurved apically.

♂ (Teneral). Differs from adult in having pale markings on either side of ocelli; the dorsum of the prothorax is likewise whitish-yellow, whilst the dorsum of the synthorax shows the oval markings of the adult male and the broad humeral band of the adult female combined.

♀ (Adult). Differs from the adult male as follows :—

Head as in young male. *Prothorax* brownish-black, with a pair of large blue spots one on either side of the middle lobe.

Synthorax : dorsum black, with a pair of humeral stripes, which are rather broad. Sides bluish-yellow with a very fine line along the second lateral suture, incomplete below. Ventral surfaces whitish-yellow.

Abdomen : dorsum brownish-black, ventral surfaces whitish-yellow. This latter colour extends up the sides of the first segment; 2-6 have the dorsal colour shading to black apically dorsum whitish-blue-black. Distal half of 8 and distal of 9 whitish-blue.

Legs as in male.

Penis : Apical process of third segment bilobed, but not so deeply cleft as in *C. didyma*. Terminal lobe large and hood-like.

Posterior margin of female prothorax : median process much reduced scarcely visible in profile. Lateral processes small.

This fine species is readily distinguished by the black ventral surface of the synthorax and the white anal appendages of the male. It is recorded from moderate elevations in the neighbourhood of Darjeeling, and Martin also includes it in his list of species from Tonkin. This latter however I am inclined to query as to the correct identification.

Coelliccia erici Laidlaw.

(Pl. I, figs. 13, 25 ; Pl. II, figs. 1, 2 ; Pl. III, fig. 11.)

Material examined : 1 ♂, 1 ♀ (*Type* and *allotype*, both much damaged) Bukit Besar, Johor, (coll. N. Annandale), 1 ♂ (in good condition) Kuala Teku, F. M. S. Museum.

Length of abdomen 42-43 mm., of hindwing 25-26 mm.

Venation : Quadrangle of hind-wing slightly longer than that of forewing. Costal side of quadrangle, of forewing about $\frac{3}{4}$ length of anal side, of hindwing about $\frac{4}{5}$.

Ab rises perceptibly before the level of *Ac*. *Rs* and *Miii* rise one on either side of subnodus. 3 discal cells on all wings. Pterostigma with inner and outer sides parallel, slightly deeper than the cell following it, covering $1\frac{1}{2}$ cells. Postnodals forewing 16, hindwing 15.

♂ (*Type*, in poor condition).

Head : black, genae and bases of mandibles blue, also a pair of small postocular spots.

Prothorax : black, a large whitish spot on either side of the middle lobe. Posterior lobe rather large, projecting backwards and a little dorsally when viewed in profile.

Synthorax : dorsum black, with a pair of very large spots of rich blue lying anteriorly. Sides bright blue with a narrow band of black along the second lateral suture. Ventral surfaces bluish white.

Abdomen : segment 1 blue at the sides dorsally brownish-black. Remaining segments much damaged, black dorsally, brownish beneath.

Legs : yellowish-white, a narrow brown line along the posterior surface of the femora, and on the anterior surface of tibiae ; tarsi and ciliae black.

Anal appendages : brownish-black, the upper pair distinctly longer than the lower. The former are shaped like a short-handled lancet, with a rounded apex, the handle excavated semicircularly, just before the blade, on either side of the excavation is a very small tooth directed ventrally.

Lower pair short, stout, blunt and apically incurved.

♀ (*Allotype*, abdomen lost) : as for the male, but the round spots of the synthorax are replaced by a very broad humeral stripe on either side of the dorsum.

Penis : resembles that of *didyma*, but the terminal fold is smaller than in that species, and the apical processes of the third segment are shorter and stouter.

Female prothorax : posterior lobe small, its hind margin *rounded*, a small spine projects directly upwards from a point just anterior to the middle of the margin.

Differs from all other species in the character of the armature of the female prothorax, as well as in the colour pattern of the male synthorax. The large spots recall those of *scutellum* but of course differ in colour.

The species appears to be peculiar to the northern half of the Malay Peninsula.

In the male from Kuala Teku, segments 2 to 6 are bronzed brown above fading at the sides to yellow which is paler ventrally.

Each of these segments has a very fine basal and apical ring of black. Segments 7 and 8 are bronzed black dorsally and on the sides ; 9 and 10 are bright blue with rather thick black margins ; anal appendages black.

***Coeliccia chromothorax* (Selys).**

(Pl. I, figs. 11, 21 ; Pl. II, figs. 3, 4 ; Pl. III, fig. 7.)

Material examined : 4 males and 1 female (fragmentary), N. Shan States, July-Nov., Col. F. Wall. 1 male Kalaw, S. Shan States, coll. Capt. F. W. Alleyne.

Type and co-type in the Selysian coll.

Length of abdomen ♂ 42-43 mm. Hindwing 26-29 mm.

„ „ ♀ 40 mm. „ 28 mm.

Venation : quadrangle of hinder wing longer than that of forewing in the ratio of 5 : 4. Costal side of quadrangle of forewing about $\frac{3}{4}$ length of anal side, of hindwing about $\frac{5}{6}$.

Ab rises distinctly before level of *Ac*. *Rs* and *Miii* rise one on either side of subnodus ; 3 or 4 discal cells in forewing, 3 in hindwing. Post-nodals, forewing 19-22, hindwing 18-22. Pterostigma rather large, its inner and outer margins parallel and oblique, covering about $1\frac{1}{2}$ cells, deeper than cell preceding and following it.

Of the forewings about 40 per cent. have 4 discal cells, and 60 per cent. have 3. The point of origin of *Miii* and *Rs* does not vary in the males but in the female *Rs* rises from the subnodus and *Miii* before it, in 3 wings.

In one male the origin of *Ab* lies much more proximal to *Ac* than it does in the other specimens.

♂ (Adult).

Head : entirely black except for a pair of small cuneiform post-ocular spots, which are bright chrome yellow.

Prothorax : dorsum black, with a pair of small yellow spots on the middle lobe, sides and ventral surface yellow.

Synthorax : dorsum with a pair of very large chrome-yellow spots occupying almost the whole of it ; separated narrowly by the fine black mid-dorsal carina. Laterally yellow less vivid, with a narrow black line along the second lateral suture, incomplete below. Ventral surfaces whitish-yellow.

Abdomen : black, first segment yellow, with black basal and apical rings and a black mark on the dorsum. Segments 2-6 yellow ventrally, and a minute yellow, lateral-basal spot on each of segments 4-6. Distal third of 9 and whole of 10 chrome-yellow.

Legs : black, with yellow on anterior surface of femora.

Anal appendages : chrome-yellow. Upper pair shorter than lower, rather club-shaped, with strong downwardly-directed spur at their middle below. Lower pair together like a pair of pincers, sloping upwards a little apically.

(According to de Selys' account the male has a fine yellow line between the ocelli and the antennae, and also a longitudinal line of yellow on the dorsum of the second abdominal segment. These marks are obsolete on fully mature specimens.)

♀: resembles the male, but the yellow markings on the dorsum of the synthorax consist merely of a pair of antehumeral stripes instead of the broad area of the male; whilst the markings on the head are more distinct. The distal half of the eighth abdominal segment is also yellow.

Penis: resembles that of *C. didyma*.

Female prothorax: posterior lobe small, margin slightly indented on either side of the small median projection, but this is much less developed than in most species.

Lt.-Col. Fraser who kindly sent me one of Col. Wall's specimens of this species, suggested to me (*in litt.*) that it should be referred to *Coeliccia* rather than to *Calicnemis*; with this suggestion I fully agree, and I find that the species falls naturally into the present genus in every respect. The origin of *Ab* well proximal to *Ac* is perhaps an approach to the condition found in *Calicnemis*, but the general build of the species is utterly unlike that of any *Calicnemis*, whilst as stated above the species agrees well in all other respects with other species of *Coeliccia*.

This is one of the most beautiful of all the species, its splendid colouring is unlike that of any of the species allied to it except perhaps *C. scutellum*. Its range appears to be restricted to the central parts of the Indo-Chinese Peninsular region.

***Coeliccia scutellum*, sp. nov.**

(Pl. III, fig. 18.)

1 ♂ Ngai Tio, 13-iv-24, 4,800 ft. Tonkin.

1 ♂ Bao Ha, 20-iv-24, Tonkin, Coll. H. Stevens.

(In Brit. Mus.).

♂ Length of abdomen 45 mm., of hindwing 27 mm.

Venation: *Rs* and *Miii* rise one on either side of the subnodus. In two specimens on one wing of each, *Ab* commences well before the level of *Ac*, in all the remaining wings (18) (*vide* Fraser) *Ab* rises at level of *Ac*.

Pterostigma small, black, covering about $1\frac{1}{2}$ cells; 3 discal cells on all wings.

Postnodals, forewing 21, hindwing 19-20.

Head: entirely black.

Prothorax: black above, yellow below and laterally.

Synthorax: dorsum black above, with a pair of citron or sulphur-yellow marks anteriorly, each shaped like an escutcheon (scutellum), its posterior border concave, rather more than one-third the total length of the dorsum; its inner margin also concave. Sides yellow, ventral surface black.

Legs: black.

Abdomen: black, with ventral border of second segment narrowly yellow. Segments 3-6 each with apical lateral yellow spots; 9 apical half yellow, the black margin undulate; 10 entirely yellow.

Anal appendages: yellow, subequal in length, superiors chopper-shaped as seen from above and with a small spine or tooth on the inner border at the point where the blade begins, apex rounded; inferiors slim, cylindrical, tapering after the base, the apices turned in rather abruptly and forcipate.

Other structures not examined.

This fine species will probably prove to be allied to *C. chromothorax*, of which it is perhaps the eastern race. It is readily distinguished from all its congeners by the colour-pattern of the synthorax.

***Coeliccia scutellum hainanense*, subsp. nov.**

In the British Museum there are four males (Mt. Wuchi, Hainan, 19-v-03) of what appear to be a distinct race of *C. scutellum* and certainly sufficiently distinct to require a name.

The chief difference lies in the greater size of the synthoracic marks which are longer, and more rounded at their upper end. The posterior half of segment 8 of the abdomen as well as the whole of 9 and 10, is yellow.

A single specimen from Bao Ha, Tonkin, a male taken by Mr. H. Stevens, 11-xii-24 is regarded by Lt.-Col. Fraser as representing a distinct but very similar species. It has only 2 discal cells on the wings, the head has more yellow marking than *scutellum*, and the shape of the yellow marks on the dorsum of the synthorax is a little different; they are shorter and squarer than in *scutellum* and with the upper margin straight. There are also small differences in the shape of the anal appendages.

The specimen is teneral, and I do not feel disposed to give it a name. A good series is necessary to determine whether the differences noted are not due to individual variation, age, and shrinkage.

In the four specimens from Hainan, in the British Museum, the number of discal cells is as follows:—

3	3	3	3	3	3	3	3
3	3	3	2½	3	2½	3	2.

***Coeliccia brachysticta* Ris.**

1 ♂, 1 ♀. (*type* and *allotype*) Coll. Ris, Naujau, Mindoro, Philippines.

Length of abdomen ♂ 44 mm., ♀ 41 mm.; of hindwing ♂ 30 mm., ♀ 30 mm.

♂. *Venation*: costal side of quadrangle of forewing not less than $\frac{2}{3}$ length of anal side; of hindwing still more nearly equal in length.

Ab rises at or exceedingly near level of *Ac*; *Rs* rises proximal to subnodus, *Miii* proximal to it; 3 discal cells on all wings. Costal side of pterostigma about one-third shorter than anal side, the inner margin more oblique than the outer. Postnodals 19 in forewing, 17 in hindwing.

Head: upper lip greenish-blue, genae and base of mandibles pale greenish-blue. Anteclypeus dark brown, postclypeus black, rest of dorsal surface black, except a reddish-brown stripe between the base of the antennae, and on either side between the posterior ocellus and the eye is a mark of the same colour for its inner half, its outer half being blue. On the occiput there is a blue band along the margin of the eyes. The first and second joints of the antennae are pale brown.

Prothorax: black, the sides bright blue.

Synthorax: dorsum entirely bronze-black, except for a very small stripe at the dorsal end of the humeral suture; the black colour extends a little more than halfway between the same suture and the stigma. Sides dull blue, a black band along the second lateral suture narrowing dorsally. Ventral surfaces pale blue, the median suture outlined with black.

Abdomen: very slender, segment 1 black dorsally, on the sides bright pale blue; 2 dark brown, its sides dull blue and a small blue spot in the mid-dorsal line; 3-7 dark brown, each with two incomplete rings of dull yellow, the anterior quite near the base of the segment, the posterior about one millimetre from its apex; 8 black, rather less than its distal half greenish-blue; 9 greenish-blue with black basal-lateral spots; 10 greenish-blue with broad lateral bands of black.

Legs: pale yellow, with a black line on extensor surface of femora, black articulations and ciliae.

Anal appendages: blackish-brown, the upper pair a trifle shorter than the lower, rather club-shaped with the apex slightly bilobed.

♀ very similar to the male, but all the light markings a little more extensive. Segments 9-10 of the abdomen entirely black.

Penis: not studied.

Female prothorax: not very different from that of the male, its posterior margin is divided by a small median indentation into two flatly curved lobes.

The female specimen has only two discal cells on the left hindwing.

***Coelliccia pungyi* Fraser.**

(Pl. I, figs. 7, 20; Pl. II, figs. 21, 22; Pl. III, fig. 4.)

Material examined:—

4 ♂♂, 13 ♀♀, Maymyo. Upper Burma. May-July, Dec. 1925.

2 ♂♂, 1 ♀, Ani Sakan. All collected by Col. Wall.

Length of abdomen ♂ 39 mm., of hindwing ♂ 24 mm.

„ „ ♀ 35 mm., „ ♀ 24 mm.

♂. *Venation*: quadrangle of forewing slightly shorter than that of hindwing. Costal side of quadrangle of forewing about $\frac{3}{4}$ length of anal side, of hindwing more nearly equal. Origin of *Miii* and *Rs* one on either side of subnodus, rather close together. Angulation of medio-anal link less marked than in other species. *Ab* rises very slightly before level of *Ac*; 3 discal cells on all wings.

Postnodals, forewing 20-21, hindwing 18-19.

Pterostigma black, covering about $1\frac{1}{2}$ -2 cells, its outer and inner sides parallel, a little deeper than the cells immediately preceding and following it.

The position of *Miii* and *Rs* with regard to the subnodus does not vary in a series of 40 wings examined, except that in some cases they are placed much nearer together than in others. On the other hand the number of discal cells, especially on the hindwing, varies, in that in about a third of all the hindwings the third cell is not complete, i.e., its distal margin lies some distance beyond the subnodus, so that the number of discal cells on that wing in about 30 per cent. is only $2\frac{1}{2}$ or $2\frac{3}{4}$.

Head : black, a spot on each side of the genae, one on either side of the ocelli, and a cuneiform postocular mark on either side blue.

Prothorax : dorsal surface entirely black, sides and ventral surface pale blue.

Synthorax : dorsum almost entirely occupied by a pair of very large oblong-oval spots of a beautiful pale blue, narrowly separated in the middle line by the mid-dorsal carina, bounded laterally by a black stripe along the line of the first lateral suture. Sides and under surface pale blue, a fine black stripe along the second lateral suture.

Abdomen : black, distal half of segment 8 and the whole of 9 and 10 chrome yellow. Distal half of sides of 1, ventral surface of 2 and small ventral basal marks on 3 and 4, blue.

Legs : entirely black.

Anal appendages : in well coloured specimens yellow, in very mature individuals deeply tinged with brownish-black. Upper pair rather spatulate, with a ventral spur projecting from each just distal to its middle. Lower pair longer than upper, slender, forcipate.

♀ (Adult).

Head : upper lip yellowish, with a black mark at its base. A transverse, pale yellow line across the frons immediately behind the level of the antennae, the basal joint of these likewise yellow. Otherwise as in the male.

Prothorax : dorsum black, sides and ventral surface yellow.

Synthorax : dorsum black, with a pair of narrow bluish-green antehumeral stripes. Sides and ventral surface yellow, with a complete but narrow black band along the second lateral suture.

Abdomen : black. Sides of segment 1 and ventral surfaces of segments 2-7 yellow. Distal half (or in some cases distal third) of segment 8 and the whole of segments 9 and 10 yellow.

Legs : black, anterior surface of femora and posterior surface of tibiae dull yellow.

Penis : terminal fold well developed and broad. Internal fold well developed. The third segment has a large tongue-like projection at its apex, and from the base of this there rises on either side a slender recurved process, similar to the terminal processes of *C. didyma*.

Female prothorax : median process of hind margin large, having the shape of an equilateral triangle, its extreme apex upturned ; the margin deeply cut on either side of it ; the lappels small.

Known only from Burma.

I understand from Lt.-Col. Fraser that the term “*poungy*” is the Burmese for a priest.

The male of this species resembles in *colour-pattern* though of course not in colour the species *chromothorax*. It is a very beautiful form and quite distinct from any other. Col. Wall writes that *loogali* and *poungyi* rest on bushes or ferns over hanging streams in shady places, or where the sunlight filters through in splashes. The females are found in deeper forest some short distance from streams to which they only come to pair. They rest with wings folded. Lt.-Col. Fraser adds that these habits are entirely similar to those of *Indoneura*.

Coelliccia pyriformis, sp. nov. (Fraser Mss.).

1 ♂. Coll. H. Stevens. Bao Ha, Tonkin. 21-xii-24.

The specimen which is the type is in the British Museum. It is fully adult. (Unique).

Length of abdomen 35 mm., of hindwing 22 mm.

Venation: *Rs* rises distal to subnodus, *Miii* proximal to it; 3 discal cells on all wings. Pterostigma black, covering about $1\frac{1}{2}$ cells.

Head: glossy black, genae, bases of mandibles and a small median spot on clypeus, yellow.

Prothorax: black, paler on the sides, without any abrupt delimitation.

Synthorax: dorsum black, the black extending on to the sides and fading gradually to a creamy white below. A pyriform mark of pale blue on either side on the dorsum with its pointed end upwards. (This mark has faded whilst the specimen was undergoing relaxation for setting, and is not now evident in the type, the whole dorsum being uniformly black).

Abdomen: black, 1 and 2, with the sides creamy white, leaving on the dorsum of 1 a narrow hour-glass shaped mark of black; 3—6 with ventral surfaces creamy white, the white extending upwards subapically to show as a pair of small spots when the abdomen is looked at directly from above. 9 and 10 entirely ochreous.

Legs: pale yellow, with a fine black line on extensor surface only of femora.

Anal appendages: ochreous, lower pair much longer than upper, angularly forcipate. Upper pair rather club-shaped, no marked projection.

This species differs from all others in the gradual shading of its colouring on the sides of the synthorax and by the large blue pyriform dorsal thoracic spots which closely resemble those found in *Caconeura botti* Fras.

Coelliccia loogali, sp. nov. (Fraser Mss.).

(Pl. I, figs. 4, 27; Pl. II, figs. 17, 18; Pl. III, fig. 1.)

Material examined: 8 ♂♂, 6 ♀♀ Maymyo, N. Shan States, vii-ix-1924. Coll. Col. Wall.

2 ♂ (teneral) Ani Sakan. v-viii-1925. Coll. Col. Wall.

1 ♂ Loimwe Cart Road. S. Shan States. 3,500 ft. Coll. Capt. Drummond. 27-ix-1923.

5 ♂♂, 2 ♀♀ Maymyo. v-vii-1924-1925. Coll. Col. Wall.

The type and allotype are from Maymyo.

Length of abdomen ♂ 43 mm., of hindwing ♂ 28 mm.

„ „ ♀ 43 mm., „ ♀ 29 mm.

Venation: (type ♂).

Quadrangle of forewing about $\frac{3}{4}$ length of that of hindwing. Costal side of quadrangle, of forewing about $\frac{3}{4}$ length of anal side, of hindwing about $\frac{4}{5}$. *Ab* rises perceptibly proximal to level of *Ac*. *Rs* and *Miii* rise on either side of the subnodus, well separated; 2 discal cells

on all wings. Pterostigma grayish-brown, covering $1-1\frac{1}{2}$ cells, its inner and outer borders parallel, rather inflated. Post-nodals, forewing 20, hindwing 19.

Variations in the venation are frequent in respect to the number of discal cells, and position of origin of *Rs*. Instead of 2 discal cells there are in many cases $2\frac{1}{2}$ or 3. Amongst the males examined (11 specimens) all cases of this variation amounted to 18 per cent. of the total, in 9 per cent. the variation was found to be symmetrical. Amongst the females (11 specimens) about 40 per cent. of the whole number showed the same variation which was symmetrical in 18 per cent. Approximately 16 per cent. of all the wings have the origin of *Rs* from the subnodus. In two females it occurs on all four wings, and in the female generally it is twice as common as in the male.

♂ (*Type*, adult).

Head : black, genae, bases of mandibles, anteclypeus and a minute spot on either side of the posterior ocelli blue, as is a cuneiform post-ocular mark.

Prothorax : entirely black on the dorsum ; sides blue fading to white ventrally.

Synthorax : dorsum black, the black colour extending nearly to the first lateral suture. A narrow blue stripe on either side, slightly curved and tapering at its extremities lies wide from the mid-dorsal carina, close to the inside of the humeral suture. Sides blue, a small black mark at the upper end of the second lateral suture. Ventral surfaces whitish.

Abdomen : almost entirely black. Sides of first segment extensively marked with yellowish-white, this colour encroaching somewhat on the black of the dorsum. Sides of second segment with whitish markings. Ventral surfaces of 3 and 6 whitish, the white colouring expanding a little at the apex of each of these segments.

Legs : white, or yellowish-white, with a narrow black line along the posterior surface of the femora. Ciliae and tarsi also black.

Anal appendages : black, upper pair shorter than lower rather lancet-shaped ; lower pair incurved and decurved apically.

♀ (*Allotype*).

Colour pattern very similar to that of the male, but the bright blue of that sex is replaced by a more yellowish colour. The following differences may be noted. On the head there is a transverse broken line of yellow from the posterior ocellus to the eye on either side. Distal half of segment 8 of abdomen, and distal quarter of 9 yellow.

Penis : internal fold well developed, terminal fold rather small and indefinite. Third segment broadly bilobate at its distal end the lobes being rather flattened laterally and with a very shallow cleft between them.

Prothorax of female : posterior margin with a minute median projection, directed upwards. Margin gently curved on either side of this. The middle lobe has on either side a deep constriction and immediately in front of this an inconspicuous spur, which is provided with a number of hairs. The lappels are placed very laterally.

Range, Upper Burma and Shan States.

Quite distinct from any other species that I have seen ; the female is similar in appearance to that of *C. poungyi* from the same region ; but apart from structural characters it is readily distinguished by the black mark on the second lateral suture of the synthorax. This in *C. loogali* is incomplete, whilst in *C. poungyi* it is complete.

The word *loogali* is I understand Burmese for a lad or youth.

Coeliccia flavicauda Ris.

(Pl. I, figs. 10, 16 ; Pl. II, figs. 19, 20 ; Pl. III, fig. 14.)

Material examined : 1 male, 1 female, Tainan, Formosa, iv. 10, coll. Rolle *ded.* F. Ris.

Length of abdomen ♂ 43 mm. Hindwing 27 mm.

„ „ ♀ 41 mm. „ 29 mm.

Venation : quadrangle of forewing about $\frac{3}{4}$ length that of hindwing. Costal side of quadrangle, of forewing about $\frac{3}{4}$ length of anal side, of hindwing more nearly equal. *Miii* rises before the subnodus, *Rs* distal to subnodus. Discal cells, 2 or 3 in forewing, usually 2 in hindwing. Pterostigma small, gray-brown, with a very fine lighter margin, its costal margin barely shorter than the anal. Postnodals 16 in forewing, 14 in hindwing.

♂ (Adult).

Head : upper lip pale yellow with a fine black line at its base. Anteclypeus greenish, postclypeus, genae, and bases of mandibles, greenish-white.

Rest of upper surface black, with a small yellow stripe on either side of the hinder ocelli, and a very small whitish line on the crest of the occiput ; postocular spots whitish. Apex of first and second joints of antennae also whitish.

Prothorax : black, with large lateral spots of yellow.

Synthorax : dorsum black, the black colour extending to a line along the middle of the mesepimerite.

On either side of the middorsal carina there is a large oblong-oval spot of a bluish-yellow colour, extending about halfway up the dorsum anteriorly.

Just to the outer side of the humeral suture and lying along its upper half there is, on either side, a cuneiform bluish mark, its apex directed downwards and forwards.

In some specimens this mark is continuous at its upper end with the light colour of the sides.

Laterally the synthorax is bluish-yellow, with a band of black along the second lateral suture. The ventral surfaces are greenish-white.

Abdomen : segments 1-8 black dorsally. First segment greenish yellow at the sides and below ; second laterally yellowish and with a very small longitudinal dorsal stripe on its basal half ; 3-7 with lateral-apical lunules of bluish-yellow, that on 7 very small ; 8 entirely black ; 9 variable, either all black, or with a dorsal apical spot of yellow, or entirely yellow ; 10 also variable, all yellow, or with small basal-dorsal and basal-lateral spots of black.

Legs : whitish-yellow, femora and tibiae with black carinae ; tarsi and ciliae black.

Anal appendages : yellow. Upper pair a trifle shorter than the lower rather cylindrical, with a squarish ventral process. Lower pair forcipate, a little hooked downwards at the extreme apex.

♀ (Adult).

Colour pattern of head and prothorax as in adult male, but the markings on the head more extensive than in the other sex. Synthorax also as in the male.

Abdomen with segments 1-7 again as in the male ; basal half of 8 black, apical half yellow ; 9 all yellow ; 10 and appendages black.

Penis : inner and terminal lobes well developed. Third segment with short, rounded median process, on either side of this a stout, rather short, lateral process.

Female prothorax : hind-margin with small median projection directed upwards and backwards. Lappels rather small.

Dr. Ris describes two colour varieties of the female Var. α with the oval spots of the synthorax reaching only about $\frac{1}{2}$ of the length of the dorsum, and the mark just external to the humeral suture only represented at its upper end, where it is continuous with the colour of the side.

Var β . Oval spot of synthorax still more reduced, only about $\frac{1}{4}$ length of dorsum ; and spot outside humeral suture reduced to a very fine line, not continuous with the colour of the side. In the female of this variety the oval spot is represented merely by a fine point of colour.

This species is very distinct, and is remarkable for the close similarity of the colour pattern of the two sexes.

Known from Formosa only.

***Coeliccia cyanomelas* Ris.**

Type and cotype from Hoozan, Formosa, v. 10, in Ris collection. Occurs also in South China (Tsa-Yiu-San).

Length of abdomen ♂ 39-42 mm. Hindwing 26-28 mm.

„ „ ♀ 40 mm. „ 29 mm.

Venation : costal side of quadrangle of forewing about a fifth shorter than anal side, of hindwing a little more nearly equal. Three discal cells in forewing, two in hindwing. *Ab* rises just before level of *Ac*.

Miii rises proximal to subnodus, *Rs* distal to subnodus. Costal margin of pterostigma a trifle shorter than anal.

20 postnodals in forewing, 18 19 in hindwing.

♂ (Adult).

Head : upper surfaces black, with blue anteclypeus, genae, and bases of mandibles. A whitish spot on either side between the base of the antennae and the hinder ocellus. Post-ocular spots whitish.

Prothorax : black, laterally bright blue.

Synthorax : dorsum black ; on either side of the mid-dorsal carina there is a light blue spot, extending along about the anterior third of the dorsum, and narrowing at its upper end. Externally to this there lies on either side a small streak of the same colour, parallel to the upper

third of the humeral suture. Laterally the black colour reaches half-way between that suture and the stigma, its margin being rather wavy. The rest of the side light lilac-blue, with a very fine black line along the second lateral suture. Ventral surfaces whitish-yellow.

Abdomen : very slender ; first segment whitish with a small black longitudinal line on the dorsum ; 2-7 black dorsally, sides of 2 whitish-blue, this segment also has a whitish longitudinal line on the dorsum ; 3 has the sides yellowish, with a fine basal ring, interrupted mid-dorsally, of blue ; 4-7 narrow lateral markings of whitish colour, the basal colour extending a little dorsally at the apex of each. Basal half of 8 black, distal half blue ; 9 pale blue, with small lateral basal spots of black ; 10 dorsum blue, sides black.

Legs : whitish-yellow, black lines on the dorsal sides of the femora, and ventral sides of the tibiae, tarsi, ciliae and articulations black.

Anal appendages : upper pair pale blue above, black ventrally ; lower pair black with yellowish markings on the outside and on the ventral-medium margin.

Both pairs almost equal in length, the upper straight, rather conical, with a stout mid-ventral tooth.

♀ Differs from male as follows.—Anterior margin of upper lip yellow. On the synthorax the median pair of spots on the dorsum are absent. Segment 9 of abdomen black save for a greenish apical-dorsal spot ; 10 and appendages entirely black.

Penis : not examined.

Female prothorax : posterior margin, has the median process developed as a very small rather obtuse triangle, with small lappels on either side, not unlike those of *C. flavicauda*.

C. Group **membranipes**.

Coelliccia membranipes (Ramb.).

(Pl. I, figs. 3, 17 ; Pl. II, figs. 15, 16 ; Pl. III, fig. 13.)

Material examined : Several of both sexes from N. Borneo.

Type in the Paris Museum collection.

Length of abdomen ♂ 43 mm. Hindwing 26-28 mm.

„ „ ♀ 40 mm. „ 27 mm.

Venation : quadrangle of forewing $\frac{7}{5}$ length of that of the hind ; costal side of quadrangle of forewing $\frac{3}{4}$ length of anal side but $\frac{4}{5}$ the length in the hind ; *Rs* rises distal to subnodus, *Miii* from the subnodus. Three discal cells in all wings ; 18 postnodals in forewings, 15-16 in the hind.

Pterostigma small, covering scarcely more than one cell, its inner and outer margins approximately parallel. Origin of *Ab* perceptibly distal to *Ac*.

The venation shows a large amount of individual variation more than in any other species perhaps. My account refers only to the Bornean form, and I do not know that material from Sumatra or Java would show the same amount or the same kinds of departures from what I take to be the really typical venation of the species.

The chief variation is in the position of origin of the sectors *Rs* and *Miii*. In at least 30 per cent. of all wings examined (32) these originate one on either side of the subnodus, further, whilst as a rule they are not very closely approximated at their origins, the spacing of the two varies from wing to wing even in the same individual, but in such slight amounts that it is not possible to tabulate. On one hindwing of a female specimen, (and also in the female figured by Dr. Ris) there are only two and a half discal cells.

♀ (Adult).

Head : with yellow genae, and a yellow margin to the eyes, otherwise as in immature males.

Prothorax : as in male but the yellow lateral spots relatively larger.

Synthorax : colour pattern as in male, but the blue replaced by yellow.

Abdomen : brown fading ventrally to yellow, with traces of lunules on segments 3-7. Basal half of 8 darker, almost black ; 9 and 10 wholly black, save for a small subapical yellow mark on 9. The first segment is pale yellowish.

Penis : almost exactly as described below for *C. nigrohamata*.

Female prothorax : posterior margin deeply cut on either side of the median projection, which is directed upwards and a little backwards. Lappels rather large.

Anterior part of the middle lobe with a simple conical boss on either side.

This race is barely distinguishable from the type from Java, which also occurs in Sumatra, the most obvious difference is that, whilst the type specimen from Padang in Java has the anal appendages of the male blue, all the males from Borneo now before me, as well as some others that I have seen, have these structures black.

(In Javan specimens all the abdominal markings are blue and there is also a subapical blue annule on segment 8 ; the sides of segments 9 and 10 are black. All pale markings of thorax are definitely blue. In some specimens only the apical half of segment 9, but the whole, dorsum of 10 is blue.)

Though my grounds are not very secure, I keep the specimens from N. Borneo distinct as a race, to which the name *nemicola* must be applied.

The following is a description of this race, to which description I add a note pointing out the few features which may serve to distinguish it from the type race which occurs in Sumatra and in Java.

♂ (Adult).

Head : black, with blue post-clypeus, and blue, cuneiform marks postocularly (younger males with an irregular blue stripe on either side of the ocelli).

Prothorax : dorsum black, with a pair of lateral spots of yellow (? blue).

Synthorax : dorsum black, with a pair of stripes one on either side just internal to the humeral suture, blue in colour, slightly crescentic in shape, rather broader anteriorly. Sides blue, with a black band incomplete below along the second lateral suture. Ventrally whitish yellow.

Abdomen : black, segments 9-10 blue, 9 with a black basal triangle, its apex posterior, along the basal half of the segment. Segments 1 and 2 largely yellow at the sides, segments 3-8 yellow below, with sub-apical, lateral-ventral lunules.

Legs : primrose yellow, with black lines on the femora and tibiae, the tarsi and ciliae also black.

Anal appendages : black, the upper pair shorter than the lower, which have the pincer-like shape characteristic of the genus ; the upper pair are slightly club-shaped, or when viewed from above, triangular.

***Coelicia lieftincki*, sp. nov.**

(Pl. I, figs. 8, 14 ; Pl. II, figs. 13, 14 ; Pl. III, fig. 2.)

Material examined : 1 pair *in cop.*, Nusa Kambangan, Java, 18-vi-27, Coll. F. C. Drescher.

Male.—Abdomen 36 mm. Hindwing 24 mm.

♂. *Wings* : hyaline ; 16 postnodals in forewings, 14 in the hind ; 3 cells between quadrilateral and subnodus in all wings ; costal margin of quadrilateral two-thirds the length of anal margin in forewing ; three-fourths in the hind ; *Miii* arising at the subnodus ; *Rs* distad (in both sexes) ; wings distinctly broader in the middle and with more rounded apices than in *C. membranipes* (Ramb.). Pterostigma dull ochreous with fine pale framing, nearly rectangular, broader than the underlying cells ; in the male the sides approximately parallel but in the female, the costal margin much shorter than the anal margin, especially in the forewing ; in general the pterostigma less oblique than in other species.

Head : Labium yellowish ; labrum and postclypeus glossy black ; frons and vertex black ; first joint of antennae, and an irregular stripe at level of ocelli yellowish ; occiput black, bearing two large postocular rounded spots.

Prothorax : largely bluish white, dorsum with a large X-shaped black mark connected posteriorly with the black middle lobe.

Synthorax : dorsum black with small bluish white antehumeral stripes incurved and pointed below ; also a distinct, nearly rectangular bluish white spot at the upper part of each shoulder to outer side of antehumeral stripes along the upper end of humeral suture. Sides yellowish green with a brown line at the second lateral suture extending as far as the stigma. Ventrums yellowish white.

Legs : yellowish, the joints, spines and a minute line on the femora brown.

Abdomen : segment 1 bluish white with a small dorsal brown spot ; dorsum of segments 2 to 6 brown with distinct yellowish green rings just before the darker brown ends. These light coloured rings incomplete above but separated by a very small longitudinal line ; segment 7 dark brown dorsally ; segment 8 blackish brown with a pale bluish green transverse spot near the end ; segments 9 and 10 wholly black ; 9 with a large scutate pale blue spot above, and 10 also blue dorsally. Ventral side of segments 1 to 7 yellowish, of 8 to 10 black. Abdomen broader and more robust than in *C. membranipes*.

Anal appendages : black ; superiors of the same length as inferiors ; seen from above thick and straight, each with two projections directed inwards and downwards respectively. Inferiors cylindrical, slightly incurved and somewhat broadened at end.

Female. Abdomen 37 mm. Hindwing 27 mm.

Very similar to the male ; wings differing as mentioned above, prothorax with simple posterior lobe, but with a small horn-like protuberance on each side of the anterior lobe, not present in the male.

Abdomen with pale markings at ends of segments 2 to 6 dull yellowish ; basal third of segment 8 black, the remaining portion entirely pale yellow ; segments 9 to 10 black.

Type male and female in Lieftinck collection.

***Coeliccia dinoceras* Laidlaw.**

(Pl. I, figs. 2, 18.)

Material examined : 1 male (*autotype*), Kolambugang, Mindanao, Philippine Islands, in author's coll. (Female unknown.)

Length of abdomen 36 mm. Hindwing 25 mm.

Venation : quadrangle of forewing about length of that of hind. Costal side of quadrangle of forewing about $\frac{3}{5}$ length of anal side, and in hindwing about $\frac{4}{5}$; *Miii* arises at subnodus, *Rs* distal to it. *Ab* arises at level of *Ac* ; 3 discal cells in all wings ; pterostigma almost square, covering 1 cell. Postnodals 16 to 17 in forewing, 15 in the hind.

♂ (Adult).

Head : black, except genae and anteclypeus, which are blue, as are small oval-oblong, postocular spots and small transverse marks on either side of antennae, the basal joints of which are white.

Prothorax : black, with a large blue spot on either side of the middle line. Posterior lobe carries a pair of large horns, projecting upwards and forwards. Colouring ventrally pale yellow.

Synthorax : dorsum black with a pair of narrow blue bands tapering towards their upper extremities. To the outside of these, close to the antealar sinus, is a minute spot of the same colour. Sides blue (in life) with a narrow band of black along the second lateral suture.

Abdomen : long and very slender. Segments 7-8-9 progressively a little stouter than the others. First segment probably blue in life, with narrow longitudinal line of black middorsally. Sides of 2-3, distal third of 8, and whole of dorsum of 9-10, also blue. Otherwise colour generally dull brownish-yellow paler ventrally, and passing to black on the hinder segments.

Legs : yellow, with narrow line of black along hind surface of femora. Tarsi and ciliae black.

Anal appendages : black both pairs long and slender, lower pair decidedly longer than upper, the former cylindrical, hooked downwards, and inclined inwards apically, the upper pair club-shaped with bluntly pointed apices.

Penis : terminal lobe inconspicuous, as is the inner. Third segment hood-like, its apex widening abruptly just before its termination.

A very remarkable species, unique in the genus in that the male possesses a pair of horn-like processes on the prothorax which do not seem to be homologous with the prothoracic processes of females of other species of the genus. It is further remarkable for its very long and slender abdomen and appendages; the penis is, in a general way, not unlike that of *C. campioni*.

On the whole the species seems to stand most naturally in the *membranipes* section of the genus.

***Coelliccia flavostriata* Laidlaw.**

Material examined: 1 ♂ (*paratype*) Mt. Merinjak, Borneo. *Autotype* ♂ in Brit. Mus., Mt. Merinjak.

Length of abdomen 35 mm., of hindwing 21.5 mm.

Venation: quadrangle of forewing very slightly shorter than that of hindwing.

Costal side of quadrangle of forewing $\frac{2}{3}$ length of anal side, of hindwing $\frac{4}{5}$. *Ab* rises scarcely perceptibly before the level of *Ac*. *Miii* rises at (or barely before) the subnodus, *Rs* well after; 3 discal cells in all wings.

Pterostigma covering about one cell, its inner and outer margins parallel, scarcely deeper than the cell next distal to it.

Postnodal nervures, forewing 14-15, hindwing 13.

♂ (Type).

Head: black, anteclypeus, base of upper lip, and a pair of transverse marks one on either side of the posterior ocelli, yellowish-white.

Prothorax: anterior and posterior lobes black, median lobe yellow with a fine median longitudinal line of black dorsally.

Synthorax: dorsum black, with an orange-yellow antehumeral stripe on either side, and immediately in front of the antealar sinus a small yellow spot lying externally to the antehumeral stripe. Sides yellow with a narrow black band incomplete below, along the second lateral suture.

Abdomen: segment 1 yellow with median line of black on dorsum; 2-5 brown, paler below, with terminal black ring on each. The remaining segments progressively darker from before backward, the last two bronze-black.

A young male has a whitish diamond shaped mark on the dorsum of 10.

Legs: femora yellow with black lines, tibiae brown, tarsi and ciliae black.

Anal appendages: black, upper pair about $\frac{2}{3}$ length of lower, rather flattened apically, incurved, each carries a stout spur on its inner side at the end of the first third of its length. Lower pair slender rather cylindrical incurved apically.

(♀ Unknown).

Penis: inner lobe small, terminal lobe large, hood-like; the third segment terminates in a pair of short widely separated processes. The organ resembles closely that of the next species, and to a less extent that of *renifera*.

This pretty little species, with the closely allied *C. campioni*, will probably prove to belong to a distinct section of the genus, characterized by the colouration, open venation and genital structures of the second abdominal segment. Both of them are at first sight very much like a *Copera*, and quite unlike any of their congeners.

***Coelliccia macrostigma* Laidlaw.**

Material examined : 1 male, Baram, Borneo, 20-x-20 ; 1 female, Baram, 19-x-20.

Holotype male in Brit. Mus. Female *cotype* destroyed.

Length of abdomen ♂ 35 mm. Hindwing 21 mm.

„ „ ♀ 33 mm. „ 22 mm.

Venation : quadrangle of forewing about $\frac{3}{4}$ length of that of hindwing. Costal side of quadrangle, of forewing $\frac{3}{4}$ length of anal side, of hindwing more nearly equal ; *Miii* rises at subnodus, *Rs* distal to it. Three discal cells in all wings. Pterostigma rather large, its proximal and distal sides approximately parallel, gray in colour. 15 postnodals in forewing, 14-15 in hindwing.

Head : upper surface black, except the genae, lateral parts of postclypeus, base of antennae, and a minute spot on either side of ocelli, which are yellow, as are the postocular spots.

Prothorax : anterior and posterior lobes black, middle lobe with lateral and ventral surfaces whitish-blue, black mid-dorsally.

Synthorax : dorsum black with broad blue antehumeral stripes which are indented at the middle by a black mark projecting from the inner side. Laterally the thorax bluish white, ventrally yellowish white ; a narrow black oblique stripe extending along the second lateral suture. Legs yellowish white, the joints, spines and a line on the femora black.

Abdomen : segment 1 yellowish white with a dorsal brown spot ; segments 2 to 7 brown, becoming darker posteriorly, with narrow black apical rings, 2 has a pair of small basal blue lateral spots ; segment 8 black above, yellowish white beneath, 9 and 10 yellowish white with narrow black basal annules.

Anal appendages : yellowish brown (or blue ?) tipped with black. Superiors slightly longer than inferiors, each with a large triangular projection inwards and downwards, scarcely visible in profile. Inferiors cylindrical, slightly incurved and with a distinct elbow at the middle.

Female : very similar to the male, differs as follows :—antehumeral stripes of thorax completely divided by the black projecting mark into a broad lower part which is rounded below and pointed above—and a narrower upper part which is linear.

Abdomen : with segment 1 entirely yellowish brown above ; segment 8 pale above, probably blue during life ; segment 9 black with a pair of pale marks above on either side of the middle line ; 10 black.

Prothorax : with an unique crescentic projection on either side the middle lobe attached to main body by its convex border, which as viewed in an oblique direction is lunulate in shape, but as viewed directly from above shows as a single outstanding spur. In addition, the posterior

lobe has a fine black spur at the middle of its posterior margin which projects strongly upwards and forwards. On either side of this process lies a small lappel directed backwards.

Coelliccia campioni Laidlaw.

(Pl. I, fig. 6 ; Pl. II, figs. 5 ad 6 ; Pl. III, fig. 5.)

Material examined : 1 male, Long Semayan, 5-x-20 ; 1 female, same locality, 25-x-20 (fragmentary).

Type male, Lio Matu, Borneo, in Brit. Mus. coll.

Length of abdomen ♂ 37 mm. Hindwing 21 mm.

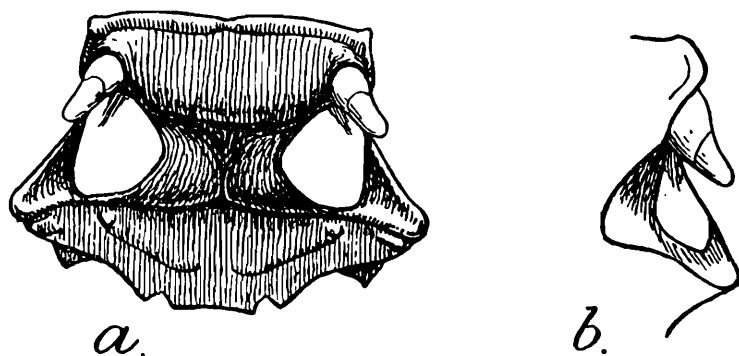
„ „ ♀ ? „ 21.5 mm.

Venation : quadrangle of forewing about $\frac{3}{4}$ length of that of hindwing. Costal side of quadrangle, of forewing about $\frac{2}{3}$, of hindwing $\frac{4}{5}$ length of anal side. 3 discal cells in all wings. Pterostigma black, not inflated, its inner and outer margins almost parallel. *Miii* rises from subnodus, *Rs* a little distal. Postnodals 13 in forewing, 11 in hindwing.

♂ (Adult).

Head : black, genae, bases of mandibles, a small rather square spot on either side of the ocelli, and a pair of very small postocular marks, yellow.

Prothorax : dorsum black, middle lobe with a pair of large yellow spots. The posterior lobe carries a very fine projecting point at either lateral angle. Under surfaces pale yellow.



TEXT-FIG. 2.—a. Dorsal view of prothorax of *Coelliccia campioni*, ♀. b. Lateral view of anterior portion of same.

Synthorax : dorsum black as far as the level of the stigma, with a stripe of yellow immediately to the inside of the humeral suture, this stripe narrows about halfway and tapers at its upper extremity. To the outside of its upper end, which is a little curved inward, a small spot of the same colour.

Sides and ventral surfaces yellow, with a black line, incomplete below, on the second lateral suture.

Abdomen : segment 1 pale yellow, with a black apical ring ; 2-10 brown becoming progressively darker from before backwards ; the terminal segments bronze-black. Ventrally yellowish brown.

Legs : yellow, the posterior sides of the femora, anterior sides of tibiae, tarsi, and ciliae black.

Anal appendages : black. Upper pair a little longer than the lower, stout and slightly incurved apically, each carries an inwardly directed spur near its middle, and is sharply hooked downwards at its free extremity. Lower pair forcipate.

♀ (Adult, much damaged) differs from the male in having the yellow stripe on the dorsum of the synthorax extremely narrow throughout, whilst the small upper spot is entirely absent.

Penis : inner lobe small, terminal lobe large, hood-like. The third segment bluntly bifid at its apex.

Female prothorax : the posterior lobe is large and collar-like, the median process very broad and truncate, separated by a shallow indentation from the small lappels which are scarcely distinguishable from the rest of the margin.

Laterally between the anterior and middle lobes, but apparently derived from the latter there is a pair of extraordinary, horn-like processes, yellow in colour. These are quite the most highly developed of any such structures that are known in the genus. They are conical, the upper half rising as though jointed on to the stouter basal pedicle-like part.

***Coeliccia nigrohamata* Laidlaw.**

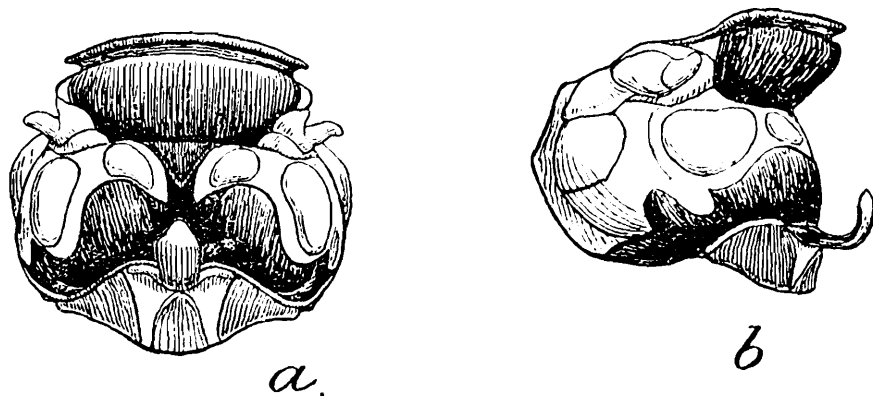
(Pl. III, figs. 15, 16.)

Material examined : 6 males, Mt. Merinjak, 21-v-14, Lio Matu, Borneo, 14-xi-14, and Kuching, Sarawak.

Length of abdomen 38 mm. Hindwing 24 mm.

Venation : quadrangle of forewing about $\frac{4}{5}$ length of that of hindwing. Costal side of quadrangle, of forewing $\frac{2}{3}$ length of anal side, of hindwing $\frac{4}{5}$; *Ac* rises distinctly after the level of *Ab*. *Miii* rises from subnodus, *Rs* distal to it; 3 discal cells in all wings, pterostigma long covering $1\frac{1}{2}$ cells, gray-brown in colour; 16-18 postnodal nerves in forewing, 16 in hindwing.

♂ (Adult).



TEXT-FIG. 3.—*a*. Dorsal view of prothorax of *Coeliccia nigrohamata*, ♀. *b*. Lateral view of same.

Head : black except for yellow marks on the genae, the base of the mandibles, and a pair of minute spots on either side of the posterior ocelli, as well as a pair of postocular spots.

Prothorax : dorsum black, sides and ventral surfaces yellow.

Synthorax : dorsum black to the level of the first lateral suture, with a pair of large hook shaped blue marks, the prong of the hooks lying close to the middle line, the shanks occupying the position of the antehumeral band.

Sides between the first and second lateral sutures blue, below the latter yellowish white, with a fine black line incomplete below along the second suture.

Abdomen : first segment yellowish white, with dark basal and apical rings, segments 2-7 bronze black above, yellowish brown ventrally, 8 black above yellow at the sides, 9-10 blue (?) with very fine basal rings of black, 9 has also a minute basal triangle of black mid-dorsally.

Legs : yellowish white, with black lines on the extensor surfaces of the femora and flexor surfaces of the tibiae. Tarsi, joints, and ciliae also black.

Abdomen : segment 1 yellow, with a narrow line of black on the dorsum, 2-7 black above, ventrally yellowish-brown, 8 with yellow at the sides, posteriorly forming a pair of lunules, 9-10 blue.

Anal appendages : black, but a younger male has the upper pair blue, the lower pair are in all cases black. Upper pair a little shorter than lower with each two small internal projections ; lower pair more strongly incurved apically than in most species, each with a bend inwards at about its middle, at which point also it is a little flattened, so that it has a small shelf-like process on its inner side.

Penis : inner and terminal lobes large, third segment narrow, ending in a pair of short pointed processes. At the point from where these processes rise there is a curious hood-like projection, recalling that seen in *C. albicauda*, but more prominent than in that species.

[Females belonging to at least two species, neither of which show any character by which I can definitely identify them with the present species, but which may be from their *locale*, one or other of them, the female of *nigrohamata*, are discussed below.]

Coeliccia sp.

2 ♀♀ Kuching. Borneo.

Both these specimens are very much battered and scarcely fit for description. They are probably the female of *nigrohamata* but as this is not definitely ascertainable I prefer to describe as many of their characters as are in condition for description under a separate heading.

The venation is in general the same as that of *C. nigrohamata*. The only other characters sufficiently available for study are those shown by the prothorax and synthorax.

The dorsum of the synthorax is black and has a pair of humeral stripes shaped each like an inverted “!” but with the upper and lower parts of the mark conjoined. This mark is like the mark on the dorsum of *C. nigrohamata* without the prong of the hook.

The sides and ventral surfaces as in *C. nigrohamata*.

The prothorax is yellowish-white dorsally, with the anterior and posterior lobes black.

The median process of the posterior lobe projects upwards and backwards like a trigger, the lappels are large and lie close to the median process.

On either side of the median lobe there is a conical papilla projecting outwards, lying well forward, similar to, but smaller than, that of *C. campioni*.

***Coeliccia* sp.**

Long Akar, Baram, 1.x.20.

This specimen which is very fragmentary, differs from the two females noted above in the following particulars.

The posterior margin of the prothorax is more markedly arcuate, and the median process is relatively larger, moreover its upper extremity is strongly hooked forward, and the lappels are relatively smaller. The lateral process of the middle lobe are similar but arise as the lower limb of a crescentic ridge.

The humeral marks on the dorsum of the synthorax consist of a pair of blue bands one on either side of the middle line. These bands are rather broad, and each is deeply indented on its inner side at about its middle. The black line on the second lateral suture is incomplete below.

As already stated there is nothing definite either in the venation or in any other character to guide one in placing the three females noted above under any of the species named.

It is quite certain that they are to be referred to two distinct species, and that these species are both of them very closely related to both *C. macrostigma* and *C. nigrohamata*; in fact it is quite likely that they are the females of those species, but beyond stating this probability I am not able to speak with greater definiteness.

***Coeliccia albicauda* (Förster).**

(Pl. I, figs. 1, 23 ; Pl. II, figs. 23, 24 ; Pl. III, fig. 10.)

Material examined : 1 male, Kampong Jor, Pahang ; 1 female Tamang, Pahang, 2-vi-23. Coll. F. Chasen.

Length of abdomen ♂ 43 mm. Hindwing 25 mm.

„ „ ♀ 38 mm. „ 26 mm.

Venation : quadrangle of forewing a little shorter than that of hindwing. Costal side in each case only a trifle shorter than anal side. *Miii* rises from subnodus, *Rs* distal to it ; 2 discal cells in all wings. Pterostigma almost square, black, covering one cell, very finely margined with white, scarcely deeper than the cell following it.

Postnodals forewing 18, hind wing 17-18.

♂ (Adult).

Head : black; genae, anteclypeus and the transverse postocular spots blue as also are a pair of small square spots on each side of posterior ocelli.

Prothorax : yellowish-white with the posterior margin and a broad band on the dorsum of the middle lobe black ; anterior lobe also black.

Synthorax : dorsum black, with a pair of small triangular blue marks near its anterior end, and posteriorly a very small pair of blue spots near the alar sinuses. The apices of these triangles are directed forward. Sides blue, with a narrow black line along the second lateral suture.

Ventral surface ivory white.

Abdomen : black, the first segment yellowish-white ; 2 with the same colour at the sides and below, the white extending dorsalwards subapically to form a small pair of lunules. Ventral surface of the remaining segments also whitish, 3-7 with small apical lunules. Distal third of 10 with a similar pair of spots laterally but much larger.

Legs : yellowish-white, carinae, articulations, and tarsi black.

Anal appendages : ivory-white, upper and lower pairs sub-equal in length ; upper pair each with a large ventral spur at about the middle ; lower pair forcipate.

♀ (Adult, fragmentary) differs from the male chiefly as follows :—the black band on the dorsum of the prothorax is reduced to an exceedingly narrow line, and on the dorsum of the synthorax there are a pair of narrow yellowish bands in place of the blue spots of the male. Segment 10 of the abdomen is black, whilst the black of the dorsum of segments 8-9 is reduced to a narrow band.

Penis : inner and terminal lobes well developed, the third segment carries at its apex a pair of short strap-like processes, which curve round the sides of the second segment.

Female prothorax : the middle lobe has a pair of blunt processes laterally, one on either side ; these are quite inconspicuous, but resemble the homologous processes of such a species as *C. campioni*.

The median process of the hind margin is small and triangular and does not project upwards, nor does it extend backwards so far as the small lappels.

I have seen three females of this species. They differ entirely from the form described by De Selys as *octogesima*, and I think there can be no doubt but that this species is quite distinct, though it belongs to the same group. Förster's name must therefore be retained for the species, which is a very beautiful one. It certainly includes the specimens I described as *C. borneensis* from the Malay Peninsula. The locality, from which the specimens described were taken, is the same as that from which came Förster's type.

***Coelliccia octogesima* Selys.**

Type male from Labuan, now in MacLachlan coll., *cotype* female from Singapore, in Selysian coll.

Length of abdomen ♂ 37 mm., ♀ 32 mm., of hindwing ♂ 21 mm., ♀ 21 mm.

Venation : *Rs* rises distal to subnodus, *Miii* at subnodus.

♂ (Adult).

Head : black, with the genae, postclypeus, a mark on either side of the ocelli, and cuneiform postocular spots yellowish.

Prothorax : black with a large yellow spot on either side of the middle lobe.

Synthorax : dorsum black with two blue spots on either side of the middle line. The lower of these is oval, the upper is smaller and almost round and lies near the antealar sinus. Sides blue with a dark line along the second lateral suture. Ventral surfaces yellowish white.

Abdomen : long and slender, the first segment yellowish with a black line dorsally ; 2-8 shiny-black above, brownish yellow below. This colour paler and more extended on the sides on 8 ; 9-10 pale bluish, with black articulations and a basal lateral black mark on the sides of 9.

Anal appendages : upper pair bluish-white above, darker below, stout at their base, narrowing to a point apically ; the lower, black beyond the base, pincer-shaped, touching each other apically.

♀ (Adult).

Differs from the male as follows :—

Prothorax yellow, with a narrow, longitudinal line of black mid-dorsally ; its posterior margin notched, median process projecting upwards and a little forwards.

Synthorax : the blue markings on the dorsum are less widely separated from one another than in the male, forming on either side almost a figure 8.

Abdomen : brownish-black, segment 8 paler, but dark at the base and dorsum ; 9 black, with an incomplete pale band on either side of the mid-dorsal carina.

Legs : pale, with a trace of a dark line on the posterior surface of the femora.

I think it very unlikely that these specimens should be conspecific. The account given above is translated from De Selys' description, and I have not been able to examine either of the specimens.

***Coeliccia borneensis* Selys.**

(Unknown to me.) *Type* from N. Borneo, in MacLachlan Coll.

Length of abdomen 30 mm. Hindwing 20 mm.

Described from a single female ; male unknown.

Venation : *Miii* arises from the subnodus, *Rs* distal to it ; 13 post-nodals in forewing.

Head : black, genae and anteclypeus yellow, a blue spot between the posterior ocellus and the eye, on either side.

Prothorax : black with a large blue spot on either side of the middle lobe.

Synthorax : dorsum black as far as the first lateral suture, with a (blue) antehumeral band, narrowing above and not reaching the antealar sinus. The rest of the sides and ventral surface pale yellow, with indications of a black line, incomplete below, on the second lateral suture.

Abdomen : black above, brownish-yellow below as is also the distal half of the eighth segment.

Legs : yellow, a black line on the posterior surfaces of the femora and on the anterior surfaces of the tibiae. Tarsi also black.

Posterior margin of prothorax forms two rounded lobes (the lappels), scarcely separated by a small indentation, in the middle of which lies a small tubercle (the median process).

This species appears to be quite distinct from any of the other described forms. It is distinguished by the small number of postnodal nerves, and by the colour pattern of the synthorax, as well as by the prothoracic margin.

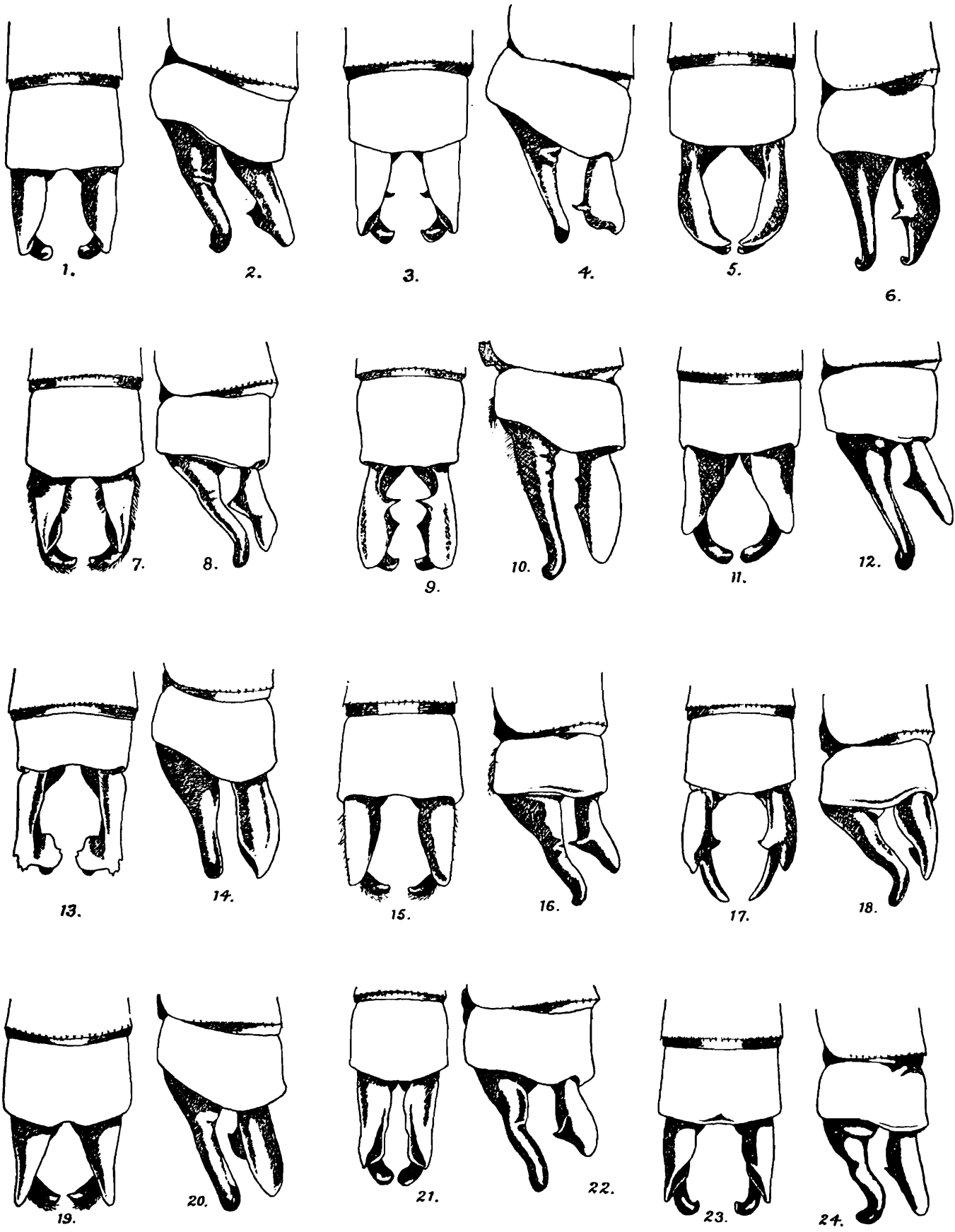
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EXPLANATION OF PLATE II.

Anal appendages viewed from the dorsum and right side.

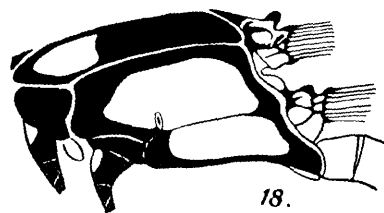
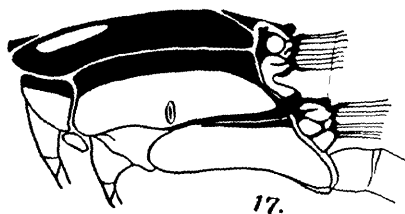
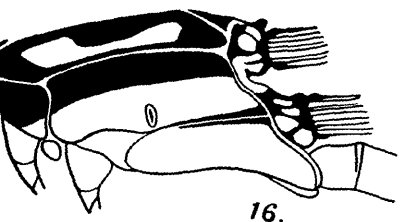
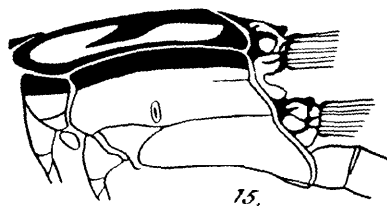
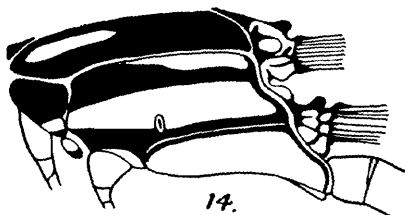
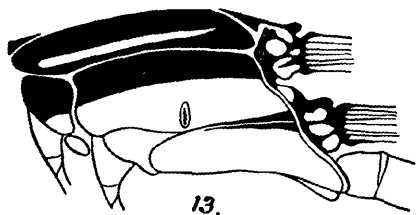
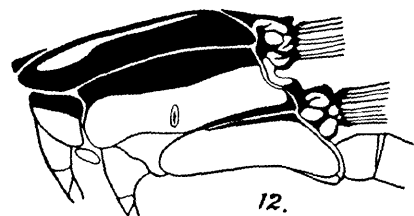
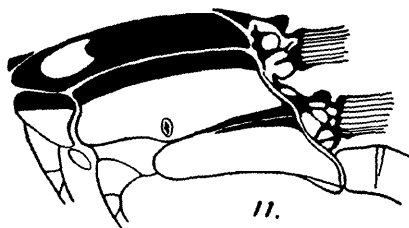
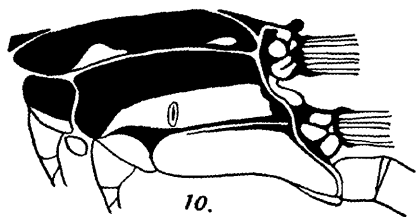
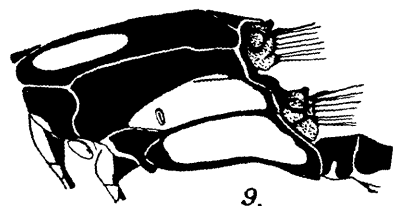
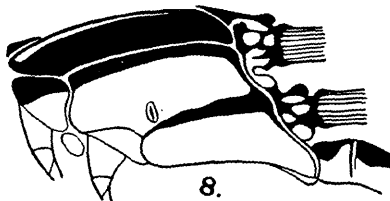
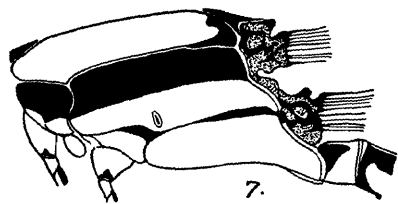
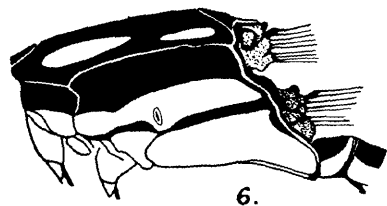
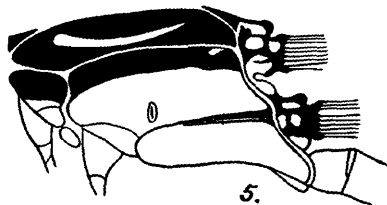
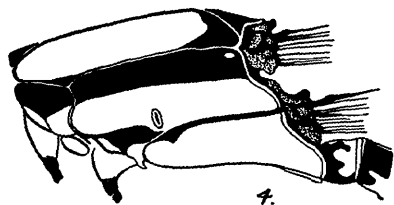
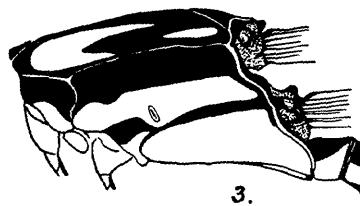
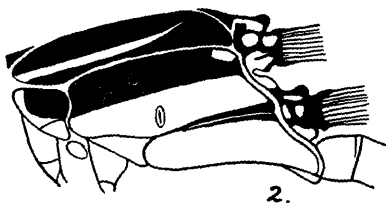
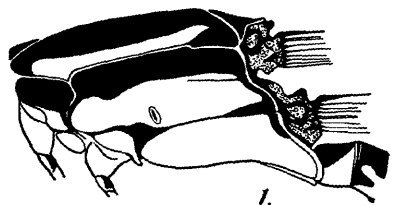
- FIGS. 1, 2.—*Coelicia erici* Laidlaw.
FIGS. 3, 4.—*Coelicia chromothorax* (Selys).
FIGS. 5, 6.—*Coelicia campioni* Laidlaw.
FIGS. 7, 8.—*Coelicia loringae*, sp. nov.
FIGS. 9, 10.—*Coelicia fraseri*, sp. nov.
FIGS. 11, 12.—*Coelicia renifera* Selys.
FIGS. 13, 14.—*Coelicia lieftincki*, sp. nov.
FIGS. 15, 16.—*Coelicia membranipes* (Ramb.).
FIGS. 17, 18.—*Coelicia loogali*, sp. nov.
FIGS. 19, 20.—*Coelicia flavicauda* Ris.
FIGS. 21, 22.—*Coelicia poungyi* Fraser.
FIGS. 23, 24.—*Coelicia albicauda* Förster.



EXPLANATION OF PLATE III.

Lateral view of thorax of :—

- FIG. 1.—*Coelliccia loogali*, sp. nov., ♂.
FIG. 2.—*Coelliccia lieftincki*, sp. nov., ♂.
FIG. 3.—*Coelliccia loringae*, sp. nov., ♂.
FIG. 4.—*Coelliccia poungyi* Fraser, ♂.
FIG. 5.—*Coelliccia campioni* Laidlaw, ♂.
FIG. 6.—*Coelliccia didyma* Selys, ♂.
FIG. 7.—*Coelliccia chromothorax* (Selys), ♂.
FIG. 8.—*Coelliccia fraseri*, sp. nov., ♂.
FIG. 9.—*Coelliccia renifera* Selys, ♂.
FIG. 10.—*Coelliccia albicauda* Förster, ♂.
FIG. 11.—*Coelliccia erici* Laidlaw, ♂.
FIG. 12.—*Coelliccia bimaculata* Laidlaw, ♀.
FIG. 13.—*Coelliccia membranipes* (Ramb.), ♂.
FIG. 14.—*Coelliccia flavicauda* Ris, ♂.
FIG. 15.—*Coelliccia nigrohamata* Laidlaw, ♂.
FIG. 16.—*Coelliccia nigrohamata* Laidlaw, ♀.
FIG. 17.—*Coelliccia bimaculata* Laidlaw, ♂.
FIG. 18.—*Coelliccia scutellum*, sp. nov., ♂.



ON A NEW GENUS AND SPECIES OF STREPSIPTERA.

By T. V SUBRAMANIAM, *Senior Assistant Entomologist, Department of Agriculture in Mysore, Bangalore.*

(Plate IV.)

While searching for stylopised Jassids on grass and other low vegetation, the writer happened to come across large numbers of a small, very active black cricket (*Tridactylus* sp.) commonly found in superficial tunnels and burrows in damp soil, especially along irrigation channels in orchards and kitchen gardens. Many of these crickets were found parasitised by a species of Strepsiptera and from the material collected a couple of males and a number of triungulins were reared out in Bangalore. Excepting a reference by Hofeneder (1) to a stylopised *Gryllotalpa* found by Voeltzkow in Wituland, Africa, nothing is on record of stylopised Gryllidae. It is not unlikely that more forms associated with these hosts may be found in India.

At the outset it was evident that it belonged to the super-family Halictophagoidea, Pierce, owing to the male having three-jointed tarsi, which is characteristic of this super-family. The super-family is divided by Pierce (4) in the following manner into two families.

Super-family Halictophagoidea, Pierce.

- | | |
|--|--------------------------|
| A. Male antennae four-jointed with flagellum of the third and the fourth joint elongate, sub-equal | Diozoceridae, Pierce. |
| B. Male antennae seven-jointed with the third, fourth, fifth and sixth joints laterally produced, and the seventh elongate | Halictophagidae, Pierce. |

This insect has seven joints in the antennae and therefore belongs to the family Halictophagidae. As regards the character of the antennal segments, however, the insect differs from all the species of Halictophagidae so far known, for they all have the third, fourth, fifth and sixth segments laterally produced. In this insect however only the third joint is so produced, the rest being normal.

The structure of the antennae in this insect is so unique that it cannot fit into either of the two families named above.

It may be necessary for the new species to be considered as the type of a new sub-family, but for the present I desist from taking this course. The erection of a separate genus for the reception of the new species seems to me, however, clearly indicated. I propose for it the name *Tridactylophagus*.

Tridactylophagus gen. nov.

Head very much excavated behind. Eyes large and reaching the base of the elytra. Antennae (Pl. IV, fig. 1) slender, elongate, seven-jointed, with sensory pits; third joint laterally produced and longer than the fourth and fifth; seventh joint about as long as the fifth and sixth, pointed at the distal end.

Pro-thorax (Pl. IV, fig. 7) conical, with an indentation at the apex, fitting into the excavated portion of the head. The two lower extremities of the prothorax produced at the sides to form a band.

Meso-thorax consisting of three transverse pieces.

Wings with seven primary veins, most of them broad and smoky in colour.

Oedeagus (Pl. IV, fig. 2) broad and sinuous near the base, obtusely flexed near the apex, with a very minute triangular piece attached to the curve at the outer angle.

Genotype : *Tridactylophagus mysorensis*, sp. nov.

***Tridactylophagus mysorensis*, sp. nov.**

Male : 2.04 mm. long. General colour smoky black, eyes and halteres piceous. Base of the scutellum and lower two-thirds of the postscutellum suffused with smoky black. Whole insect covered with fine hairs, and with a silvery bloom. Head large, as broad as thorax or slightly broader ; the facets of the eyes large and well separated with the interspaces hirsute. *Mandibles* large and triangular ; their bases very broad and apices constricted to a fine point which do not meet. *Maxillae* two-jointed, about two-thirds of the length of the mandibles ; the first joint stout, cylindrical, the second very tiny and more or less circular. The frontal portion of the head between the eyes—the portion comprising the epistome and the labrum of Perkins (3)—is highly chitinised and forms a pattern as shown in Pl. IV, fig. 3. The broad distal end of the fourth joint of the antennae with a circular sensorial organ (Pl. IV, fig. 1, *a*) more or less similar to the one described by Hofeneder (1) in *Mengenilla choubati*, by Ogloblin (2) in *Delphacixenos anamalocerus* and by the writer (5) in *Indexenos membraciphaga*.

I have reason to believe that these sensory organs are characteristic of the family *Halictophagidae* because of the fact that these are present in the males of several species reared out by me from different hosts, which have not yet been identified.

Mesonotum pre-scutum oval, with the base slightly arched. Scutum and scutellum broad, with the posterior angles produced to form a band. Halteres very long and ladle-shaped. *Metanotum* with the prescutum elongate, key-stone shaped, truncate at the posterior end and well separated from the scutellum. Scuta oblique, the basal portions of their outer angles lower than that of the prescutum and separated very slightly from the scutellum at their outer angles (Pl. IV, fig. 7). *Scutellum* broad, about as broad as the three pieces of the metanotum in the middle. The sides behind the outer angle of the scutii concave, anterior angles rectangular, the posterior very slightly produced upwards at the sides, the base sinuate and the apex arched (Pl. IV, fig. 7). *Post-scutellum* broad, elongate, much longer than prescutum, scutum and scutellum together (Pl. IV, fig. 7). *Abdomen* with the sixth, seventh and eighth segments drawn out to a point underneath, the last prolonged to over half the length of the ninth, the latter being produced very much beyond the tenth (Pl. IV, fig. 4).

Female.—Cephalothorax light brown, more less domeshaped, and very slightly longer than broad ; the edges dark brown and highly

chitinised ; the sides (Pl. IV, 5, *a* and *b*.) constricted at the base, diverging as far as the spiracles, near which there is a slight constriction, and gradually becoming narrow towards the mandibles which are stout and broad and possess one short stout tooth. Four genital tubes entering the brood canal.

Measurement of female.

(Taken with K.7 Zeiss micrometer ocular and A. A. objective, 1 division equals 0.015 mm.)

Length from base to vertex	0.41 mm.
Length from spiracles to vertex	0.32 mm.
Width at emargination at the base of mandibles	0.11 mm.
Width between spiracles	0.32 mm.
Width at base	0.30 mm.
Width at base of head	0.30 mm.

Described from two males bred from *Tridactylus* sp. in Bangalore, Mysore State, in June, 1927 and two females out of a number collected at Bangalore in June, 1927

Triungulins (Pl. IV, fig. 6). These are found to shoot out into space on emergence from the genital opening as described by the writer (5) in *Pyrillozenos compactus*. Only some stray ones are found crawling over the body of the host. Immediately on emergence, the triungulins are dark, with a very light yellowish tint, but the latter is lost after some time. They have a pair of spines, one on each side of the ten abdominal segments. The tenth segment ends in two long and two short stylets. On the ventral side of the ninth segment there are two long spines arising from a more or less triangular space in the middle and two small curved spines arising close to the base of the above. Short hairs are found arranged parallel to one another on the ventral portion of the abdominal segments and also a group of 5 or 6 closely-set hairs on the venter of the three thoracic plates. The triungulins are very active and can hop like typical Trypetid maggots.

The following are the measurements of the triungulins (fresh specimens mounted in glycerine).

Length excluding stylets	0.13 mm.
Length of stylets	0.05 mm.
Width of body at the broadest portion	0.08 mm.
Width of head	0.06 mm.

The writer wishes to acknowledge the encouragement and help he has received in this work from Dr. Leslie C. Coleman, the Director of Agriculture in Mysore, and Dr. K. Kunhikannan, the Entomologist.

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EXPLANATION OF PLATE IV.

***Tridactylophagus mysorensis*, gen. et. sp. nov.**

(All figures are very much enlarged. The drawings were all made with a camera lucida, excepting fig. 7.)

FIG. 1.—Antenna *a*. The position of the sensorial organ on the fourth antennal joint.

FIG. 2.—Oedeagus.

FIG. 3.—Front view of head of male.

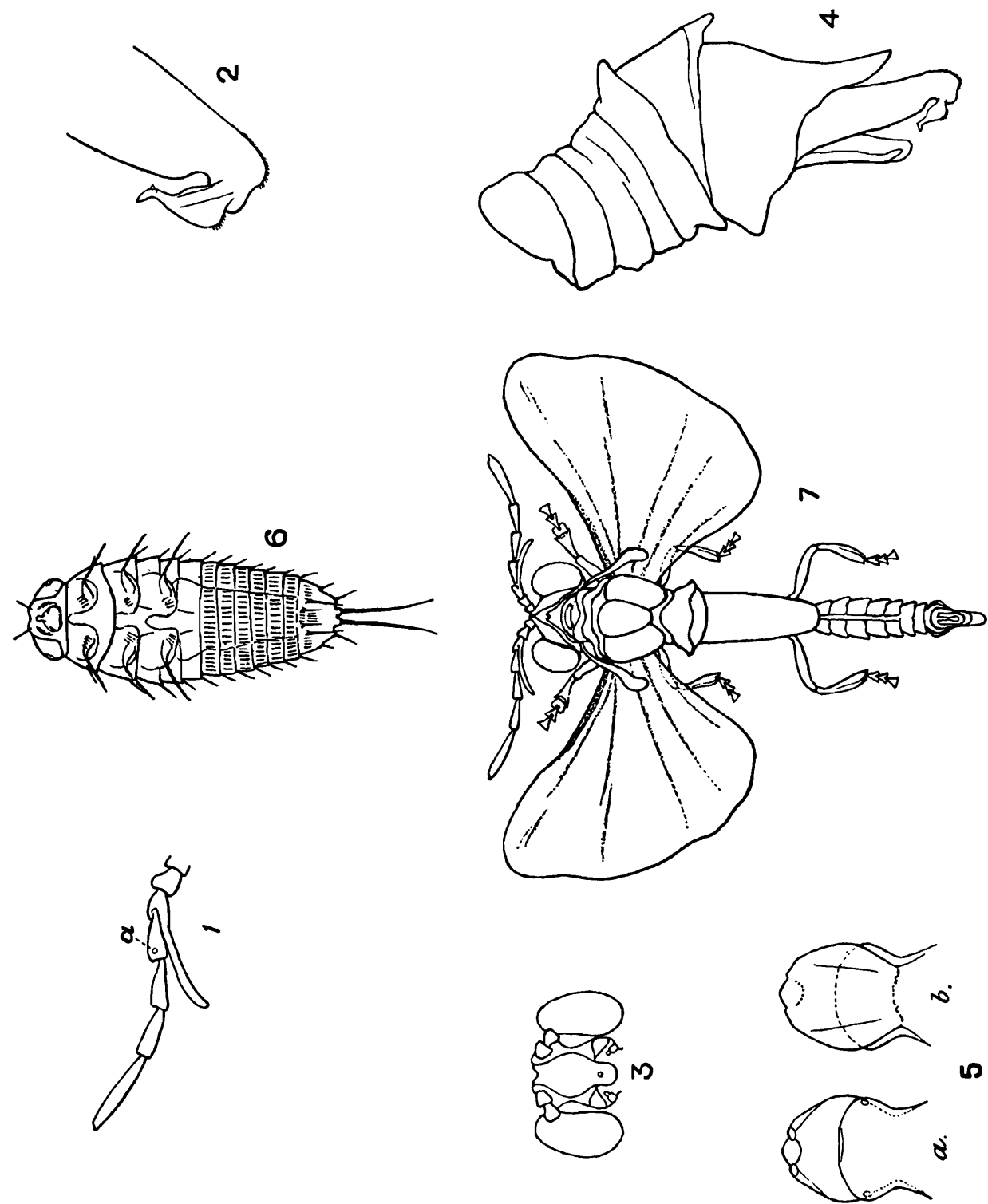
FIG. 4.—A few posterior segments of the abdomen.

FIG. 5.—*a*. Cephalothorax of female, ventral view.

b. „ „ „ dorsal view.

FIG. 6.—Triungulin.

FIG. 7.—Male, dorsal view.



Tridactylophagus mysorensis, gen. et. sp. nov.

DESCRIPTION OF A NEW SPECIES OF COLLEMBOLA AND ITS ANATOMY.

By DURGADAS MUKERJI, *University Lecturer in Zoology, Calcutta University.*

(Plates V-VII.)

INTRODUCTION.

A number of species of Collembola has been recorded from India by Parona (1893), Ritter (1910-11), Imms (1912), Carpenter (1917, 1924) and Handschin (1929). Owing to the difficulty of making a thorough collection of these minute insects, our knowledge of the Indian species of the group is far from complete. Moreover, the mouth-parts which are of considerable importance from the points of view of phylogeny and taxonomy, have received in the case of the Indian species, scanty attention, and a general account of the anatomy of the Indian species is lacking. Again, most of the authors who deal with the structure and function of the organs of those species of Collembola that occur outside India are at variance. For their various views, the works of the following authors, among others given in the bibliography at the end of this paper, may be referred to : Sommer (1884-85), Oudemans (1888), Folsom (1899), Willem (1900), Imms (1906), Hoffmann (1904, 1905, 1908, 1911), Philpitschenko (1906, 1908) and Denis (1928).

In the present paper a description of a new species of Collembola collected from Calcutta is given, together with an account of its anatomy. In dealing with the anatomy I have chiefly confined myself to descriptions of the digestive system and cephalic glands, as these offer considerable structural peculiarities.

I wish to acknowledge with thanks my indebtedness to Dr. G. W. Carpenter to whom the specimens were sent for confirmation of the identification, for his kind help and valuable suggestions. My best thanks are due to Lt.-Col. R. B. Seymour Sewell, Director of the Zoological Survey of India, Indian Museum and Dr. H. S. Pruthi of the Entomological Section, Indian Museum, for permitting me to examine the type specimens of Collembola preserved in the Indian Museum. It is a pleasure to record my thanks to Lt.-Col. Sewell for his ready help and advice.

Technique.

Live specimens of the species were observed under a binocular microscope and their habits were noted. For dissection of the mouth-parts, specimens were killed in hot water and treated with KOH solution. The dissected parts were either mounted in glycerine or stained in alcoholic eosin and mounted in canada balsam. For serial section cutting the following method, after trial, was found to be highly satisfactory. Fresh specimens were killed in hot 70 per cent alcohol containing 1 per cent acetic acid. They were then fixed in the following mixture.

Saturated solution of picric acid in 90 per cent alcohol 75 parts, formalin 25 parts, nitric acid 5 parts. Fixed material, after dehydration, was cleared in cedar wood oil, embedded in paraffin and serially cut. In a few cases the material after dehydration was cleared for a short time in clove oil and was infiltrated in the cold by celloidin dissolved in clove oil. The infiltrated specimens were then transferred to a thick drop of celloidin solution put on a cover slip previously coated with a thin layer of paraffin. This layer of paraffin, before the celloidin solution was dropped on it, was cross marked by a soft china glass pencil; the specimens were oriented under a binocular microscope. The celloidin mass containing the specimens was then solidified by dipping the cover slip into chloroform and later was re-embedded in paraffin. The pencil marking impressed on the celloidin mass could be seen through the thin coating of the paraffin block and indicated the position of the specimen. The double embedding in celloidin and paraffin was particularly advantageous for facilitating easy orientation of these minute insects during section cutting.

Sections were stained by Ehrlich's haematoxylin, and counter stained by alcoholic eosin, Heidenhain's iron haematoxylin, or Mallory's mixture (Säurefuchsin, Orange G. and Wasserblau). Mallory's stain, after slight modification of the concentration of the stain and a suitable adjustment of timings, yielded the best results.

Camera lucida drawings and microphotographs of typical sections were taken.

Family PODURIDAE Lbk.—Bör.

Sub-family ACHORUTINAE Bör.

Tribe ACHORUTINI Bör.

Genus **Protanura** Börner (1906).

This genus includes those Achorutini in which the maxillae have toothed apices and are provided with lamellae and basal lobes. The allied genus *Neanura*, which along with *Protanura* was included in the *Neanurinae* Börner (1901) but subsequently was transferred to the *Achorutinae* by Börner himself, differs from *Protanura* in having a maxilla that is pointed and is without any tooth or lamella.¹

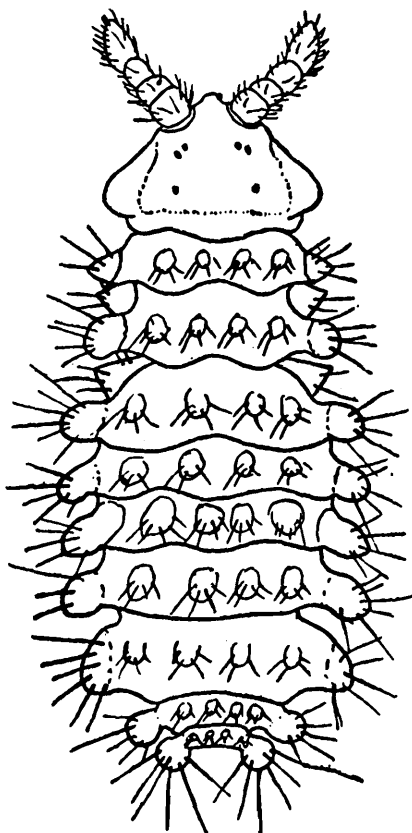
The number of species of *Protanura* and *Neanura* previously recorded from India, Burma and Ceylon is one and seven respectively. But since the mouth-parts of the majority of these species are not known, it is doubtful, as has been pointed out by Carpenter (1917), which of these described species are really referable to *Protanura* and which to *Neanura*.

¹ It is worth mentioning in this connection that *Neanura*, which Börner now calls *Achorutes*, was proposed by Macgillivray (1893) to replace the genus *Anoura* erected by Gervais (1842), as the latter generic name was preoccupied. *Achorutes* (Templ., 1835) and *Anoura* Gerv., (1842), however, as expounded by Tullberg (1871) in his monograph "*Sveriges Podurider*," are two different genera. The substitution of *Neanura* Macgillv., by *Achorutes* Templ., Bör., in accordance with Börner's classification, is, therefore, not without the danger of confusion and was contested by Carpenter (1916).

***Protanura carpenteri*, sp. nov.**

Length, 1.2 to 2.5 mm.

Head broader than long. Pigmented ocelli, three in number, on each side of the head; two of them close to each other, the third being placed towards the base of the head at a slight distance from them. Antennae, with antennal organ and sensory hairs, a little shorter than the head in length. The proportional lengths of the segments of the antenna are approximately 1.6 : 2 : 1 : 1.8. The segments of the trunk are approximately related to one another as 6 : 11 : 12 : 10 : 8 : 10 : 11 : 4 : 3.



TEXT-FIG. 1.—Dorsal view of *Protanura carpenteri*, sp., nov., $\times$ ca. 28.

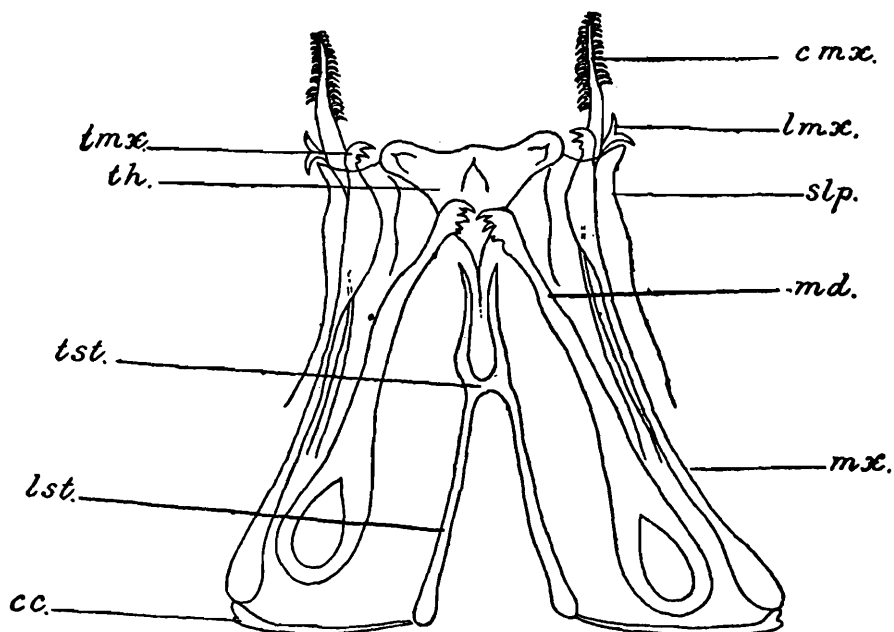
Tubercles carrying three or four sensory bristles present on the dorsal and lateral sides of the body. An additional pair of small ventro-lateral tubercles on the meso- and meta-thoracic segments. The tubercles of the last two abdominal segments well developed and lobed. Legs short, femur and tibia of the third leg subequal; superior claw without a tooth; lower claw vestigial.

Colouration deep red, but white when preserved in spirit. The species is gregarious in habit and occurs in Calcutta in shady and moist places. Examples of the species were also collected from other parts of Bengal under decaying vegetable leaves and leaf-stems of plantain trees.

The mouth-parts consist of labrum, labium, hypopharynx or tongue, mandible and maxilla. The detailed structure of the mandibles and maxillae, which offer certain specific peculiarities and are of advantage in discussing the affinities of the species, is best seen in dissected material previously treated with a solution of potassium hydroxide. The rest of the mouth-parts and their topographical positions with reference to the head and buccal cavity will be taken up, for the sake of convenience, when describing the digestive system.

The mandible (text-fig. 2 *md.*) is an elongated tubular chitinous structure, stout at the base and narrow at the apex. The apical region bears five teeth and may be designated the dental portion. The dental portion is slightly bent, its outer surface being convex and the inner concave. Four of the teeth are inserted on the concave side, and one tooth on the dorsal side. The apices of all these teeth are directed inwards and in dissected specimens are found to oppose, in the region of the tongue, members of the opposite side. The first tooth is curved inward. The second tooth, which arises from the dorsal side of the dental portion, is pointed. The third tooth is stouter and slightly smaller than the preceding ones. The fourth and fifth teeth are minute in size and are so close to each other that it appears as if they were united at their bases. The basal portion of the mandible runs back obliquely as far as the posterior third of the head and reaches the angle subtended by the cardo and stipes. It is hollow for the insertion of the muscles.

The maxilla (text-fig. 2 *mx.*) is a chitinous rod, a little longer than the mandible, and can be subdivided into two regions: an apical region carrying a toothed process, a comb-appendage and a lamella, and a basal region, called stipes, which constitutes the supporting stalk of the apical region. The toothed process is comparable to the galea described by Carpenter (1904, p. 303) in the case of *Protanura citronella* (Carpenter), and bears three teeth. The first tooth is sickle-shaped and pointed at its extremity. The second is conical and pointed. The third tooth, lying behind the second, is peculiar in being truncated and blunt. The



TEXT-FIG. 2.—Diagram of the mouth-parts: $\times ca. 112$. *cmx.*, comb-appendage of the maxilla; *cc.*, cardo; *lmx.*, lamella of the maxilla; *lst.*, lingual stalk; *md.*, mandible; *mx.*, maxilla; *slp.*, superlingua; *th.*, tongue; *tmx.*, toothed process of the maxilla; *tst.*, transverse bar joining the lingual stalk.

comb-appendage (text-fig. 2, *cmx.*) is composed of a tapering median axis with two rows of bristles forming a bipinnate structure. Sometimes the two rows of bristles are directed to one side and give the appearance of a brush. The axis itself is gently sinuate. The comb-appendage is comparable to the lacinia of *P. citronella* (Carpenter, 1904).

The apices of the maxillae anteriorly converge towards each other, while the stipes towards the posterior end are divergent. The base of the stipes is connected by a ligamentous joint with the outer end of the cardo. The cardo (text-fig. 2, *cc*) is a straight chitinous rod, lying transversely to the main axis of the body near the posterior region of the head, and corresponds to the articulare of *Neanura muscorum* (Templ.), depicted by Tullberg (1871). The outer end of the cardo nearly subtends an angle of 45° with the stipes with which it is joined. The inner end of the cardo is attached to the basal end of the lingual stalk (text-fig. 2, *lst*) and lies nearly perpendicular to it. The lingual stalk is a straight chitinous rod ending anteriorly in a sharp point. The terminal end of the lingual stalk converges towards its fellow of the opposite side and at about the junction of the middle and distal thirds of their length they are connected with each other by means of a transverse thin chitinous bar (text-fig. 2, *tst*). The portions of the stalks lying anterior to the transverse bar, support the base of the tongue (text-fig. 2, *th*) with which they are intimately connected. The lingual stalk corresponds to the 'fulcrum hypopharyngis' of *Neanura muscorum* (Templ.), described by Tullberg (*l.c.*), and is called the hypopharyngeal apodeme by Snodgrass (1928). It is interesting to note that Snodgrass (*l.c.*) holds that the hypopharyngeal apophyses of the Apterygota are the primary elements of the Pterygote tentorium, and the "Zungen-apparatus" is homologous with this structure (Prell, 1913). It is also worth noting that the lingual stalks resemble the lingual lorae of crustacea, which according to Crampton (1921) are the precursors of portions of the tentorium of insects.

The tentorium in Collembola has been reported as a distinct chitinous piece by Folsom (1899), Hoffmann (1905) and Denis (1928). The body of the tentorium in the present instance is best seen in a transverse section, lying between the oesophagus and the sub-oesophageal ganglia.

The mouth-parts of the present species, while agreeing in general with those of *Neanura muscorum* (Templ.), as given by Tullberg (1871), differ markedly from the latter in the presence of the teeth and the comb-appendage of the maxilla. They also differ in a similar way from those of *Neanura sexoculata* Carpenter (1916), which is recorded from Peradeniya (Ceylon) by Handschin (1928) under the name *Achorutes sexoculatus* (Carp.). *N. sexoculata* Carpenter possesses a maxilla with an acute apex and a single delicate process.

The present species can easily be distinguished from *Protanura spinifera* Carpenter (1917), collected from the North-East of Assam and Lower Burma, and also from *Protanura kraepelini* Börner (1906), obtained from Java, by the character of their mandibles and maxillae. In both *P. spinifera* and *P. kraepelini*, the mandible is provided with a delicate dorsal lamella beset with fine teeth, which is absent in the present case. The comb-appendage of the maxilla of *P. spinifera* has an inner row of bifid teeth, whereas in the present instance the comb-appendage is without any bifid teeth and has, instead, two rows of bristles forming a brush extended over one-third the length of the axis of the appendage. The maxilla of *P. kraepelini*, again, is without the lamella noted in the present species. Of all the species of Neanurinae, the present one, if

the structure of the maxilla be considered as the basis of comparison, comes nearer to *Protanura citronella* (Carpenter, 1904), reported from the Sandwich Islands. In both, the maxilla possesses a distinct toothed galea, a lacinia fringed with curved setae, and a lamella or basal lobe. The row of curved setae in the comb-appendage (lacinia) is, however, single in *P. citronella*, and is double in this species. The basal lobe in *P. citronella* is in the form of a conical palp, while in the present species it is bifid. So far as the mandible is concerned, the Hawaiian species *P. citronella* closely resembles *P. spinifera* and *P. kraepelini* and differs from the species under report in the details of the structure of the mandible. If the structural details of the mouth-parts are taken into consideration, this species is, in many respects, distinct from those previously described. It is also easily distinguished from the remaining Indian species of Neanurinae, whose mouth-parts are not known. It is separated from *N. dubiosa* Ritter (1910-11), collected from Peradeniya "under stone", by the pigmented eyes of the latter. It is also marked off from *N. corallina* Imms (1912), which it resembles, by the number of eyes. *N. corallina* Imms has two eyes on either side and is reported from Peradeniya (Ceylon). It also differs from *N. intermedia* Imms (1912) collected from Bhowali, Nainital district, in the number of eyes and in the presence of dorso-lateral protuberances of the body. *N. intermedia* Imms possesses two eyes on either side and lacks dorso-lateral protuberances of the body. From the description of *N. pudibunda* Imms (1912), which was found in the Khayen Caves near Moulmein, Lower Burma, the species under report seems to be allied to it, but is distinguished by its dorso-ventrally flattened body and by the absence of a tooth in the superior claw. *N. pudibunda* Imms, types of which I had the opportunity of examining, possesses a subcylindrical body and is without any lateral protuberance in the thorax. The species also differs from *Achorutes indicus* Handschin (1928), obtained from Dodabetta (Nilgiris), by the number and character of eyes. In *A. indicus* Handschin, the eyes are two in number on each side and are devoid of pigment. The species also differs from *Achorutes hirtellus* Börner (1906) reported by Handschin (1928) from Coonoor (Nilgiris) and Dodabetta (Nilgiris), by the character of the eyes, the structure of bristles on the body and the nature of the claw. In *A. hirtellus* Börner, the bristles are feathery, whereas in this case they are simple. It is important to note also that none of the known species of *Protanura* and *Neanura* hitherto recorded, have been from Bengal and the occurrence of the genus *Protanura* in Bengal is recorded here for the first time.

The Digestive System.

In the following account of the digestive system I have given, for the convenience of description, first, a brief outline of the head and its appendages, and then have passed on to the description of the alimentary canal. The topographic position of the mouth-parts, the structural peculiarity of which has already been referred to, is treated in connection with the buccal cavity which contains them. Glandular structures present in the head region have been dealt with under a separate heading, as their physiological activity in relation to the process of alimentation is controversial.

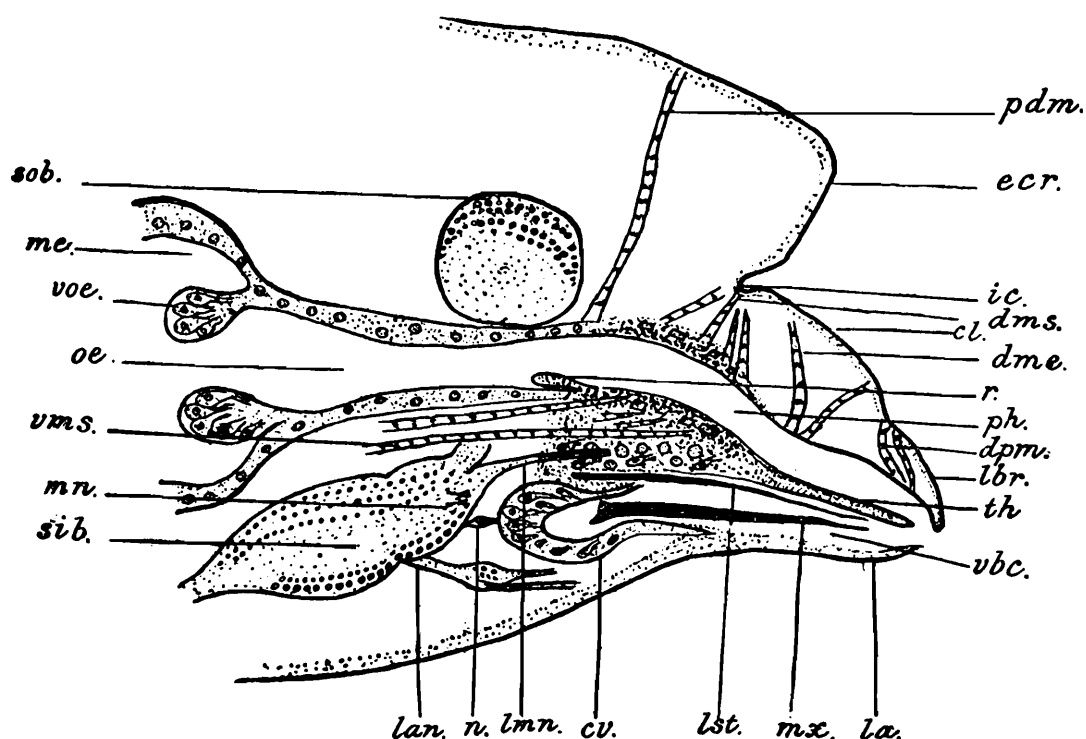
The head, as in other Collembola, is bounded above by the labrum and the clypeus, and below by the labium, and its sides are called by Denis (1928) "pli oral." The labrum is suspended from the lower edge of the clypeus and in sagittal section is seen to be drawn out anteriorly in the form of a beak (text-fig. 3). The labium is similarly drawn out beyond the head. By the meeting of the edges of these mouth-parts, projecting beyond and beneath the head, a kind of snout is formed. The external surface of the labrum bears sensory hairs. A transverse suture shows the line of junction of the clypeus and the labrum. The clypeus slopes upwards and posteriorly meets the epicranium of the head, its posterior limit being marked by a deep transverse suture formed by the infolding of the chitinous cuticle (text-fig. 3, *ic.*). The region in front of this transverse groove, according to Denis (1928), belongs to the gnathocephalon and may be called the frons or clypeo-frons. The ventral surface of the head is constituted by the labium. The labium not only retains its paired condition but anteriorly the members of the pair are distinctly separated from each other by the presence of a narrow median slit-like gap (pl. V, fig. 2, *mo*). The paired labial pieces carry setigerous protuberances, which are sensory in function. The setigerous portion corresponds to the "Kalaunteil" of Hoffmann. Folsom (1899) considers those portions of the labium, which are tactile in function, to be palpi, and according to Prell (1913) they represent the palpi as well as the external lobes. In the posterior region the labial pieces are fused with each other in the median plane and form the ventral wall of the head.

The alimentary canal is represented by a long cylindrical tube running more or less straight from mouth to anus, and giving off along the middle region of its course a few narrow and small diverticula. Three distinct regions can be recognised, namely the foregut, the midgut and the hindgut. The limits of these regions are easily made out by the differences in their widths, by the character of their epithelium and the presence of internal valves.

The foregut commences from the mouth and reaches the anterior region of the prothorax; the midgut extends from the prothorax to the third abdominal segment; and the hindgut commences from the posterior limit of the third abdominal segment and terminates at the anus. With regard to their relative lengths, the midgut is the longest, being about three times the length of the foregut, while the foregut and hindgut are nearly equal in length. The diameter of the digestive tube also varies in different regions; the midgut is the widest, while the hindgut is narrower than the foregut. The histological peculiarities of each of these regions of the alimentary canal are dealt with later.

The foregut, again, is, divisible from before backwards, into the buccal cavity, pharynx and oesophagus, owing to structural distinctions between them. With regard to the limits of these portions it may be stated that the buccal cavity, which represents the anterior end of the foregut, dorsally extends from the tip of the snout to the level of the middle region of the clypeus (text-fig. 3), while ventrally it reaches back nearly to the level of the junction of the pharynx and the oesophagus. The pharynx (Pl. V, fig. 1, *ph*), commencing from the posterior limit of

the epipharyngeal groove, slopes at first gently upwards, then curves down and finally, passing through the circum-oesophageal nerve connectives, is continued posteriorly as the oesophagus. The oesophagus (Pl. V, fig. 1, *oe*) comprises the portion of the foregut lying between the level of the fused supra-oesophageal ganglion and the midgut. The oesophagus widens as it passes backward to open into the midgut and at the point where it joins the midgut, forms a protrusion into the lumen of the latter, the rim of the projecting portion being thick and fringed with papillae. This projecting rim constitutes the oesophageal valve (text-fig. 3, *voe*), which guards the aperture of communication between



TEXT-FIG. 3.—A sagittal section of the head (diagrammatic): $\times$ ca. 274. *cl.*, clypeus; *cv.*, clump of sensory cells; *dme.*, dorsal dilator muscle of the epipharynx; *dms.*, dorsal muscle of the pharynx; *dpm.*, depressor muscle; *ecr.*, epicranium; *ic.*, chitinous infolding of the cuticle; *lbr.*, labrum; *lst.*, lingual stalk; *la.*, labium; *lmn.*, lingual nerve; *lan.*, labial nerve; *me.*, midgut; *mn.*, mandibular nerve; *mx.*, maxilla; *n.*, nerve joining the sensory cells with the suboesophageal ganglion; *oe.*, oesophagus; *pdm.*, postero-dorsal dilator muscle of the pharynx; *r.*, ridge of the pharynx; *ph.*, pharynx; *sob.*, supraoesophageal ganglion; *sib.*, suboesophageal ganglion; *th.*, lingua; *vbc.*, ventral chamber of the buccal cavity; *voe.*, oesophageal valve; *vms.*, ventral dilator muscle of the pharynx.

the foregut and the midgut. The valve consists of cells whose body, as pointed out by Sommer (1884), is drawn out in the form of a flask with a long neck and a broad base. The base contains the nucleus and projects into the lumen of the midgut. A thin delicate membrane, which is continuous with the lining intima of the oesophagus, covers these valves.

Having given above the limits of the different regions of the foregut I now pass on to the composition of the mouth and the buccal cavity, and give in that connection histological peculiarities of the different sub-regions of the foregut indicated above.

The mouth, as in *Neanurina*, is produced, cone-like, beneath the head, giving rise to the formation of a short snout, reference to the composition of which has already been made. The mouth leads into the buccal cavity.

The buccal cavity (Pl. V, fig. 2) occupies a large part of the inside of the head and is separated from the haemocoelic cavity, dorso-medially by the epipharynx and dorso-laterally by ligaments that are hypodermal in origin. It is capacious and is divided by the tongue or hypopharynx into an upper or dorsal and a lower or ventral chamber (Pl. V, fig. 3). The dorsal chamber of the cavity is occupied by the epipharyngeal groove (Pl. V, fig. 2, *epr*) and the ventral chamber contains the mandibles, maxillae and lingual stalks whose apices support the medial portion of the tongue (text-fig. 3). The upper and lower portions of the buccal cavity, though sharply marked off from each other in the region of the head, are confluent with each other at the tip of the snout. The upper portion of the buccal cavity, which can be identified with the epipharyngeal groove, leads into the pharynx, which is continued posteriorly as the oesophagus to open into the midgut. The nutriment taken into the mouth with the help of the mandibles and maxillae passes along the passage leading from the dorsal chamber of the buccal cavity to the midgut. The whole of this passage is situated above the ventral chamber of the buccal cavity and constitutes the food-channel (Pl. V, fig. 1).

The epipharyngeal groove is bounded above by the epipharynx and below by the dorsal surface of the free portion of the tongue. The epipharynx (Pl. V, fig. 2, *eph*) is a thin chitinous membrane continuous at the tip of the snout with the clypeus, that forms the roof of the epipharyngeal groove : in this species it is peculiar in not being provided with teeth in its anterior region. Posteriorly it reaches the level of the middle region of the clypeus, and there merges into the roof of the pharynx. The epipharyngeal groove is narrow at its anterior end and gradually widens posteriorly. In cross section the groove (Pl. V, fig. 3) is dorso-ventrally compressed. The lining membrane of its lumen is chitinous in nature and when examined under a high power reveals fine striations. Anteriorly the epipharyngeal groove and the ventral chamber of the buccal cavity are continuous around the sides of the tongue and it thus receives the apices of the mandibles (Pl. V, fig. 2). The epipharynx gradually merges into the roof of the pharynx, and it is thus difficult to draw a sharp line of demarcation between them ; but the two regions can to a certain extent be distinguished by the character of their linings and by the arrangement of their musculature. In general it may be stated that the protoplasm of the lining membrane of the pharynx is granular and contains distinct nuclei, whereas, in the case of the epipharynx, which is chitinous in nature, nuclei could not be made out, specially in the anterior region.

Distinction can also be made in a similar way by the character of linings between the pharynx and the oesophagus which follows it. The walls of the pharynx and the oesophagus consist of three layers, as described by Imms (1906) in the *Anurida*. The chitinous intima forms the innermost layer, the middle layer is represented by an epithelium, and the outer by a muscular ring. Imms remarks, however, in this connection that it is uncertain whether the epithelial layer spoken of here is composed of true epithelium or not. The character of the epithelial layer of the pharynx and the oesophagus is as follows : in the

anterior region of the pharynx the cytoplasm of the epithelial layer is granular and completely fills up the space between the inner chitinous intima and the outer ring musculature, the cell outlines being indistinct (text-fig. 4, *ph*). In the region of the pharynx lying immediately in front of the supra-oesophageal ganglion the cytoplasm of the epithelial layer, however, shrinks, so as to leave a space between the chitinous intima and the ring musculature. The protoplasm is reticulated in appearance, and contains nuclei. In the region where the base of the tongue is intimately fused with the ventral wall of the pharynx, the floor of the pharynx is peculiar in being thickened and raised in the form of a broad ridge that projects backwards into the lumen of the pharynx (text-fig. 3, *r*). This protruding ridge has also been noted by Hoffmann (1905) in the case of *Tomocerus*. The ventral area of this region of the pharynx contains a number of flask-shaped cells having large nuclei. I am not certain whether these are sensory or glandular cells. In the oesophagus the epithelial layer occupies the whole of the area between the chitinous intima and the ring musculature; its cytoplasm is distinctly reticulated and the nuclei are prominent. The lumen of the oesophagus (Pl. V, fig. 5, *oe*), when cut transversely, is more or less circular, whereas that of the pharynx and the epipharynx is elliptic in contour.

With regard to the musculature it may be recalled that a layer of circular muscles surrounds the epithelial wall of the pharynx and oesophagus in the form of a ring. This ring-musculature is absent in the region of the epipharyngeal groove: but towards the posterior end of the groove, near its junction with the pharynx, two sectors of circular muscles are found above the lining membrane of the epipharyngeal groove (Pl. V, fig. 3).

The disposition of the radial muscles serves also to distinguish the epipharyngeal groove from the pharynx. The epipharyngeal groove is supplied with a single set of radial muscles dorsal in position to the alimentary canal. The pharynx on the other hand is supplied with two sets of radial muscles; one set, dorsal, inserted into its roof and the other, ventral, attached to its floor. The arrangement of these radial muscles is clearly brought out in the sagittal sections of the head region.

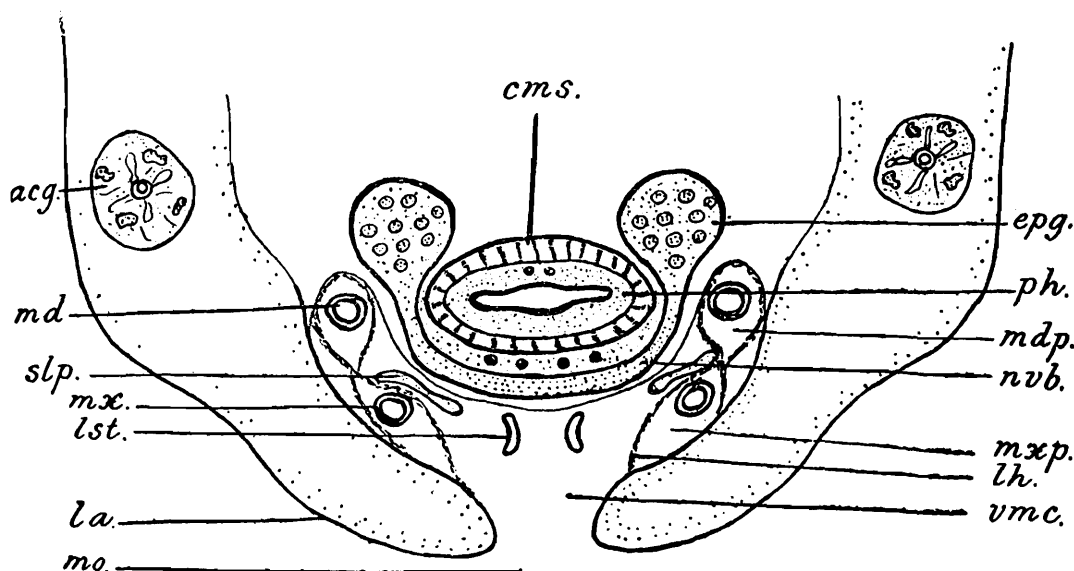
In text-fig. 3, a pair of radial muscles is seen inserted into the anterior end of the epipharynx. This pair slopes backwards and is attached to the labrum at its junction with the clypeus. This pair of muscles (text-fig. 3, *dpm*) is called by Hoffmann (1905) in *Tomocerus plumbeus* (L.), the depressor of the labrum, since by pulling on the labrum it brings about the closure of the lumen of the epipharyngeal groove. Posterior to the point of insertion of this muscle other longitudinal muscles occur. These are termed by Hoffmann (*loc. cit.*) dilators of the epipharynx (text-fig. 3, *dme*), as they help in widening the lumen of the epipharyngeal groove. According to the direction and point of attachment, these dilator muscles of the epipharynx can be grouped into two series. The first series includes the anterior muscles which are directed forward to be attached to the inner surface of the clypeus, while the second series comprises the posterior muscles that run obliquely backward to join the chitinous infolding of the head at the posterior limit of the clypeus. The dorsal set of radial muscles of the pharynx (text-fig. 3, *dms*) can

similarly be grouped into two series : an anterior series composed of more than eight longitudinal muscles, arising from the dorsal surface of the pharynx and converging to be attached to the chitinous infolding of the roof of the head and a posterior series (text-fig. 3, *pdm*) represented by one or two longitudinal muscles that are inserted into the pharynx close to the supra-oesophageal ganglion and pass up to be attached to the epicranium of the head. The ventral set of radial muscles of the pharynx (Pl. V, fig. 1; text-fig. 3, *vms*), supplying its floor, pursues a slanting course more or less parallel to the longitudinal axis of the oesophagus and is attached to the tentorium. The ventral wall of the pharynx at the place of insertion of the ventral set of radial muscles shows considerable thickening and contains nuclei of large dimensions, evidently of sensory cells : such a thickening does not occur on the ventral side of the epipharyngeal groove or of the oesophagus. The radial muscles are distinctly striated transversely and are directly inserted into the chitinous intima lining the lumen of the foregut. The radial sets of muscles of the pharynx by their contraction widen the cavity of the pharynx and are known as dilators of the pharynx. It is interesting to note also that a dorsal set of radial muscles, such as is present in the pharynx, does not occur in the region of the oesophagus, which can thus easily be distinguished from the pharyngeal region, which is richly supplied with both dorsal and ventral dilator muscles.

The ventral chamber of the buccal cavity is more capacious than the dorsal chamber and lodges the mandibles, maxillae, hypopharynx and the lingual stalks (Pl. V, fig. 3 ; Pl. VI, fig. 1). The disposition of the ventral chamber with reference to the enclosed mouth-parts, however, varies considerably as we pass from the tip of the snout to basal region of the head.

The tongue, or hypopharynx as Denis calls it (1929, p. 16), separates the dorsal chamber from the ventral one (Pl. V, figs. 2, 3). It is composed of a median part known as lingua and two lateral lobes termed superlinguae (Pl. V, fig. 2, *slp*). These lobes have been homologised by Crampton (1921) with the paragnaths of Crustacea and since the terms paraglossae and maxillulae are undesirable, the term superlinguae employed by Folsom (1899) has been applied to them, in accordance with the suggestion made by Denis (1928) and Imms (1925). The lingua (text-fig. 3, *th*) in a sagittal section is seen to extend as a chitinous shelf within the buccal cavity and forms the floor of the epipharyngeal groove and part of the pharynx. The base of the lingua is fused with the ventral wall of the pharynx and its apical region is supported on the terminal parts of the lingual stalks. The posterior portion of the lingual stalk slopes down as it passes below the ventral wall of the pharynx (text-fig. 3 ; Pl. V, fig. 1). The position of the lateral lobes of the tongue varies somewhat in different regions of the head. In Pl. V, fig. 2 of a transverse section through the snout, the sides and partially the floor also of the buccal cavity are seen to be bounded by the labial pieces (*la*). The lateral lobes (*slp*) of the tongue are here seen together with the median lobe or lingua (*th*), separating the buccal cavity into the upper and lower chambers, as mentioned above. The median portion of the upper chamber represents the epipharyngeal groove (*epr*) which is in communi-

cation with the lateral pouches containing the mandibles (*md*). It is for this reason that the mandibles are seen in this figure to lie inside the



TEXT-FIG. 4.—A transverse section of the head through the anterior region of the pharynx, (diagrammatic). (Upper half not shown in the figure): $\times$ ca. 225. *acg.*, acinose gland; *cms.*, circular layer of muscle; *epg.*, epipharyngeal ganglion; *lh.*, hypodermal ligament; *la.*, labium; *lst.*, lingual stalk; *md.*, mandible; *mx.*, maxilla; *mdp.*, mandibular pocket; *mxp.*, maxillary pocket; *mo.*, median gap in the labium; *ph.*, pharynx; *nrb.*, nerve band; *slp.*, superlingua; *vmc.*, median portion of the ventral chamber of the buccal cavity.

superlinguae (*slp*), which are bent inward in the form of a L. The cut portions of the lingual stalks (*lst*) lie immediately below the medial portion of the tongue, flanked on the sides by the inner ends of the superlinguae. The maxillae (*mx*) are found to lie just below the horizontal limbs of the superlinguae and a little away from the lingual stalks. The configuration of the lateral lobes of the tongue changes, however, as we pass towards the posterior end of the head. In text-fig. 4 the lateral lobes of the tongue are seen as chitinous transverse bars imperfectly dividing the ventral chamber of the buccal cavity into upper and lower halves. In the section figured in Pl. V, fig. 3 the epipharyngeal groove is shut off completely from the lateral pouches containing the mandibles, as well as from the medial portion of the ventral chamber. The superlinguae appear as stumps flanking the medial portion of the ventral wall of the epipharynx. In dissected specimens (text-fig. 2, *slp*) the lateral lobes of the tongue are found as chitinous plates slightly rolled into an imperfect tube through which the maxillae are seen to pass: they closely resemble the maxillulae of *Protanura spinifera*, Carpenter (1907) and *Protanura citronella* Carpenter (1904).

It is clear from the study of these transverse sections that the anterior region of the ventral chamber of the buccal cavity is somewhat different from its posterior portion. In Pl. V, fig. 3, the anterior region of the mid-portion of the ventral chamber of the buccal cavity lies below the epipharyngeal groove. In the posterior region, however, the ventral chamber (Pl. VI, fig. 1, *vmc*) gives off two dorso-lateral evaginations forming two pouches, one on either side of the food-channel. These pouches enclose the basal portions of mandibles and maxillae. These

pouches again are divided imperfectly by means of ligaments (text-fig. 4, *lh*) into upper and lower halves, the upper half containing the bases of mandibles and the lower half those of maxillae. The pouches containing mandibles and maxillae have been described by Denis (1928, p. 14) as "pouche mandibulaire" and "pouche maxillaire" respectively.

The lateral pouches (Pl. V, fig. 4, *lbc*) extend back as far as the level of the anterior end of the supra-oesophageal ganglion and are separated from each other at their posterior limit by means of a broad partition composed of cells, which seem to be glandular in nature (Pl. V, fig. 4, *mcp*).

The buccal cavity is comparable to the 'Mündhöhle' of *Tomocerus plumbeus* (L.), described by Hoffmann (1906, 1908) and resembles, to a certain extent, the atrial cavity defined by Denis (1928-29, p. 13). It corresponds also to the pre-oral cavity of a generalised insect as depicted by Snodgrass (1928, p. 48, fig. 19). Snodgrass' figure, however, refers to an insect having mouth-parts of an ectognathous type, while in the present instance the mouth-parts are concealed within the head as in other species of Collembola. Folsom (1899) and Imms (1906) have called the anterior end of the foregut, that encloses the mouth-parts, the pharynx, and the remaining portion of the foregut the oesophagus. Sommer (1884-85), however, divides the foregut of *Macrotoma plumbea* L., excluding, it seems to me, the portion called by me the buccal cavity, into the pharynx (Schlund) and the oesophagus on account of the differences of musculature along the length of the foregut. It seems, therefore, that the portion of the foregut called pharynx by Sommer really corresponds to the anterior portion of the part designated oesophagus by Folsom and Imms. In the present instance the buccal cavity enclosing the mouth-parts is quite distinct from the remainder of the stomodaeum which is distinguishable into two distinct regions, the pharynx and the oesophagus. The employment of the term pharynx to denote the buccal cavity, enclosing the mouth-parts, and in addition the anterior portion of the oesophagus, seems to be confusing. I have therefore adopted the term buccal cavity, first employed by Fernald (1890), to indicate the mouth-cavity, enclosing the mouth-parts, and have, restricted the term pharynx to the anterior portion of the foregut lying between the buccal cavity and the oesophagus. The histological differentiation and the method of formation of the box-like cavity enclosing the mouth-parts by the fusion of the fundaments of labium and labrum with the lateral evaginations of the facial region in the embryo, as mentioned by Imms (1906), justify also the employment of the terms used here. Tullberg (1871) first described the epipharynx in Collembola. The term epipharyngeal groove has been adopted from Hoffmann (1905, pp. 643-646) who called it "epipharyngeal Rinne". It should be noted, however, that the epipharyngeal groove described by Hoffmann contained chitinous hooks which in this instance are wholly absent.

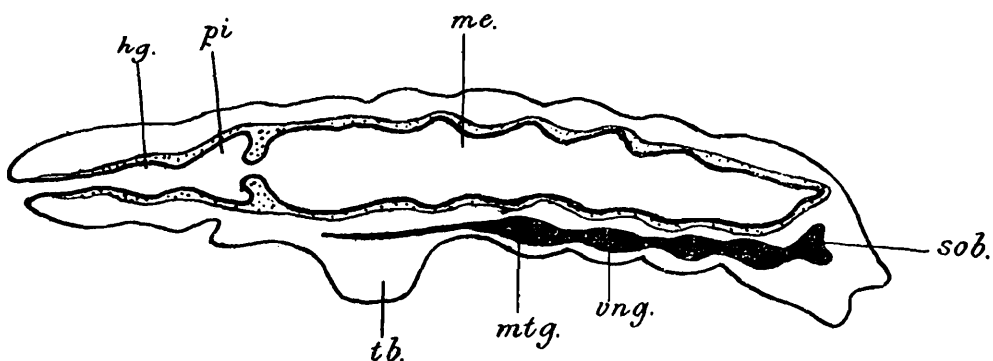
The midgut is cylindrical in form and its limits have already been mentioned. In specimens mounted whole in canada balsam, the midgut becomes sufficiently transparent to allow the granular food matter contained in it to be seen. The wall of the midgut consists of an epithelium (Pl. VII, fig. 3, *mcp*) resting externally on a tunica propria and

surrounded by a muscular coating, as in the case of *Anurida* described by Imms (1906). The external muscular coat is formed by a system of circular and longitudinal muscle fibres. The epithelial layer is composed of cubical cells with distinct nuclei. The boundaries of the epithelial cells are clear; but distinctness of these cells, as pointed out by Imms (1906), depends largely upon the particular phase of the physiological activity of the digestive system. In some of my preparations the protoplasm of these cells is found aggregated in the form of a granular heap toward the lumen of the gut. In some the internal free edge exhibits fine striations recalling the "Harschensaum" or ciliated band which Fernald (1890, p. 439) believes to be produced as a result of poor fixation. The protoplasm either in the middle or peripheral zone of these cells is vacuolated. Embedded in the peripheral zone of the epithelial layer, are found small vesicles deeply stained like the nuclei, which occupy a more central position. Imms (1906) mentions these vesicles as chromatic particles of unknown function. In my sections these granules closely resemble nuclei in structure with this difference, that they are smaller in size. The cytoplasm around them is also marked off from that around the nuclei. In view, however, of the fact that no selective cytological reagent was employed in order to test the nature of these vesicles, it is impossible to say whether they are to be regarded as chromatic particles or true nuclei. After examining a number of sections differently stained, I am, however, inclined to believe that these particles are nuclear in nature and that the epithelium surrounding the lumen of the midgut is possibly, therefore, composed of two layers.

In the thoracic region the midgut gives off laterally a number of shallow diverticula (text-fig. 5). Similar thoracic diverticula have been recorded in the case of *Neanura muscorum* by Tullberg (1871) and Willem (1900). Since these diverticula are not known to occur in other subfamilies of Collembola it is possible that they represent a character peculiar to the Neanurinae. The wall of these diverticula is similar in composition to that of the midgut. In addition to these diverticula, a pair is given off that is directed forward and runs into the head (Pl. VI, fig. 8, *dve*). Such a pair has not, so far, been recorded as occurring in the head region of Collembola, and from their peculiar position in the body I have termed them "cephalic diverticula." Their origin from the midgut is interesting. The anterior end of the midgut, on account of the inclination of the axis of the oesophagus to that of the midgut, presents on its dorsal side a median sac-like cavity projecting a little forward beyond the line of junction of the two regions: a similar cavity has also been noted by Sommer and also by Fernald (*loc. cit.*). The cephalic diverticula (Pl. VI, fig. 2, *dve*) arise from this dorsal cavity, one on either side of the oesophageal valve, and extend nearly as far as the posterior limit of the supra-oesophageal ganglion. Their method of origin and their relation to the oesophageal valves are clearly seen in transverse sections through this region. Near their origin, these diverticula lie close to each other, so much so that their medial walls are confluent with each other: as they pass forward, they diverge and lie above the plane of the oesophagus, one on each side (Pl. V, fig. 5, *dve*). Their diameter is wider than that of the oesophagus but narrower than the

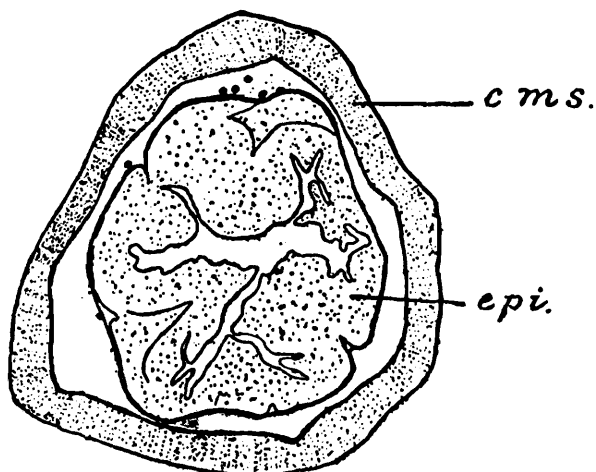
lumen of the midgut. The wall of the cephalic diverticula is closely similar in composition to that of the midgut, being formed of a thick epithelium: the nuclei of the epithelial cells are distinct and the cytoplasm is reticulated; the inner zone of the epithelium is thicker in comparison with that of the midgut proper and shows fine striations when examined under the high power. These cephalic diverticula bear some resemblance to the anterior caeca of *Petrobius*, described by Oudemann (1888), and it is possible that they are homologous organs: it is, however, equally possible that they may be an example of parallelism in evolution. It would be premature, therefore, to say whether the presence of these organs has any bearing on the question of the affinities of Thysanura and Collembola.

The hindgut extends, as already mentioned, from the third abdominal segment to the anus; it is separated from the midgut by means of valves projecting inwards (text-fig. 5). Immediately posterior to the



TEXT-FIG. 5.—A sagittal section through the body (diagrammatic): $\times$ ca. 38. *hg.* hindgut; *me.*, midgut; *mtg.*, metathoracic ganglion; *pi.*, tubular pocket of the hindgut; *sob.*, supra-oesophageal ganglion; *vng.*, ventral nerve cord; *tb.*, ventral tube.

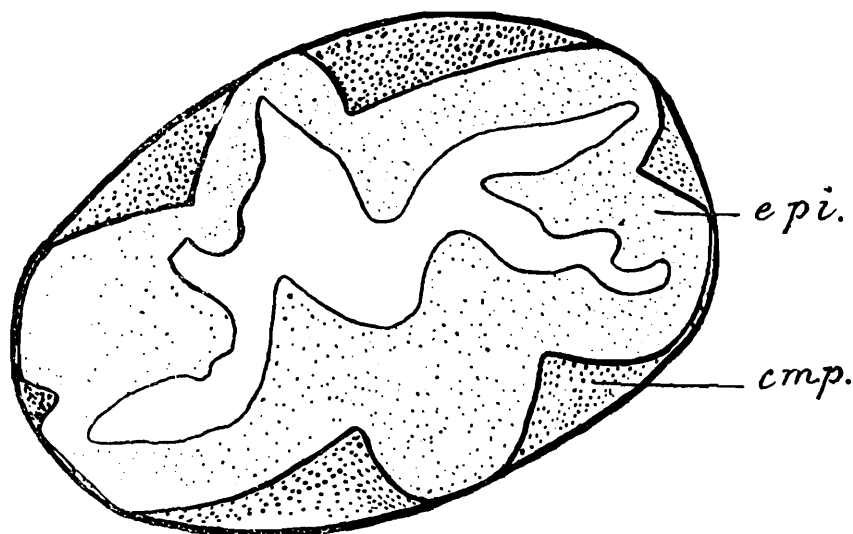
valves and at the commencement of the hindgut the lumen of the digestive tube suddenly widens out to form a small pocket-like cavity (text-fig. 5, *pi*). The rest of the lumen of the hindgut is not uniform along its length. Along the whole of the length of the hindgut the epithelial layer surrounding the lumen is granular and is without distinct cell



TEXT-FIG. 6.—A transverse section through the middle region of the hindgut: $\times$ ca. 466. *cms.*, circular layer of muscles; *epi.*, epithelium of the intestine.

boundaries. The chitinous intima lining its lumen is, comparatively speaking, well developed and in the anterior region lies closely applied

to the epithelial layer : in the anal region, however, it lies detached from the epithelial lining, leaving a narrow space between them. This detachment of the intima from the epithelial membrane may, however, have been caused by fixation or be due to moulting. The muscular coat, external to the epithelial layer, varies in thickness in different regions of the hindgut : in the anterior region the muscular ring is thin and is in close contact with the epithelial layer ; but towards the posterior end, this ring musculature gains in thickness and in the middle portion of the hindgut forms a broad circular band (text-fig. 5, *cms*) that completely surrounds the gut ; but a large clear space intervenes between the inner limits of the muscle ring and the basement membrane of the epithelial layer. The space thus enclosed communicates freely with the haemocoelic cavity of the body : Imms reports the presence of blood corpuscles in this intervening space. Sommer working on *Macrotoma plumbea* describes a similar cavity in the region of the rectum and hints at its respiratory function, as it is filled with blood. I have noted several granules in this space but I do not find any blood corpuscles in it. The physiological significance of this space is, therefore, obscure ; it is possible, however, that it is a mechanical contrivance for the expansion of the hindgut when choked with contents. Towards the posterior end of the hindgut, in the region of the rectum, the muscles are arranged in six longitudinal bands that come into direct contact with the peripheral zone of the epithelial layer and in transverse sections through the anal region, form a series of six projections into the lumen. These projections are conical in shape and small in size (text-fig. 7, *cmp*). Radial muscles, called ' *dilatores recti* ' and ' *dilatores ani* ' occur in the rectum, as described by Imms (1906) in *Anurida*.



TEXT-FIG. 7.—A transverse section through the posterior region of the hindgut : $\times$ ca. 533. *cmp.*, muscular projections ; *epi.*, epithelium of the rectum.

The nature of the epithelial layer of the hindgut, varies somewhat along its length. In the anterior region the cell-boundaries of the epithelial layer are indistinct and the protoplasm of the cells is granular and vacuolated : the chitinous lining is very thin and the cytoplasm of the epithelial layer from its inner surface sends up irregular processes into the lumen. Near the middle region, where the ring musculature is prominent, the epithelial layer and the chitinous intima are thrown

into folds and ridges (text-fig. 6, *epi*) and, as a result, the lumen of the hindgut in this region becomes irregular. In the region of the rectum the epithelial layer, as already mentioned, projects into the lumen of the gut in the form of conical processes, the protoplasm is granular and without cell-boundaries, and in my sections nuclei cannot be detected.

From the nature of the mouth-parts and the buccal cavity, the mouth can be regarded as a sucking apparatus. Willem (1900) in the case of *Neanura* (Gerv.) considers the buccal cavity to be adapted for sucking and the tongue, which he terms the ligula, as playing the role of a piston within the buccal cavity. The mandibles and maxillae are considered by him to be perforating organs. As the mandibles in the present instance, are provided with teeth I am of the opinion that the mandibles cut the soft woody tissues and the maxillae help in seizing and bringing food into the mouth by means of the feathery appendage and toothed lamellae attached at their ends. It may be pointed out that in live specimens the maxillae are protruded out beyond the oral aperture, and their purpose may, therefore, be to draw food into the buccal cavity and reduce it to pulp, so as to help in the suction of the juice. The dilatation of the buccal cavity and the pharynx by means of muscles will further help in the suction of food. In order to ascertain the nature of their food I kept examples in the laboratory in large, open vessels filled with earth, dug from the neighbourhood of a tank and periodically moistened with water. Individuals were kept alive for weeks together, although no food was added. Apparently they lived on the organic vegetable matter contained in the soil. According to Macnamara (1924) the Collembola fall into three categories, *viz.*, (i) vegetable feeders, (ii) carnivorous, and (iii) those that live on a liquid diet. Species depending on a vegetable diet possess mandibles provided with a molar surface. In the present instance the mandibles do not possess a molar surface and individuals have not been observed in the field either feeding on animal matter or present in the neighbourhood of a carcass. Further, Macnamara (1924, p. 99) observes "the suctorial species seem to find an innocent nourishment in the fluids of rotting wood and fungi" I presume, therefore, that this species chiefly lives on vegetable nutriment, rich in juice.

The Nervous System.

The nervous system is built on the same plan as that of *Podura aquatica* (L.), described by Willem (1900) and also differs but little, except in details from that of other examples of the Collembola investigated by Folsom (1889), Willem (1900), Imms (1906), Hoffmann (1908), Hilton (1913) and Denis (1928). It consists of the supra-oesophageal ganglion, the suboesophageal ganglion and the nerve cord comprised of three thoracic ganglia (text-fig. 5). These ganglia usually occur in insects in pairs, but in this species the members of each pair are so intimately fused with each other that they appear as a single ganglion (Pl. V, fig. 4, *sob*).

The supra-oesophageal ganglion (text-fig. 3, *sob*), formed by the fusion of proto-, deuto- and trito cerebral lobes, gives off paired nerves to the ocelli, antennae and labrum. The labral nerve trunk originates from the supra-oesophageal ganglion near the junction of the latter with the

oesophageal connectives and after coursing forwards over the pharynx, divides into three branches which innervate the pharynx, epipharynx and labrum respectively. The oesophageal connectives are stout and pass round the oesophagus to connect the supra-oesophageal ganglion with the anterior end of the suboesophageal ganglion. The suboesophageal ganglion (text-fig. 3, *sib*) is like the supra-oesophageal, a complex ganglion being formed, according to Imms (1906), by the coalescence of four primitive ganglia. It is spindle-shaped and extends below the oesophagus. It gives off paired nerves to the mandible, maxilla and labium, and an unpaired nerve (text-fig. 3, *lmn*) to the lingua or tongue. The mandibular (text-fig. 3 *mn*) and the maxillary nerves, soon after their origin, divide into two branches: a branch passes to the base of the appendage concerned and terminates in a mass of filiform cells, while the other innervates the muscles supplying the appendage. The labial nerve (text-fig. 3, *lan*) arises as a main trunk which divides and ultimately terminates in sensory cells in the labium. The median nerve supplying the lingua arises from the anterior end of the suboesophageal ganglion close to the points of attachment of the oesophageal connectives and, passing through the thick ventral wall of the anterior portion of the pharynx, breaks up there into fine fibrils.

A peculiarity worth noting is that in transverse sections through the anterior region of the pharynx or through the epipharyngeal groove a large mass composed of flask-shaped cells (text-fig. 4, *epg.*; Pl. VI, fig. 1) is noticed to lie on either side of the digestive tract. This mass is connected with its member of the opposite side by means of a nerve band (text-fig. 4, *nvb*) that passes ventral to the digestive tube, a little below the level of the points of insertion of the ventral dilator muscles of the pharynx. Similar masses of cells have been described by Hoffmann (1908) in the case of *Tomocerus plumbeus* (L.) under the name epipharyngeal ganglion. The cells composing the mass are evidently sensory nerve-cells and may be gustatory in function.

Again, in sagittal sections passing through the head a little lateral to the median vertical plane, a large clump of similar cells (text-fig. 3, *cv*) is noted lying in the ventral chamber of the buccal cavity close to the basal region of the maxilla. The clump (text-fig. 3, *cv*) is connected with the suboesophageal ganglion by means of a short nerve (text-fig. 3, *n*) that is swollen in the mid-region into a ganglionated knot. I believe this mass is distinct from the superlingual or maxillary ganglion and different from the cephalic glands of the ventral tube. It seems to me that the constituent cells represent sensory cells but I am uncertain of the exact homology of this organ.

The ventral nerve cord, as in other Collembola, is a concentrated one and is composed of three ganglia that are serially placed in the pro-, meso- and meta-thorax. The meta-thoracic ganglion (text-fig. 5, *mtg*) is considered to be formed by the fusion of the last thoracic and the first abdominal ganglion which has migrated forwards. All the three thoracic ganglia are joined to one another by distinct double connectives. A pair of stout and parallel nerves arise from the last ganglion of the nerve cord (Pl. VII, fig. 3, *mt*) and pass backwards over the ventral tube. This, however, does not reach the posterior extremity of the body.

Cephalic Glands.

Diverse views have been expressed regarding the disposition homology and function of the glands existing in the head region of Collembola. A review of these is given by Folsom (1899), Willem (1900, 1901), Hoffmann (1904), Imms (1906) and recently by Denis (1928). I, therefore, refer here to the principal controversial points only.

Denis (1928) classifies the glandular systems belonging to the head region of Collembola as follows : (1) Cephalic glands of the ventral tube, composed of (a) tubular glands and (b) globose or acinose glands. Secretions of these glands, according to this author, flow out of the buccal cavity through the labial cleft to the ventral groove and finally reach the ventral tube, which, being thus smeared with the secretions, acts as an adhesive organ. (2) Salivary glands composed of (a) an anterior pair situated on the external wall of the "pli oral" and opening into the atrial cavity, and (b) a posterior pair located within the cephalic cavity above the level of the maxillary pouch. The ducts of these glands follow the mandibles closely and open into the buccal cavity. (3) Excretory glands—(*Reins Céphaliques*)—closed glands without any duct and containing concretions of urates.

Attention may be directed to the fact that, so far as the structure and function of the cephalic glands of the ventral tube are concerned, Denis is in general agreement with the observations of Fernald (1890), Willem and Sabbe (1897), Willem (1900, 1901), Hoffmann (1904) and Imms (1906); but he differs from Folsom (1899), who held that the secretion of the cephalic glands could not pass to the ventral tube, since the ventral groove, which was thought by Fernald (1890) to be the connecting passage between the opening of the duct of these glands and the ventral tube, was itself interrupted in places. Folsom (*loc. cit.*) noted further, that the secretion from these glands which were called by him salivary glands, was conveyed through the trough like median cleft of the labium to the border of the mouth to moisten the food before it was taken in. The ducts of these glands were shown to open separately into the buccal cavity and thus they differed in their course from that indicated by Willem and his school.

The cephalic glands of the ventral tube have, on more than one occasion, been confused with the salivary glands. Fernald (1890), who first showed that a morphological connection between the cephalic glands and the ventral tube existed by means of the ventral groove, called these glands salivary glands. Willem and Sabbe (1897), to whom the credit belongs for explaining the functional correlation between the cephalic glands and the ventral tube alluded to, called these glands, since they supply adhesive substance to the ventral tube, the cephalic glands of the ventral tube. Willem (1901) clearly distinguished the cephalic glands of the ventral tube from the salivary glands, and pointed out that the salivary glands mentioned by Tullberg and Nassanow were tubular glands, and that Lubbock (1862, 1873) and Olffer (1862) mistook adipose cells for these glands. According to him, the cephalic glands of the ventral tube are composed of tubular and globose glands; the ducts of the tubular glands anteriorly receive the ducts from the globose glands and open by a common duct into the buccal cavity close to the

labial cleft on the ventral side of the head ; further, in addition to these, a pair of salivary glands occurs in the head and their ducts are quite distinct from those of the tubular and globose glands, and open on the hypopharynx. Hoffmann (1904) studied the structural details of the cephalic glands of the ventral tube and agreed in most respects with Willem. Imms (1906) accepted the nomenclature of the glands enunciated by Willem and Hoffmann but pointed out that Fernald mistook the cephalic glands for the salivary glands. Sommer (1884) and Folsom (1899) on the other hand advocated different views. Sommer (1884) reported that in place of the so-called salivary glands recorded by earlier authors, cells containing concretions of urate occur, which must have been mistaken by them for the salivary glands. Folsom (1899) maintained that the salivary glands, as meant by him, were homologous to the salivary glands depicted by Tullberg (1871) and Nassanow (1887). Besides these Folsom described another pair of glands, situated close to the bases of the mandibles and maxillae and having chitinous ducts which coursed down between the mandible and the maxilla. It seems from the topography and structure of the glands that those mentioned by Folsom as lying near the mandible really correspond to the salivary glands mentioned by Willem and the salivary glands described by Folsom are comparable to the tubular glands indicated by Denis. Philpitschenko (1908) describes two pairs of salivary glands, an anterior and a posterior, and also a pair of tubular glands. He regards the tubular glands as excretory in function.

The homology of these cephalic glands is by no means certain. Willem considers that the tubular glands belong to the segment corresponding to the first maxilla and that the salivary glands belong to the mandibular segment. Imms on the basis of Uzel's observation concludes that the salivary glands are homologous with the shell glands of Crustacea. Philpitschenko assigns the tubular glands to the labial segment and regards them as homologous with the antennary and maxillary glands of Crustacea and representing the head kidney. The anterior pair of salivary glands, according to him belongs to the mandibular segment and the posterior pair of salivary glands to the labial segment. The salivary glands, further, in his view are comparable to the cephalic glands of *Lithobius* and *Scolopendra*. Denis, however, is of the opinion that both the tubular and globose glands belong to the labial segment and the salivary glands to the mandibular segment. He points out also that the anterior pair of salivary glands, mentioned by Philpitschenko, correspond to the salivary glands described by him, while the posterior ones correspond to the globose glands.

With regard to the excretory glands described by Denis it may be said, that they too are not beyond the range of controversy. Hoffmann (1904) has the credit of first reporting these glands as "Kopfnieren" : but Becker (1910) contests that they are sensory cells of the post-antennal organ. Nabert (1913) is opposed to Becker's view but Quiel (1915) supports the latter. Denis (1928) upholds Hoffmann's observation, and, further, is of the opinion that though these glands can be compared with fat cells containing a deposit of urate, any homology between them and the antennary and maxillary glands of Crustacea, as indicated by

Philipschenko, is untenable. He considers these glands as belonging to the trito-cephalic metamere.

It is likely that the above differences of opinion may to a certain extent have been caused by the structural similarity hinted at by some of the authors, between salivary, tubular and acinose glands and also by the difficulty of tracing the ducts of these glands ; but the possibility of variation in number, arrangement and disposition of these glands in different groups or species, cannot be ignored. Further observations on species other than those already investigated are needed before any definite conclusion can be reached.

The glandular organs located within the head region of the present species of *Protonura*, occur in pairs and fall, according to their structure, into two distinct systems : (a) tubular glands, (b) acinose or globose glands. In dividing the cephalic glands into the above two categories only, I have excluded those structures which have not been established beyond doubt to be true glandular elements and which, on account of their morphology, have been included by me in the nervous system as sensory cells ; and I have relied neither on the topographic position of the glandular organs in the body, which itself is variable, nor on the course of their ducts, which cannot be traced without some element of doubt, but have been principally guided by their form and histology.

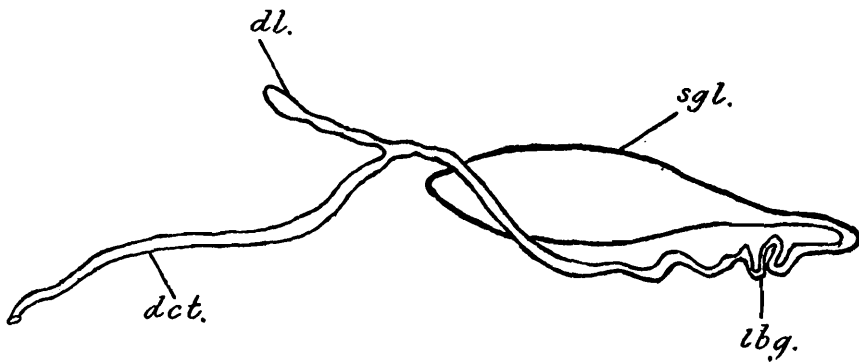
I also refrain from homologising the above two types of glands or giving any definite names to them, as, so far, previous authors have not made out a clear histological differentiation between the acinose gland proper and the salivary gland or between the tubular gland and the salivary gland.

(a) *Tubular gland.*

The tubular gland (Pl. VI, fig. 3, *tbg*), in its essential principle, is built up of a long convoluted tube with a well defined lumen and a wall composed of a single layer of gland cells, and extends from the middle region of the head as far as the metathorax, lying on the sides of the alimentary canal. It can be subdivided into the following three parts : (a) a sac, (b) a labyrinth, and (c) a duct.

The sac (Pl. VI, fig. 2, *sgl*) is situated in the prothoracic region and encloses a large cavity and is compressed from side to side. The sac as one traces it towards the posterior end of the body, becomes narrower and cylindrical, and on reaching the metathorax, bends down in the form of a U (Pl. VII, fig. 1, *tbg*). The lower limb of this is continued forwards as the labyrinth. The labyrinth, which has a narrow bore, passes anteriorly below the sac, following a somewhat winding course, and on reaching the prothoracic region ascends upwards and comes to lie above the level of the sac (text-fig. 8). In the anterior region of the prothorax, it forms loops. A dorsal loop (Pl. VII, fig. 2, *dl*) is given off which passes into the head and comes very close to the anterior acinose glands of the head, and a ventral loop (Pl. VII, fig. 2, *vl*) that continues forward as the duct of the tubular gland and, crossing the level of the suboesophageal ganglion, lies on the floor of the buccal cavity. The duct which is narrower than the labyrinth passes onward through the hypodermal layer and joins its fellow of the opposite side to form a common

chitinous duct which slopes down to open to the exterior on the ventral surface of the head immediately posterior to the median gap between the abial pieces.



TEXT-FIG. 8.—Diagram of the tubular gland. *sgl.*, sac; *lb.g.*, labyrinth; *dl.*, dorsal loop; *dct.*, duct.

The end-sac and the labyrinth, which together constitute the greater portion of the tubular gland, represent the secretory part of the organ and the duct leads the secreted substance to the exterior. The tubular gland and its duct throughout their length are lined by a single layer of cells but the character of these lining cells varies in the three parts into which the tubular gland has been divided by me. In the end-sac the cells are rectangular, being longer than broad. Cell-boundaries are quite distinct and the nuclei are prominent. In a few sections, these cells, when examined under an oil-immersion lens, revealed the presence of very fine canals. Possibly the secretions of these cells pass through these canals into the lumen of the sac. The cavity of the sac enclosed by these cells is spacious in comparison to that of the labyrinth or the duct. The secretions evidently first collect in the lumen of this sac, and are then conducted to the exterior; the end-sac therefore may be looked upon as forming a reservoir, the wall of which is secretory. The glandular cells lining the labyrinth, though similar to those of the end-sac, differ from them in shape and size and in the absence of fine canals. The walls of the duct are thicker than those of the preceding portions and differ from these in that cell-boundaries are here absent and the lining appears to form a syncytium.

The divisions of the tubular gland as made here correspond, to some extent, to those indicated by Philpitschenko (1908) with this difference that the sac is not thin-walled.

The shape and the course of the tubular gland in this species, it may be noted, closely resemble that of the tubular gland of *Orchesella* described by Willem (1901), but with this difference that the common duct in the present instance does not receive the ducts of the acinose glands situated in the anterior region of the head, as shown by Willem. The gland differs from the tubular gland described by Hoffmann both as regards the character of the common duct and the convolutions of the tube.

(b) *Acinose Glands.*

The Acinose gland comprises a group of unicellular glands, each with a fine ductiole which opens into a common chitinous duct of narrow bore and without an epithelial wall of its own.

In sections (Pl. VI, figs. 2, 3 ; Pl. VII, fig. 2) each acinose gland is seen to be composed of a group of gland cells arranged in the form of a ring with a common duct in the centre. The outer margin of each gland cell is slightly indented inwards and faint lines mark the limit of the edges where the adjoining cells meet. Each gland cell is characterised by the possession of a large multilobed nucleus and a narrow ductiole within the substance of the cell. The ductioles from each cell open into the common duct enclosed in the centre of the group. In addition to the ductiole, minute fissures, disconnected from each other, are also seen in sections cut through various planes. In my preparations these, along with the ductiole and the common duct, did not take up any stain. Evidently they represent either fine collecting canals opening into the ductiole or cut portions of the ductiole which were not running in the same plane. The appearance of the cytoplasm of the gland cells varies somewhat according to the mode of staining and the plane of section. The common duct, seen in frontal sections of the head to be located in the centre of the ring of glandular cells, does not possess any special lining of epithelial cells but the wall shows under high magnification fine striations, and is probably chitinous in character. The final opening of the common duct is very difficult to observe and I must confess I have not been able to ascertain it with certainty. I have, however, been able to trace the duct, starting from the glandular cells and passing through the tissues, towards the lateral pouches of the buccal cavity. In Pl. VI, fig. 6, the origin and direction of the course of the common duct are clearly seen. The duct is difficult to distinguish in frontal or sagittal sections as it does not take up any selective stain. From a careful examination of several sections, stained differently and cut in different planes, I am led to believe that the common duct of each of the acinose glands opens separately into the lateral pouches of the buccal cavity.

The acinose glands are widely scattered over the head region, but they do not, like the tubular gland, extend into the thoracic region. These glands may be noted on the sides, roof and floor of the head region, either embedded in the hypodermis or wedged in between them, and they also occur close to the tubular glands that lie in the head region. Sometimes, as in the case of transverse sections through the head anterior to the region of the brain, these acinose glands extend deep into the haemocoelic cavity and can be found just below the dorsal layer of fat cells and a little above the lining intima of the buccal cavity. In transverse sections passing through the anterior region of the cephalic diverticula of the gut, a few gland cells are found adjoining the cephalic diverticula or very close to the end sac. I have not been able to trace any ducts from these latter groups and from their appearance it looks as if those glands that extend into the haemocoelic cavity of the head, are different from those lodged in the hypodermis and constituting the acinose ring referred to above ; and, in consequence, they might easily be taken for the excretory glands mentioned by Denis (1929). Examination of a series of sections shows, however, that though these glands are variable in their position and occur equally on the sides and floor of the head embedded in the hypodermis or in the haemocoelic space, there is no disparity between them and the other acinose glands, so far as their

structure is concerned. I consider them, therefore, irrespective of their topographical position and size, as component parts of the same gland system. The excretory glands described by Denis, it may be remembered, are without any duct and contain concretions of urates. The number of groups of acinose glands can roughly be computed from the frontal and sagittal sections of the head. There are four pairs in the head. They are distributed as follows: a pair in the anterior region of the head, a pair in the basal region of the head and two pairs, one behind the other, intervening between the anterior and the posterior pairs. The anterior and the posterior pairs are situated near the dorsal wall of the head. The intervening pairs occupy a more lateral position in the ventro-lateral portions of the head. Each group possesses a duct of its own which opens into the lateral pouches of the buccal cavity.

Since all four pairs of acinose glands closely resemble each other in structure and in the position of the openings of their ducts they cannot be separated into salivary glands and acinose glands. The acinose glands proper, it may be remembered, have been pointed out by previous workers as opening into the anterior end of the common duct of the tubular gland and the salivary glands have been shown to have ducts of their own opening independently into the buccal cavity. In this case no such difference could be made out and, therefore, the observations recorded here differ from those of previous workers. The whole series appears to belong to the group hitherto called salivary glands by Denis (1928).

So far as the function of the acinose glands are concerned, as these glands open into the buccal cavity and as no separate salivary glands have been found by me, it is possible that they act as salivary glands. That the secretions liberated by them have a softening effect on succulent vegetable tissues, the juices of which the animals probably suck, has been mentioned by Willem (1900) in the case of *Neanura*. I do not agree, therefore, with Denis that both salivary and acinose glands occur as separate glands though the posterior pairs of acinose glands, from their topographic position at the base of the head, may correspond to the so-called salivary glands.

Ventral Tube.

The ventral tube has been the subject of much discussion. The conflicting views of earlier authors have been summarised by Hoffmann (1904) and Imms (1906), it is therefore, unnecessary, to state them again here beyond mentioning the chief controversial points. Previous authors ascribed particular functions to the ventral tube, such as those of support, reproduction, respiration, lubrication, absorption of moisture from the surface of the body and adhesion. Opposing views are also expressed as to the presence or absence of secretory gland cells within it. The consensus of opinion at present is in favour of regarding the ventral tube as an organ of adhesion, enabling the Collembola to walk over smooth surfaces; but the way in which such adhesion is effected has not been settled beyond dispute. Again, while its adhesive function is admitted, the possibility of a respiratory function is also emphasised (*vide* Willem, 1900; Hoffmann, 1904; Imms, 1907). Macnammara (1919), however,

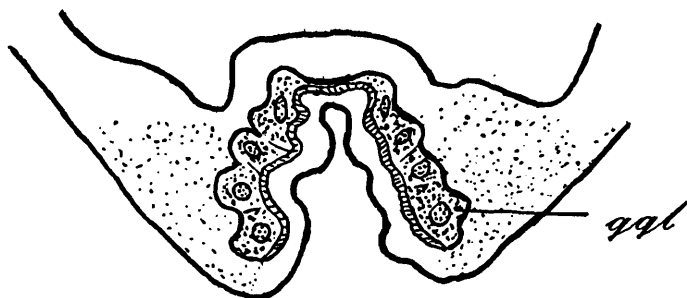
denies its respiratory function. The diverse views as to the manner, in which the adhesion of the ventral tube to a smooth surface is effected, may be grouped for sake of convenience under three different categories : (a) mechanical adhesion by suction, (b) adhesion helped by the secretion of adhesive substance elaborated by the glands of the ventral tube itself, (c) adhesion by reasons of the adhesive substance supplied to the ventral tube by the cephalic glands. Bourelet, Olfer, and Tullberg partly support the first view. The opinions of de Geer, Nicolet, Lubbock Macnammara and Tillyard come under the second category ; while Willem, Hoffmann, Imms and Denis hold the last.

In view of the contradictory statements about the ventral tube the necessity of re-investigation is clear. I have, therefore, studied the organ in the living state as well as by microscopical sections. It may also be noted that the observations of previous authors were based upon specimens belonging to genera other than *Protanura* Börner and it is hoped, therefore, that a comparison of my observations with those of previous authors will be fruitful in clearing up the doubts about its function.

The ventral tube is a cylindrical organ, the terminal portion of which is divided into two equal halves by a median furrow. It is situated on the first ventral abdominal segment. Comparatively speaking, the ventral tube is small in the present species and in the ordinary resting state appears as a small medially cleft knob, the apex of which is nearly flush with the ventral surface of the other abdominal segments but when extended the ventral tube is nearly perpendicular to the longitudinal axis of the body. The groove dividing the organ into two symmetrical halves runs, in the contracted condition, in an antero-posterior direction parallel to the longitudinal axis of the body and nearly reaches to the base of the tube. In the extended condition two small flat lobes, one at the tip of each half, are simultaneously evaginated and pressed against the surface on which the animal moves. The portion of the ventral tube, within which the eversible lobes can be withdrawn, may be called the collar. The lobes are spoken of by Tillyard (1925) as eversible sacs. In the retracted condition the eversible lobes remain covered by the extension of the external wall of the tube up to its apex, and only in the extended state can the ventral tube be differentiated, as shown by Hoffmann (1904), into (a) a cylindrical tube, (b) a collar and (c) the eversible lobes. The ventral tube is hollow and highly contractile and the contraction is brought about by means of muscles that pass through the cylindrical tube into each of the eversible sacs. Elongation of the ventral tube possibly takes place, as is held to be the case by most of the authors alluded to above, as the result of turgescence produced by the inflow of blood, controlled by the ventral muscles of the abdomen which when contracted bend the body of the insect and force blood into the ventral tube.

Since the chief points of dispute centre round the question whether the eversible sacs of the ventral tube exude a sticky substance, the clue to the solution lies in the presence or absence of glandular elements, in or connected with the ventral tube. In Pl. VII, fig. 4, a transverse section through the terminal region of the ventral tube is given. The

plane of the section passes slightly oblique to the longitudinal axis of the ventral tube and in consequence the two halves are not symmetrically disposed. The deep median furrow is seen to divide the distal end of the ventral tube into right and left lateral halves or lobes. The chitinous cuticle not only surrounds the ventral tube but also runs within the furrow separating the two lobes. A narrow cavity is seen inside each lobe. The inner wall of each lobe facing the median furrow contains a thick layer of large cells with distinct nuclei (*ggl*). These cells are the glandular elements in the ventral tube. The outer portion of the wall of each lobe contains a thin peripheral layer of hypodermis (*hy*) and a layer of fat cells adjoining it. In transverse sections of the body (text-fig. 9) passing



TEXT-FIG. 9.—A section of the ventral tube cut by a plane passing transversely across the body: $\times ca. 146$. *ggl.*, glandular layer of cells of the ventral tube.

through the tip of the ventral tube and, therefore, through the eversible sacs, the cavity enclosed within each lobe is seen to be lined on all sides by a layer of glandular cells (*ggl*) and the hypodermal layer and fat cells are found confined to the external wall of the ventral tube. Such a condition is due to the tucking in of the eversible sac within the tube, and the glandular cells lining the cavity of the each lobe represent, therefore, the external wall of the eversible sac whose glandular nature thereby is established. Sagittal sections through the ventral tube (Pl. VII, fig. 3, *vt*) are also instructive inasmuch as they serve to show the extent of the gland cells along the length of the ventral tube. In such sections the glandular cells, containing granular cytoplasm and large nuclei, are found at the tip of the ventral tube. The hypodermal layer on the anterior and the posterior walls of the tube, it may be observed, is very thin and the constituent cells can be easily distinguished from the glandular cells by the size and character of their cytoplasm and nuclei. The cavity of the ventral tube, as may be seen, is largely encroached on by the inner layer of fat cells.

It may here be pointed out that glandular elements in the apical region of the ventral tube were long ago shown to be present by Sommer (1884); but Hoffmann (1904) contested that the so-called glandular cells were really hypodermal cells. Since the same objection, in spite of the clear distinction between the hypodermal and the glandular cells made in this case, may crop up again, I have attempted to check the results derived from morphological investigation by direct observation on living specimens. Direct exudation of fluid from the tip of the ventral tube is a convincing proof of the presence of glandular elements in the ventral tube. Before I pass on to record my observations on live specimens a brief reference to the ventral groove must be made as the

latter morphologically appears to connect the external openings of the tubular glands and the ventral tube, as was first shown by Willem and Sabbe (1897).

The ventral groove (Pl. V, fig. 5, *vgr*) runs in an antero-posterior direction along the longitudinal axis of the body on the ventral surface. It starts from the posterior end of the labial cleft and reaches as far as the ventral tube. The anterior portion of the groove which is very small in comparison to the remaining portion, can be separated from the remainder by the difference in the character of the groove and by the presence of the external opening of the common duct of the tubular glands. The external opening of the common duct, which opens into the groove at the point of separation of the anterior and the posterior portions of the groove, is very difficult to see, but its position can easily be located by a reference to the configuration of the internal structures. The external opening of the duct and, consequently, the line of demarcation between the anterior and the posterior portions of the ventral groove lie in a plane that cuts the head transversely and passes through the extreme anterior limit of the supra-oesophageal ganglion. The anterior portion of the groove that serves as the external communicating passage between the ventral cleft of the labium and the external opening of the common duct of the tubular glands is formed by the infolding of the external chitinous cuticle investing the ventral side of the head. The groove in transverse section appears as a narrow-necked flask the broad inner end of the flask protruding slightly into the haemocoelic cavity. The ventral cleft of the labium, which posteriorly meets the anterior portion of this groove, extends as far as the oral aperture. From my observations on live specimens and from its structural peculiarity, it is inferred that the secretion from the tubular glands is conducted forward along the anterior portion of the groove to the mouth and not backward to the ventral tube.

The posterior portion of the ventral groove, reaching back as far as the ventral tube, is formed by the curling in of the edges of the chitinous cuticle of the body. The two bent limbs of the groove look like curved horns attached dorsally and directed downwards (Pl. V, fig. 5, *vgr*). In spite of the difference between the anterior and posterior portions of the groove, the two portions are continuous with each other. The groove morphologically forms a communicating channel between the ventral cleft of the labium and the ventral tube and is not interrupted as mentioned by Folsom (1899). Folsom's contention that the ventral groove is ill adapted for the conveyance of a sticky fluid, secreted by the cephalic glands, from the base of the head to as far as the ventral tube seems justifiable for reasons other than that of the discontinuity of the groove. The passage of a sticky fluid over a comparatively long distance through a narrow open chitinous channel, exposed below to dust and atmospheric air, seems untenable on physical grounds ; but such objection cannot be raised with equal force if the fluid secreted passes anteriorly from the opening of the common duct of the tubular glands to the ventral cleft of the labium and thus to the mouth, as in such a case the substance extruded has only to traverse a very short distance through the anterior portion of the groove.

Live specimens of different sizes with a small quantity of the débris of earth, on which they are found in the natural state, were gently put in a small glass vial with a narrow neck. As examples of the present species do not survive in a dry atmosphere, a few drops of water were introduced into the tube to keep the contents moist. The specimens lived for a week and were active in their habits. Observations of their movements were made from time to time under a binocular dissecting microscope and the glass plate, to which they were transferred, was from time to time turned over to facilitate observation of the organ from the ventral side. The animals progressed on vertical walls with the tips of their legs resting on the surface and the ventral tube in the contracted state: the eversible lobes of the ventral tube were seen at short intervals to be closely applied against the surface of the glass and appeared to act as a sucker. The pair of lobes, when pressed against the glass, appeared to be soft, membranous and moist. In a few cases the evaginated lobes, while adhering to the surface, were found to be drawn forward, sliding over the surface of the glass, to a distance equalling half the length of the animal. In no case, however, were the insects found to keep the end of the ventral tube continuously in touch with the surface. The terminal portion of the tube was attached to the surface by means of the lobes whenever the legs appeared to slip against the glass and the lobes at this time secreted fine droplets of fluid. The animals behaved similarly when they ran upside down on the horizontal under-surface of the glass plate. The movements of these insects were watched for hours but in no case was any viscous fluid noticed to be running along the ventral groove. On the contrary some individuals after walking for an hour or so, stopped moving, pressed the end of the ventral tube against the surface of the glass and remained with their bodies hanging in the inverted position with the tips of their legs resting upon the lower surface of the glass: in this position, they bent their body: their fore legs were drawn near the mouth and a drop of viscous fluid was noticed to collect gradually at the mouth. It is possible, as mentioned before, that the fluid was derived from the tubular glands and flowed from the external opening of the common duct of the gland to the mouth through the short anterior portion of the ventral groove. The tips of the fore legs were then brought in contact with the fluid and thus became smeared with it. By the contraction of the body the middle legs were also drawn close to the mouth and the tips of these legs, later on, rubbed against each other. Thus the fluid, collected near the mouth, was used to smear the tips of the legs. After this the animals again began to walk upon the tips of their legs in the inverted position. All these operations could be clearly seen, and it seems obvious that the extruded secretion was sticky in nature and that the legs were smeared with the secreted fluid to enable the animals to move over smooth surfaces with agility.

It is interesting to note that though Reuter (1880) was wrong in his interpretation that the tarsal claws gathered water to the mouth, he must have noticed that these claws were brought to the mouth, as has been observed by me.

It is seen from above that my observations, based on this species, lend support to Folsom's view (1899) that secretions elaborated by the

tubular glands, pass to the mouth and do not reach the ventral tube through the ventral groove as advocated by Willem, Hoffmann, Imms and Denis. I differ, however, from Folsom in my belief that the secretions of these glands are smeared over the claws of the feet and thereby help the animal to walk over smooth surfaces irrespective of the presence or absence of tenent hairs (*cf.* Packard, 1909, p. 99). It is also possible that these secretions may have a cleaning effect on structures which are smeared with them, and I do not deny the possibility that the secretions of the tubular glands, conducted to the mouth, may become mixed up with the secretions of the acinose glands and have a softening effect on the food taken in by the mouth: but observations on live specimens do not lend support to this inference.

From the structure of the tubular glands we have seen that they resemble the tubular glands described by Bruntz and Philpitschenko, and may, therefore, be comparable to the excretory glands of Crustacea. Even if such a homology be held to be correct, the change in function, as indicated above, is not hard to reconcile, in view of the fact that the last nephridium of the land leeches exudes fluid adhesive in action (Moore, 1927).

With regard to the function of the ventral tube I wholly agree with Folsom, Macnammara and Tillyard that the ventral tube exudes adhesive secretions. Sommer, therefore, was right in indicating the glandular elements in the ventral tube, though he was led astray in attributing to it a function like the preening gland of a bird. A special respiratory function of the ventral tube, ascribed to it by Hoffmann and others, can not be entertained, for, in the absence of tracheae the surface of the body appears to be well adapted for cutaneous respiration and the ventral tube does not possess any special features adapted for carrying on gaseous exchange.

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EXPLANATION OF PLATE V.

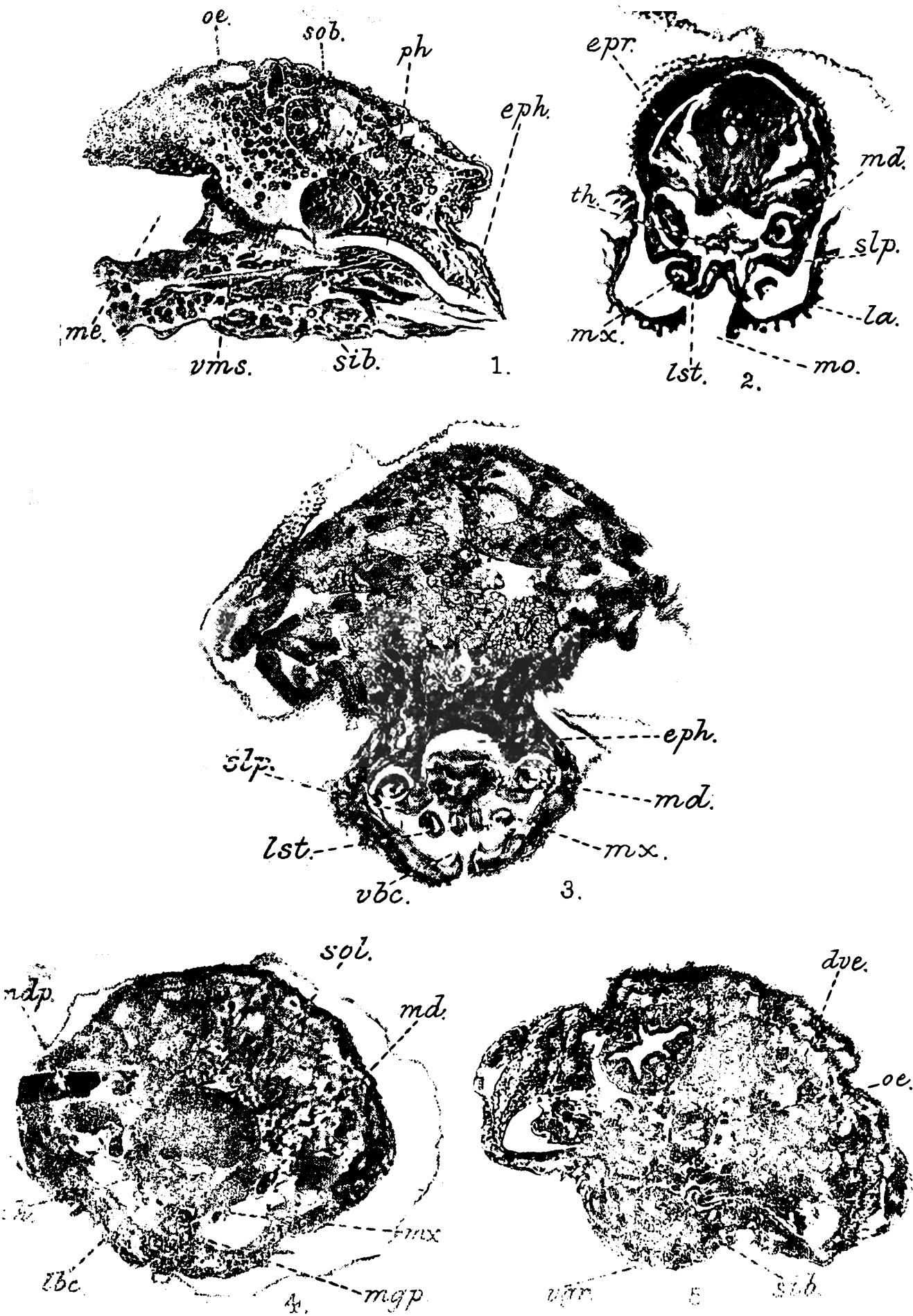
Protanura carpenteri, sp. nov.

(The figures represent photomicrographs of sections).

- FIG. 1.—A median sagittal section of the head, showing the divisions of the foregut: $\times 160$.
- FIG. 2.—A cross section of the snout, showing the position of the mouth-parts: $\times 400$.
- FIG. 3.—A transverse section of the head at the level of the junction of the pharynx and epipharynx, showing the division of the buccal cavity into the dorsal and ventral chambers: $\times 280$.
- FIG. 4.—A transverse section of the head passing through the anterior end of the supra-oesophageal ganglion, showing the lateral pockets of the buccal cavity: $\times 180$.
- FIG. 5.—A transverse section through the basal region of the head, showing the cephalic diverticulum of the midgut: $\times 170$.

REFERENCE LETTERS.

dve., diverticulum of the midgut; *eph.*, epipharynx; *epr.*, epipharyngeal groove; *lbc.*, lateral pocket of the buccal cavity; *mgp.*, median glandular partition separating the lateral pockets of the buccal cavity; *vgr.*, ventral groove; other letters same as in text-figs. 3 and 4.



Georgi Photo

Protanura carpenteri, sp. nov.

EXPLANATION OF PLATE VI.

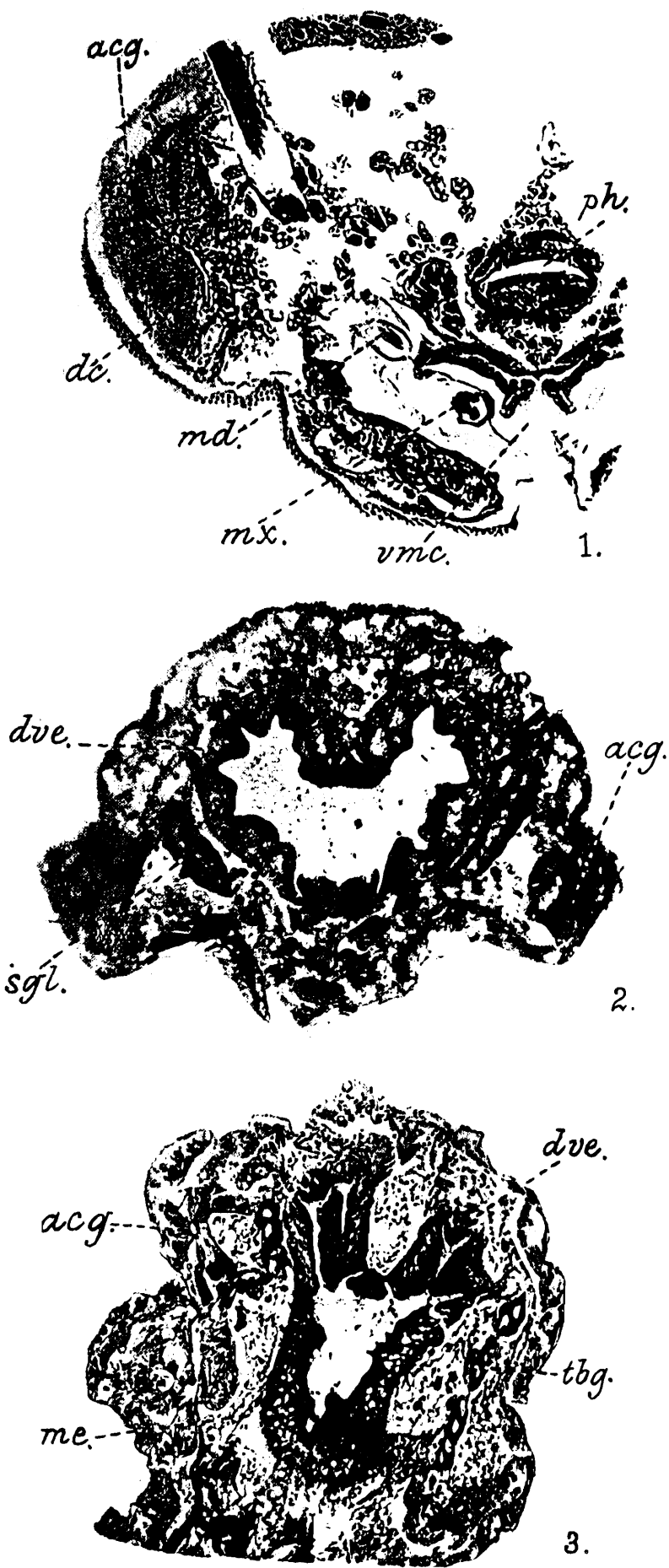
Protanura carpenteri, sp. nov.

(The figures represent photomicrographs of sections).

- FIG. 1.—A cross section of the head through the region of the pharynx (the right hand portion not shown in the figure), showing the acinose gland and the median portion of the ventral chamber of the buccal cavity.
- FIG. 2.—A cross section of the body through the junction of the oesophagus and the midgut, showing the cephalic diverticulum of the midgut.
- FIG. 3.—A frontal section of the head, showing the course of the tubular gland and the cephalic diverticulum.

REFERENCE LETTERS.

dve., cephalic diverticulum; *sgl.*, sac end of the tubular gland; *dc.*, duct of the acinose gland; *tbg.*, tubular gland; other letters same as in text-figs. 3 and 4.



Bagchi Photo.

Protanura carpenteri, sp. nov.

EXPLANATION OF PLATE VII.

Protanura carpenteri, sp. nov.

(The figures represent photomicrographs of sections).

- FIG. 1.—A lateral sagittal section through the thoracic region, showing the course of the posterior end of the tubular gland in the thorax.
- FIG. 2.—A lateral sagittal section through the head and anterior region of the prothorax, showing the dorsal and ventral lobes of the tubular gland in the region of the head.
- FIG. 3.—A median sagittal section of the body passing through the region of the ventral tube, showing the glandular cells in the ventral tube.
- FIG. 4.—A cross section of the ventral tube, showing the gland cells in the inner wall of the ventral tube.

REFERENCE LETTERS.

dl., dorsal loop of the tubular gland ; *ggl.*, glandular cells in the ventral tube ; *hy.* hypodermal cells ; *lbg.*, labyrinth ; *mep.*, epithelium of the midgut ; *mt.*, metathoracic ganglion ; *vl.*, ventral loop of the tubular gland ; *vt.*, ventral tube ; other letters same as in text-figs. 3 and 4.

