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HIBERNATION AND AESTIVATION IN GASTROPOD MOLLUSCS.

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INTRODUCTION.

By SUNDER LAL HORA.

The fascinating problems of hibernation and aestivation in gastropod molluscs, resorted to by these animals to tide over unfavourable climatic conditions, seem to have received very little attention at the hands of the earlier students of this group in India. A perusal of the literature on the subject has shown that with the exception of a few casual remarks no serious attempt has been made to study these phenomena in detail as regards the snails inhabiting this country. The exigencies of the service to which I belong necessitate extensive touring in various parts of India at different times of the year, and during such travels I have been able to look for snails and to devote some time to the study of their habits both under natural conditions and in the laboratory. That my work in this particular branch has met with success is shown by the results that I have already published[1] and by the two notes that are given below. Two aestivating species, *viz., Succinea crassinuclea* Pfeiffer and *Macrochlamys glauca* Benson were found by me at Nurpore in the Kangra Valley : a few observations were made in the field about their peculiar habits and, as all the specimens of the latter species that I collected arrived in Calcutta in the same comatose condition as that in which they were found, they were entrusted to Dr. H. Srinivasa Rao for further study. I must express here my great indebtedness to Dr. Rao for his valuable help in this matter. The second note deals with the mode of hibernation of a species of *Glessula* from the Darjeeling District and a few observations on other land molluscs.

To study this problem in detail it is essential that field observations on the animals be made throughout the year and it thus becomes in the main a problem for investigation by local scientists, though other investigators, while on tour, should devote as much attention as is possible to the animals as soon as they are obtained.

Most places in India are subject to two periods of rainfall alternating with two periods of drought. From October to December there is a cold and dry season, towards the end of December and in January we usually get a few showers from the N. E. Monsoon, but from February begins the hot and dry season which lasts till June when we get the S. W. Monsoon : this continues with interruptions up to October. Twice during the year the animals have to tide over conditions that are un-

[1] Hora, *Rec. Ind. Mus.* XXVII, pp. 401-403 (1925) ; *Journ. Bombay Nat. Hist. Soc.* XXXI, pp. 447-449 (1926).

favourable, namely a condition either of dryness and cold or of heat and drought, and this they do by withdrawing themselves into their shells and by secreting an epiphragm, or by tightly closing the mouth with the operculum in the case of certain operculate molluscs.

The two phenomena of hibernation and aestivation are outwardly very similar in type but physiologically they must be quite different. Any species that has acquired the one or the other of these habits, in response to changing climatic conditions, must of necessity either be limited in its range of distribution as regards elevation in the hill regions, or must be so plastic as to be able to adapt itself to extremes of climate.

Major Sewell has gone through the manuscript and has made valuable suggestions : for all this my best thanks are due to him.

NOTE ON TWO SPECIES OF AESTIVATING GASTROPOD MOLLUSCS FROM THE KANGRA VALLEY.

By H. SRINIVASA RAO.

While touring in the Kangra valley, Western Himalayas, in the months of May and June 1926, Dr. Sunder Lal Hora observed instances of aestivation in two species of molluscs belonging to the families Succineidae and Zonitidae. He was able to study them in the field and record his observations. The present note is based on his observations and those of mine in the laboratory. I have here to thank him sincerely for giving me the opportunity of examining the molluscs and of making use of his field notes.

One of the species is represented by a young individual of *Succinea crassinuclea* Pfeiffer,[1] which is recorded from various places in N. India including the Simla Hills and the Punjab Salt Range. The species was hitherto known only from the shell. I have, in the specimen from Dr. Hora's collection, the soft parts also which are in a good state of preservation. I therefore take this opportunity of adding a brief note on the soft parts before proceeding to describe its habits.

In external features the species does not differ very strikingly from other species of *Succinea*. The jaw is quadratic in form with a saucer-shaped cutting-piece. Its anterior and posterior margins are concave, and the former has in its middle a mound-shaped projection. The arms of the cutting-piece are short and have their extremities broadly conical. The sides of the accessory basal plate are more or less straight, while its posterior margin is cup-shaped in the centre. The jaw is fairly well chitinised in the cutting-piece and on the sides of the basal plate. In the shape of the jaw the species stands distinct, though it is remarkable that the cutting-piece approaches in certain respects those of *Lithotis tumida*[2] and *Lithotis rupicola*,[3] two rupicolous species known to live and hibernate in certain parts of the Western Ghats, Bombay Presidency.

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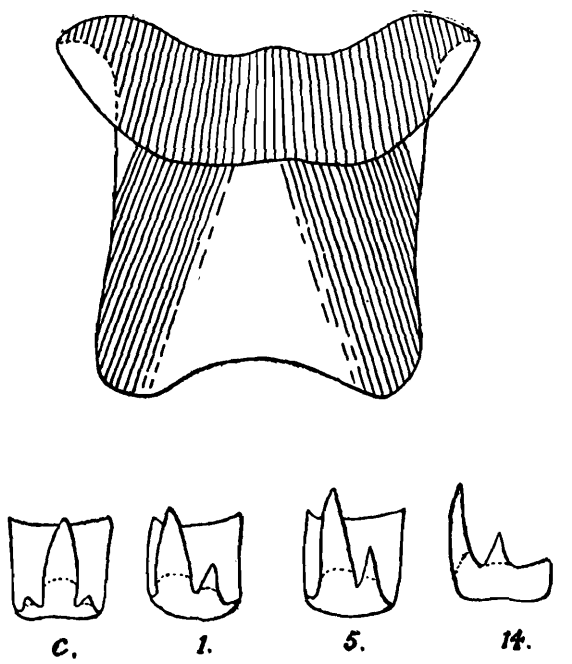
[1] Rao, *Rec. Ind. Mus.* XXVI, p. 387 (1924).
[2] *Id. Ibid.* p. 393, fig. 6*d*.
[3] Rao, *Rec. Ind. Mus.* XXVII, p. 390, fig. 3 (1925).

This resemblance does not suggest, in my opinion, any natural affinity, but only brings into prominence the fact that two structures functioning similarly in two different species under the same conditions may tend to resemble each other.



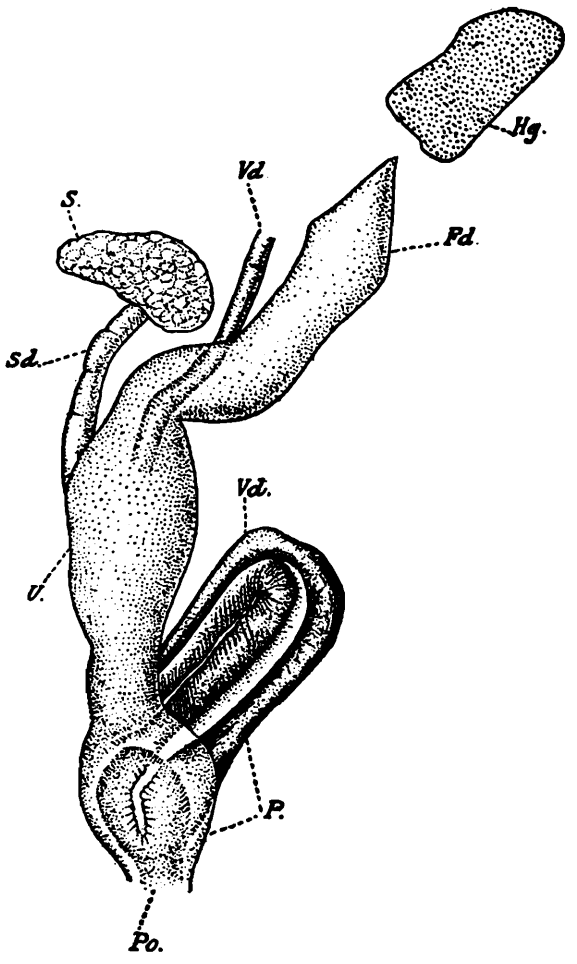
Text-fig. 1.—Jaw and radular teeth of *Succinea crassinuclea.*

The radular teeth in each transverse row of the radula are few in number. The central has the form of a spear-head and has a sharp leaf-like median cusp and two small basal cusps, one on each side. The median cusp is of the same height as the basal plate. The differentiation between the laterals and the marginals is apparently not yet established, and the dental formula may be expressed as 14.1.14. The outermost tooth in each half of a transverse row has, like the laterals, only two cusps which, however, are narrower, the one nearer the central being sickle-shaped. The radular teeth are characteristic of the species. The central, however, differs little from that of *S. crassinuclea* f. *vitrea.*

The genitalia are not well developed, and I have been able to make out only some of the distal parts of the genitalia which are here figured. The spermatheca is roughly oval and lies at right angles to its duct. The uterus is large and barrel-shaped. There is a slight constriction between its distal end and the point where it is joined by the male duct. The vas deferens is doubled back on itself and ends in a bulbous penis.

The specimen under question was picked up by Dr. Hora under a stone on the hill side at Nurpore (Kangra District, Punjab) on the 21st of May 1926. It was probably the driest month in the valley, and, as was to be expected, the mollusc was in a torpid condition. It was found attached to the stone by a sticky membrane. Dr. Hora observed that when removed from its position and transferred to a glass tube, it stuck to the sides of the tube by a sticky secretion which on drying formed a delicate membrane completely closing the mouth of the shell. The animal had retreated into the shell, and all movements had ceased.

Dr. Hora tried the effect of water by placing the aestivating mollusc in a small quantity of it. In a few minutes the animal began to expand



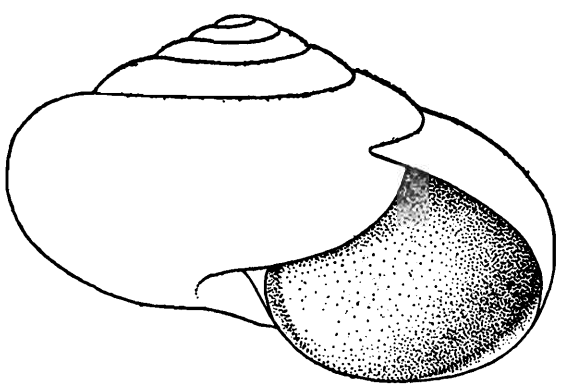
TEXT-FIG. 2.—Genitalia of *Succinea crassinuclea*. *Hg.*, hermaphrodite gland; *Fd.*, oviduct; *P.*, penis; *Po.*, common genital opening; *S.*, spermatheca; *Sd.*, duct of spermatheca; *Vd.*, vas deferens; *U.*, uterus. The proximal part of the vas deferens and the oviduct is incomplete.

itself, and breaking open its membranous epiphragm resumed its normal activity. When removed from water and left in a dry place the animal gradually curtailed its movements, withdrew into the shell and secreted an epiphragm. This device of shutting itself up in the shell seems to be common in other species of the family which live under similar conditions. In a former paper on the molluscs of this family I have drawn attention to the fact that the species fall into three natural groups according to their habitat [1]. The present species seems to come under the terrestrial group, the members of which live, in favourable seasons, exposed either on plants or on wet rocks and feed on fresh vegetation. At the approach of dry weather, when the rocks are dry and the plants do not afford enough protection, these molluscs retire for a season from active life by retreating into their shells, and by secreting an epiphragm protect themselves effectively against desiccation due to the excessive heat of the summer sun. The signal for their emergence is given by the first heavy shower which renders their habitat fit for the next period of active life. A curious instance of a Succineid from the Western Ghats hibernat-

[1] Rao, *Rec. Ind. Mus.* XXVII, p. 386 (1925).

ing on tree trunks during the monsoon rains has been recorded by Dr. Hora, and the attention of the members of the Indian Science Congress held in Bombay in 1926 was drawn to it.[1] It may be worth while to draw attention here to the fact that the only other kind of Succineid mollusc collected by Dr. Hora during his recent tour belongs to *Succinea indica* Pfeiffer. This is an amphibious species and was obtained in abundance from the under side of leaves of water-hyacinth plants, covering the surface of a big pond behind the Dak Bungalow at Pathankote. The abundance of individuals of the amphibious species as compared with those of the terrestrial form is noteworthy.

The second species of aestivating mollusc with which the present note deals is *Macrochlamys glauca* Benson of the family Zonitidae. This is also strictly terrestrial in habit and, like most terrestrial Succineids, seeks protection from desiccation during the dry weather by retreating within the shell and closing the aperture by an epiphragm secreted for the purpose by the animal itself. The epiphragm is, however, in this species of a thick shell-like substance unlike the membranous structure of other hibernating molluscs. Dr. Hora has made the following observations in the field book : " When the shell is placed in water the epiphragm is lifted up like an operculum after a long time (2 or 3 hours) and the animal by its movements begins to shake it off. It seems that forming the margin of the operculum and coming in contact with the shell there is a thin area which becomes very soft and dissolves in contact with water, setting free the epiphragm."

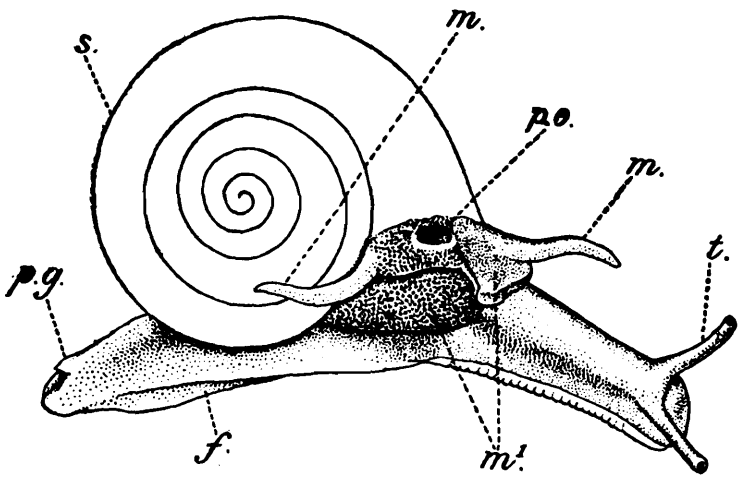


Text-fig. 3.—Shell of *Macrochlamys glauca* showing epiphragm *in situ* in an aestivating individual.

The phenomena of hibernation and aestivation in land molluscs do not seem to have received as much attention as they deserve in the many species possessing these habits. This is not surprising in view of the fact that the earlier students of the mollusca, at any rate those who lived and worked in India before the time of Stoliczka, Blanford, and Godwin-Austen, were merely conchologists, and did not sufficiently realise the importance of studying the anatomy and the habits of the animals inhabiting the shells. It is, however, interesting to note that as early as 1848 H. E. Strickland observed and recorded the hibernating habits

[1] Hora, *Ibid.* pp. 401-403 (1925).

of *Nanina vitrinoides* (Deshayes), which seems to be a *Macrochlamys*,[1] from Ajmere. "Like many of the Helicidae of hot climates," he observed "especially those which are exposed to long intervals of drought, the *Nanina vitrinoides* secretes a calcareous *poma* or deciduous operculum every time that it retires into a state of torpor. The specimens in question had formed two or three successive *pomata*, one within the other, during the process of their desiccation. In hopes of restoring their animation, I placed them upon some wet moss in a warm room. Two of them proved to be past recovery, but the animal of the third was seen through the transparent shell to be gradually enlarging in bulk by the absorption of moisture, and at the end of a week it finally reached the door of its dwelling, threw off the *poma* and began to crawl." His observations go to show that the condition necessary for its revival from the torpid state was only moisture, and that so long as it was kept in a moist condition and was supplied with food, there would be no necessity for aestivation to intervene.



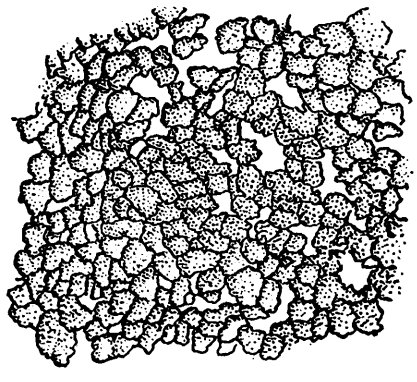
TEXT-FIG. 4.—*Macrochlamys glauca* in an active state. f. foot; *m.*, superior mantle lobes; m^1, inferior mantle lobes; *pg.*, anal process; *po.*, pulmonary aperture; *t.* tentacle; *s.*, shell.

The snails of *Macrochlamys glauca* which Dr. Hora brought back from the Kangra valley had their epiphragm intact. A few of these were placed in a dish of water for an hour, at the end of which time all the animals one after another threw off their epiphragm and began to crawl about. Another snail was kept in a tube plugged lightly with cotton wool and the tube half immersed in a bottle of cold water for several hours, but no activity was observed in the animal, and the epiphragm remained in its place. The same snail was then dropped in a dish of cold water and allowed to remain there for a few minutes. It pushed the epiphragm from inside and came out of the shell. This suggests that actual contact with moisture helps the animal to throw off its epiphragm, and that a cool atmosphere alone is not enough to arouse it from its seasonal slumber. But snails thus stimulated did not appear to be capable of continued activity, nor were they inclined to feed on succulent leaves of plants that were supplied to them, for after a few hours of timid crawling they withdrew again into their shells and formed a fresh

[1] Godwin-Austen, *Land and Freshwater Moll. Ind.* Part III, pp. 80-82 (1883).

epiphragm, which was, however, not so thick as the one formed at the commencement of their natural season of aestivation. It was whitish in colour, thin and membranous, and had the same structure as that of the thicker epiphragm, but without the characteristic reddish brown colour of the inner surface of the latter. The same snails were revived again by contact with water, and they remained active for over six hours, after the lapse of which time they again withdrew into the shell closing the aperture of the shell with a still thinner epiphragm. When the process was repeated a third time, a few snails secreted only a portion of the epiphragm, and still fewer retreated as far back into the shell as possible with only traces of a very thin epiphragm at the mouth of the shell. The secretion of an epiphragm is apparently a process of exhaustion for the animal, and seems to decrease progressively when they are alternately allowed to desiccate and revive at short intervals.

One of the starved snails was revived by contact with water, and given bits of raw plantain on which it fed. This kept the animal active for about 30 hours, during which it crawled all over the glass tube in which it was kept, with the tentacles, eye-stalks, and mantle lobes well-expanded. Shortly after feeding the snail passed out tiny masses of coiled up thread-like faecal matter, and thereafter showed no inclination to feed again. After the lapse of thirty hours the snail withdrew into the shell closing the mouth of the latter by a freshly-secreted epiphragm which was comparatively thick. After about six hours the animal (on its own initiative and without the stimulus of added water) threw off its epiphragm and commenced crawling, apparently in search of food, which had been removed from the tube. A short while after, the snail retreated into its shell secreting a thin epiphragm. This process was repeated thrice and on the fourth occasion it did not secrete an epiphragm, even of the thinnest kind. Nevertheless the heart was beating, the process of respiration continued in a regular manner, and the surface of the mantle lobes was constantly dimpled by waves of muscular contraction.



Text-fig. 5.—Portion of epiphragm of *Macrochlamys glauca* (× 250).

The epiphragm that is formed at the commencement of the aestivating period fits exactly into the mouth of the shell, is convex on the outer surface, somewhat rough in appearance, and has a white deposit. The inner surface is concave, very minutely granular and somewhat reddish in colour. When viewed by transmitted light the epiphragm presents a cellular appearance.

The process of formation of the epiphragm seems to be as follows, at any rate, under artificial conditions: The animal gradually withdraws itself into the shell, the anterior part being the first to be drawn in. Later on the whole of the foot is withdrawn and the mouth of the shell is completely closed by the lobes of the mantle. The surface of these lobes is always moist and has a pitted appearance, the result of a continual wave of depressions or pits being formed on them from one end to the other. A sticky mucous-like substance is secreted by the activity of the mantle lobes which on drying becomes a thin diaphanous membrane stretching across the mouth of the shell. By further secretion the thin epiphragm becomes thick, opaque, reddish on the inside and white outside. During the process of secreting the epiphragm the animal breathes regularly, as is evidenced by the rhythmical opening and closing of the pulmonary aperture. The heart can also be seen through the shell to be pulsating regularly. When a complete epiphragm has been formed, the heart gradually ceases its pulsation and the pulmonary aperture is completely closed.

The difference in colour between the outer and inner surfaces of the epiphragm is apparently due to the action of the atmosphere on the sticky substance, the outer surface being exposed becomes white, the inner, being excluded from further contact with air and augmented by the deposition of fresh layers of the sticky substance, retains its reddish colour.

ON THE HABITS OF A HIBERNATING SPECIES OF GASTROPOD MOLLUSC FROM PASHOK (EASTERN HIMALAYAS), WITH REMARKS ON CERTAIN OTHER SPECIES.

By SUNDER LAL HORA.

In this note I have to record my observations on the habits of *Glessula* (*Rishetia*) *hastula* Benson, several specimens of which were collected in loose earth at the base of big trees in the jungle at the sides of the main road at Pashok (alt. 2,600 ft.) in the Darjeeling District. I was at Pashok from the 16th to the 21st of December 1926, and most of the observations recorded here were made during that period.

Babu D. N. Bagchi, the artist, who accompanied me on tour, collected an individual of *G. hastula* in a state of torpor on the 16th from underneath a big stone at the side of the P.W.D. Bungalow hill in a more or less shady place. On account of ill health I was keeping in bed on that day and after noticing the peculiar condition of the animal left it in a tube under my pillow. A couple of hours afterwards (about 3 P.M.) it was found that the animal had become active and was crawling about the sides of the tube with the tentacles fully expanded. About an hour afterwards it shut itself up again and did not come out though it was kept immersed in water for a considerable time. The behaviour of the animal showed that the warmth of the day, and especially its position underneath my pillow, had stimulated it to activity and that the fall of temperature in the evening had induced it to retire into its shell again in a state of torpor.

I was very busy with other matters for the next two days, but on the 19th, while going to Ghum, I left instructions with my servant to look for these molluscs at the base of big trees in loose earth. On my return late in the evening I was delighted to find a big collection of them waiting for me. All of these were in a comatose condition and were reposing inside their respective shells after having formed a series of epiphragms to save themselves from desiccation. The whole of the next day was devoted to their study. A number of them were kept in water, some were put in a tube and placed under a pillow, while the remainder were allowed to lie on a table in the open air. By 11 A.M. it was found that some of those that were left in the open air had become quite active and were crawling about on the table, while the rest were breaking the series of epiphragms in order to become free again. By about 2 P.M. all the individuals of this lot had become active. In the case of the other two lots the animals took a comparatively much longer time to regain appreciable activity. This I account for by the fact that the air in the room was much warmer (being heated by the rays of the sun throughout the day) than either the water in which the individuals were placed or the conditions afforded by the cover to those placed under the pillow. In the evening the animals withdrew again into their shells and were then preserved for laboratory study.

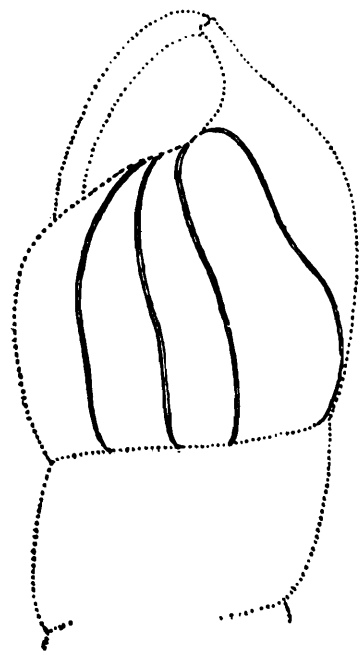
On the last day at Pashok about half a dozen individuals were collected by me on the way and were brought alive to Calcutta. For a couple of days I was very busy and could not attend to them, but on the third day I found them exactly in the same comatose condition in which they were collected at Pashok. The maximum temperature in the shade in Calcutta during this period did not rise above 79°F. A couple of individuals were placed in direct sunlight, two others were immersed in water and then taken out and kept in a moist tube in the shade, while the remaining two were left in a dry tube. Only those that were in the moist tube became active, while those in the other two lots remained in a torpid condition. This observation shows to a certain extent that direct sunlight does not of itself stimulate the activities of these animals and, secondly, that warmth in moderation along with a high degree of humidity suits them very well. There are two points of special interest that can only be investigated on the spot[1], (i) the range of this species in correlation with the altitudes at which it is found in the Eastern Himalayas and, (ii) the habits of the animal under various climatic conditions throughout the year. *Glessula hastula* was described by Benson from specimens collected by W. T. Blanford at Punkabari (alt. 1,800ft.), below Kurseong, Darjeeling District. Godwin-Austen[2] is of opinion that this species is endemic in the Eastern Himalayas and that its occurrence in other widely separated places is erroneously recorded.

As has been pointed out already, the animal secretes a series of epiphragms at the time of hibernation. As many as 5 to 6 of these thin membranes were found stretched across the lumen of the shell situated at varying distances from the mouth but chiefly inside the last

[1] Mr. R. S. Lister of the Pashok Tea Co. has very kindly promised to carry on work on the mode of life of this interesting snail.

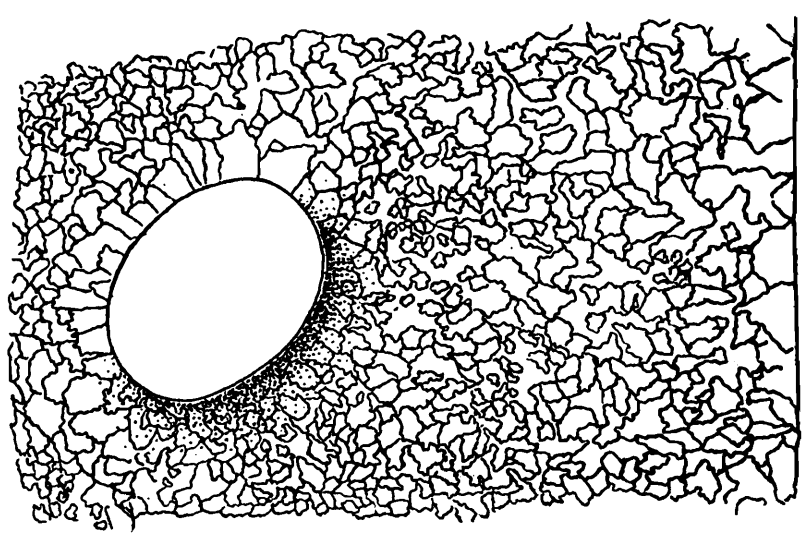
[2] Godwin-Austen, *Land and Freshwater Mollusca of India*, III, pt. I, p. 16 (1920).

whorl. An epiphragm at the mouth of the shell was found in only 7 out of 41 individuals examined and even in them the outermost cover was



TEXT-FIG. 6.—Animal of *Glessula hastula* showing a series of four epiphragms secreted during its period of hibernation. (The outline of the shell is shown by a dotted line).

cracked in places. It seems probable that either the epiphragm at the mouth is liable to injury or that the animal as a rule secretes its outermost membrane somewhat interior to the mouth. Each epiphragm is thin and translucent and is chiefly calcareous in composition as can be readily tested by the action of any dilute acid on it. The texture is cellular except at its margins and at the margins of the aperture that is

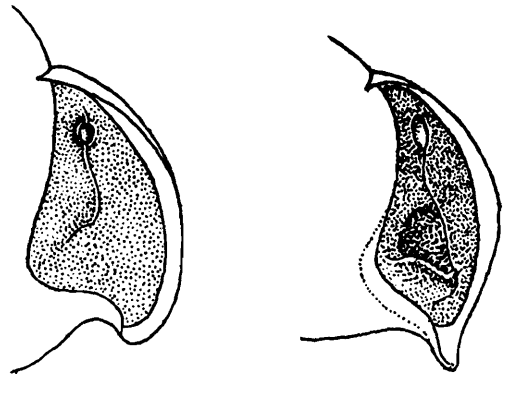


TEXT-FIG. 7.—A portion of the epiphragm of *Glessula hastula* showing the texture from its margin inward. The opening is also shown.

situated in its narrow portion, where the calcareous matter forms a regular rim. This rounded or oval aperture is situated at the top of a small pyramid and its margins are greatly thickened. In position it corresponds to the pulmonary opening of the animal, and corresponding to the line of union of the two mantle folds there is a thickened ridge on

the epiphragm running from the aperture towards its broader end. The presence of such an aperture in the epiphragm in this particular position is of the greatest use to the animal and, so far as I am aware, is a rare occurrence among hibernating gastropod molluscs. As the animal secretes a series of epiphragms, not a single one as is common in other species, so it must make provision for respiration as it gradually recedes inside the shell and the aperture is probably a very efficient device to serve this purpose.

The process of formation of the epiphragm is similar to that described by Dr. Rao for *Macrochlamys glauca* Benson. The two mantle lobes cover the entire animal when it withdraws itself inside the shell. The



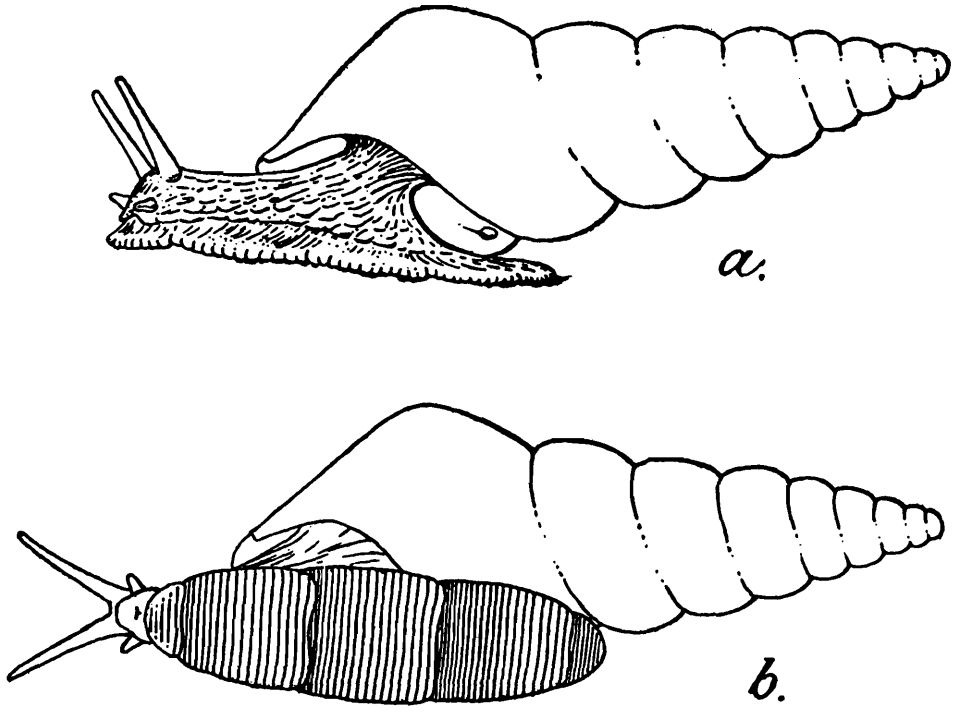
Text-fig. 8.—The epiphragm and the hibernating animal of *Glessula hastula.*

(*a*) An epiphragm at the mouth of the shell. (*b*) Comatose animal after removal of epiphragms and the 1st whorl. The black triangular area represents the position of the foot.

foot is seen through the mantle as a small triangular patch, black in colour. By the rhythmical opening and closing of the pulmonary aperture the line of union of the two mantle lobes becomes apparent. The mantle is covered with numerous white dots which are probably the glands that secrete the calcareous epiphragm.

It has been observed in *M. glauca* that the margins of the epiphragm become soft in contact with water and thus the entire structure is set free from the shell and is carried by the animal for a short time as a false operculum. In *Glessula hastula* exactly the same thing happens. An individual with the outermost epiphragm at the mouth of the shell was placed in cold water. After a short time the entire epiphragm was observed floating on the surface of the water. The animals were observed to moisten the membrane from the inside and then push it out. In this process the entire membrane was usually lifted up, though in some cases it got broken at the extreme corners where probably the fluid had not been sufficiently applied. Several specimens were found crawling about with the entire outermost epiphragm sticking to the sides of their feet. It may be remembered in this connection that the structure of the epiphragm near the margin is somewhat different from that of the rest of the plate.

The method of progression of the animal is also worth recording. A series of about four folds are seen on the foot passing from behind forwards. These divide the foot into five parts and each of these presents a corrugated appearance. These folds are not visible on the foot when the animal is stationary. The animal crawls about in jerks as can be readily seen from the movement of the shell. At the conclusion of each peristaltic motion the animal advanced a little.

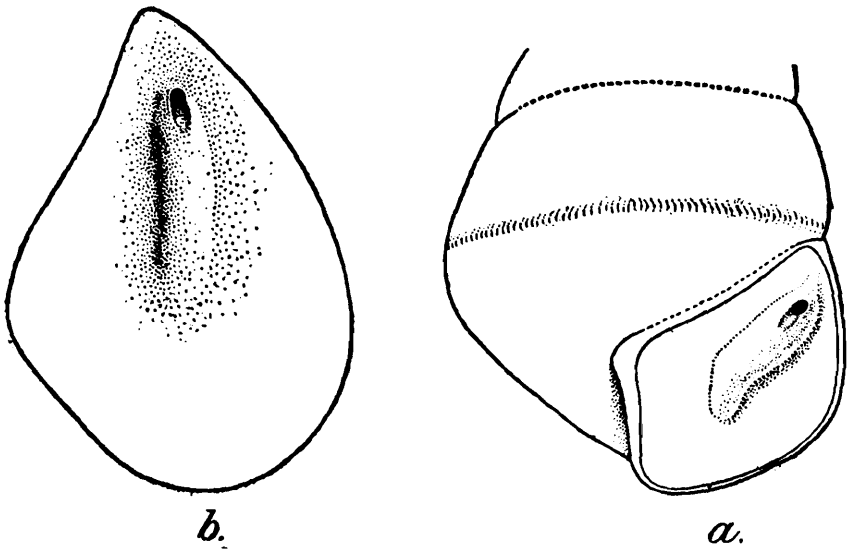


TEXT-FIG. 9.—The crawling animal of *Glessula hastula* showing definite wrinkles on the foot. *a*. Side view. *b*. Under surface.

Dr. H. Srinivasa Rao has very kindly drawn my attention to a statement made by Annandale and himself[1] regarding *Zootecus insularis* (Ehrenberg) in their account of the Molluscs of the Salt Range, Punjab, collected by me in July 1922. They say, "In one specimen the epiphragm remained complete. It had the form of a thin calcareous plate occupying the extreme outer part of the mouth and somewhat convex externally. Towards the upper extremity there was an elongate transverse hole. Further into the shell there were at least two similar plates separated by short intervals, both with similar holes. The soft parts had completely disappeared but we extracted an embroyonic shell. Possibly the hole had been made by some enemy which had devoured the snail." This statement is of great interest and has led me to investigate in detail the conditions present in *Zootecus insularis*. From a large number of specimens collected at various places in the Salt Range, Punjab, I have been able to find about a dozen examples in which the epiphragm was still intact and in these I have noticed a series of three epiphragms either situated very close together or at short intervals. The outermost epiphragm is thicker than the inner two, which decrease in thickness as they recede from the mouth. In a com-

[1] Annandale and Rao, *Rec. Ind. Mus.* XXV, pp. 394, 395 (1923).

plete epiphragm there is a small hole towards the upper extremity, situated at the end of an elevated and tunnel-like portion of the epiphragm.



Text-fig. 10.—Epiphragm secreted by the aestivating animal of *Zootecus insularis* (Ehrenberg).

a. An epiphragm *in situ* × 10. *b.* An epiphragm showing its general form × 18.

The hole is of a variable size and probably, in the specimen examined by Annandale and Rao, the elevated portion in the series of epiphragms had been damaged by some enemy for the purpose they suggest and thus an " elongate transverse hole " was left in each epiphragm.

The structure of the epiphragm is similar to that described for *Glessula hastula.* I could take off complete epiphragms by shaking a dead shell in a glass tube. This shows that there is a special area at the margin of the epiphragm coming in contact with the shell that is of a different consistency.

I would also like to clear up an ambiguity that occurs in Strickland's statement about " *Nanina vitrinoides* (Deshayes)" quoted by Dr. Rao in the preceding paper. He mentions a succession of two or three ' *pomata* ' formed one within the other during a process of desiccation. I presume that he does not mean the formation of two or three complete epiphragms, one within the other as is usual in *Glessula hastula* and *Zootecus insularis,* for in " *Nanina vitrinoides* " no hole is left in the epiphragm for purposes of respiration. He may either mean that on the removal of one epiphragm the animal is capable of secreting another further into the shell or, as sometimes happens, that the animal starts to form an epiphragm but before this is entirely completed a portion of it dries and curls up and then the animal starts afresh. There may thus be a succession of 2 or 3 epiphragms in one individual.

I have noticed such a series of epiphragms in certain specimens of *Macrochlamys glauca* Benson, kept under observation in our laboratory in Calcutta.

I may also point out here that a large number of specimens of *Buliminus* (*Subzebrinus*) *dextrosinister* Annandale and Rao, collected by me in the Salt Range, were found attached to tree trunks in an apparently

comatose condition, but at that time I did not notice their method of aestivation in detail. Dr. Rao informs me that he has seen on several occasions specimens of *Ariophanta* in South India attached to *Cactus* plants in the dry season in a state of aestivation. These instances are mentioned here in order to elicit further information about them.

DESCRIPTIONS OF TWENTY NEW INDIAN DRAGONFLIES.

By Lt.-Col. F. C. FRASER, *I.M.S.*

During the past three years several large collections of dragonflies have been sent to me for identification, among which nearly forty new species have been found.

A number of these have been described in various Journals and Memoirs by myself, but owing to pressure of work in other directions I have been unable so far to deal with the rest. It had been my intention to include these in a paper dealing with the Odonata of Northern India and Upper Burma, which was to form a companion to that dealing with the dragonfly fauna of Western India, published in these *Records* (Vol. XXVI, 1924), but owing to the time needed to digest the enormous volume of notes collected during the past ten years, and in order not to delay further the publishing of these new species, I have thought it better to include the latter in a separate paper.

The most important collections, which have furnished material for this paper, were made by Mr. T. Bainbrigge Fletcher in Assam, by Mr. Chas. Inglis in Sikkim and Bengal, by Mr. H. V. O'Donel in the Duars, Bengal, and lastly by Col. F. Wall, I.M.S., in Upper Burma and Ceylon.

Several interesting facts are illustrated in these collections, among which are the discovery of a new *Dysphaea*, the first of its genus to be reported from Burma, and the second from the Indian Empire; a new *Philoganga*, the first to be reported from Burma, and the third species to be reported belonging to this most interesting and archaic genus. A new *Macromia* is reported from Ceylon, and is noteworthy as being the first member of the subfamily Corduliinae to be found in that island. There is a new *Onychogomphus* from Upper Burma, whose colouring is totally at variance with all other known members of the genus, whilst a new *Gynacantha* is as brightly coloured as any *Aeschna*, a circumstance which is explained by its being a diurnal flyer, a hitherto unknown habit of any species of the genus. A subspecies of *Agrionoptera insignis* has been taken in the Duars, Bengal, this being the most westerly point of distribution so far reported; another species of *Hylaeothemis* has been discovered in North India, a rather unexpected find; a *Macromidia* from Upper Burma, which I had mistaken for *rapida* Mart., from Tonkin, after comparison with the type in the Paris Museum, turns out to be a distinct new species, the second of its genus to be found in India, and the first from Burma. Happily it combines the characters of *donaldi* from Western India, with those of *rapida* and *fulvia* from Tonkin and Borneo respectively. The four known species, although separated by enormous gaps, are thus seen to be closely linked. Another new subfamily has been added to the genus *Aeschna* by the discovery of *Petaliaeschna* from Assam, characterized by the extreme petiolation of the hind wings. The male of *Allogaster latifrons* has at last been discovered

after nearly half a century from the discovery of the female, and, by a curious coincidence, another species belonging to the same genus has been taken in the same locality. Both are described here.

I take this opportunity of thanking the various collectors mentioned above, who have so generously supplied me with the material upon which this paper is based. Types of all new species will be lodged in the British Museum.

The following new species are described below :—

Sub-order Anisoptera.

Subfamily Libellulinae.

Agrionoptera insignis dorothea.
Hylaeothemis gardeneri.

Subfamily Corduliinae.

Macromidia shanensis.
Macromia aculeata.
Macromia zeylanica.

Family Aeschnidae.

Aeschna quadrilateralis.
Periaeschna nocturnalis.
Petaliaeschna fletcheri.
Gynacantha biharica.
Gynacantha albistyla.

Subfamily Cordulegasterinae.

Allogaster hermionae.
(*Allogaster latifrons* Selys.)

Family Gomphidae.

Onychogomphus pulcherrima.

Sub-order Zygoptera.

Family Agrionidae.

Philoganga loringae.
Anisopleura subplatystyla.
Dysphaea walli.

Family Epallagidae.

Rhinocypha hilaryae.
Rhinocypha perforata beatifica.

Family Coenagrionidae.

Ischnura mildredae.
Copera superplatypes.
Caconeura dorsalis auricolor.

The text-figures are all original and, with the exception of the two wing-figures, have been drawn from camera lucida studies.

Agrionoptera insignis dorothea, subsp. **nov.**

Male.—Abdomen 24-25 mm. Hindwing 25 mm.

Head.—Labium bright chrome yellow, the midlobe and contiguous borders of lateral lobes black ; labrum bright citron yellow, its anterior border narrowly black ; ante- and post-clypeus and lower border of frons, as well as a broader area at the sides, pale creamy yellow ; frons above this area and on upper surface brilliant metallic blue, vesicle similarly coloured ; eyes brown ; occiput glossy black.

Prothorax black, unmarked.

Thorax black variegated with greenish yellow as follows :—a narrow stripe on each side of the middorsal carina, a small upper humeral spot and a large quadrate lower one, a small spot on the centre of humeral suture, a large spoon-shaped spot lying between the two lateral sutures, with two small spots above just under the base of forewing, a large elongate spot bordering the front of the second lateral suture, and lastly, the greater part of the metepimeron.

Legs black, anterior pair of femora with a streak of yellow on inner aspect.

Wings hyaline, uniformly enfumed in old specimens : nodal index :— $\frac{10-14}{10-11} \mid \frac{13-10}{12-9}$, $\frac{10-11}{10-11} \mid \frac{12-11}{12-9}$. Pterostigma blackish brown, over 2-3 cells ; trigones and hypertrigones entire, subtrigone of forewing traversed once, loop of only 6 to 7 cells, very short and obtuse ; only 1 cubital nervure in all wings ; *Rspl* and *Mspl* absent ; 2 rows of discoidal cells in forewing to level of node or beyond.

Abdomen blood-red, or in tenerals, bright ochreous. Marked with black narrowly along the borders of each segment, and more broadly at the apical ends, where the black forms complete rings on each.

Segment 1 dull ochreous green clouded with brown laterally. Segments 8 to 10 entirely black.

Anal appendages black, superiors subcylindrical, arched as seen in profile, with the apex tapering to a fine point and curled evenly upward ; inferior triangular, its apex curling gently up.

Genitalia not differing markedly from *insignis insignis*, the hamular hooks rather more curled, the lobe constricted at its base, longer and bulbous at its apex.

Female.—Abdomen 27 mm. Hindwing 28 mm.

Differs in a few respects from the male. The wings are rather more deeply enfumed ; the yellow of the labrum brighter and split into two spots by a broad median black fascia ; the lateral markings of the thorax broader, the spoon-shaped mark on the sides being confluent with the upper anterior spot, and the elongate spot bordering the last suture broken into two spots ; the ground colour of the abdomen ochreous ; the 8th segment dilated laterally to form prominent wing-like borders ; the anal appendages short and conical ; the markings on segments 2 and 3 brighter and broken up by a broad subdorsal lateral black stripe.

Distribution.—Hasimara, Duars, Bengal and Gopaldhara, Darjeeling dist., 4 males and 1 female from the former place, and 1 female from the latter, the former lot from the Duars collected by Mr. H. V. O'Donel, the latter by Mr. H. Stevens.

Mr. Stevens' specimen was badly broken-up and its colours faded, but a comparison with the Duars female proves them to be conspecific. This constitutes the most westerly record of the genus as well as the most northerly. The species may be distinguished from *insignis insignis* by its smaller size, lower nodal index, the thoracic markings, and lastly by slight differences in the genitalia. It has been named after Mrs. H. V. O'Donel.

Hylaeothemis gardeneri, sp. nov.

Male.—Abdomen 25 mm. Hindwing 29 mm.

Head.—Labium bright citron yellow, mid-lobe with a median black stripe; labrum yellow with a broad median and a narrow blackish brown border; rest of face bright citron yellow; frons and vesicle metallic blue; occiput black, very minute.

Prothorax black marked with yellow, the posterior lobe moderately large, bordered with yellow.

Thorax black marked with greenish-yellow as follows:—a fine yellow line on either side of the middorsal carina, no antehumeral stripe, a humeral stripe narrow above, broadening irregularly below.

The greater part of the sides greenish-yellow, the second lateral suture heavily mapped out in black, this stripe splitting below to enclose the root of the hind leg. Coxae yellow behind, black anteriorly; legs black, posterior femora with a row of closely-set, short robust spines, gradually increasing in length as traced towards the end of femur; mid femora with a row of closely-set, short spines on the proximal half only, and four much longer and gradually lengthening spines, very widely spaced on the distal half.

Wings hyaline, pterostigma black, squared inwardly, oblique outwardly, unbraced, over $2\frac{1}{2}$ cells; (neuration irregular in the right hindwing of type, where the trigone is entirely deformed and a nervure is present in the median space; the antenodals also in this wing do not coincide), nodal index $\frac{9\ \ 16}{9-14} \mid \frac{14-9}{15-9}$; 2 rows of postanal cells in hindwing, only 1 in the fore; 1 cubital nervure in forewing, 3 in the hind; trigone in the normal hindwing traversed once; loop with 3 cells in both hindwings; 1 row of discoidal cells in forewing nearly as far as termen.

Abdomen black marked with bright yellow as follows:—segment 1 with a large spot on either side, extending to ventral border and from end to end, also a dorsal apical triangular spot, segment 2 with a median dorsal subapical spot and a broad L-shaped spot on each side, segments 3 to 7 with lateral stripe split into a basal part, by the black jugal suture, and a median longer. On segment 3 the basal part confluent with a ventral stripe, on 4 the basal spot oval, on 5 and 6 the basal part represented by a small round spot, which is quite absent on segment 7; 8 to 10 unmarked.

Anal appendages black, inferior appendage equal in length to superiors, the latter pointed and with a blunt spine beneath the apex, on which are developed several smaller minute spines.

Genitalia.—Lamina projecting cowl-like; hamules very conspicuous in profile, robust, outer ones foliate, inner small, strongly recurved hooks, lobe narrow pointed, very prolonged.

Distribution.—Kampison, Himalayas, 9th April 1924. A single male coll. by S. Chatterjee. *Type* in Museum of Forest Research Institute, Dehra Dun, N. India. Differs in markings and in genitalia from *fruhstorferi* and *clementia*. Venational details also differ in several respects.

More closely related to *clementia* but differs by the yellow labrum, shape of genitalia, etc.

Macromidia shanensis, sp. nov.

Male.—Abdomen 38 mm. Hindwing 32 mm.

Head.—Labium whitish yellow; labrum dark brown; anteclypeus pale yellow; postclypeus, face, frons and vesicle brilliant metallic dark green; occiput dark brown; eyes emerald green.

Prothorax palest brown on dorsum, yellow at the sides.

Thorax brilliant metallic green marked with citron yellow:—an antehumeral stripe extending about halfway up the dorsum of thorax, a narrow medial lateral stripe, a small isolated spot above and a narrow hinder stripe on the metepimeron.

Legs black, coxae of anterior pair yellow. All tibiae keeled.

Wings hyaline; discoidal field in forewing of a single row of cells for a distance of 8 cells, or to level of inner end of bridge; 2 cubital nervures in forewings, 4 in the hind; hypertrigones traversed twice in forewings, once in the hind; nodal index $\frac{9-17}{13-9} \mid \frac{16-9}{10-12}$; pterostigma black, rather short, over $2\frac{1}{2}$ cells. Membrane brown.

Abdomen black, segment 1 metallic green with a narrow lateral apical yellow border, segment 2 with the small oreillet, a spot behind it, and a sharply defined linear spot on the middorsal carina extending basad as far as the jugum, bright citron yellow, segment 3 with a linear middorsal stripe tapering away apicad, all other segments unmarked, except 6 which has an oblong middorsal spot of yellow.

Anal appendages black, shaped similarly to those of *rapida*.

Female.—Abdomen 36 mm. Hindwing 34 mm.

Exactly similar to the male. The yellow lateral spots on segment 2 forming a continuous broad stripe, which is continued on to segment 3 as far as the jugal suture. The spot on segment 6 rather larger, shaped like a long necked flask, with the tapered end pointed basad.

Anal appendages small, black. Vulvar scale projecting, deeply bifid into two spine-like processes, half the length of segment 9.

Wings tinted with saffron at the bases, especially in the cubital and subcostal spaces, as far out as the arc; 12-13 cells in the loop; discoidal field in forewings irregularly of one or two rows of cells, or of two rows with an occasional single cell intercalated; nodal index:— $\frac{9-15}{11-10} \mid \frac{16-10}{10-11}$, pterostigma similar to male.

Distribution.—Maymyo, Upper Burma, 2 females and a single male collected by Col. F. Wall, I.M.S., 31st May 1925, 7th June 1925.

The species is important as it links up *rapida* with *donaldi* in its venation. It is distinguished from the former by the colour of its appendages and by the very restricted markings of abdomen, etc.; from the latter by its much larger size and differently shaped anal appendages.

The large identification mark on segment 6 is strikingly similar to that found in *donaldi*. *Type* in the Fraser collection.

Macromia aculeata, sp. nov.

Male.—Abdomen 48 mm. Hindwing 36 mm.

Head.—Labium brownish yellow; labrum and face brown with some ill-defined yellow markings,—a small oval spot at the base of each side of the labrum, a small spot at the middle of anteclypeus and a larger well-defined spot shaped like a broad-brimmed hat at the centre of postclypeus; frons brown in front, obscurely yellow above, where it is deeply notched; vesicle and frontal eminences slightly blue metallic; occiput black. Eyes blue.

Prothorax brown. Thorax brown in front marked by a yellow ante-humeral stripe, which is well defined below, but gradually fades away above; laterally blue metallic with a bright citron yellow stripe at its centre and another on hinder border of metepimeron.

Wings hyaline, pterostigma black, over 1 to 2 cells; nodal index :— $\frac{6-13}{8-10}$ | $\frac{13-6}{10-9}$; 4 cubital nervures in forewing, 3 in the hind; hypertrigones traversed twice in forewings, once in the hind. Membrane white.

Abdomen black marked with bright citron yellow as follows :— the basal half of segment 2 and the tip of lobe, broad median rings on segments 3 to 6, the basal half of 7 and rather more than the basal third of segment 8, remainder unmarked. Segment 10 with a prominent acute dorsal spine.

Anal appendages black, superiors slightly shorter than the inferior, stout, curved slightly in at apex which is blunt and very slightly upturned. On the outer side, well beyond the middle of appendage, a short very robust spine. Inferior triangular, curled very slightly up, its apex more so, and split into two minute points. (The spine on segment 10, in type, bears three small spines at its apex, but this may be abnormal.)

Genitalia.—Lamina very depressed, notched, coated with short stiff golden hairs, hamules very long, slightly tapered, ending in a well curved hook which overhangs the lobe, (very similar in shape to that of *bellicosa*), lobe prolonged, narrow, projecting perpendicularly to long axis of abdomen, its hinder border bevelled, coated with short stiff golden hairs.

Distribution.—Maymyo, Upper Burma, a single male collected by Col. F. Wall, I.M.S., 25th May 1925, in my own collection. It belongs to group *cingulata*, but is distinguished from all other species by its genitalia.

In my group characters, given for the genus in *Records of the Indian Museum*, Vol. XXV, p. 452, instead of " well-defined stripe," I should have said, " well isolated stripe," for in *cingulata* itself, there is a well-defined stripe, but it is confluent with the other yellow markings of the face. In all other members of the group the stripe is absent or poorly defined.

In addition to this male taken by Col. Wall, there are two females taken in the same locality on 3rd-25th May 1925, but their markings show them to belong to group *calliope*. Here follows their description.

Macromia sp. Female (male unknown).

Abdomen 43 mm. Hindwing 39 mm.

Head.—Labium with midlobe citron yellow, its centre narrowly brown, lateral lobes brown, citron yellow basad; labium black with an elongate oval citron yellow spot at base; rest of face and frons glossy black with a broad transverse citron yellow stripe across postclypeus. Occiput and vesicle black. Eyes blue.

Prothorax brown.—Thorax metallic greenish-blue marked with an antehumeral stripe extending nearly up to alar sinus, a broad medial lateral stripe, and a third, on hinder border of metepimeron, all vivid citron yellow.

Legs black, trochanters marked with yellow.

Wings hyaline.—In an adult specimen the apices of forewings enfumed, the extreme bases of both pairs golden yellow. In a teneral specimen the whole of the wings palely enfumed, the bases golden yellow as far out as level of 2nd antenodal nervure; nodal index :— $\frac{7-16}{9-11} \mid \frac{17-6}{10-10}$; 13 to 15 cells in loop (only 6 in *aculeata*); hypertrigones traversed 3 to 4 times in forewings, twice in the hind.

Abdomen black marked with citron yellow as follows :—segment 1 with a small spot on either side, 2 entirely yellow except for a narrow dorsal apical black border, segment 3 with a baso-lateral spot, narrowly confluent with a pair of middorsal confluent spots, segments 4 to 6 with a pair of medial middorsal spots which decrease gradually in size as traced from segment to segment, 7 with a broad basal ring covering nearly half the segment, 8 with a minute quadrate ventral spot, remainder unmarked.

Anal appendages small, black. Vulvar scale minute, triangular, bifid, glossy black.

Macromia zeylanica, sp. nov.

Male.—Abdomen 38 mm. Hindwing 33 mm.

Head.—Labium citron yellow, the middle lobes broadly bordered with black; labrum black with a citron yellow spot at its base; anteclypeus black, postclypeus bright citron yellow, forming a curved transverse stripe on lower part of face. A small yellow spot against each eye nearly confluent with the yellow stripe, and lastly, a small oval spot on the upper surface of each side of frons.

Prothorax black.—Thorax brilliant metallic bluish green marked with citron yellow as follows :—an antehumeral stripe extending nearly up to alar sinus, which is itself yellow, a narrow mediolateral stripe and the hinder border of metepimeron. A large spot on anterior trochanter and a smaller on the middle one.

Legs black.

Wings hyaline, very faintly enfumed; pterostigma black, small, over $1\frac{1}{2}$ cells; 6 cells in loop; hypertrigones traversed 4 times in forewings, once in the hind; 4 cubital nervures in forewings, 3 in the hind; nodal index $\frac{6-14}{9-9} \mid \frac{15-5}{10-10}$; membrane white.

Abdomen black marked with citron yellow as follows :—segment 2 with a dorsal duplicate spot limited apicad by the jugal suture and prolonged basad as two points, a large baso-lateral spot limited to the

basal half of segment, segment 3 with a triangular baso-lateral spot and a paired medial dorsal spot, segments 4 to 6 with similar dorsal spots, but almost obsolete on 6, segment 7 with a narrow subbasal ring, 8 with a narrow dorsal basal spot almost confluent with a large quadrate ventral spot. Segments 9 and 10 unmarked, the latter with a robust dorsal spine.

Anal appendages very similar to those of *cingulata*, but the superiors more tapered, the lateral robust spine situated further from the apex.

Genitalia very similar to that of *cingulata*, the hamules are stouter, the terminal hook not so long. Lobe similar, its apex level with the apex of hamules.

Distribution.—Kandy, Ceylon. A single male collected by Col. F. Wall, I.M.S., 13th September 1924, at present in my own collection. Closely related to *cingulata*, but distinguished easily by the markings of face and by slight differences in the anal appendages and genitalia. This is the first species of the subfamily Corduliinae to be discovered in Ceylon.

Aeschna quadrilateralis, sp. nov.

Male.—Abdomen (first 5 segments) 30 mm. Hindwing 53 mm.

Labium light warm brown; labrum, face and frons pale yellowish brown, the upper surface of frons dark blackish brown; occiput olivaceous, small. Eyes palest brown, probably blue during life.

Prothorax brown, its posterior border laterally greenish yellow.

Thorax warm reddish brown marked with bright greenish yellow as follows:—narrow antehumeral sinuous stripes sloping obliquely upward and inward so as to converge, but not nearly meeting the antealar sinus; two lateral stripes, the first lying between the humeral and first lateral suture, the second occupying the central area and greater part of the metepimeron, both bordered diffusely with blackish.

Legs.—Femora dark reddish brown changing to black distad, tibiae and tarsi black. Hind femora with a row of very small, very closely-set, sharply sloped short spines.

Wings hyaline with a diffuse clouding of dark blackish brown at the bases of all wings, occupying the costal, subcostal and median spaces in the forewing, and a much smaller area in the hindwings, extending out for about the 8th antenodal nervure in forewings.

Pterostigma very short, over $3\frac{1}{2}$ cells in forewing, over 2 in the hind. In the latter wings, in the space immediately next to the pterostigma, are two opaque blackish brown cells, their colour being confluent with the pterostigma so that the latter has a peculiar stunted, quadrate appearance. Relatively to the size of the insect, the size of the pterostigma is the smallest known within the genus.

Details of the wings are as follows:—median space entire; nodal index $\frac{22-29}{22-19} \mid \frac{27-21}{19-23}$; 6 cubical nervures in forewings, 6-7 in the hind; trigones of forewings with 7-8 cells, the inner one cleft in two, in the hind shorter, only 5 cells; 12-14 cells in the loop; outer side of trigones sinuous and sending off a supplementary nervure which runs parallel with *Mspl* for a long distance; *Mii* sharply angulated towards the costa

about 2-4 cells proximad of pterostigma; *Rs* forked about 5-7 postnodal cells proximad of pterostigma, 4 rows of cells between the branches of fork; 3-4 rows of cells between *Rs* and *Rspl*; 3 cells in anal triangle; base of hindwing oblique, shallowly excavate; reticulation very close. Membrane yellowish white.

Abdomen dark brown, the base of each segment very narrowly yellow, as also small paired apical lunules. The oreillets small, bright greenish-yellow above, acutely pointed outwardly and furnished with a border of about 12-14 minute teeth. (The last 5 segments lost, apparently knocked off with the rim of the net.)

Genitalia.—Lamina tumid, deeply cleft into two tumid lateral masses; hamules of curious structure, at first curled out of the genital sac, then curling back again as they converge towards each other, then abruptly angulated towards the base of abdomen, tapering to a fine point, forming two closely approximated pointed scales which pass high up in the arch formed by the lamina; lobe scrotal shaped and with a median narrow longitudinal sulcus.

Distribution.—A single incomplete male from Hasimara, 19th April 1924, Duars, Bengal, collected by Mr. H. V. O'Donel.

Periaeschna nocturnalis, sp. nov.

Male.—Abdomen 48 mm. Hindwing 40 mm.

Head.—Lips and face dark ochreous; frons brownish yellow; occiput blackish brown, very minute; penultimate joint of antennae bright yellow; eyes lustrous greeny grey.

Prothorax and thorax dark brown, the middorsal carina bright yellow, and on the sides two vestigial yellow stripes or oval spots, the larger on the metepimeron.

Legs reddish brown, the distal ends of femora darker brown; hind femora armed with two rows of robust short moderately closely spaced evenly sized spines.

Wings hyaline, nodal index $\frac{19-25}{21-18} \mid \frac{24-19}{19-20}$; cubital nervures $\frac{6-8}{7-7}$; hypertrigones traversed $\frac{6-7}{4-4}$; loops 10-celled; a basal antenodal nervure in all wings; one row of cells between *Rs* and *Rspl*; trigones of forewings traversed 6 to 7 times, those of the hind 5 times; 4 to 5 median nervures in all wings; the 6th and 7th the primary antenodal nervures in forewings, the 5th in the hind. Two rows of cells between forking of *Rs*; a poorly developed supplement to trigones. Pterostigma bright yellow, very small, well braced, over $2\frac{1}{2}$ to $3\frac{1}{2}$ cells; membrane greyish white, very short and limited in hindwing to the petiole; reticulation very close.

Abdomen dark brown marked with citron yellow as follows:—a diffuse basal bordering to segment 1, segment 2 with the jugal suture finely yellow and a fine line on the middorsal carina apicad to the jugal suture. Laterally, on this segment, a stripe moderately broad at base, tapering as far as jugum where it curves up above oreillet and continues as far as apical border of segment, 3 with a small baso-lateral spot near the ventral border, a fine well-defined line on the jugum expanding dorsalwards, lastly a pair of apico-dorsal triangular spots. Segments 4

to 7 with similar dorsal and apical spots, segment 8 with only vestiges of these, and 9 with a vestige of the jugal marking only. Segment 10 diffusely yellow at the base for about half the segments length.

Anal appendages dark brown, superiors shaped like an assegai as seen from above, equal in length to segments 9 and 10, pointed at apex, fringed with long hairs within. Inferior triangular, curled strongly up as seen in profile, the apex minutely recurved.

Genitalia compressed and difficult to make out, lobe short, spined along its lower border.

(Female unknown.)

Distribution.—Shillong, Assam. Described from a teneral male coll. by Mr. T. Bainbrigge Fletcher, 14th June 1924. Beaten up from jungle during the day and evidently a crepuscular insect. *Type* in the Pusa Museum, Bihar. (I believe since transferred to the British Museum.)

Possibly the colouring of the adult insect is more defined, especially the lateral markings of thorax, which may well be green or bright citron yellow.

Petaliaeschna, gen. nov.

Head globular, face deep and narrow as in *Gynacantha*; eyes broadly contiguous, occiput very minute.

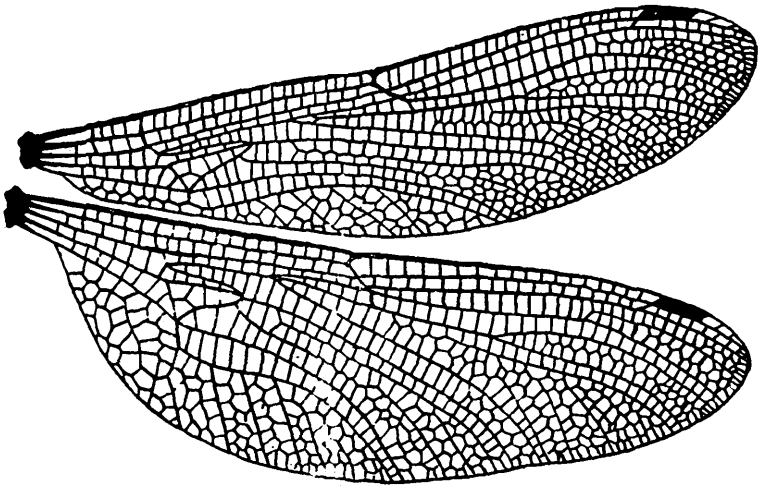


FIG. 1.—Wings of *Petaliaeschna fletcheri*, sp. nov. Male.

Thorax short, robust, its middorsal carina strongly keeled. Legs moderately long, hind and mid femora with two rows of short, robust, closely-set spines, and two or three longer distal ones.

Wings long and broad, reticulation very close, hindwings distinctly petiolated, the forewings less so; base of hindwings very oblique, very shallowly excavate, tornus right angled; basal space reticulated; cubital nervures numerous; loop very narrow, made up of 2 rows of cells only; 5 cells in anal triangle; trigones rather long and narrow, that of forewing the longer, 5-celled in the male, 6 to 7-celled in the female; *Rs* forked from about midway between the node and pterostigma, only 2 rows of cells between its branches; *Rspl* not well defined, a single row of cells between it and *Rs*; pterostigma short, over 3 to 5 cells, that of hindwing slightly the longer; a supplementary nervure springing from

the distal side of all trigones ; a basal subcostal nervure to all wings (rarely absent).

Anal appendages nearly as long as the two last abdominal segments, typically Aeschnine in shape (see under species). Vulvar scale forked, minutely spined, very similar to that of *Cephalaeschna.*

Genotype *Petaliaeschna fletcheri*, sp. nov.

Distribution.—Assam and Sikkim.

Petaliaeschna fletcheri, sp. nov.

Male.—Abdomen 52 mm. Hindwing 40 mm.

Head.—Lips, face and frons uniform olivaceous yellow, no basal marking to frons or its creat ; occiput reddish brown ; vesicle brown.

Prothorax brownish yellow. Thorax with middorsal carina bright yellow, area between it and humeral suture warm brown bordered with blackish brown ; laterally two bright citron yellow stripes separated by a median narrow band of dark brown.

Legs yellow, middle and hind femora with two rows of dark brown spines as for genus.

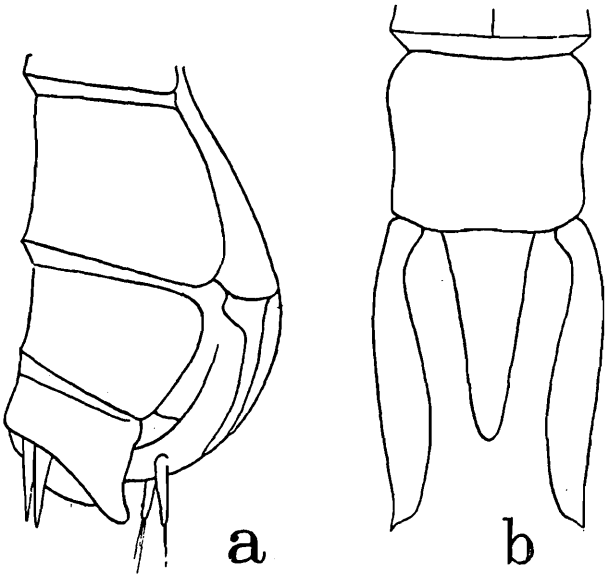


FIG. 2.—*a.* End segments and genitalia of *Petaliaeschna fletcheri*, female, right side, viewed in profile. *b.* Anal appendages of male of same species.

Abdomen dark olivaceous brown marked with bright yellow as follows :—segment 1 with the sides yellow, segment 2 with a dorsal stripe tapering towards the apical border, a baso-lateral spot and the oreillets, the latter bordered with black and a row of fine black spines ; segment 3 to 7 with basal middorsal spots becoming more obscure as traced towards the anal segments ; segment 3 with baso-lateral and apico-lateral spots, segment 4 with the latter spot only ; 8 to 10 with obscure basal rings, rather broader and more distinct on segment 10.

Wings hyaline ; pterostigma yellow, short, over $3\frac{1}{2}$ cells or more, unbraced ; 6 median nervures in forewing, 5 in the hind ; 8 cubital nervures in forewing, 6-7 in hind ; nodal index $\frac{21\ \ 21}{21-16} \mid \frac{23-20}{18-21}$; anal triangle 5-celled.

Genitalia.—Too distorted to make out in the only male studied.

Anal appendages.—Superiors nearly twice the length of segment 10, dark brown, narrow and sinuous as seen from above, with a strong dorsal longitudinal keel and a fine point directed outwards at apex. Each appendage at first inclined outwards and then curving in, converging ever so slightly. Slightly dilated at the middle, inner border fringed with hairs. Inferior appendage pale yellow tipped with brown, triangular, curling upward at apex.

(Of an adult in the living state, Mr. Bainbrigge Fletcher makes the following note :—Eyes greenish brown; the whole face bright yellow, duller above. The midthoracic ridge, lateral stripes and legs bright yellow. Inferior appendage yellowish white.)

Female.—Abdomen 47 mm. Hindwing 44 mm.

Very similar to the male but a more robust insect. Abdomen brown, with a bright yellow, almost unbroken ventro-lateral stripe running from base of segment 2 to base of 9. Other markings as for the male. Loop rather larger than in the male, with 8 to 9 cells; nodal index :— $\frac{23-24}{23-18} \mid \frac{26-23}{18-22}$.

Distribution.—Assam and Sikkim. *Type* in the Pusa collection, but probably since transferred to the British Museum. Closely related to *Cephalaeschna*, from which it is separated by the long, narrow face, etc. To this genus belongs, I think, *Cephalaeschna acutifrons* Mart. Its face is far too narrow for *Cephalaeschna*, and the venation except for some minor details agrees with the above.

Shillong, Khasia Hills, Assam, 19th-23rd May 1924, collected by Mr. T. Bainbrigge Fletcher, who has sent me the following notes about its habits and colouring :—Lies up in scrub during the day, beaten up in bushes behind upper stream in fruit garden, Shillong; flew a few yards and then settled again, flight rather weak. Eyes greenish brown, whole face bright yellow, duller above. Midthoracic ridge, lateral stripes and legs bright yellow. Inferior appendage yellowish white.

Gynacantha biharica, sp. nov.

Male.—Abdomen 45 mm. Anal appendages 5·9 mm. Hindwing 42 mm.

Head.—Labium yellowish brown; labrum olivaceous; face and frons pale green, the latter with a broad black T-like mark on its upper surface; occiput bluish green; eyes glaucous green.

Prothorax brown.—Thorax apple-green with bright blue spots at bases of wings on tergum. (Dark brown in the dry state.)

Legs reddish yellow, distal ends of femora blackish brown.

Wings evenly enfumed, the centres of areolets paler; pterostigma 3 mm. long in forewing, 3·75 in the hind, brownish yellow, its costal border yellow, hinder border black, over $3\frac{1}{2}$ cells, sinuously braced. Membrane absent. 1 row of cells between *Cui* and *Cuii* at origin; 12 cells in loop; 5 rows of cells between *Rs* and *Rspl*; nodal index :— $\frac{18-25}{20-18} \mid \frac{24-16}{17\ \ 18}$, trigones $\frac{7-6}{6-7}$, cubital nervures $\frac{9-8}{7-7}$.

Abdomen blackish brown marked with turquoise blue and grass-green as follows :—segment 1 with its sides broadly, and its apical border

narrowly turquoise blue ; 2 with the sides irregularly blue, a large, basal spot on upper and lower surfaces of oreillets, the basal side of the jugal suture and the surface behind it, except the middorsal crest, turquoise blue ; oreillets with a broad black border bearing 7 robust spines ; segment 3 with a large basal spot at sides and two large spots on apical border, narrowly interrupted by the dorsal crest, turquoise blue, these spots narrowly confluent laterally by an isthmus of blue ; segments 4 to 6 with subtriangular baso-lateral spots extending along the ventral border grass-green, in addition a pair of dorsal apical spots of the same colour, segments 7 and 8 with the basal spots only, 9 and 10 unmarked, the latter with a pair of small dorsal tubercles.

Anal appendages dark blackish brown, paler reddish brown at the middle. Superiors very long, outer sides straight, inner sinuous, apical thirds broadening markedly, then narrowing to a fine point which is in line with the outer border. In profile, almost dead straight but with a slight bayonet-like bend at the junction of basal and middle thirds. Inner borders lined with coarse black hairs. Inferior appendage less than half the length of superiors, sloping down, almost straight in profile, triangular and narrow as seen from above, tapering rapidly to a blunt point.

Distribution.—Pusa, Bihar. Two males collected by Mr. T. Bainbrigge Fletcher, 7th August 1924. *Type* in the Pusa collection, paratype in Fraser collection. Easily distinguished from all other species by its display of colours, and quite the most handsome species of the genus. I am indebted to Mr. T. Bainbrigge Fletcher for his notes on the colours during life. He states that it is a day-flyer and flew into the bungalow about 1 P.M. This may explain the vivid colouring so unique in a dowdy genus.

Gynacantha albistyla, sp. nov.

Male.—Abdomen 41 mm. Hindwing 34 mm.

Head.—Eyes brown or olivaceous during life ; labium yellow ; labrum olivaceous, yellow at free border ; face, frons and bases of mandibles golden brown changing to bluish at the sides ; vesicle blackish brown ; occiput pale greenish white. No marking on upper surface of frons save for an obscure brownish bordering along the crest. Prothorax brown.

Thorax pale brown dorsally, pale bluish green laterally. Legs pale ochreous with black spines.

Wings hyaline ; pterostigma yellowish brown, over 3-4 cells ; nodal index :—$\frac{15-16}{16-12} \mid \frac{18-14}{12-16}$; loop 8-celled ; 5 cells in trigone of forewing, 4 in the hind, the basal cell in each bisected by a transverse nervure to form two cells ; 3-4 rows of cells between *Rs* and *Rspl* ; 5 cubital nervures in forewings, 6 in the hind.

Abdomen variegated with pale blue and black as follows :—segment 1 with a large triangular dorsal black spot broadening apically, segment 2 with the dorsum broadly black, the sides blue, a fine middorsal line of blue and a similar bordering the jugal suture basad, finally small subapical, subdorsal blue lunules, segments 3 to 8 similar, the subdorsal

lunules confluent narrowly with blue on the sides, from which prolongations are sent up at the base of segment and along the apical border of jugum, segment 9 broadly black, the sides reddish brown, with a pale blue subdorsal stripe expanding apicad, narrowing basad but not quite reaching the base of segment, 10 black with an irregular subdorsal spot confluent with a triangular spot on the dorsal carina, which tapers as far as the base.

Anal appendages long, straight, of the same width from base to apices, apex very slightly broadened, blunt, subrotundate, with an abbreviated outer point, reddish brown, darker at apices, keeled above for rather less than the apical half, fringed with long hairs on the inner side. Inferior appendage narrowly triangular, only half the length of superiors, its apex turned up very slightly as a minute upper spine, white, tipped with dark brown at apex.

Oreillets large, but smaller than in *biharica*, pale bluish, finely bordered with brown and bordered with 4-5 spines.

Female.—Abdomen 43 mm. Hindwing 38 mm. Appendages 4 mm.

Colour and markings almost identical to those of male. The blue not extending up along the jugal sutures, markings on segments 8-10 slightly modified to suit the length and formation of segments.

Anal appendages brown, shorter than in the male, broadening from the middle to apices which are subrotundate and without a spine. Wings similar to male; cubital nervures 6-8; loop 11-8, nodal index as for male. Pterostigma pale brown.

Distribution.—Pusa, Bihar, a single pair in the Pusa collection, collected by Mr. T. Bainbrigge Fletcher, 5th September 1924. There are many points of resemblance between this and *biharica*, but the latter insect is much larger, and the occiput bears a black T marking. It also, like *biharica*, appears to be a diurnal species.

Allogaster hermionae, sp. nov.

Male.—Abdomen 44 mm. Hindwing 35 mm.

Head.—Labium dark ochreous; labrum, face and frons uniform dark reddish brown; upper surface of frons and occiput rather darker brown; eyes brown. Face very broad, frons projecting as in *latifrons*, higher than occiput, a fringe of hairs along its crest projecting straight forward, a short distance behind which is another fringe projected back. Occiput with a fringe of coarse hairs projecting back.

Prothorax dark reddish brown, unmarked.

Thorax mahoghany brown marked with citron yellow with a faint greenish tinge as follows:—two dorsal pyriform spots, short and almost triangular on the upper half of dorsum, a narrow humeral stripe and a shorter and broader one on the middle of metepimeron, both framed rather broadly in black.

Legs dark reddish brown, tibiae and tarsi black. Armature as for *Cordulegaster*.

Wings hyaline, base very oblique, scarcely notched; pterostigma differing in size in the wings, 2·45 mm. in forewings, 3·25 in the hind, over 3 cells, reddish brown between black nervures, very narrow and non-braced; 3 to 4 cubital nervures in forewings, 2 in the hind; nodal

index $\frac{12-18}{13-18} \mid \frac{18-13}{14-14}$; all trigones traversed once by a nervure running from costal to outer side; 4 cells in anal triangle; 6 cells in loop; membrane pale brownish white. (The specimen is remarkable for the clarity with which it shows the plastic formation of node, arc, etc.)

Abdomen reddish brown marked with bright citron yellow as follows:—segment 1 unmarked, segment 2 with a dorsal saddle-shaped marking which is bifid apicad and limited basad by the jugal suture, except for a small triangular prolongation which does not extend quite to base of segment. Laterally the small blunt oreillet is coloured yellow. Segment 3 with two large dorsal triangular spots finely separated by the ground colour. Segments 2 and 3 with narrow apical dorsal lunules, 4 to 8 with similar dorsal spots but gradually decreasing in size from 4 to 8, rest of abdomen unmarked.

The abdomen is shaped exactly as for *Anotogaster nipalensis*.

Anal appendages reddish brown, the superiors directed straight back, as long as segment 10, narrow at base, pointed at apex, with a fine pointed ventral spine situated a little basad of middle of appendage and directed somewhat inward. A second broader and more robust spine situated beneath the extreme base of appendages.

Inferior appendage shorter than superiors, blunt at apex and slightly bifid, curled up evenly and slightly hollowed out above.

Genitalia.—Lamina depressed, its border emarginate; inner hamules foliate, thin squarish plates which curl inward. Outer hamules broad blunt spines; lobe tongue-shaped, shallowly bifid at apex and hollowed out above.

Distribution.—A single male from the Darjeeling district, on the wing in July. It differs from the rest of the Asiatic species of the family except *Allogaster latifrons*, from which it may be distinguished by its much smaller size and abdominal markings. It is strongly reminiscent of some members of the allied genus *Cordulegaster* from North America, especially *sayi* and *maculatus*. *Type* will be deposited in the British Museum.

Allogaster latifrons, Selys.

The male of this species has not been described. Mr. Chas. Inglis has taken a male at Nathui La, near the Thibetan-Sikkim border, which will be deposited in the British Museum. Its description follows:—

Male.—Abdomen 52 mm. Hindwing 40 mm.

Head, thorax and legs coloured and marked exactly as for type.

Wings hyaline with a slight saffronation at extreme base of both and without any trace of the dark brown clouding so characteristic of the female. Reticulation very close; pterostigma narrow, 3 mm. long in forewings, 3·5 mm. in the hind, reddish brown between black nervures, over 4 to 5 cells; 3 cubital nervures in forewings, 2 in the hind including the base of subtrigone; all trigones traversed once; nodal index $\frac{14-18}{15-15} \mid \frac{18-15}{14-13}$; membrane greyish white; loop 5 cells; anal triangle 4-celled.

Abdomen black on dorsum, reddish brown on sides and beneath, marked with citron yellow as follows:—segment 1 reddish brown,

unmarked, segment 2 with two small dorsal lunules on the apical side of the jugal suture, and two longer narrower apical lunules, segments 3 to 8 with small triangular paired dorsal spots replacing the dorsal lunules, and segments 3 to 6 with similar apical lunules, which on segment 7 are represented by a tiny point only. Segment 9 unmarked, segment 10 with two small apical subdorsal spots.

Anal appendages black. Superiors compressed, the apex pointed, slightly curled so as to lie in a different plane to rest of appendage. A median ventral robust tooth and a similar one beneath the extreme base of appendage. Inferior subquadrate, the apex a little turned up and very shallowly notched, hollowed out above, nearly one third shorter than superiors.

Genitalia.—Lamina depressed, coated with very long hairs; anterior hamules broad and foliate, the apices curling in towards the mid line; posterior hamules long stilette-shaped organs, ending in a blunt apex, directed obliquely towards each other and meeting over dorsum of penis; lobe short and broad, scrotal-shaped, the apex very slightly bifid and cupped.

This male is distinguished by its abdominal markings and by its much larger size from *hermionae*, which it resembles in general facies and in its ground colour. Two other females collected from the same district do not differ from the cotype described by myself in the *Journal of the Bombay Natural History Society*, but in one the wings are unenfumed as in the male described above.

The posterior lobe of the prothorax of male is citron yellow, as also is the trochanter and coxa of the first pair of legs. The dorsal thoracic stripe is much abbreviated and shorter than in *hermionae*.

Onychogomphus pulcherrima, sp. nov.

Male.—Abdomen 40 mm. Hindwing 30 mm.

Head.—Labium yellowish; labrum pale green, the anterior border of former narrowly reddish brown; face and especially frons vivid pea-green above as well as in front; vesicle and vertex dark blackish brown; occiput grass green, brownish at the sides.

Prothorax dark reddish brown marked with yellow, the posterior lobe, a large geminate spot in the middle line confluent with it, and a narrow anterior collar.

Thorax dark mahoghany brown marked with green as follows:—Nearly the whole of the dorsum, where are two very broad green antehumeral stripes confluent with a narrow mesothoracic collar, which latter is continuous with a narrow yellow midthoracic suture. This suture merely separated from the antehumeral stripes by a clouding of warm reddish brown. Laterally the whole of the sides greenish except for a moderately broad reddish brown stripe on the second lateral suture broadening anteriorly below.

Legs blackish brown, the extensor surfaces of anterior pair of femora yellow, of the two hinder pairs, reddish brown.

Wings hyaline, palely saffronated and distinctly tinted with yellow at extreme base. Pterostigma dark reddish brown, framed in blackish brown, but with a fine yellow streak between the ground colour and black

frame, strongly braced, over $3\frac{1}{2}$ to $4\frac{1}{2}$ cells; 4 cells in anal triangle; 1st postanal cell entire, not extending basad beyond the centre of subtrigone; other details typical of venation of genus *Onychogomphus*; nodal index $\frac{10-14}{12-10} \mid \frac{14-9}{10-10}$.

Abdomen dark ochreous and blackish brown; the first two segments marked with yellow, segment 1 with the lower parts of the sides broadly light greenish yellow, segment 2 with the same area, including the oreillets, yellow tinged with ochreous, the dorsum brown, this colour passing down on each side as a narrow stripe behind the oreillets. Segment 3 with the base and dorsum broadly dark ochreous, segments 4-7 dark reddish brown deepening to black at apices, segments 8-10 gradually paleing in colour from dark to bright reddish brown. The apical borders of all segments narrowly black.

Anal appendages yellow, reddish at apices. Superiors subcylindrical, tapering very slightly, the apical ends turned in and down rather abruptly and compressed, the outer angle of this part bearing four minute brown spines. At the centre and inner aspect of each appendage a small elongate tumid eminence, below which the appendages become laminated to form a very obtuse spine with broad base. Inferior appendage deeply cleft into two widely divaricate branches, which, seen in profile, are bent at a right angle at about one th rd of their length from the base. Curving at first down, they then sweep upward towards the superiors, each branch minutely spined on the outer border, slightly sinuous as seen from below, and ending in a point. Superiors as long as segments 9 and 10, inferior as long as segment 10.

Genitalia.—Lamina projecting markedly, its border slightly emarginate and concave; anterior hamules long fine stilette-like hooks ending in a fine recurved spine, directed back and converging; posterior hamules much stouter structures, broad, abruptly narrowed near apex, where they form a very robust slightly recurved spine; lobe deeply cleft into quadrate, slightly bifid branches with a shallow groove on the outer surface, its base tumid.

Distribution.—Three males taken by Col. F. Wall, I.M.S., at Maymyo, Upper Burma, 31st May 1925. Female unknown. The bright apple-green markings on a mahoghany red background are so unique in the genus as to easily distinguish it from all other species. *Type* will be deposited in the British Museum.

Philoganga loringae, sp. nov.

Male.—Abdomen 41 mm. Hindwing 39 mm.

Head.—Labium dirty yellow; labrum greenish yellow with a small median comma at base: bases of maxillae and cheeks as far up as level of antennae citron yellow; rest of head matt-black with some scattered pruinescence. Eyes brown.

Prothorax black with a median dorsal citron yellow stripe which broadens anteriorly and on the posterior lobe.

Thorax black marked with pale citron yellow as follows:—The midthoracic suture narrowly black, bordered on either side by a narrow yellow stripe, a narrow slightly sinuous antehumeral stripe, the sides

entirely pale yellow except for the second lateral suture which is strongly mapped out in black.

Wings very long and very narrow, petiolated from a point slightly proximal to *ac*; palely and evenly enfumed; pterostigma blackish brown, rather short, over 3½ cells, unbraced; nodal index :—$\frac{22-13}{20-13} \mid \frac{13-21}{11-19}$; 2 basal subcostal nervures in all wings, occasionally 3 in one or another; the so-called crossing of *Rs* greatly delayed, and no evidence whatever of an oblique vein in any wings examined.

Legs long and slim, the hind femora extending as far back as the middle of the second segment, anterior femora black, the middle and hinder pairs darkest ochreous; tarsi and tibiae black.

Abdomen dark reddish brown, segment 1 greenish yellow, segment 2 with a broad latero-ventral bright yellow stripe bordered above by black, the dorsum reddish brown, segment 3 with a continuation of the black stripe, which is here very diffuse and largely blocking the dorsal reddish brown; the ventral border dark ochreous, segments 4 to 10 similar but the black stripe gradually extending so as to black out most of the ground colour. On segment 9 a middorsal bright ochreous spot bisected by the broadly black middorsal carina. On segment 10 two bright ochreous rounded spots at the middorsum.

Anal appendages black. Inferiors aborted, merely two small eminences, invisible from the side. Superiors nearly twice the length of segment 10, pincer-like, curling gradually in to enclose a space shaped like a bishop's mitre. Only slightly dilated at the apices as seen from above and ending in an abrupt blunt point. A few very minute spines on the outer border of apices, much smaller than those found in *montana*. Seen from the side, these appendages lie in a horizontal plane, directed straight back, but curling up at apices. Below, slightly hollowed out, especially at apices.

Genitalia.—Lamina and hamules in one piece, the former very deeply cleft, the sides of the fissure so formed parallel. Laterally the lamina is continued as the hamules as a broad cowl-like plate which projects at a sharp angle from the genital sac, and the roof of which is accommodated in the cleft of the lamina. Lobe scrotal-shaped, very depressed, glossy black, resembles the flattened tumid body of a tick.

Female.—Abdomen 42 mm. Hindwing 37 mm.

A much bulkier insect in all respects than the male, the abdomen being especially robust. Colours identical to those of the male. Wings differing in a few details only, thus there are 2 basal postcostal nervures in some wings and only 1 in others. In one wing, two such nervures are in the closest apposition. Petiolation distinctly proximal of *ac*. Pterostigma slightly longer, over 4½ cells; as in the male, there is no vestige of an oblique nervure in any of the wings.

Nodal index $\frac{22-12}{18-10} \mid \frac{13-20}{12-19}$.

Abdomen very similar, the sides of segments 9 and 10 broadly ochreous, the dorsal spots replaced by a diffuse dark ochreous.

Vulvar scale similar to that of *montana*.

Anal appendages brownish yellow tipped with black, short, narrow conical and pointed.

Distribution.—Maymyo, Upper Burma. One pair taken *in cop*, and one other male, 1st July 1925, coll. by Col. F. Wall, I.M.S.

Differs from *montana* by its much smaller size, abdomen 41 mm., hindwing 39 mm. to 52 mm. and 48 mm. respectively. Nodal index correspondingly lower.

Anisopleura subplatystyla, sp. nov.

Male.—Abdomen 34 mm. (with appendages). Hindwing 28 mm.

Labium black, midlobe pruinosed; labrum bright apple-green very finely encircled with black; cheeks, epistome and frons pale ochre, rest of head black with a largish reniform spot, ochreous in colour on the outer side of the ocelli, the hilum of the spot directed inward. Eyes brown.

Prothorax black with a large oval spot on each side and a narrow triangular one on each side of the posterior lobe yellow.

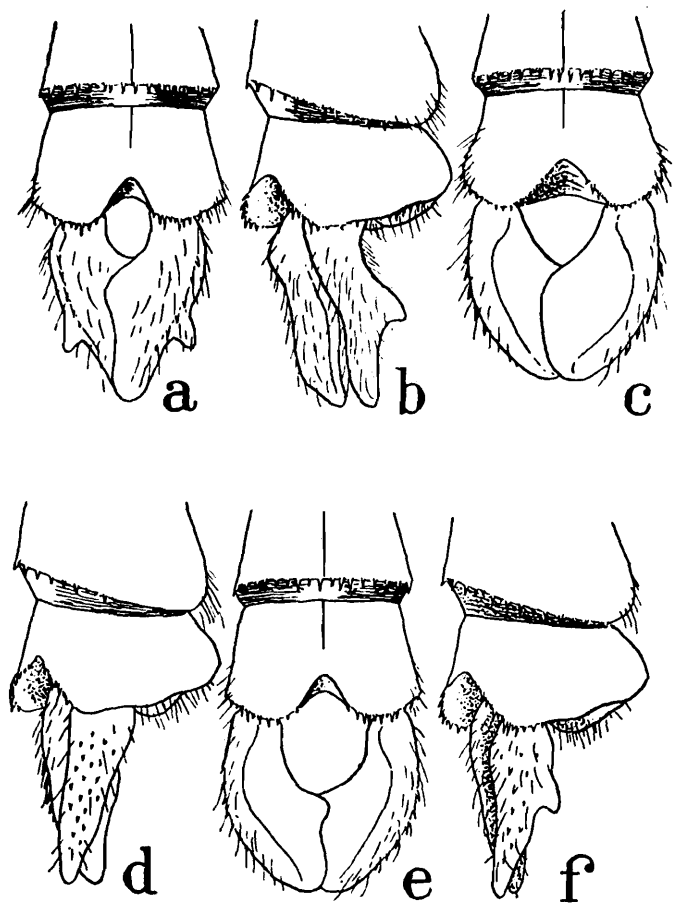


FIG. 3.—*a*. Anal appendages of *Anisopleura lestoides* Selys, dorsal view. *b*. The same seen from the right. *c*. The same of *Anisopleura comes* Selys, dorsal view. *d*. The same seen from the right. *e*. The same of *Anisopleura subplatystyla*, sp. nov., dorsal view. *f*. The same seen from the right.

Thorax velvety black, pruinosed beneath, marked with bright yellow as follows:—narrow antehumeral stripes running close to and parallel with the middorsal carina, the upper end of the stripes curved and strongly hooked outward; a narrow humeral stripe running parallel

to the former and broadly confluent with it below, but not quite meeting the outwardly curled part above. A small upper spot lying close to the outer side of the humeral stripe. The sides broadly yellow with a broad black stripe on the second lateral suture.

Legs black, inner and proximal part of the two anterior pairs of femora pale greenish yellow.

Wings hyaline, bases of both pale greenish yellow. A pale cloud of black at the extreme apices of the forewings. Pterostigma dark blackish brown, over 4 cells; 17 antenodal nervures and 22 postnodals to forewings, 14 and 20 respectively in the hind. Quadrilaterals entire; 4 cubital nervures.

Abdomen black, segments 9 and 10 pruinosed white on the dorsum, segment 1 broadly greenish yellow on the sides, this colour extending apicad on to dorsum as an almost complete ring. Segment 2 with a broad lateral stripe, 3 to 6 each with a baso-lateral spot followed by a long narrow stripe.

Anal appendages.—Superiors broad, roughly triangular and broadly hollowed out as seen from above, the outer border thickened. Conical as seen from the side and with a stout ventral spine which is continued back from near middle of appendage to the base. Inferiors practically obsolete, barely discernible from above or in profile.

This species differs from *lestoides* which has the epistome glossy black, the spots on the vertex greenish and nearly circular, only a single dorsal thoracic stripe and lastly by the anal appendages subcylindrical and with an acute spine on the outer sides.

It more nearly resembles *comes* but may be distinguished from it by the presence of the humeral spot which is absent in *comes*, and also by the tooth on the appendages which is also absent in *comes*.

From *furcata* it is distinguished by the shape of the superior anal appendages which are broadly bifid in *furcata* and shaped like a crab's claw. The humeral stripe is also absent in the latter species.

Distribution.—Shillong, Khasia Hills, 5,000 ft., collected by Mr. T. Bainbrigge Fletcher, 28th May 1924, 4th June 1924. Several specimens of both sexes. *Type* in Pusa collection. Paratypes in Fraser collection.

Dysphaea walli, sp. nov.

Male.—Abdomen 35 mm. (with appendages). Hindwing 31 mm.

Head glossy black with a small obscure spot of yellow on the upper part of each cheek.

Prothorax black with a large oval spot of yellow on each side the middle lobe.

Thorax black marked with yellow as follows:—narrow complete humeral and antehumeral stripes connected above by a short horizontal bar near the alar sinus, converging and confluent below; four bright yellow stripes on the sides, one at the first lateral suture, a second broader along the anterior border of the second lateral suture, a third very fine on the anterior part of the metepimeron and lastly the whole of the basal half of this structure.

Legs black, the hinder femora broadly yellow on the outer flexor surface.

Wings palely and evenly enfumed, the bases of all four dark blackish brown for nearly two-thirds of the distance from base to node in the forewings, and fully three-fourths of that distance in the hind; the outer margin of this fascia slightly convex. Nodal index :—$\frac{21-28}{21-23} \mid \frac{27-20}{19-18}$; trigones traversed once in the forewings, once or twice in the hind; pterostigma black, long, narrow, over 6 to 8 cells.

Abdomen black, narrow and cylindrical, segment 10 without dorsal spine, segment 1 with a large triangular lateral yellow spot, segments 2 to 5 with a lateral stripe of blue, broad at base, tapering to a fine point to end of each segment, remaining segments unmarked.

Anal appendages black, the inferiors in closest apposition, very short and barely visible in profile, superiors as long as segment 9. Seen laterally, rather broad at base, tapering to a rounded apex. Seen from above narrow at base, broadening apicad and then finally narrowing, hollowed out on the inner surface. Apices curled strongly in to overlap each other.

Genitalia.—Hamules broad and confluent medially; lobe of penis small, pouch-like, black.

Distribution.—Maymyo, North Shan States, Upper Burma, collected by Col. F. Wall, I.M.S., 30th May 1924, four males (female unknown). *Type* in British Museum.

One specimen has decidedly broader thoracic markings, the antehumeral stripe is complete, the humeral and other stripes broader, and the whole of metepimeron greenish yellow except its anterior border. By analogy, we may safely assume that the female is very similar to that of *D. ethelae*, that its wings are unmarked, or at the most enfumed, with perhaps cloudy apices, its body marked with bright greenish-yellow markings more broadly than in the male, and extending to all segments of the abdomen.

The discovery of two species of *Dysphaea*, in widely different areas, within Indian limits, and within the space of one year, when the genus had hitherto been unreported, is worthy of comment. This new species is not very closely related to *limbata*, which has the basal black of wings much more extensive, and more so in the hindwings than in fore, its entire costal margin black, and the apices of all wings broadly so. It is easily distinguished from *ethelae* which has the wings unmarked and much narrower. From *dimidiata* (Java) the same points separate it as seen in *limbata*. There is some resemblance to *Pseudophaea masoni*, but the spined segment 10 of the latter will at once separate the two species.

Rhinocypha hilaryae, sp. nov.

Male.—Abdomen 23-24 mm. Hindwing 28-29 mm.

Head velvety black marked with azure blue as follows :—labium unmarked; labrum with two triangular spots inclined obliquely towards one another and confluent at a point below, a narrow stripe bordering the eyes and a small isolated spot on the cheeks nearly confluent with the stripe; the mandibles entirely blue, a spot on either side the rhinarium, two large subquadrate spots angulated outwards on the

epistome, and two pentagonal spots on the frons, the former well separated, the latter pair nearly confluent; a small linear spot on the outer side of each posterior ocellus, lastly a tiny round postocular spot on each side.

Prothorax velvety black, with a narrow median longitudinal azure blue stripe which expands slightly on the posterior lobe.

Thorax velvety black, the mesothoracic triangle azure blue, extending from the antealar sinus but not quite reaching the anterior border of triangle, although it invades the black here as a median point. The median suture of the alar sinus yellow. A fine linear humeral spot parallel with and bordering the alar sinus, and below a fine humeral stripe represented in some specimens by a vestigial spot. Laterally a fine bluish stripe, stilette-shaped, bordering the hinder border of humeral suture in its upper two-thirds. Lastly a broad oblique, very ragged, very broken stripe or fascia extending the whole length of side, filling the centre of metepimeron, broadly interrupted by the second lateral suture and bluish yellow in colour. Above a small linear spot behind the first lateral suture and another linear spot below base of hindwing.

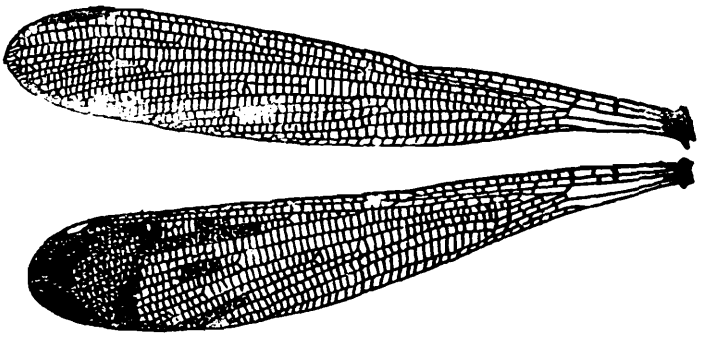


FIG. 4.—Wings of *Rhinocypha hilaryae*, sp. nov., male.

Legs black, the four hinder tibiae markedly pulverulent white on the flexor surfaces, the femora less so.

Wings palely saffronated, especially at the bases. The extreme apices of forewings bordered with dark brown for a depth of one cell, this colour continuous with pterostigma which is black and covers 7-8 cells. Apices of hindwings black from about the level of middle of pterostigma, the black fascia tapering away on the hinder border of wing and extending inward for rather more than one fourth the length of wing. The inner border of fascia very irregular, zigzagged, and sending a short prolongation inward just below pterostigma and to about its middle. Below this point, the fascia rapidly narrows until it is only one cells depth along the hinder border of wing. At about 7 cells proximad of inner end of pterostigma, a small black spot made up of 3 to 5 cells, subquadrate, or in others bifid posteriorly. This spot may or may not be confluent with a prolongation from the hinder border of wing, usually it is widely separated. The greatest variability is seen in these markings, differing in almost every specimen. In some lights the black apex is dark metallic green. The area enclosed by it and by the inner spots, as well as three spots just proximad of the level of the subcostal

black spot, vitreous and a beautiful lilac or peacock blue according to the angle of view. Of the row of three vitreous spots, the anterior is more or less continuous with the black spot and is about 20 cells in length, the median spot is only 6 cells long by 2 wide, whilst the hinder is about 10 cells long and rather irregular.

The broad intercalated vitreous area has its inner border distinctly concave. Pterostigma black with an elongate azure blue spot rather variable in size, on its upper surface, covers 8 cells. Forewings with 15-18 antenodal nervures, and 36-38 postnodals. Hindwings with 16-18 antenodals, and 29-33 postnodals ; quadrilaterals with 3-5 cross nervures ; petiolation begins slightly proximad of the 2nd antenodal. Fore- and hind-wings moderately broad, the hind not broader than the fore.

Abdomen black marked with bluish spots as follows :—segment 1 with a large triangular subdorsal spot, its base on the apical border ; segment 2 with a linear stripe on the hinder two-thirds of each side, and a small triangular subdorsal apical spot ; segments 3 to 6 or 7 with lateral linear stripes, decreasing in length from segment 3 to 7, on the latter of which it is either obsolete or vestigial. Segment 3 has also a small subdorsal apical spot.

Anal appendages black, the superiors about twice the length of segment 10, long, linear, stilette-shaped, their apices curving evenly in until they meet. The inferiors only half the length of superiors, subconical, pointed, sloped in, so that their apices meet in the middle line.

Female.—Abdomen 22 mm. Hindwing 31 mm.

Labium black, a small trace of yellow at the base of the lateral lobes ; labrum greenish yellow, its anterior border broadly black, its base very narrowly so and a small median tongue of black which partially divides the ground colour ; the epistome black in front finely encircled with yellow, black above with a prominent spot on either side, other spots on upper surface of head very similar to those found in the male. An additional small central spot on the hinder border of occiput.

Prothorax black with a fine median dorsal stripe bright yellow, on the sides a rounded spot at the middle and another larger triangular just above trochanter.

Thorax black.—The mesothoracic triangle ascending nearly to alar sinus, narrowly mapped out in palest yellow ; a narrow complete antehumeral stripe curled strongly out above, a narrow humeral stripe incomplete below, lying just posterior to the humeral suture. Laterally a thick, very ragged bright yellow fascia running almost parallel with the ventral border of thorax, lastly a fine curved stripe above between the roots of the fore- and hind-wings. Beneath bright citron yellow with a black mark shaped like a thistle-head on a long stalk.

Legs black, not pruinosed.

Wings hyaline, no black or metallic markings. Pterostigma black, its outer half yellow ; nodal index :—$\frac{33-18}{33-18} \mid \frac{16-31}{18-30}$; trigones traversed 3 times ; petiolation begins slightly distad of the basal antenodal nervure. Wings saffronated in the basal and costal areas about as far as node or less.

Abdomen as for male. Anal appendages small and conical. Vulvar scale as for genus.

Distribution.—Maymyo, Upper Burma, several of both sexes collected by Col. F. Wall, I.M.S., during the month of July 1924. Belongs to group *bifasciata-trifasciata.*

Rhinocypha perforata beatifica, subsp. nov.

Male.—Abdomen 19 mm. Hindwing 23 mm.

Head.—Labium cinereous; labium and epistome glossy black; rest of head velvety black marked sparcely with small blue spots:—a small reniform spot with its hilum facing inwards, on the outer side of each posterior ocellus, a linear spot on the hinder border of the occiput, and a rounded spot to the outer side and front of latter.

Prothorax black with a large pale blue spot on each side of the middle lobe, and the posterior lobe pinkish.

Thorax black with the mesothoracic triangle pale salmon pink and extending only halfway up the dorsum of thorax; a large triangular spot on each side of the mesothoracic triangle lilaceous in colour; an upper antehumeral spot of pale blue, a fine curved posthumeral lilaceous stripe which expands at its lower part. Lastly the sides broadly pale blue except for the hinder suture which is narrowly black.

Legs black, the middle and hind pair of tibiae heavily pruinosed white on the flexor surface.

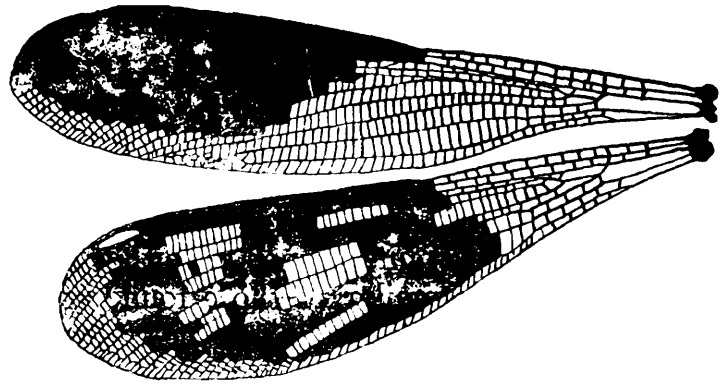


Fig. 5.—Wings of *Rhinocypha perforata beatifica*, subsp. nov., male.

Wings hyaline for slightly less than their proximal halves, this basal portion tinted palely yellow, whilst the outer apical half is opaque black. The opaque portion beginning at the node in all wings, bevelled zigzag fashion in the forewing downwards and outwards towards the termen which however it just fails to reach, leaving a narrow hyaline vitreous bordering about one-fourth the breadth of the wing in depth, which extends as far as the apex of wing, and which has a brilliant violet metallic reflex. In the hindwing the opaque area runs back almost straight to the termen, but has a very ragged and indented margin. The basal hyaline area is continued along the hinder margin of the wing as a vitreous area one cell wide, as far as the apex, where it turns upward to the pterostigma, occupying the whole of apex of wing as far inwards as to slightly overlap the outer end of pterostigma. This area, as well as two rows of vitreous spots in the opaque area, brilliant metallic emerald green. The apical row of spots lies about 4 cells proximal to the inner

end of pterostigma and consists of two spots, the anterior of which is 5 cells wide by 9 long, the posterior 3 cells wide by 5 long and separated from the first spot by a single row of cells. This row of spots lies two cell rows from the costa, as does also the second or proximal row, which consists of 3 spots. The anterior spot is situated about 9 to 10 cells from the outer row, and it and the posterior spot are one cell wide, whilst the middle spot of the series is from 2 to 3 cells wide. All spots are about 7 to 9 cells long. The posterior spot is confluent by its outer cell with the bordering vitreous area on margin of wing. Finally another long vitreous spot is seen at the inner end of the opaque area, projecting well into the hyaline area.

Both wings narrow, the hind only slightly broader than the fore, and its apex rounded. Pterostigma black, its hinder half azure blue. Antenodal nervures :—$^{11}_{13}$ | $^{12}_{12}$; trigones traversed 3 times in all wings; petiolation beginning at level of the 2nd antenodal nervure.

Abdomen black with a dark bluish green metallic reflex, marked with azure blue as follows :—a large triangular spot on each side of segment 1, a broad lateral stripe on segment 2 which broadens markedly at the apical border of segment, a similar stripe on 3 which tapers to a fine point near the base; triangular latero-apical spots on segments 4 to 8; short linear ventral spots on 3 to 5, merely vestigial in the last.

Anal appendages black, very similar to those of *quadrimaculata*, the superiors twice the length of inferior, equal in length to segment 9, linear, pincer-like, their apices curving in gently until they meet.

Distribution.—Two males only of this beautiful insect are known, one in my own collection was taken at Nungba, in the Naga Hills, Assam, 8th April 1924, the other is in the Pusa collection.

Ischnura mildredae, sp. nov.

Male.—Abdomen 24 mm. Hindwing 16 mm.

Head.—Labium white; labrum blue, its base narrowly black; epistome, frons and vertex black with a small round blue postocular spot on each side of occiput; eyes dark olivaceous green.

Prothorax black on dorsum, yellowish laterally.

Thorax black on dorsum with narrow bluish green antehumeral stripes. Laterally bluish green with short linear spots at upper ends of sutures. Legs yellowish, the extensor surfaces of femora, especially anterior two pairs, black.

Wings hyaline, faintly enfumed; pterostigma lozenge-shaped, acutely pointed at both ends, bright tawny with the two inner borders finely black. Forewing with 8 postnodal nervures, hind with 7.

Abdomen.—Segment 1 pale greenish with a quadrate spot of black on dorsum, 2 greenish at base changing to bright reddish orange at apex, marked with a large quadrate black spot on dorsum of basal half, and a rounded spot on apical half, the two narrowly confluent, the latter spot confluent with a narrow apical ring, segments 3 to 6 bright reddish orange with narrow black apical rings, 7 to 10 black, segment 8 bearing a small blue spot on centre of dorsum,

Anal appendages carneous, the inferior tipped with black. Superiors very short, curled on themselves, about half the length of segment 10, tumid; inferiors broad at base, rapidly tapering to a blunt point, the apices curled strongly in and nearly meeting.

Female.—Abdomen 24 mm. Hindwing 16 mm.

Almost identical in colouring to the male. Abdomen stouter, segment 2 with a goblet-shaped spot on dorsum quite different to that of male, the stem of goblet very narrow, its base situated subapically but confluent with a narrow apical ring by a medial prolongation of the stem, which passes through the foot of goblet and apical ring on to base of segment 3. The blue spot on segment 8 very large, covering nearly the whole dorsum save for a narrow basal and a narrower apical ring of black. The basal ring has two minute points invading the blue, whilst laterally the blue is bordered narrowly with black. Segments 7 to 10 with the ventral borders tawny.

Anal appendages small, pointed, tawny. Pterostigma yellow, narrowly framed in black.

Distribution.—Maymyo, Upper Burma, collected by Col. F. Wall, I.M.S., 7th June 1925. *Types* will be deposited in British Museum, paratypes in Fraser collection. This species, which has been named after Mrs. Wall, a keen collector, closely resembles *annandalei*, and is the first of that group discovered bearing blue colouration on the end segments, thus bringing the group into relationship with the *inarmata* group.

Copera superplatypes, sp. nov.

Male.—Abdomen 26 mm. Hindwing 15 mm.

Head.—Labium white; labrum, anteclypeus and cheeks palest blue, almost white; rest of head black save for a narrow pale blue transverse stripe running from eye to eye at level of ocelli.

Prothorax black with a pale whitish blue stripe laterally and a small white spot below it.

Thorax black as far as the first lateral suture, with a pale blue humeral stripe bordering the front of that suture. A tiny white spot just behind upper end of humeral suture. Laterally after the first lateral suture pale bluish, with the second lateral suture mapped out in black, a large central isolated black spot on the metepimeron and another between the sutures, confluent partly with the black on fore part of sides.

Wings hyaline; pterostigma black, diamond-shaped, slightly longer than broad, covers one cell; 12 to 13 postnodal nervures in forewings, 1 in the hind. Petiolation begins proximal to *ac* which lies nearly midway between the two antenodal nervures; 2 cells between the quadrilateral and subnode.

Legs very short, pure creamy white with fine black spines. The distal halves of all femora jet black. Tibiae enormously dilated, much more so than in *annulata*. (See text-figure 6.)

Abdomen black, the sides of segment 1 bluish white, segment 2 with a pair of eye-like bluish dorsal spots (similar to those seen in *Agriocnemis clauseni* group), the sides of same segment rather broadly bluish at apical end, narrowly so at basal, segments 3 to 5 with the ventral border bluish and confluent with interrupted narrow basal rings; seg-

ments 6 to 8 similar but the rings more widely interrupted and with a subapical extension of the bluish area. Segment 9 unmarked, 10 with the dorsum creamy white.

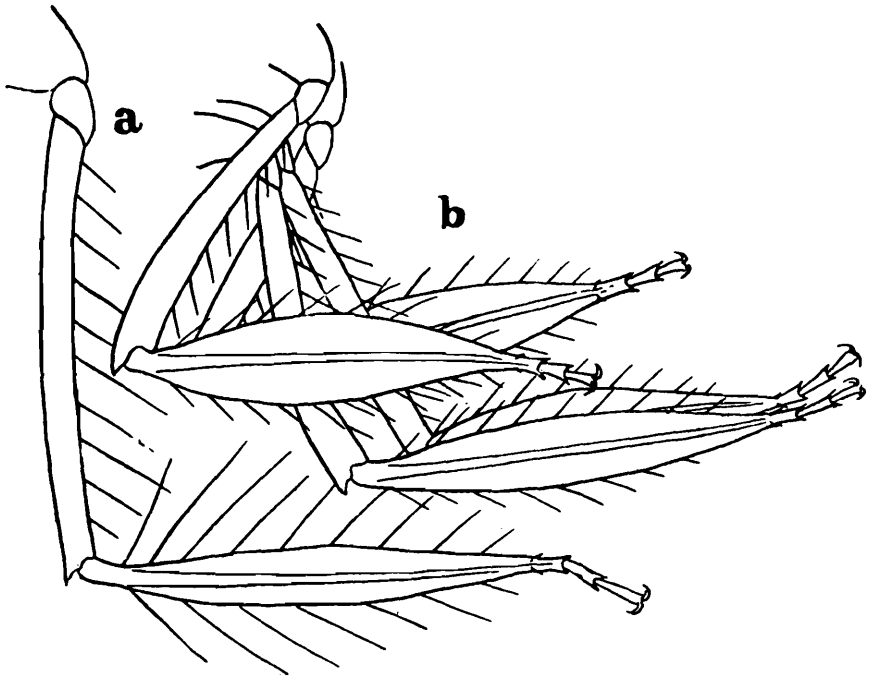


FIG. 6.—Legs of:—*a. Copera annulata* Selys, male. *b. Copera superplatypes*, sp. nov., drawn to the same scale.

Anal appendages as long as segment 10, creamy white to the tips, the inferiors blackish at the base, both pairs similar in shape, simple, broad at base tapering to a fine point, the inferiors more robust and slightly longer.

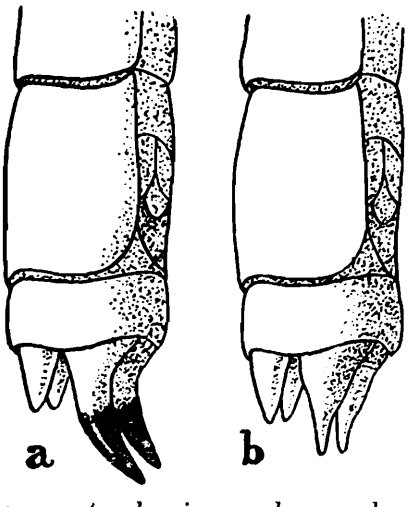


FIG. 7.—End abdominal segments, showing anal appendages of:—*a. Copera annulata* Selys, and *b. Copera superplatypes*, sp. nov.

Distribution.—A single male from Hasimara, Duars, collected by Mr. H. V. O'Donel, at present in the Fraser collection. This striking insect is the smallest of the *annulata* group and is marked quite differently from the rest. The head markings are more like those of *membranipes* group, as also are the anal appendages. The very short legs and enormous dilatation of tibiae serve readily to distinguish it.

Caconeura dorsalis auricolor, subsp. nov.

Male.—Abdomen 29 mm. Hindwing 18 mm.

Head.—Labium black ; labrum yellow, cheeks and epistome palest blue ; rest of head velvety black traversed from eye to eye at level of anterior ocellus by a broad belt of bright chrome yellow ; eyes olive green with an equatorial belt of black.

Prothorax black marked with a moderately broad subdorsal stripe of pale creamy yellow extending from base to apical border.

Thorax black marked with bright chrome yellow and palest green. The whole of dorsum between the humeral sutures, except for a narrow line mapping out the middorsal carina, bright chrome yellow. Laterally a broad pale greenish stripe lying between the lateral sutures, and a second occupying the hinder half of metepimeron.

Wings hyaline, pterostigma dark blackish brown framed in black, with a second inner frame of pale yellow, covers 1 to 1½ cells, diamond-shaped. Postnodal nervures 14 in forewing, 13 in the hind.

Legs.—Femora whitish on flexor surface, black on extensor, tibiae yellow on extensor surface, black on flexor.

Abdomen black marked with pale green and blue as follows :— segment 1 with a large pale greenish spot on each side, segment 2 with a narrow ventro-lateral stripe of the same colour and a fine middorsal carinal stripe of pale blue, segments 3 to 7 with paired basal dorsal spots, and subapical ventro-lateral blue spots, segments 8 and 9 unmarked, 10 broadly azure blue on dorsum.

Anal appendages blue, as long as segment 10, of the usual *Caconeura-Disparoneura* shape, superiors shaped like the butt and of a pistol, inferiors thick at base, tapering strongly to apices.

Female.—Abdomen 30 mm. Hindwing 20 mm.

Head marked similarly to male but the transverse stripe more narrow and pale straw coloured. The subdorsal stripe on prothorax bluish grey in colour.

Thorax black marked with narrow creamy white antehumeral stripes and laterally a broad medial stripe and the hinder three-fourths of metepimeron the same colour, clouded with darker yellow.

Legs dirty white with longitudinal beaded black stripes on the extensor surface.

Wings as for male, 13 postnodal nervures in forewings, 12 in hind.

Abdomen blackish brown marked with creamy yellow as follows :— the ventral and apical borders of segment 1, the apical portion interrupted by the black carinal ridge, segment 2 with fine ventral and subdorsal stripes confluent at the base of segment, 3 to 7 with fine medio-lateral stripes which are confluent with moderately broad, subapical incomplete white rings ; each segment has in addition a pair of basal bluish white lunules. Segment 8 with its ventral border narrowly creamy white, 9 and 10 with the dorsal carina and ventral border similarly coloured.

Anal appendages very small, creamy white, conical, pointed.

Distribution.—Maymyo, Upper Burma, a large number of specimens collected by Col. F. Wall, I.M.S., 5th August 1925. *Type* in British Museum.

THE INDIAN EPHEMEROPTERA (MAYFLIES).

PART I.—THE SUB-ORDER EPHEMEROIDEA: FAMILIES PALINGENIIDAE AND POLYMITARCIDAE.

By B. CHOPRA, *D.Sc., Assistant Superintendent, Zoological Survey of India, Calcutta.*

(Plates VIII—X).

CONTENTS.

INTRODUCTION.

Shortly before his lamented death Dr. N. Annandale, the late Director of the Zoological Survey of India, suggested to me the study of this interesting group of insects, with a view to publishing a memoir dealing chiefly with their taxonomy and bionomics. The work was started early in 1924, but owing to various interruptions of different sorts could not be continued for a considerable part of the last two years. The collection of mayflies in the Indian Museum, which was fairly large to start with, has in the meantime been growing rapidly by additions made by the officers of the Zoological Survey, and other outside workers, as well as by loans, for the purpose of examination and comparison, from various scientific institutions in India interested in insects. The result of this has been that the work has assumed much larger proportions than was originally contemplated either by me or by Dr. Annandale. My original intention was to publish my results in one comprehensive memoir, but as I now find that this would entail considerable delay and would mean the holding up of the earlier parts of the work for periods much longer than is generally desirable, I have decided with the permission of Major R. B. Seymour Sewell, Director, Zoological Survey of India, to publish my results piecemeal. The present contribution is the first of a series of papers that I hope to publish from time to time in the *Records of the Indian Museum.*

The collection of mayflies in the Indian Museum has for the most part been made at different times by the officers of the Zoological

Survey, chiefly by the late Dr. Annandale and Dr. S. W. Kemp and recently by my colleague Dr. S. L. Hora. Of outside collectors not directly connected with the Survey the name of Lt.-Col. F. C. Fraser, I.M.S., must be mentioned. At my request he made a special collection of the mayflies of Coorg in the Western Ghats and sent me very useful notes on the habits of some of them. For all this I owe him my best thanks.

Of the different scientific institutions in India interested in work on insects that have helped me by lending their named and unnamed collections I must first of all mention the premier entomological institution in India, namely the Agricultural Research Institute at Pusa in Bihar. Mr. T. Bainbrigge Fletcher, the Imperial Entomologist, attached to this Institute, placed his entire collection, named and unnamed, at my disposal, and also sent me a very useful list of references to Indian mayflies that he had prepared for his own use. My best thanks are due to Mr. Fletcher for all the help he has given me. I am also indebted to Dr. F. H. Gravely, Superintendent, Madras Museum, and Rao Sahib Y. Ramchandra Rao, Officiating Government Entomologist at Coimbatore (Madras) for lending me for examination the unnamed collections under their respective charge. The Entomologist attached to the Forest Research Institute at Dehra Dun has also recently sent me some unnamed mayflies.

From outside India also I have received valuable help. Dr. Walther Horn of the Deutsches Entomologische Museum at Berlin sent me a number of duplicates of Central European mayflies determined chiefly by Dr. Georg Ulmer. Drs. F. Maidl and H. Zerny of the Naturhistorisches Museum at Vienna also sent me a large number of named duplicate specimens chiefly from the Palaearctic Region. They also very kindly lent me for examination the type-specimen of Pictet's *Polymitarcys indicus*. The loan of this specimen has helped me a great deal in correctly identifying my Indian examples of this species and for this I owe these gentlemen my best thanks. Professor J. G. Needham of the Cornell University, Ithaca, New York, has helped me a great deal in the course of my work by making several valuable suggestions and also by sending me some duplicate specimens. He has also returned to me a large unnamed collection belonging to the Indian Museum that was sent to him for naming several years back, but which he had not so far been able to deal with on account of other engagements. This collection, partly on account of its being old and partly because of the severe shaking it has had during its journey to the United States of America and back, is at present in a very unsatisfactory condition of preservation and is not of much use. With this collection Professor Needham has sent me a number of slide-mounts that he had made at the time the collection was sent to him. I offer my sincere thanks to Professor Needham and all the other eminent entomologists mentioned above for the help that I have received from them.

The late Dr. Annandale took a great deal of personal interest in this work during the short time that he lived after it was started, and helped me by making several valuable suggestions. I owe him a great debt of gratitude for the encouragement that he gave me in all my work.

Dr. Baini Prashad, Superintendent, Zoological Survey of India, helped me in translating several passages from German into English, and for this I desire to express my thanks to him.

Major R B. Seymour Sewell has kindly gone through the manuscript with me, and has made several valuable suggestions, for which my best thanks are due to him.

The drawings illustrating this paper have been made under my supervision by Babu D. N. Bagchi, one of the talented artists of the Zoological Survey. I am greatly obliged to him for the care that he has taken in this work, and for the fidelity of delineation that he has displayed.

Following the accepted arrangement, as also for purposes of convenience, I have divided mayflies into three groups, the Ephemeroidea, the Baëtoidea and the Heptagenoidea, giving each of these the rank of a sub-order. The present paper deals with the first-named sub-order. The plan of breaking up into parts a work of a monographic nature is often unsatisfactory in so far as repetitions are sometimes unavoidable, and some important points are often likely to be left out. I have tried to overcome the former difficulty in at least so far as references to literature are concerned, by omitting a complete bibliography from the present paper, and by giving only the most important references. I hope to be able to give a complete bibliography in my last paper.

Under the title "Indian Ephemeroptera " I have, for the most part, included mayflies from the territorial limits of India, including in it Burma and Ceylon. Two species from Mesopotamia have also been included, chiefly because they happen to be in an Indian collection, *viz.*, that of the Entomologist at Coimbatore. Another species from Borneo preserved in the Indian Museum collection has also been included. Though there is a large collection of mayfly nymphs in the Indian Museum, in the present paper I have restricted myself to imagos and subimagos only.

I have provided analytical keys wherever it has been practicable, but in most cases these have been wholly or partly adopted from the works of previous authors.

In the descriptive parts of the paper I have employed the most commonly used terms. In spite of the extensive work on wing venation by Comstock, Needham, Miss Morgan and Tillyard, the question of the nomenclature of the different veins of the Ephemerid wing is yet far from settled. The arrangement adopted by Eaton and earlier workers is perhaps more convenient for descriptive work than the system laid down by Comstock and Needham and amplified or amended by later writers, including Comstock himself, but the homologies with wing venation in other orders of insects that this arrangement represents are not generally accepted by the present-day entomologists. I have, therefore, thought it best to follow Comstock and Needham's system. I have gone into this question of wing venation somewhat more fully in another part of this paper.

In describing colouration I have used the names of different shades and tints as given and illustrated by Ridgway.[1] Unless standard

[1] Ridgway, Color Standards and Color Nomenclature: Washington (1912).

colour names referrable to some easily obtainable standard work are used in describing insects the confusion now prevailing in systematic work on several orders of insects will continue as at present or perhaps become worse in course of time.

MATERIAL.

The major part of the collection dealt with by me is preserved in spirit, while insects in some of the older collections are pinned. Like several other workers I also find small insects like the mayflies, especially the smaller species, keep better in spirit than when pinned. In many old collections it is a common experience to find that many insects have vanished from the cabinets, only the pins and the labels or at most fragments of the body remaining behind. This is due either to the ravages of cabinet pests or to the shaking and handling that the collection receives. Professor J. G. Needham is also of the same opinion, for in one of his letters to me he writes " Mayfles should not be pinned, at least, the smaller ones should not. They vanish from the pins as if by evaporation, falling away bit by bit, and soon only the pins and labels remain. When I went to Cambridge, Mass., to study Hagen's types of mayflies, I found them nearly all represented by bare pins. I keep my own in alcohol, and when prepared for study, on slides, with only a few pinned ones for comparison with the remnants in other conventional collections."

HISTORICAL.

Comparatively little work has been done on the Indian mayflies. Walker's descriptions (1853) of certain Indian and Cingalese species, in his " *Catalogue,*" are, as is the case with most of his work, very meagre and it is difficult in many cases to recognize definitely the forms that he has described. Eaton's " *Revisional Monograph* " (1883) of the world species contains an account of all the then known Indian mayflies, and is to this day the standard work on the subject. In this monograph are included all of Walker's species, and in several cases the descriptions have been amplified. Some of Eaton's other papers also, notably those published in the *Transactions of the Entomological Society of London,* contain references to Indian mayflies. In 1892 this eminent entomologist (1892a) described in the *Journal and Proceedings of the Asiatic Society of Bengal* some mayflies belonging to the Indian Museum, which are still preserved in our collection. Prior to the publication of Eaton's famous monograph Hagen (1858, 1859) in a couple of papers published some notes and descriptions of some Cingalese mayflies. Needham in 1909 in his account of the Neuroptera of the Indian Museum included some Ephemerids also ; in this paper he redescribed Walker's *Caenis perpusilla* that had been very inadequately described before. Banks in 1914 gave in the *Records of the Indian Museum* a short account of the mayflies that the Zoological party attached to the Abor Expeditionary Force had brought back ; in the same year (1914b) he described in the *Proceedings of the Academy of Natural Sciences of Philadelphia* two Ephemerids from Ceylon, one of which *Anagnesia greeni* is believed

to be synonymous with Pictet's *Polymitarcys indicus*. In 1920 Gravely revised the Asiatic species of *Palingenia* (*s. l.*) and described a new species from Sarawak. Recently Lestage (1923) has revised the world-known species of the Palingeniidae, and has formed two new genera, one based on Morton's (1921) *Palingenia mesopotamica* from Mesopotamia, and the other to accommodate an insect from New Guinea. He gives in this paper good analytical keys for the identification of various genera and species of this family.

Of recent authors dealing with Oriental mayflies Ulmer and Lestage are perhaps the most prominent. During the last few years these two entomologists have written several valuable papers on this group of insects. Pictet's (1843) description of *Polymitarcys indicus* from the "East Indies" is about the oldest account of an Oriental mayfly. Walker, Hagen and Eaton, the last in his *Revisional Monograph*, have also described Oriental species.

Of publications not dealing exclusively with Oriental forms Eaton's memoir cited above is indispensable to all workers on mayflies. Ulmer (1920) in *Stettiner Entomol. Zeitung* has given very useful keys to the families and genera of mayflies, and has included references to all the known species that he considers valid. The keys are in most cases easy to work, and the references to species are reliable and accurate; the practical usefulness of this work cannot be too highly estimated. Lestage's revisions and notes are also very useful; his notes on Eaton's Monograph (1924b) bring the latter work up to date.

Comstock (1899 and 1918), Needham, Miss Morgan (1912) and Tillyard (1923) have done a great deal of work on the wing venation of mayflies and Miss Morgan's paper (1913) on the "Biology of Mayflies" is an interesting study of the habits and life-cycle of these insects. The last mentioned paper also includes a very useful bibliography of the biological, morphological and the more important systematic works dealing with mayflies. For descriptions of larvae and nymphs Eaton's *Revisional Monograph* is still the best work on the subject, while Needham (1905, 1917-18) and several other authors also have made useful contributions to this branch of study. Lestage (1921) in his paper in the series "Les Larves et Nymphs Aquatiques des Insectes d' Europe" has described all the European nymphs and has figured several of them. He has included in this paper keys for the identification of the European nymphs which are very useful.

WING VENATION.

Though a considerable amount of work has been done on the wing venation of mayflies the homologies of some of the veins with those in other orders of insects are far from definitely established. The earlier notation as adopted by Eaton (1883) and several other workers need not be considered in any detail, for the homologies of several important veins that this system represents are not accepted by any of the present-day entomologists. Leaving, therefore, Eaton's notation out of consideration, the system of vein nomenclature that has so far received the largest amount of recognition is the one originally expounded by Comstock and Needham (1899).

According to Comstock and Needham the " intercalary " veins which have been considered to be such a characteristic feature of mayfly wings are of course present. The radial sector (Rs) is well developed, and forms, after forking twice, four branches R_2, R_3, R_4 and R_5 The radius (R) is a separate vein and its trunk forms the anterior R_1. The media (M) is supposed to be rather poorly developed and forks only once, and, with an intercalary vein lying in the fork, has three branches M_1, M_2, M_3. The cubitus (Cu) is a strong vein, often strongly curved and divides once. This has also an interpolated vein in its fork. The three anals (1A, 2A, 3A) are well developed and distinct. No account was taken by Comstock and Needham of the small veins lying behind the third anal, or of some of the intercalary veins lying in the complex radial sector system. The results, as briefly mentioned above, of these two American entomologists were based not only on an exhaustive study of the adult wing, but the tracheation of the nymphal wing-pad was also taken into account. In fact Comstock and Needham are the earliest workers who, in studying the wing venation of mayflies, took the tracheation in the larval wing-pads into consideration. Excellent as the results of these two eminent entomologists are, they, as pointed out by Miss Morgan (1912), unfortunately studied only those wing-pads in which the bases of the radial and medial (according to Miss Morgan, but radial sector according to these authors) tracheae were closely approximated. They were thus led to interpret as Rs a part of the complex media (as understood by Miss Morgan : *vide infra*).

I have given in the accompanying table and illustration (pp. 98, 99) a comparative statement of the different principal notations that have been used or are being used at present in describing mayfly wings.

Following upon Needham's discovery (1903) of the crossing over of the radial sector in certain dragonflies Miss A. H. Morgan (1912) took up the study of wing venation in mayflies. She studied in great detail the tracheation in the wing-pads of nymphs belonging to a large number of mayfly genera, and offered an interpretation which brought the venation of mayflies in a line with that of Anisopterous dragonflies, in so far as the crossing over of Rs is concerned. She believes that what Comstock and Needham considered to be Rs is really a part of the complex media. The latter vein is greatly developed and has four branches besides a large number of interpolated veins. The radius is unbranched ; the radial sector is a small almost insignificant vein which has shifted its position and instead of being attached to the radius, as should be expected, it has been stranded on to the first branch of media (M_1), thus altogether losing its connection with the parent stem—the radius. In no adult mayfly can one see this supposed Rs to be connected with R_1 and only in some nymphs of one genus did Miss Morgan find this connection to be actually existing. It must, however, be pointed out that in most wings the supposed radial sector shows near its proximal end a strong upward curving thus suggesting that it may have once been connected to the radius. The cubitus and the three anals, according to Miss Morgan, are exactly as Comstock and Needham described them. The evidence in support of Miss Morgan's view regarding a shifting of the radial sector is, however, far from conclusive, and she herself no

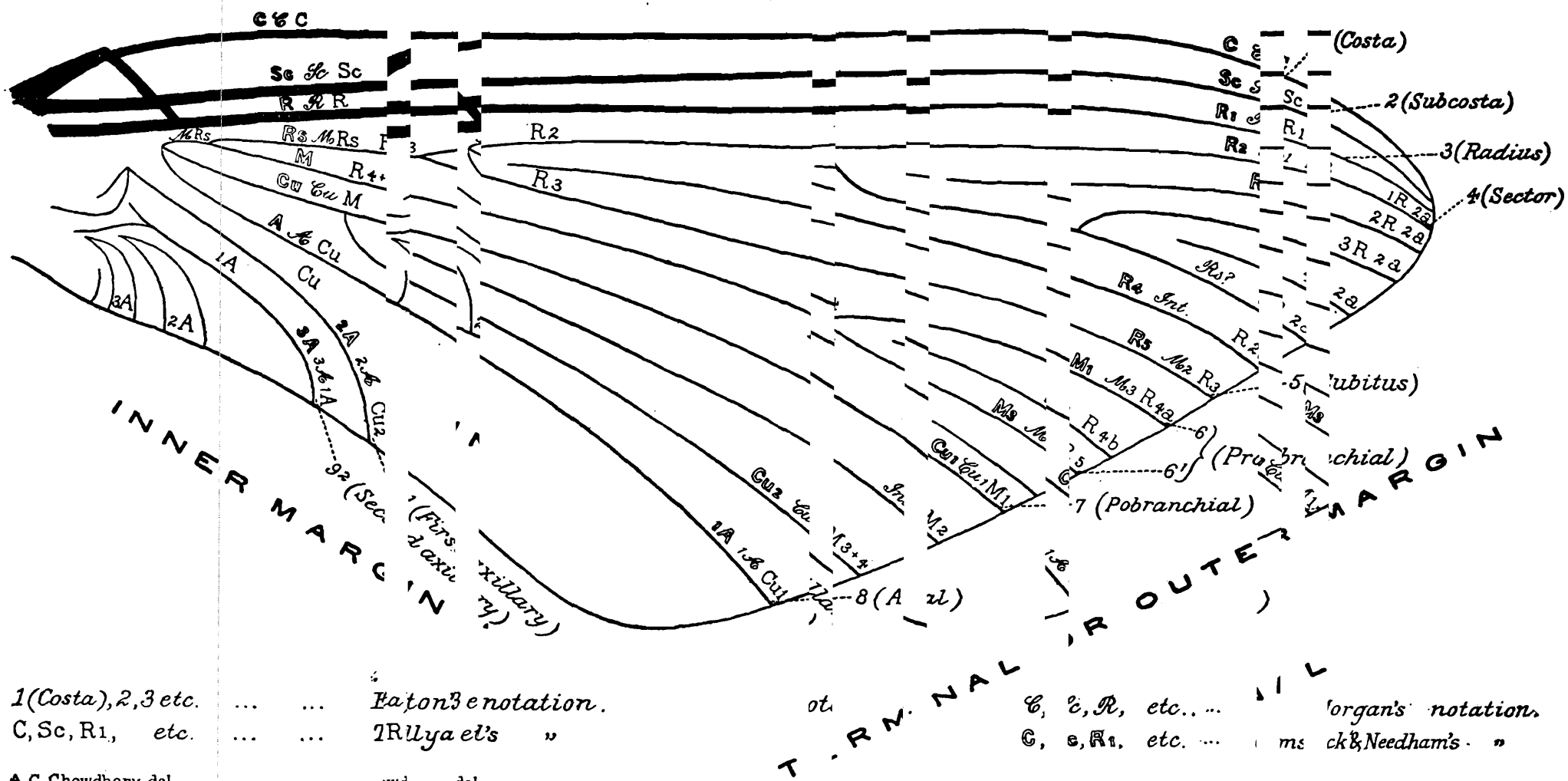
doubt was fully aware of the weakness of her position for in describing this problematic vein she called it Rs ? In fact the fundamental principle which no doubt influenced Miss Morgan in arriving at these conclusions—the supposed shifting of the radial sector in certain dragonflies —is now strongly challanged by Tillyard and others. Whatever views one might hold regarding Miss Morgan's conclusions one cannot help admiring her painstaking and thorough work.

Comstock in his " Wings of Insects " (1918) and more recently in his " Introduction to Entomology " (1924) has agreed with Miss Morgan's conclusions. He has no doubt that Miss Morgan's Rs ? represents the true radial sector of other insect wings. He has also given names to some of the intercalary veins that Miss Morgan had left unnamed.

Tillyard (1923) in an admirable piece of work based on an exhaustive study of the fossil wing of the mayfly *Protereisma* sp., as also that of some nymphal wing-pads, has recently expounded a new notation altogether different from any previously in vogue. From a study of dragonfly wings and by homologising the veins in the wing of mayflies to those of the dragonfly wing he has been able to lay down a plan which brings the wing venation of mayflies more or less in a line with that in other insects. In the first place Tillyard does not believe in the presence in the mayfly wing of any intercalary veins. In *Protereisma* all the veins branch off from the main trunks, and Tillyard believes that the discontinuity of the so-called intercalary or interpolated veins has been brought about by absorption of the basal connections with the trunks, of which these are the true branches. In the second place the anal area or the clavus in mayfly wings is reduced almost to insignificance, and further the radial sector is enormously developed. What Miss Morgan calls the media and Comstock and Needham had considered the combined radial sector and media becomes, according to Tillyard, the complex radial sector having four branches R_2—R_5. The media of Comstock and Needham [Praebrachial of Eaton] has thus become a part of the radial sector forming R_4 and R_5. The cubitus of Comstock and Needham, Miss Morgan and others [Pobrachial of Eaton] now becomes the media, and the first anal of everybody else is regarded by Tillyard as the cubitus, or rather its first branch Cu_1, the second anal becoming the Cu_2. The third anal of previous authors is Tillyard's first anal, and two small almost insignificant veins near the base of the inner margin, that everybody had so far ignored, are supposed to be 2A and 3A. From the comparative statement given in the accompanying table the profound changes introduced by Tillyard will be easily understood. The second radial (R_2), as will be seen from the table and the illustration, is divided into five branches, which have been given distinct though rather perplexing names. Of these, $5R_{2a}$ is Miss Morgan's Rs? and Comstock's Rs.

For checking and confirming his results—as very briefly mentioned above—Tillyard combined three different and independent methods of study, *viz.*: (1) the study of the wings of fossil mayflies ; (2) the study of the tracheation in some nymphal wing-pads ; and (3) the application of the principle of convex and concave veins. I do not propose

Eaton.			Comstock and Needham.		Morgan.		Comstock.		Tillyard.	
Veins near base.		Veins at margin.	Near base.	At margin.	Near base.	At margin.	Near base.	At margin.	Near base.	At margin.
Costa		1 Costa ..	C	C	C	C	C	C	C	C
Subcosta		2 Subcosta ..	Sc	Sc	Sc	Sc	Sc	Sc	Sc	Sc
Radius		3 Radius ..	R	R_1	R	R	R	R	R_1	R_1
Cubito-sector	Sector	4 Sector ..	Rs	R_2	M	M_1	M	M_1	Rs	R_{2+3} R_2 1 R_{2a}
		Adventitious ..		R_3		Omitted		IM_1		2 R_{2a}
		Adventitious ..		Omitted		Omitted		Omitted		3 R_{2a}
		Adventitious ..		Omitted		Omitted		Omitted		4 R_{2a}
		Adventitious ..		Acessory Radial 1.	?	Rs ?	?	Rs		5 R_{2a}
		Adventitious ..		R_4		Intercalary		IRs		R_{2b}
	Cubitus	5 Cubitus ..		R_5		M_2		M_2		R_3
Praebrachial ..		6 Praebrachial ..	M	M_1		M_3		M_3	R_{4+5}	R_4 R_{4a}
		Adventitious ..		M_2		Omitted		IM_3		R_{4b}
		6^1 Praebrachial		M_3		M_4		M_4		R_5
Pobrachial ..		7 Pobrachial ..	Cu	Cu_1	Cu	Cu_1	Cu	Cu_1	M	M_1
		Adventitious ..		Intercalary		Intercalary		ICu_1		M_2
		Adventitious ..		Cu_2		Cu_2		Cu_2		M_{3+4}
Anal		8 Anal ..	A	1 A	A	1 A	A	1 A	Cu	Cu_1
Axillary		9^1 First axillary		2 A		2 A		2 A		Cu_2
Axillary		9^2 Second axillary		3 A		3 A		3 A	A	1 A
		Omitted ..		Omitted		Omitted		Omitted		2 A
		Omitted ..		Omitted		Omitted		Omitted		3 A



EXPLANATION OF DIAGRAM AT

Diagram of an archaic type of mayfly fore-wing to illustrate the different notations used in describing venation. Different type-faced letters represent different notations, those adopted by Eaton, Tillyard, Miss Morgan and Comstock and Needham respectively. Reading successively from costal margin inwards, the terms "Praebranchial" and "Pobranchial" *read* "Praebrachial" and "Pobrachial."

A, anal trunk; 1A, 2A, 3A, first, second and third anal veins. Cu, trunk of cubitus; Cu_1 and Cu_2, first and second cubitus veins. ., fat, intercalary veins of Miss Morgan. M, trunk of media; M_1, M_2, M_3, M_4 its four branches; MRs, combined trunk of media and radial sector. R, radius; R_1, Rd; R_2 and R_4, R_5, its five branches with $1R_2a$, $2R_2a$, $3R_2a$, $4R_2a$, $5R_2a$, R_2 and R_4a, R_2ab (Tillyard's) their further branches. Ris, radial sector trunk; Rs? Miss Morgan's radial sector vein. Sc, subcosta.

Some of these intercalary veins, as shown on the next page, have been named by Comstock as: I M1, intercalary vein of media one; IRs, intercalary vein of radial sector; IM3, intercalary vein of media three and ICu_1, intercalary vein of cubitus one.

going into the details of his elaborate arguments, nor am I in a position to offer a criticism of Tillyard's conclusions, for besides studying the tracheation in the wing-pads in about half a dozen genera of Indian mayfly nymphs I have not studied the question of wing venation in mayflies from any of the three aspects from which Tillyard has approached it. My own observations, scanty though they are, agree more with Miss Morgan's conclusions than they do with Tillyard's. In no adult mayfly wing and in very few nymphal wing-pads does Tillyard's Rs appear to form a connection with the radius. In some genera Rs (as interpreted by Tillyard, or by Comstock and Needham as well) near its base lies very close to R but in no recent adult mayfly does it appear to branch off it. In the hind-wing this appears to be even more well marked than in the fore-wing. In the Permian mayfly *Protereisma*, however, the radial sector (Tillyard's) at its base lies so close to the radius that it appears to arise from it. The same is observable in the " nth " instar of *Ameletus ornatus*, as figured by Tillyard. But even in these cases it is very difficult to say whether the two merely lie close together or are really a part of one stem. In " (n + 1)th " and later instars of *Ameletus*, however, the radius and the radial sector lie apart from each other.

The triadic branching of the main vein stems by which, according to Tillyard, it is assumed that a positive vein, for instance in dividing, forms two positive branches and one negative between these is an ingenious way of explaining the alternating arrangement of convex and concave veins.

Tillyard's conclusions, though one may not entirely agree with them, are based on an intensive study of wing venation and are likely to rank always as a very important contribution to the question of the homologies of different veins in the mayfly wing. They have not been before the scientific world long enough to have evoked criticism or confirmation from many entomologists, though some workers on mayflies, notably Lestage (1924) among them, have already adopted them. In the succeeding pages I have followed Comstock and Needham's system originally expounded in their " Wings of Insects." I have done this not because I think that this system represents the correct or the most nearly correct homologies with other insect groups, but because I am unable to subscribe fully to either of the two later systems—Miss Morgan's or Tillyard's. Comstock and Needham's notation has at least one advantage over the other two systems, that it is older and has been extensively used in descriptive work. Until the homologies of veins in mayfly wings are definitely decided I think it will save further confusion if one sticks to an old and commonly used system.

Systematic Account.

The history of classification given by Eaton (1883) extends back to the days of Linnaeus when all the known mayflies were arranged in a single genus " Ephemerus " with two sections, one for species with two caudal setae, and the other for those having three. In his most valuable paper entitled " Übersicht über die Gattungen der Ephemeropteren, nebst Bemerkungen über einzelne Arten " Ulmer (1920), besides giving

an up-to-date classification of the mayflies of the world, gives an interesting account of the classifications adopted by writers from the time of publication of Eaton's famous *Revisional Monograph* to his own day. At that time and even to a considerably later period mayflies were considered to constitute only a family of the composite order " Neuroptera." Even though some of the present writers, notably Needham among them, give mayflies a family rank only, most entomologists, however, are agreed that they form a distinct order separable on well-defined characters from other orders of Insecta. The order Ephemeroptera (sometimes called Ephemeroida), according to this view, is divided into three sub-orders, the Ephemeroidea, the Baëtoidea, and the Heptagenoidea, each having approximately the same position as " Group I," " Group II " and " Group III " of Eaton (1883) respectively. According to Eaton, however, " Potamanthus Type " (now the family Potamanthidae) was included in his " Group II " ; it is now considered to be a family of the first sub-order Ephemeroidea and not of the second Baëtoidea. Further, Eaton placed the genus *Oligoneuria* in his " Palingenia Type " in " Group I " ; now it is included in the family Oligoneuridae in the sub-order Baëtoidea. Except for these comparatively minor changes the classification of Eaton is followed, in its broad outlines at least, up to the present day. What Eaton called the " Types " have now become the families, and thus the order Ephemeroptera is now believed to consist of fourteen families (thirteen " Types " of Eaton, and the Oligoneuridae of later writers), four under the sub-order Ephemeroidea, six under Baëtoidea and four under Heptagenoidea.

In the following pages Ulmer's classification of the order, as given in the paper cited above, has been followed almost completely.

The three sub-orders of mayflies may be distinguished from one another with the help of the following key :

A. In fore-wing cubitus (Cu) and first anal vein (1*A*) strongly divergent near base. [Hind-tarsus with only four (sometimes fewer) freely movable segments, fifth segment, if ever present, more or less completely united with tibia and immovable ; venation never greatly reduced.] .. .. Ephemeroidea.

B. In fore-wing cubitus (Cu) and first anal vein running more or less parallel near base, rarely weakly divergent

I. Hind-tarsus with only four freely movable segments, fifth segment, if ever present, more or less completely united with tibia and immovable. [Venation sometimes greatly reduced.] .. .. Baëtoidea.

II. Hind-tarsus with five freely movable segments. [Venation never greatly reduced.] .. .. .. Heptagenoidea.

Sub-order EPHEMEROIDEA.

The four families into which the sub-order Ephemeroidea is divided may be separated from one another as follows :—

A. Subcosta of fore-wing concealed in a fold of membrane under radius and not visible along costal margin except near base. [Both wings dull, at most translucent ; legs of female weak and often functionless, those of male well developed.] .. Palingeniidae.

B. Subcosta of fore-wing not concealed in a fold of membrane, fully developed and well displayed.
I. Wings dull, at most translucent, sometimes slightly shining in male; legs weak, specially in female, fore-legs of male often long .. .. .. Polymitarcidae.
II. Wings shining, transparent; legs well developed in both sexes.
1. In fore-wing third anal vein not forked, but connected with inner margin of wing by many cross veins; genital forcep of male four-segmented, basal segment small, second longest .. .. Ephemeridae.
2. In fore-wing third anal vein forked once, rarely connected with inner margin by cross veins; genital forcep of male three-segmented, basal segment longest .. Potamanthidae.

In the synoptic key given by Ulmer (1920, pp. 100, 101) the family Ephemeridae is separated from the Potamanthidae on the character, among others, that in Ephemeridae "Im Vorderflügel ist Analader 1 nicht gegabelt, sondern durch mehrere bis zahlreiche Queradern mit dem Flügelrande verbunden," while in the other family the first anal vein in the fore-wing is described as being forked once, with the cross veins wanting. Fletcher[1] in his "Tentative keys to the Orders and Families of Indian Insects" has repeated the same statement. This, however, is obviously incorrect as the first anal vein in the fore-wing in both the families is not forked, and is connected in both to the inner margin by a number of small veins. It is the third anal vein that is forked in the Potamanthidae and is not forked in the Ephemeridae, and is connected with the wing margin in the latter family, while it is not so connected in the former.

Family Palingeniidae.

In his "Étude sur les Palingeniidae" published in 1923 Lestage (1923a) gives an excellent account of the insects comprising this family. The historical sketch, the important features characterising these insects, their geographical distribution and their taxonomy are all so well treated that nothing need be added to them. In this paper the author has also described two new genera, one *Mortogenesia* based on a Mesopotamian insect already described by Morton (1921) under the name of *Palingenia mesopotamica* and the other *Tritogenesia* from New Guinea. All the world species are recorded and briefly characterised.

Gravely's "Notes on some Asiatic species of *Palingenia*" published in the *Records of the Indian Museum* also form a very useful contribution to the subject. In this paper all the then known Indian species (including one from Mesopotamia) are dealt with, and a new one from Borneo is described. Descriptions of nymphs of two species are also given for the first time.

Of the five genera into which this family has been divided by Lestage, *viz.*, *Palingenia* (Burmeister) Eaton, *Anagenesia* (Eaton) Ulmer, *Pletho-*

[1] Fletcher, *Bull. Agric. Research Inst. Pusa*, No. 162, pp. 15—18 (1926).

genesia Ulmer, *Mortogenesia* Lestage and *Tritogenesia* Lestage, the first, second and fourth are met with in the Oriental Region, while the remaining two, *Plethogenesia* and *Tritogenesia*, are so far known to live in New Guinea only.

The three Oriental genera of this family may be distinguished from one another with the help of the following key :—

A. Media (M) of fore-wing forked well beyond middle of wing ; more than one subsidiary vein present in fork of first anal vein ; fore-tarsus of male 2½ times as long as femur. [Genital forcep of male 6-7 segmented, basal segment very long, others short ; hind-tarsus with a double claw.] .. *Palingenia.*

B. Media of fore-wing forked before middle of wing ; only one subsidiary vein in fork of first anal vein ; fore-tarsus of male about as long as femur.

I. Hind-tarsus with a single claw ; media of fore-wing usually forked before forking of radial sector (Rs); genital forcep of male three-segmented, basal segment long, others short .. .. .. *Anagenesia.*

II. Hind-tarsus with a double claw ; media of fore-wing forked later than forking of radial sector ; genital forcep of male seven-segmented, basal segment very long, others short .. .. *Mortogenesia.*

The remarkable absence of the members of this family from America has already been noted by Lestage.

Genus **Palingenia** (Burmeister) Eaton.

1839. *Palingenia*, Burmeister, *Handbuch d. Entomol.* II, p. 803 (*partim*).
1883. *Palingenia*, Eaton[1], *Trans. Linn. Soc. London* (2) III, pp. 23-25.
1920. *Palingenia*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.
1923. *Palingenia*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, pp. 107, 108.

According to Eaton the genus *Palingenia*, as restricted by him occurs in the " Eastern N. Temperate region " only, the two species known to him having been met with in Central Europe and the Caucasus respectively. The range of the genus is now known to extend considerably eastwards ; the Central European species has been found in Mesopotamia also and another has been described from Seistan in Persia.

The genus, as now understood, consists of three species only ; *P longicauda*, the genotype, from Central Europe and the near East ; *P. fuliginosa* from the Caucasus and *P. orientalis*, sp. nov., from Seistan in Persia. The last named species was first described by Needham (1909) as *P.* sp. (probably *Anagenesia robusta* ?), and was later confused by Gravely (1920) with the Central European *P. longicauda*. The reasons that have led me to set up a new species for the insect from Seistan are given in their appropriate place.

The history of this genus has been fully described by Lestage in the paper cited above and nothing need be added to it.

[1] For earlier references to this genus see the synonymy given by Eaton in this paper under *Palingenia longicauda*.

Palingena longicauda (Oliver).

1791. *Ephemera longicauda*, Oliver, *Encyclopedie Methodique* Vl, p. 418.
1839. *Palingenia longicauda*, Burmeister, *Handb. d. Entomol.* II, p. 803.
1883. *Palingenia longicauda*, Eaton, *Trans. Linn. Soc.* (2) III, p. 24, pl. i, fig. 1*a*.
1920. *Palingenia longicauda*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.
1920. *nec Palingenia ? longicauda*, Gravely, *Rec. Ind. Mus.* XVIII, pp. 138-140.
1923. *Palingenia longicauda*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 107.

A single specimen of this cosmopolitan Central European form is in the collection of the Madras Government Entomologist at Coimbatore. It was collected at Karradah, on the Tigris River in Mesopotamia by Mr. Y. R. Rao on 24th May, 1920. The species is perhaps fairly common in Mesopotamia, though Gravely's reference to " large Mayflies on the Euphrates at about the beginning of April " point to those insects being *Mortogenesia mesopotamica* rather than the present species. As will be seen from Morton's account of his *mesopotamica*, as also from my notes on it (*vide infra*, p. 122), this species appears in large numbers in the beginning of April ; *P. longicauda* is not known to emerge so early.

Through the courtesy of the authorities of the Vienna Museum I have been able to examine a specimen of this species from Central Europe, and find that it agrees exactly with mine from Mesopotamia. The Mesopotamian example is a pinned male, about 18 mm. long. The colour is very slightly faded, but agrees closely with Pictet's coloured picture of this species, as also with the Central European specimen. The forcep limb of one side is broken, but the other is like that shown by Eaton. In all respects the Mesopotamian example conforms with the published accounts of the species. My specimen is, however, somewhat smaller than the usual size of the species in Europe.

The occurrence of this species in Mesopotamia considerably extends its geographical range. It was hitherto thought to be confined to " the large rivers of middle Europe from Rotterdam to Hungary," and the present record from Mesopotamia extends its range eastwards a great deal. Further, it is interesting to note that the species emerges in Central Europe in the latter half of June or beginning of July, while in Mesopotamia it seems to come out considerably earlier.

Palingenia orientalis, sp. nov.

(Plate VIII, figs. 1—3).

1909. *Palingenia* (*Anagenesia*) sp.? (*robusta* ?), Needham, *Rec. Ind. Mus.* III, p. 191, pl. xx, fig. 8.
1920. *Palingenia* (*s. str.*) ? *longicauda*, Gravely, *Rec. Ind. Mus.* XVIII, pp. 138-140, pl. xviii, fig. 1-4 (nymph), pl. xx, figs. 21-23 (imago).
1923. *Palingenia* sp. ? *longicauda*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 108.

I have based this new species on a number of pinned male specimens from Seistan preserved in the collection of the Indian Museum. There are nine specimens in the collection and they are all in a poor state of preservation. The legs and the caudal setae are missing in most of the examples, the forcep limbs are broken, and the wings in most cases are all but fragmentary. There is another male specimen in the Indian

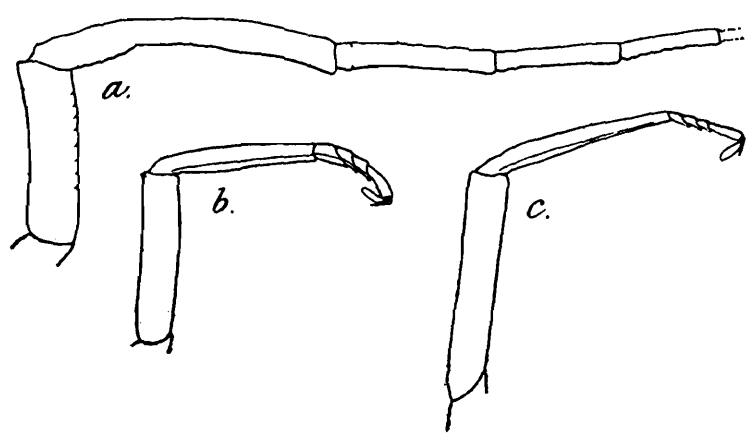
Museum collection preserved in spirit. This specimen also is in very poor condition and the head and a part of the thorax are altogether missing. It was sent probably along with other specimens to Professor Needham and was returned by him named as *P.* sp. (? *robusta*).

Imago ♂ (dried).—The general colouration of the body is a dirty white varying to a shade of ochraceous buff. The head is black, but the area between the eyes is in most specimens fuscous. The pronotum is of the general ground tint, but the mesonotum and metanotum are warmer. In one specimen the notum is considerably suffused with smoke gray. The dorsum of the abdomen is ochraceous buff to ochraceous tawny, with light annulations at the segmental joints. The last two segments are considerably warmer than the rest and are almost tawny. The venter is dirty white.

The legs and setae are missing in most of the specimens; they are dirty white to cream in colour. The wings are transparent and somewhat dull, and have no prominent colour markings. They are a very light shade of ochraceous buff, with opaque warm buff neuration.

In the fore-wing the arrangement of veins, as illustrated in Gravely's figure quoted above, corresponds more or less closely with that in the wing of *P. longicauda*, as given in Eaton's figure of it. The small intercalary and even the cross veins are more or less similarly disposed. The media forks well beyond the middle and there are, as emphasised by Eaton, two sets of longitudinal nervures proceeding in pairs to the terminal margin. There are several longitudinal nervures contained in the fork of the first anal.

The hind-wing is also like that of *P. longicauda*. The subcosta is well displayed and all the other veins are well developed. The media forks well in advance of the middle, and the intercalary vein (M_2) enclosed between the two branches extends almost up to the forking point. There are two subsidiary veins on either side of M_2. The cubitus and the anals are also well developed. As in the fore-wing there is a large

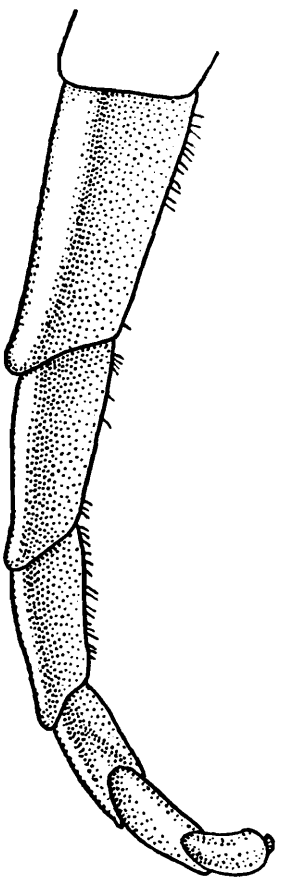


TEXT-FIG. 1.—*Palingenia orientalis*, sp. nov.
Legs of male, all drawn to same magnification: × 6.
a. 1st leg (incomplete). *b.* 2nd leg. *c.* 3rd leg.

number of small intercalaries along the terminal margin and the cross veins are plentiful.

The legs are broken in most of the specimens, and the fore-tarsus is missing or incomplete in all. The fore-leg is the longest and the second is the shortest of the three. In the first leg the femur is considerably shorter than the tibia, and the tarsus appears to be the longest part. The latter is probably formed of four distinct and one rudimentary joint. In no specimen are more than three tarsal joints, exclusive of the rudimentary one, now present, and of these the first is slightly longer than the second, while the third is considerably shorter than either of these. In the second leg the tibia is somewhat longer than the tarsus; the latter is four-segmented, the proximal three segments being subequal, and the terminal much longer than any other. In the hind-leg the tarsus is much shorter than the tibia; the first three tarsal segments are in this case also subequal, and the fourth is longer than any other two put together. The claw is strongly developed and is biunguiculate, the two ungues being markedly unequal.

The genital apparatus of the male has been figured by Gravely, and his illustration shows the various parts clearly. The genital forceps are concolorous with the posterior abdominal region and each is formed of a long grooved basal joint and about six or seven terminal ones, of which the most distal are minute. The basal joint on its inner side near the base has a small rounded projection—not shown in Gravely's figure—like that shown in Eaton's illustration of *P. longicauda*. In most of my specimens the forceps are missing or broken, but in two or three they are fairly complete. As will be seen from the accompanying figure (Plate VIII, fig. 3) the basal joint is about three times as long as all the others put together, is distinctly grooved and seems to have fine hairs along both sides of the groove. Besides the long basal segment there are six well-developed joints and another extremely reduced one. This is clearly shown in the accompanying text-figure (fig. 2). The penis lobes, as shown by Gravely, are fairly long and are only slightly narrower at the apex than near the base. Their shape, etc. is exactly as seen in Gravely's figure.



Text-fig. 2.—*Palingenia orientalis*, sp. nov. Genital forcep of male, terminal region only: ×77.

The setae are present in a broken condition in only a few of the specimens. They are like narrow ribbons, finely pubescent throughout their length.

The ♀ is not known.

Length of body, ♂ 22-26; wings up to 25 mm.

The nymphs have been described and figured by Gravely in detail.

Type-specimen.—9417/14, Zoological Survey of India (*Ind. Mus.*).

Locality.—The nine pinned male specimens preserved in the Indian Museum were collected in Seistan, Persia, by Col. A. H. McMahon of the

Seistan Boundary Commission. The exact locality in Seistan where the specimens were collected is not known.

As will be seen from the synonymy given above the specimens on which I have based this new species were erroneously referred by Needham in 1909 to the genus *Anagenesia*. That the specimens do not belong to this genus is evident from a study of the wing venation and the genital forceps of the male. As shown in Gravely's figure of the fore-wing, quoted above, the media forks well beyond the middle ; in *Anagenesia* it always divides before the middle. Similarly the genital forceps are formed of a long basal segment and six or seven terminal ones ; in *Anagenesia* there are never more than three segments present. Gravely correctly placed the specimens in the genus *Palingenia* (*s. str.*), but provisionally referred them to the European *P. longicauda*. They, however, differ from the latter species in having a duller and more uniform colouration. The colour of the Seistan specimens has no doubt been greatly affected by poor preservation, but it is hardly likely that it was ever anything like that of *P. longicauda*. The wings are also considerably lighter in colour and instead of being dull brownish or medium sepia in colour are almost dirty whitish. Further the penis lobes in the European species are markedly constricted near the tip, while in *P. orientalis* they are more or less of a uniform thickness, showing only a very slight constriction near the apex.

The type-specimen seems to have been examined by Professor Needham and bears a label in his hand-writing " Palingenia sp. subgenus Anagenesia Eaton."

Genus **Anagenesia** Eaton.

1883. *Anagenesia*, Eaton, *Trans. Linn. Soc. London* (2) III, pp. 25—28.
1920. *Anagenesia*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.
1923. *Anagenesia*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, pp. 108, 109.

As mentioned by Eaton the genus *Anagenesia* occurs in the " Indo-Malayan region and Irkutzk." All the species so far known are from the same region.

In all 8 species have been definitely included by Lestage in this genus, out of which only three occur in India. Of these *A. lata* can be easily recognized by its dark brown wings and body, and by the fact that the two terminal joints of the male genital forcep are subequal. *A. robusta* is of about the same size as *A. lata*, but the body and wings have a very light colour and the last segment of the genital forcep is longer than the one preceding it. The third, *A. minor*, is a distinctly smaller insect and has a light colour more or less like that of *A. robusta*, but the posterior abdominal tergites have a characteristic clouding of gray, which is better seen in the female than in the male. *A. picta*, a Bornean species described by Gravely from specimens preserved in the Indian Museum, is also large, and has the body coloured reddish brown (slightly comparable to the warm sepia of *A. lata*), but the wings are dirty whitish with the costal margin infuscate.

With the help of the key given by Lestage, in the work quoted above, these species can be easily distinguished from one another as also from other species of the genus.

Of the three Indian species, *A. lata* and *A. robusta* are so far known from Assam only, while *A. minor* seems to be " very widely distributed over the Indian Empire,"[1] examples of this form having been met with in Bengal, Bihar, Burma and Karachi (?).

Anagenesia lata (Walker).

(Plate VIII, figs. 4—6).

1853. *Palingenia lata*, Walker, *Brit. Mus. Catal. Neuropt.*, part III, p. 550.
1871. *Palingenia lata*, Eaton, *Trans. Ent. Soc. London*, p. 63, pl. iii, fig. 18.
1883. *Palingenia (Anagenesia) lata*, Eaton, *Trans. Linn. Soc. London* (2) III, p. 26, pl. i, fig. 1*b*.
1892. *Palingenia lata*, Eaton, *Journ. As. Soc. Bengal* LX, p. 407.
1920. *Palingenia (Anagenesia) lata*, Gravely, *Rec. Ind. Mus.* XVIII, p. 140, pl. xx, fig. 17.
1920. *Anagenesia lata*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.
1923. *Anagenesia lata*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 108.

This species is known from Sylhet and Sibsagar in Assam and is represented in the Indian Museum collection by a number of pinned male specimens from the latter locality. All the specimens have been examined and named by Eaton and are in a good state of preservation.

Eaton's descriptions of the species (1871, 1883 and 1892) are adequate for its proper determination, and his figures, as also one by Gravely (1920), illustrate the different parts quite accurately.

The species is easily recognized by the brownish colour of the body and wings. The thorax and parts of the head are vandyke-brown to warm sepia, but the wings are considerably lighter. At the present time they are more snuff brown than light vandyke-brown as described by Eaton. In the fore-wing the costal region is considerably warmer, and the first three longitudinal veins and the great cross vein are vandyke-brown. The remaining longitudinal nervures and the cross veins in the basal half of the disc of the fore-wing are lighter in colour. The cross veins in the distal half of the disc are almost whitish. The venation is like that figured by Eaton, though the small veins near the terminal margin seem to be somewhat reduced.

The eyes (Plate VIII, fig. 4) of the male are somewhat distantly placed and are blackish in colour ; the ocelli are brownish encircled with black.

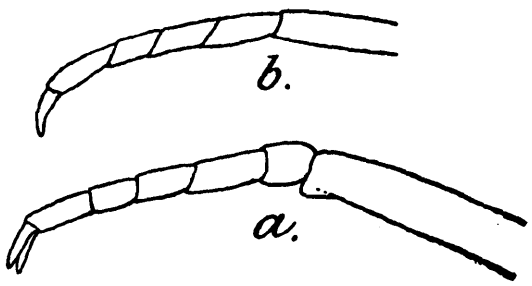
The abdomen is russet, with the posterior ends of the segments vandyke-brown. The last three segments are considerably warmer in colour than the rest of the abdomen. The venter is light tawny.

The legs are exactly like those described by Eaton, and the hind tarsus, as in other species of the genus, has a single claw. The proportion of the different segments forming the fore- and the hind-tarsi is clearly seen in the accompanying text-figure 3.

The genital forceps are light brown in colour and are composed of a large ventrally grooved basal joint, about three times as long as the two terminal ones put together, and have a fairly prominent projection at the inner side of the proximal end. The two terminal joints are

[1] Gravely, *Rec. Ind. Mus.* XVIII, p. 143 (1920).

subequal in length and the ultimate one tapers somewhat distally. The penis lobes have the usual shape, are rather short and thick set,



TEXT-FIG. 3.—*Anagenesia lata* (Walker).
a. Fore-tarsus of male : × 16. *b*. Hind-tarsus of male : × 16.

triangular in shape, broad at the base, and narrow at the apex, where a constriction marks off the terminal portion.

The setae are as described by Eaton, and the median seta is rudimentary and very small.

The ♀ is not known.

The largest specimen from Sibsagar is slightly over 22 mm. long, with the wings and setae of the same proportionate length as given by Eaton.

The nymphs of this species are not known.

The species is so far known to occur in Assam only, and has been collected at Sylhet and Sibsagar. The specimens collected at the latter locality by the late Mr. S. E. Peal are preserved in the Indian Museum.

As remarked by Eaton, this is the only dark-winged species of *Anagenesia* so far found in India. *Anagenesia picta* Gravely (*vide infra*, p. 119), a Bornean species, has the costal margin of the fore-wing infuscate, but the general surface is whitish.

Anagenesia robusta (Eaton).

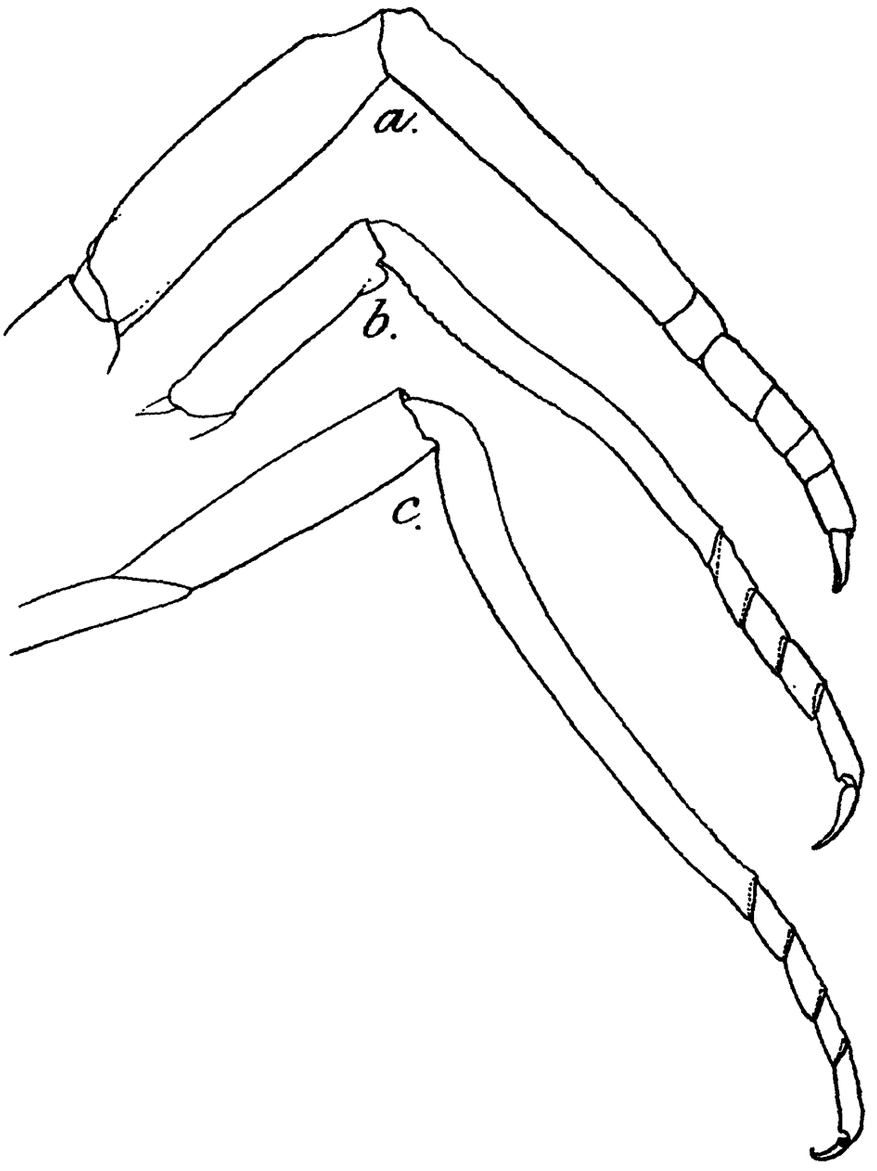
(Plate VIII, figs. 7—10).

1892. *Palingenia robusta*, Eaton, *Journ. As. Soc. Bengal* LX, pp. 407, 408.
1920. *Anagenesia robusta*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.
1920. *Palingenia* (*Anagenesia*) *robusta*, Gravely, *Rec. Ind. Mus.* XVIII, pp. 140—143, pl. xx, figs. 19, 20.
1923. *Anagenesia robusta*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 108.

Like the preceding species *Anagenesia robusta* is so far known to occur in Assam only. The two specimens on which Eaton based his original description were collected in Cachar, and one of these is still preserved in the Indian Museum collection. This specimen is at present in an imperfect condition, the abdomen being altogether absent, and the legs and wings broken. Besides this there are two pinned males, and a number of males and females in spirit in the Indian Museum collection. All these specimens are in good condition.

The colouration of the male has been accurately described by Eaton and nothing need be added here. The eyes are almost pitch black and are placed somewhat remote from one another. The ocelli are encircled with black. The wing venation is more or less like that of *A. lata*, but the

smaller subsidiary veins and the cross veins near the terminal margin are almost transparent, so that in transparent slide mounts the wing membrane near the terminal margin appears to be almost entirely devoid of small veins. In pinned specimens, however, there are clearly seen to be a large number of veins in this area. In the hind-wing the costal projection is not very prominent, and the venation is ample. The media forks quite close to the wing base, and the anal area is rather poorly developed.



Text-fig. 4.—*Anagenesia robusta* (Eaton).
Legs of male, all drawn to same magnification: × 12.
a. 1st leg. *b.* 2nd leg. *c.* 3rd leg.

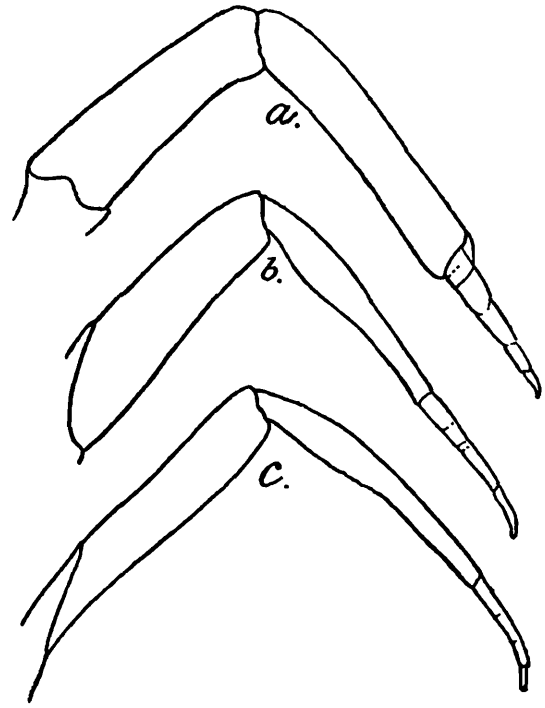
The legs are poorly developed in both sexes, but in the female they are far more reduced than in the male. In the male fore-tarsus the segments are as described by Eaton, but in the second and third tarsi the first segment is almost entirely suppressed, the second, third and fourth are more or less subequal, while the fifth is the longest. All the tarsi

are shorter than their respective tibiae, the first and the second tarsi being only slightly so, while the hind-tarsus is about half as long as the hind-tibia. The first leg is biunguiculate, the two ungues being nearly of equal length ; the second and the third legs each have only a single unguis.

The male genital apparatus is like that of the preceding species. The genital forceps are slightly darker in colour than the venter, and have the usual shape. They are formed of a large ventrally grooved basal segment, having a prominent projection near the base, and two small terminal joints about two-fifths as long as the basal. Of the terminal segments the last is distinctly longer than the one preceding it, and, as shown in the figure (plate VIII, fig. 10), is sometimes subdivided in two. Of the two secondary segments thus formed the proximal one is distinctly shorter than the distal. This fact has also been mentioned and illustrated by Gravely (*op. cit.*, p. 141, pl. xx, fig. 20). The penis lobes are like those of *A. lata.*

The caudal setae are long and ribbon-like and are densely pubescent. The rudimentary median caudal seta is much better developed than in most other species and is easily visible.

The female imago of *A. robusta* is considerably darker in colour than the male. The head is much warmer in colour, and is almost bister brown. The eyes are blackish-slate and the ocelli are whitish encircled with black. The notum is raw umber, and the mesonotum has a number



TEXT-FIG. 5.—*Anagenesia robusta* (Eaton).
Legs of female, all drawn to same magnification : × 12.
a. 1st leg. *b.* 2nd leg. *c.* 3rd leg.

of dark dusky streaks. The dorsum of the abdomen is extensively suffused with light dusky brown, and the last three segments are coloured almost uniformly in that shade. The sides, venter and the wings are as in the male.

The legs are greatly reduced. The comparative atrophy of the legs in the two sexes is clearly brought out in the accompanying text-figures 4 and 5, where legs of a male and a female imago of about the same size are drawn on the same scale. The part most reduced in the female leg is the tarsus, and the reduction has gone so far that even the segments composing it are hardly demarcated. In the fore-tarsus the segments are more or less distinct, but in the hinder tarsi most of the lines of demarcation are to some extent obliterated. The claw is very poorly developed in all the tarsi, and appears to be uniunguiculate. The tarsi are considerably shorter than their corresponding tibiae.

The wings and the setae are as in the male.

A. robusta is a large species, some of the males being as much as 28 mm. long with the caudal setae about 70 mm. The wing is about 24 mm. long. The female appears to be somewhat smaller, the body and wing in the specimens I have seen not generally exceeding 25 and 21 mm. respectively. The setae in all the three females appear to be broken, but they are considerably shorter than those of the male insect.

The nymphs have been described and figured by Gravely.

Type-specimen.—5941/14, Zoological Survey of India (*Ind. Mus.*).

Locality.—The species is so far known to occur in Assam only ; Eaton's type-specimens were collected in Cachar, and those described by Gravely come from Nazira on the bank of the Dikho River near Sibsagar. The exact locality in Cachar where the type-specimens were collected and the name of the collector are not known. The Dikho River examples, two pinned and six spirit males, three spirit females and a number of nymphs of both sexes, were collected by Mrs. E. S. Maxwell at about the end of October in 1918 and 1919. All the specimens collected by Mrs. Maxwell as adults were males ; the females were caught as nymphs and hatched in captivity. The type-specimen is, as already mentioned, in a fragmentary condition.

A. robusta is easily recognized from the remaining large-sized species of the genus by the light colour of its body and wings. The preceding species, as also *A. picta* (*vide infra*, p. 119), are of about the same size as *A. robusta*, but both are of a distinctly warmer colour. This species is further distinguished from the other two on account of the last joint of the male forcep being longer than the penultimate ; in *A. lata* the two joints are subequal, while in *A. picta* the last segment is shorter than the one preceding it.

Gravely's notes on the biology of the species, based chiefly on information supplied by Mrs. Maxwell, are very interesting. Large numbers of individuals are said to " emerge annually at about the end of October, and for three or four days float down the river in countless millions. The natives say that they also appear on other rivers, such as the Desoi, Desang and Dihing, and that they come out at and under the edge of the water in the shallows after the rivers have left the hills and where they run through silt only ; but Mrs. Maxwell says that so far as she knows they do not occur on rivers actually rising in flat districts. The natives believe that until they have appeared there is always a chance of further floods and consequently it is no use building the temporary bamboo bridges which they put up every cold weather until

these ' pani-pooka ' (water insects) have gone. The caudal appendages of the males were 3 inches long and semi-transparent when fresh. The insects are so light and hollow that they cannot be kept under water ; when just out they are white and creamy and look like foam when blown together by the wind."

Anagenesia minor (Eaton).

(Plate VIII, fig. 11, plate IX, figs. 1—4).

1892. *Palingenia minor*, Eaton, *Journ. As. Soc. Bengal* LX, p. 408.
1920. *Anagenesia minor*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 102.
1920. *Palingenia* (*Anagenesia*) *minor*, Gravely, *Rec. Ind. Mus.* XVIII, p. 143, pl. xx, fig. 18.
1923. *Anagenesia minor*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 109.

Anagenesia minor was described by Eaton from one specimen collected at Nattor in Eastern Bengal, and two labeled " Karachi Mus.", but the provenance of which is not known. Gravely later referred two more specimens to this species, one from Sara Ghat in Bengal and the other collected in Upper Burma. Eaton's " Karachi Mus." specimens, which I regard as the types, are in the Indian Museum collection, and are in rather a poor state of preservation. They were in a " much damaged " condition at the time Eaton described them, and age has in no way improved them. The wings and legs in both the specimens are fragmentary and in one the abdomen is altogether missing. The Nattor specimen is not in the Indian Museum.

I refer to this species a large number of specimens of both sexes, pinned as well as in spirit, collected in different places in Bihar. I have compared these specimens with Eaton's types and have no doubt of their identity. The clouding of the posterior segments of the dorsum with gray, as described by Eaton, seems to be a characteristic feature of the species. This character, though not visible in Eaton's specimens now, nor clearly in Gravely's, is very well marked in the Bihar examples.

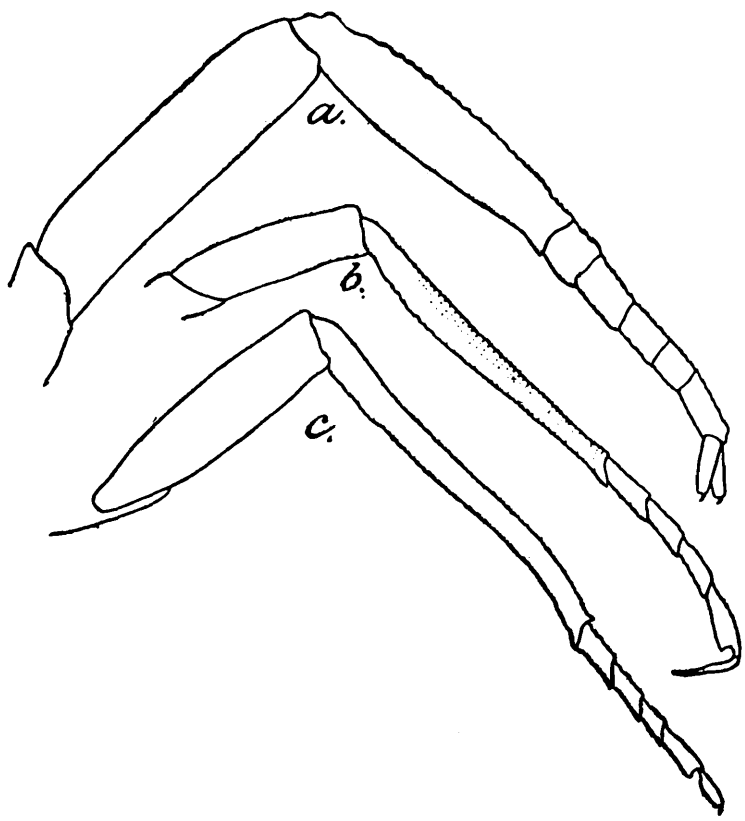
From an examination of the fresh material now available it has been possible for me to redescribe the male in greater detail than could hitherto have been done, and to describe the female for the first time.

Imago ♂.—In the pinned examples the general colour of the body varies between warm buff and cinamon buff, with the notum and parts of the head considerably warmer. In some specimens in which the segments are strongly telescoped the colour appears to be almost tawny. The head as described by Eaton is ochre brown with the area around the ocelli blackish. The eyes are not closely approximated and are black, and the ocelli are white encircled with black. The pronotum is of the ground colour with warmer patches of colour near the sides, and has a longitudinal depression in the middle line with a shallow circular pit in the centre. The mesonotum is considerably warmer than the pro- and metanotum, being more or less concolorous with the head. The dorsum of the abdomen is warm buff, with the segmental margins somewhat darker. The last two or three segments are considerably warmer in tint than the anterior ones, being ochraceous buff, and segments 7-9 are perceptibly clouded with gray. The gray colour is confined to a small area about the middle of the posterior half in the 7th segment,

but extends almost throughout the back in segments 8 and 9. This clouding, which appears to be a characteristic feature of the species, is better seen in spirit specimens than in the pinned ones. The venter and sides are slightly lighter in colour than the dorsum, being very light ochraceous buff. The legs are concolorous with the venter and have conspicuous markings, and the setae are light buff to light ochraceous buff. The wings are dull whitish, with opaque neuration, except in the costal region where the principal veins are light buff.

In the spirit material the colour of the insects is considerably lighter than in the pinned examples. The general colour varies from light ivory to cream buff, sometimes almost varying to light ochraceous buff. The mesonotum is warmer than the pro- or metanotum, being almost ochraceous buff. The dorsum of the abdomen is light buff, with the posterior segments warmer. The clouding of segments 7—9 with gray is better seen in these specimens than in the pinned ones. In some examples the 6th segment is also very faintly clouded, and in one or two the clouding extends even up to the 5th. The venter, sides, legs and setae are slightly lighter than those of the dry specimens.

In both the type-specimens the wings are broken, and it is impossible to see much of the venation. In Gravely's specimens the wings are intact, and seem to be identical with those of the Bihar examples. The wing venation is ample, and there is a large number of small veinlets along the terminal margin. As described by Eaton the venation is



TEXT-FIG. 6.—*Anagenesia minor* (Eaton).
Legs of male, all drawn to same magnification: × 15.
a. 1st leg. *b.* 2nd leg. *c.* 3rd leg.

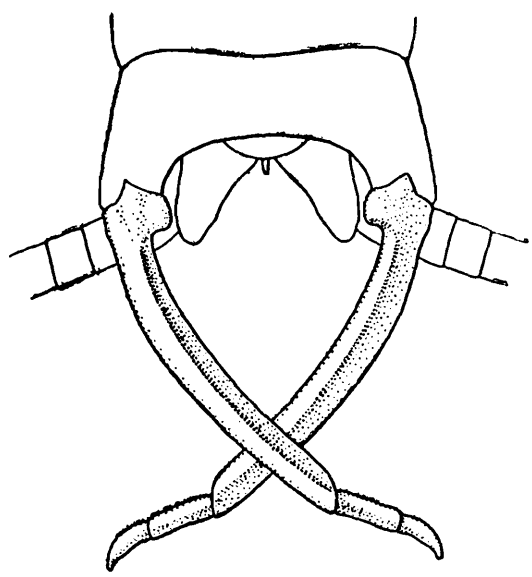
fairly comparable to that of *A. ampla* Eaton, as figured by him, but the veinlets ending in the posterior half of the terminal margin are not

appreciably shorter in the Indian species. There also appear to be a larger number of veinlets along the terminal margin. The fork of the first anal, as usual in the genus, contains a single longitudinal nervure, and a large number of cross veins on both sides of it.

In the metathoracic wing the costal projection near the humeral angle is not very prominently developed. The forking of the three large viens Rs, M and Cu is not well marked, and the venation along the inner margin is somewhat poor.

The legs are well developed. The fore-tarsus is of about the same length as the tibia and is slightly shorter than the femur. The tarsus is made up of five distinct segments, of which the fifth is the longest, being only very slightly longer than the second. The first and the third are subequal and are somewhat longer than the fourth. The two ungues of the claw are well developed. In the hind-leg the tarsus is only a little more than half as long as the tibia, while the femur is also considerably shorter than the latter. The tarsus is formed of only four segments, of which the first is slightly longer than the second, the third is shorter than the second, while the last is of about the same length as the first. There is only a single claw. As described by Eaton the tibiae and tarsi are finely rugose transversly.

The sternite of the last segment forms a deep cup posteriorly to accommodate the genitalia. The penis lobes are short and broad, triangular in shape, with broad bases and rounded distal ends. There is no constriction near the tip as seen in *A. robusta*. The genital forceps are formed of the usual three segments. The long ventrally grooved basal segment has a prominent, somewhat blunt, projection on its inner side near the base, and is finely pubescent along the inner margin. The two last segments are about a fourth of the total length of the forcep,



TEXT-FIG. 7.—*Anagenesia minor* (Eaton).
Genitalia of an abnormal specimen, showing the terminal joint of the forcep shorter than the one preceding it : × 15.

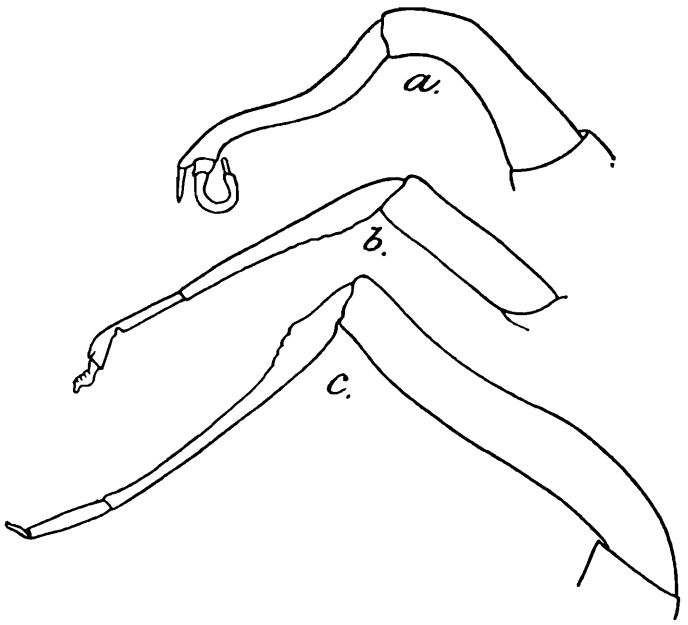
and the terminal one is distinctly longer than that preceding it. One of the Digha Ghat specimens differs remarkably from all the others in

so far as it has the penultimate segment of its forcep limb distinctly longer than the ultimate one. This is clearly seen in the accompanying text-figure 7. The specimen is, however, normal in all other respects.

The two lateral setae are very long and are uniformly pubescent throughout, except at the joints, where the hairs seem to be longer. The median seta, though not quite as well developed as that of *A. robusta*, is fairly distinct.

Imago ♀.—The female is much warmer in colour than the male. In the dry examples the general colour of the body is ochraceous-tawny to tawny. The head is fuscous, and the eyes are black. The ocelli have black rings surrounding the central white part. The pronotum is tawny, and is a little lighter than the mesonotum. The latter has some blackish streaks running longitudinally on it. The dorsum of the abdomen is tawny, with the posterior segments warmer, and considerably clouded with dark gray. This clouding with gray is present on all the tergites, but is best seen in the last three segments. The anterior five or six segments have each a small patch of gray on the middle of the tergite, that in the first two segments being almost insignificant. In the eighth segment the gray occupies the whole of the posterior half of the tergite, while in the last two segments almost the whole of the tergite is clouded with dark gray. These gray markings appear to be characteristic of the species and are very prominent. The venter and the sides are lighter in colour than the dorsum and are ochraceous-tawny. The legs are concolorous with the venter and the setae are dirty whitish. The wings are much warmer than those of the male and are very light ochraceous buff.

In specimens preserved in spirit the colour is considerably lighter than that in pinned examples. The general colour of the body is dirty whitish



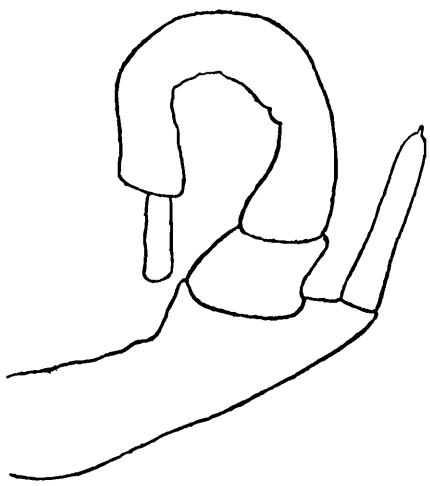
TEXT-FIG. 8.—*Anagenesia minor* (Eaton).
Legs of female, all drawn to same magnification : × 15.
a. 1st leg. *b.* 2nd leg. *c.* 3rd leg.

to ivory yellow with the notum light buff. In ovigerous females the eggs impart a distinct ivory yellow colour to the abdomen. The head

is light cream buff, and is fuscous dotted with dirty white between the ocelli. The longitudinal brownish streaks on the mesonotum are very well seen. The abdominal tergites are clouded with gray as described for the pinned examples, and the disposition of colour patches is clearly seen in the accompanying drawing (plate IX, fig. 3). The venter and sides are dirty whitish and the legs are pale whitish.

The wing venation is like that of the male.

The legs are greatly reduced in the female, and, as seen from the accompanying text-figure 8, are proportionately much smaller than those of the male. The part undergoing the greatest amount of reduction is the tarsus, and this is reduced both in size and in the number of segments composing it. In the first pair of legs the tarsus is extremely reduced, being hardly half as long as the tibia, and the segments forming it cannot be made out distinctly. A basal segment seems to be marked off more or less distinctly and at the apex a finger-like process is also demarcated. Besides these two there is no other trace of segmentation. Just below the tarsus at the outer side of the tibia there is a large forwardly-directed finger-like structure, rounded at the extremity and bearing a very minute process at the tip. I am not aware of the existence of such a structure on the leg of any mayfly, and I am unable to suggest anything regarding its nature or function. The remaining legs are also atrophied, but there is no secondary development in them. In the hind-leg the tarsus is about a third as long as the tibia, and, except for a small portion marked off at the tip, there is no segmental differentiation. The second leg is also proportionately reduced. As in the male the margins of the tibia are in places finely serrated.



TEXT-FIG. 9.—*Anagenesia minor* (Eaton).
Foretarsus of female, enlarged : ×75.

The setae are small ; the median seta can also be seen distinctly.

A. minor is a fairly large insect, the male sometimes attaining to a length of 22 mm. with the wing 18 and the lateral setae up to 56 mm. The female is generally somewhat larger, often being up to 24 mm. long with the setae about 10. In a large number of male specimens the body is strongly telescoped so that the length appears to be 14—16 mm. only.

Nymphs of this species have not been described so far.

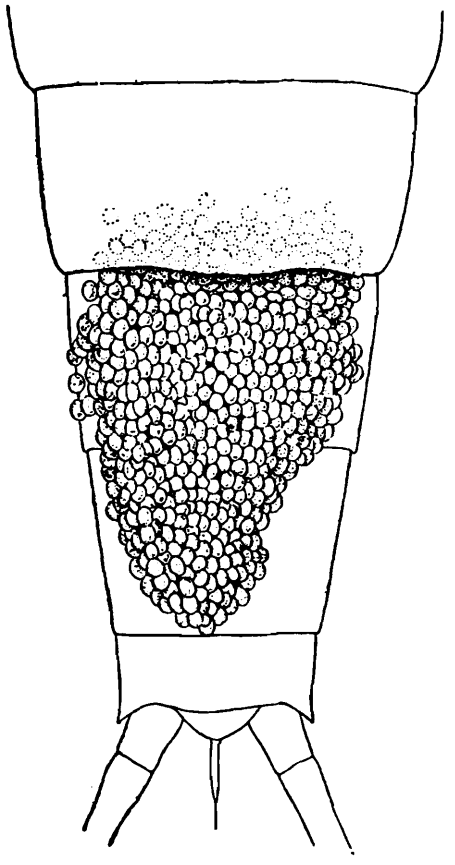
Type-specimens.—9689-90/5, Zoological Survey of India (*Ind. Mus.*).

Locality.—*Anagenesia minor* seems to be a widely distributed species having been recorded from the following localities :—

?	" Karachi Mus."	Types. 2 pinned males in the Indian Museum.
Nattor, Eastern Bengal	?	?
Sara Ghat, Bengal	J. Dovan. May, 1911.	1 pinned male in the Indian Museum.

Pakokhu, Upper Burma	E. Colenso. October, 1911.	1 pinned male in the Indian Museum.
Digha Ghat, nr. Patna, Bihar	T. B. Fletcher. May, 1915.	Several examples of both sexes in spirit in the Pusa collection and the Indian Museum.
Mokamah, Bihar	T. B. Fletcher. May, 1918.	Ditto.
Saran, Bihar	M. Mackenzie	A pinned male and female in the Pusa collection.

Leaving out of consideration the type-specimens from the " Karachi Museum," the exact provenance of which is not known, the species seems to be widely distributed in Bihar and Bengal, extending even into Burma. I have carefully examined the Upper Burma specimen referred by Gravely to this species, and cannot find any important difference between it and other specimens from Bihar and Bengal. It is, however, smaller in size than the other specimens, and like all old specimens is badly faded in colour. If the " Karachi Museum " specimens were collected anywhere near Karachi, the species, as mentioned by Gravely, would thus appear to be " very widely distributed over the Indian Empire."



TEXT-FIG. 10.—*Anagenesia minor* (Eaton).
Ventral view of the posterior abdominal sternites of the female, showing masses of eggs adhering to it : × 10.

In Bengal and Bihar the species is met with in different places along the Ganges and its branches and appears to emerge in May, chiefly in the latter half of the month. The Upper Burma specimen is said to have been collected in October.

The pinned male and female specimens from Saran are much lighter in colour than any other pinned examples. In some specimens from other localities also, notably in those from Digha Ghat, the colouration of the body is greatly affected by the strong telescoping of the abdominal segments. Thus specimens which are fully extended appear to be considerably lighter in colour than those in which the segments are telescoped. Besides affecting the colour the proportions of the body are also considerably changed by this telescoping, and insects in which telescoping occurs give an appearance of being considerably shorter and stouter than those which are normally extended.

A. minor is easily recognized from other species of *Anagenesia* by its

somewhat smaller size, paler colour and by the characteristic clouding of the posterior abdominal tergites with gray. This last character is much better seen in the female than in the male.

A very large number of eggs are produced by the female, and in most of the specimens of this sex the posterior region of the abdomen is full of egg-ma ses. The eggs on being expelled out of the distended oviducts appear to stick to the ventral surface of the last three tergites, where, as seen in the accompanying text-figure 10, they form a thick covering over the body-wall. The eggs seem to be held together by some sticky substance which is not dissolved in alcohol.

The eggs, as seen in spirit specimens, are pale yellowish in colour, and have the shape of thin circular, or oval discs. They have a very thin, almost transparent shell, through which the inner structures can be faintly made out. In eggs made transparent granules of albumen are seen in great abundance scattered about more or less evenly, but the larger ones aggregated especially towards the centre. Just inside the shell there is a very small clear space all round, and the vitelline membrane is not very clearly seen. The peripheral region in which the large albumen grains are more or less absent takes anneline stains very feebly.

Anagenesia picta (Gravely).

(Plate IX, figs. 5, 6).

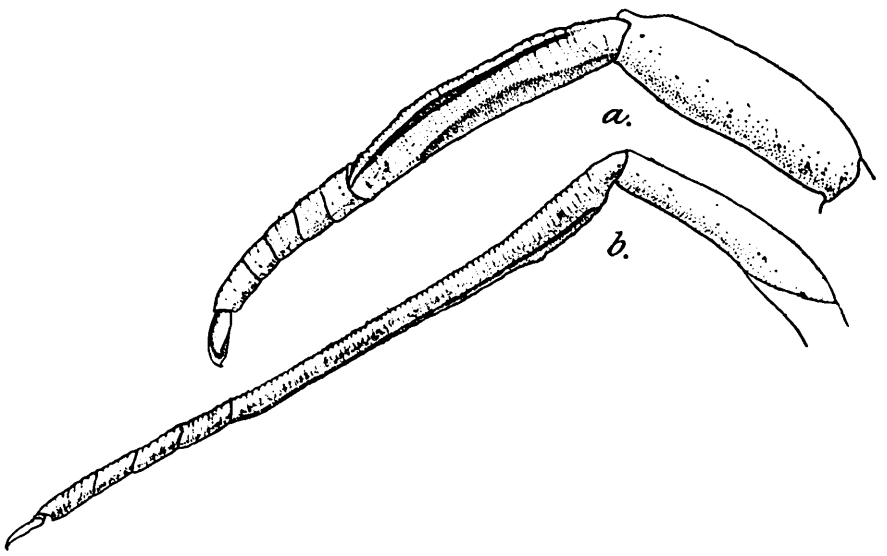
1920. *Palingenia* (*Anagenesia*) *picta*, Gravely, *Rec. Ind. Mus.* XVIII, p. 140, pl. xx, figs. 24, 25.
1923. *Anagenesia picta*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 109.
1924. *Anagenesia picta*, Ulmer, *Treubia* VI, p. 32.

Besides the two pinned male specimens from Sarawak described by Gravely, there are in the Indian Museum collection two males in spirit also from the same locality.

As pointed out by Gravely, *Anagenesia picta* is only slightly larger than *A. lata* (Walker), but can be easily distinguished from it by its different colouration. The general colouration of *A. picta* is reddish brown approaching chestnut. In one of the spirit specimens the colour is more yellowish than reddish brown resembling greatly buckthorn brown; the other spirit specimen, though somewhat faded, has a colour more or less like that of the pinned insects. The head between the eyes is fuscous black, with a median brown line on the vertex. The eyes are black. The mesonotum is concolorous with the head, and the pronotum is much paler than either of these. On the dorsum of the abdomen narrow pale streaks on the posterior borders of the tergites alternate with the broad chestnut ones covering the major portions of the segments. The last three tergites are darker than the rest and are more or less uniformly coloured. The venter and the sides are hazel and the femora of the legs are of about the same colour. The tibiae and the tarsi are considerably lighter in colour than the femora. The genital forceps are concolorous with the venter and the setae are buckthorn brown. The wings are dirty whitish to light buff, with ochraceous buff opaque venation, and, as described by Gravely, those of the anterior pair have an infuscate costal margin.

The venation of the fore-wing is clearly brought out in Gravely's figure, and greatly resembles that of *A. minor* Eaton. The number of intercalaries, however, especially in the posterior half of the terminal margin, is considerably larger than that in Eaton's species.

The hind-wing, of which I give a figure (plate IX, fig. 5), is also somewhat like that of the preceding species, but there appear to be fewer veins.

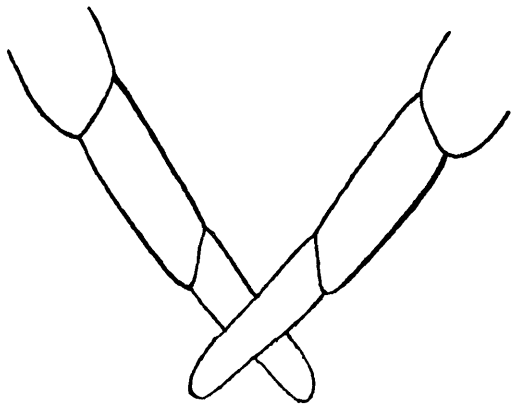


TEXT-FIG. 11.—*Anagenesia picta* (Gravely).
a. 1st leg of male : × 10. *b.* 3rd leg of male : × 10.

The legs of the male are well developed, those of the first pair being considerably shorter than the third. In the fore-leg the tibia is lighter in colour than the femur but has longitudinal streaks of a brownish colour. It has a deep groove running obliquely in a longitudinal direction, starting near the base on the inner surface of the tibia and running along the outer side to the commencement of the tarsus. This groove is clearly seen in the accompanying text-figure 11. The tarsus is lighter in colour than even the tibia and has faint grayish black rings. The tibia is considerably longer than the tarsus and is somewhat longer than the femur. The outer margin of the tibia and the tarsus is transversely rugose. The fore-tarsus is composed of five distinct segments of which the fifth is the longest, while the other four are more or less subequal. The claw is double. In the hind-leg the tarsus is only a little more than half as long as the tibia and is somewhat longer than the femur. Here also the tibia is longitudinally grooved, and the same is seen in the second leg also. The outer margin of the tibia and the tarsus is transversely rugose, while the former is rugose along the inner margin also. The tarsus has only four segments of which the last is the longest, the first a little shorter than the fourth and a little longer than the second. The third is only very slightly shorter than the second. The claw is single and is acutely pointed.

The genitalia of the male have the usual structure. The long basal segment of the genital forceps is about two and a half times as long as the two terminal ones put together. It is deeply grooved ventrally and has hairy margins. The large bluntly rounded projection on the

inner side of this segment near the base is very prominent. Of the two terminal segments the last one is distinctly smaller than the one preceding it. The penis lobes have the usual shape and are lodged in a cup-like depression of the 10th sternite. The penis lobes show only a slight constriction near the apex.



TEXT-FIG. 12.—*Anagenesia picta* (Gravely).

Terminal joints of the genital forceps of male, showing the ultimate segment only a little shorter than the penultimate one : × 26.

One of the spirit specimens differs from all the others in having the two terminal joints of the genital forceps more or less equal in length. As seen in the accompanying text-figure 12 the last segment in this example is only very slightly shorter than the one preceding it. In typical specimens, however, this segment is markedly shorter than the penultimate one.

The two lateral setae are long and ribbon-like and are densely pubescent throughout. The rudimentary median seta is very small.

Anagenesia picta is a large species, the males being a little more than 22 mm. with the wings 20 and the setae as long as 60 mm.

Type-specimens.—9221/H_2, Zoological Survey of India (*Ind. Mus.*).

Locality.—The species is so far known from Kapit, Sarawak, in Borneo only and is represented in the Indian Museum collection by the two pinned types and two other specimens in spirit. All the four specimens are males and were collected by Mr. C. W. Beebe in July, 1910.

The species does not appear to be widely distributed even in the Malay Archipelago, as it was not represented in the extensive collection from the Sunda Islands and the Philippines recently reported upon by Dr. Ulmer.

In size and general colouration of the body the present species is more or less like *Anagenesia lata* (Walker), but is easily distinguished from it on account of its dirty whitish wings. In *A. lata* the wings and body are both darkly coloured. From other Indian species of *Anagenesia*, *A. picta* is separated by the warm reddish brown colour of its body, both *A. robusta* and *A. minor* being of a very pale colour.

Genus **Mortogenesia** Lestage.

1921. *Palingenia* (*s. l.*), Morton, *Entomol.* LIV, pp. 177-180, pl. ii.
1923. *Mortogenesia*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 110.

The genus *Mortogenesia* is based on a single species from Mesopotamia that Morton had doubtfully included in the composit genus *Palingenia*. The combination of characters that this insect, however, presents—as pointed out by Morton himself—is not met with in any other genus of the family Palingeniidae, and Lestage was fully justified in setting up a new genus for its reception. In the forking of the media (of the fore-wing) before the middle, in the presence of a single intercallary vein in the first anal fork, and a double claw on the hind-tarsus, and in the possession of a seven-segmented genital forcep by the male—to mention only a few of the more important features—these insects possess a set of characters which easily distinguish them from any other member of the family to which they belong.

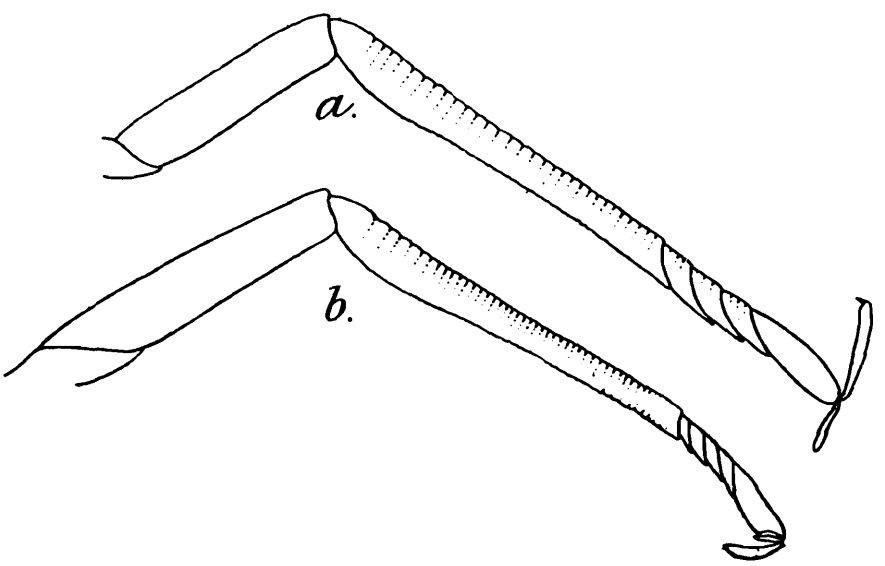
Mortogenesia mesopotamica (Morton).

1921. *Palingenia mesopotamica*, Morton, *Entomol.* LIV, pp. 177-180, pl. ii.
1923. *Mortogenesia mesopotamica*, Lestage, *Ann. Soc. Ent. Belgique* LXIII, p. 110.

This Mesopotamian species is very easily recognized by, among other characters, the dark mesonotum which stands out prominently in a light brownish dorsum. The species is represented in the collection of the Madras Government Entomologist at Coimbatore by a single male pinned specimen collected at Karradah, Bagdad, on the river Tigris by Mr. Duraisami on the 10th of April, 1920.

The Coimbatore specimen is much larger than those seen by Morton. It is a little less than 30 mm. long (ex. forceps) and the wings, which are very much crumpled, also appear to be longer. The caudal setae are fragmentary.

Morton's description of the species is quite adequate for the proper determination of this remarkable insect, and his illustrations show the



TEXT-FIG. 13.—*Mortogenesia mesopotamica* (Morton).
a. 2nd leg of male : × 15. *b*. 3rd leg of male : × 15.

necessary parts quite clearly. I, however, give here figures of the second and third legs. In the latter the claw is clearly seen to be double.

Family POLYMITARCIDAE.

In his *Revisional Monograph* Eaton included four genera in the Polymitarcidae, but of these only three are now considered to be members of this family, while *Jolia* Eaton has been abolished on the ground that the imago described by Eaton belongs to the genus *Polymitarcys*, while the nymph is a *Chirotonetes*. To the remaining three genera, *viz.*, *Euthyplocia* Eaton, *Campsurus* Eaton and *Polymitarcys* Eaton, Ulmer (1920) has added another three : *Povilla* Navás, *Exeuthyplocia* Lestage and *Asthenopus* Eaton. Of these the last named was created by Eaton in 1871, but was dropped by him in 1883 (*Revisional Monograph*) without giving any reasons ; it has, however, been rightly revived by Ulmer. *Povilla* is another genus about which there has been some discussion, Lestage (1922) considering it synonymous with *Asthenopus*, but as explained by Ulmer (1924b) there can be little doubt that the insect described by Navás cannot be included in Eaton's *Asthenopus*.

The six genera that now go to form the family Polymitarcidae can easily be distinguished from one another with the help of the excellent key given by Ulmer (1920). Lestage (1923b) in his " Notes critiques sur les *Campsurus* " has also given very good keys for recognizing the genera. There are separate keys for the male and the female insects.

The neuration of the fore-wing, especially in the anal area, presents great variation in the different members of this family. In *Polymitarcys* there are numerous subsidiary veins enclosed in the fork formed by the first anal vein, their number usually varying from 2—9 ; on the other hand in *Euthyplocia* and *Exeuthyplocia* there may be no such veins at all, and if present their number never exceeds three. In the remaining three genera the condition is more constant, there being always two veins in the first anal area. In *Asthenopus*, however, both of these arise from the first anal vein (1A), while in *Povilla* one arises from the first anal, the other from the second anal.

Of the genera included in this family only two are so far known from India, *Polymitarcys* and *Povilla*, the first from three species[1], one of which is new to science, and the other from a single species hitherto known from Java.

Genus **Polymitarcys** Eaton.

Ulmer in 1920 included definitely six species in this genus, of which one, *P. australis* Hagen, may possibly be synonymous with Pictet's *P. indicus*. Out of the remaining five only two are known from India : one, *P. indicus*, hitherto recorded from the Malay Archipelago and Ceylon only, and the other, *P. annandalei*, described in this paper for the first time. The Malayan form that has now been extensively met with in India, at least in the north-eastern parts, can be easily distinguished from my new species. In *P. indicus* the body colouration of the male is quite different from that of the female ; in the former the general colour is dirty whitish, overshadowed with light gray and with the thorax somewhat brown ; in the female the body is distinctly brownish yellow,

[1] Including *Polymitarcys* sp. of Eaton.

with grayish violet bands running transversly on the abdominal tergites. The wings are whitish, with the costal region light violet. In *P. annandalei* only the female is known, and it has a dirty whitish colour, with the thorax somewhat warmer than the rest of the body. The wings are also dirty whitish and the costal region is not coloured violet. The membrane has a distinctly mottled appearance, owing to the presence of very faint spots on almost the entire surface. Besides these two species there is another Indian form, described by Eaton (1892) as *Polymitarcys* sp. This, as explained in its appropriate place (*vide infra*, p. 133), is distinct from the other two species and can be recognized by the yellowish brown costal margin of the fore-wing. The membrane is not spotted.

The genus *Polymitarcys* has a very wide range of distribution, and occurs almost all over the world. In India it has so far been met with in Bengal, Bihar and Assam.[1] *P. indicus* is known from Bihar and Assam only, but it is likely that this species has a much wider range. *P. annandalei* is from Chota Nagpur, and Eaton's *P.* sp. from East Bengal.

Polymitarcys indicus (Pictet).

(Plate IX, figs. 7—11 and plate X, fig. 1).

1843-45. *Palingenia indica*, Pictet, *Hist. Nat. Ins. Neuropt. Ephem.* pp. 151, 152, pl. xiii, fig. 4.
1853. *Palingenia indica*, Walker, *Brit. Mus. Cat. Neuropt.*, part iii, p. 549.
1871. *Polymitacys indicus*, Eaton, *Trans. Ent. Soc. London*, p. 61.
1883. *Polymiatarcys indicus*, Eaton, *Trans. Linn. Soc. London* (2) III, p. 47.
1913. *Polymitarcys indicus*, Ulmer, *Notes Leyden Mus.* XXXV, p. 102.
1914. *Anagenesia greeni*, Banks, *Proc. Acad. Nat. Sci. Philadelphia*, pp. 612, 613.
1920. *Polymitarcys indicus*,[2] Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 107.
1921. *Polymitarcys indicus*, Lestage, *Ann. Soc. Ent. Belgique* LXI, p. 212.
1924. *Polymitareys indicus*, Ulmer, *Treubia* VI, pp. 32-34.

This somewhat common species, hitherto known from Ceylon, Java, Philippines, etc., is represented in my collection by a large number of specimens from Bihar, and a single damaged example from Assam. Of the Bihar specimens only two are males and are pinned, while all the females are in spirit. The mutilated Assam specimen, which is in spirit, is a male.

Most of the descriptions of *Polymitarcys indicus* so far published are based on dried insects, and depend chiefly on points of colouration. In specimens that have been preserved in spirit for any length of time the colour is invariably faded and does not, therefore, correspond exactly with that of the pinned insects. It is for this reason, therefore, that of the Indian examples of this species only the pinned males conform exactly with the published descriptions, while the females, that are in spirit, show some small differences from such accounts. Through the courtesy of the authorities of the Vienna Museum I have, however, been able to examine the unique female type-specimen of this species and am convinced that the Indian examples belong to Pictets' species. I have, however, considered it advisable to give a fairly detailed description of the Indian examples.

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[1] Also from Burma ; see foot-note on page 130.

[2] I am unable to say if Hagen's *P. australis* is synonymous with *P. indicus* or not. *P.* sp. Eaton, however, is a distinct form.

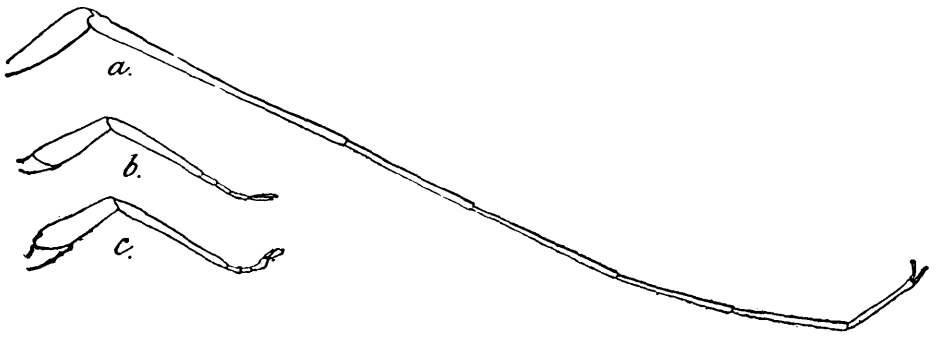
Both the dried males that I have seen agree in all material respects with Ulmer's description published in *Treubia* quoted above. The head is ochraceous brown and is somewhat darker behind the ocelli. The eyes are black, and the ocelli are dirty whitish encircled with brownish black. The eyes are widely separated from one another, somewhat oval in shape and are small in size. The ocelli are proportionately large, the median one being considerably smaller than the others. The head is more or less like that of *Polymitarcys virgo*, as figured by Eaton (1883, pl. vi, fig. 10*a*). The pronotum is light grayish yellow and has a waxy appearance. The mesonotum and the metanotum are much warmer than the pronotum and are distinctly brownish in shade. The dorsum of the abdomen is dirty whitish, with all the tergites overshadowed with gray, the posterior three being much warmer than the rest and slightly tinged with light violet. The posterior borders of the tergites are white. The venter and the sides are dirty whitish, except the sternum which is light ochraceous brown.

The legs are more or less concolorous with the venter, except those of the first pair, in which the coxa has a blackish streak along the outside ; the femur is more or less uniformly sooty black, except at its articulations ; the tibia is blackish and the tarsus is dirty whitish spotted with black.

The setae are dirty whitish with the joints white.

The wings are white, with the veins of the same colour. The costa, subcosta and the radius, with the transverse veins between them, are light violet. The venation is typical, but in the first anal area there are definitely six veins, instead of five as described and figured by Ulmer. I have carefully examined the wings of all the three specimens in my collection, but I find that the fork of the first anal vein invariably contains six subsidiary veins.

The hind-wing has a strongly developed costal projection, and the anal area is considerably reduced.

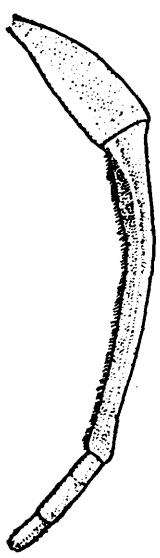


TEXT-FIG. 14.—*Polymitarcys indicus* (Pictet).
Legs of male, second and third slightly diagrammatic ; all drawn to same magnification : × 11.
a. 1st leg. *b*. 2nd leg. *c*. 3rd leg.

The legs, especially those of the first pair, are fairly well developed. In both the pinned specimens some of the legs are missing and the foretarsi are broken in both, but almost all the legs are intact in the Assam example. The first leg is almost as long as the body, but is very thin. The femur is very short, and the tibia is also hardly half as long as the

tarsus. The latter is formed of five segments of which the fifth appears to be the shortest. The claw is biunguiculate. The second and the third legs are greatly reduced, and are hardly a third as long as those of the first pair. The comparative sizes of the legs is clearly brought out in the accompanying text-figure 14. The tarsi are so reduced that it is difficult to make out their exact structure.

The genital apparatus is as described by Ulmer. The forceps are concolorous with the venter, and the penis lobes are warmer in colour, being slightly more yellow. The disposition of the genital forceps with reference to the penis lobes is interesting in the examples I have examined. As a rule the forceps lie more ventrally than the penis lobes. In the three male insects of this species that I have examined, however, the forcep of one side lies in its usual position, namely ventrally to the penis lobe of its side, while that of the other side lies dorsally to its penis lobe. In the two pinned males it is the right forcep that lies over the penis lobe of its side, while in the Assam specimen the left forcep is more dorsally placed than the left penis lobe. This character has not, however, been remarked upon by Ulmer, and it is possible it was not present in his specimens. The forceps have the usual structure. Each is formed of four segments, but their arrangement is quite different from what Ulmer has described and figured. In Ulmer's drawing there are shown only three distinct segments, of which the basal and the terminal are subequal, while the middle one is considerably longer than either of these. Besides these there is between the basal segment and the second a short articulation which is not clearly differentiated and is not fully chitinized. In my specimens the forcep is very clearly formed of four segments. The basal segment is thicker than the rest, and is about half as long as the second. The latter, which is the longest of all, is slightly grooved along the inner side, and has a low ridge running lengthwise along one of its faces. The inner side is densely hairy. The last two segments taken together are a little less than half as long as the second joint. The ultimate segment is considerably shorter than the one preceding it. Between the long second and the penultimate segments there appears to be another indistinct and only partly chitinized joint, similar to that described by Ulmer. As is clearly seen from the figure this, however, is in a different position. The penis lobes in the dried examples are exactly like those figured by Ulmer, but in the spirit specimen the terminal "hakenförmig" portion is rather bluntly terminated, as is shown in the accompanying illustration (plate IX, fig. 11). It seems, however, likely that this apparent difference is only due to the specimen being in spirit.



TEXT-FIG. 15.—*Polymitarcys inlicus* (Pictet). Genital forcep of male, enlarged : × 50.

The caudal setae are in the form of narrow ribbons. The median seta, though reduced, is quite distinct.

All the female imagos that I have examined are preserved in spirit. The general colour of the body is much warmer than that of the male, and is distinctly browner. The prevailing colour tint in the female is brownish yellow, approaching yellow ochre, while that of the male is dirty white. The head is drab coloured and is conspicuously bordered with black. The eyes are black and the ocelli are white encircled with black. The pronotum has a waxy appearance and is light ochraceous buff, tinged with brown in the median parts, but without any trace of violet. The mesonotum and the metanotum are ochraceous tawny, but are lighter in some specimens. The five regular stripes on the mesonotum mentioned by Ulmer are not visible in my specimens. There are, however, two parallel closely running thin longitudinal streaks of dark brown in the middle of the mesonotum, and some near the margins, but they are not as described by Ulmer. The posterior median projection of the metanotum is bordered with black. The dorsum of the abdomen is light brownish yellow, but all the tergites have grayish violet bands of a fairly dark colour running transversely along their posterior margins. These bands extend considerably forwards and in specimens in which the abdominal segments are telescoped a continuous broad longitudinal dark band is formed in the median line. The last two or three segments are somewhat more extensively coloured than the preceding ones. The venter and sides are pale yellowish, with the head and thorax warmer than the rest of the body.

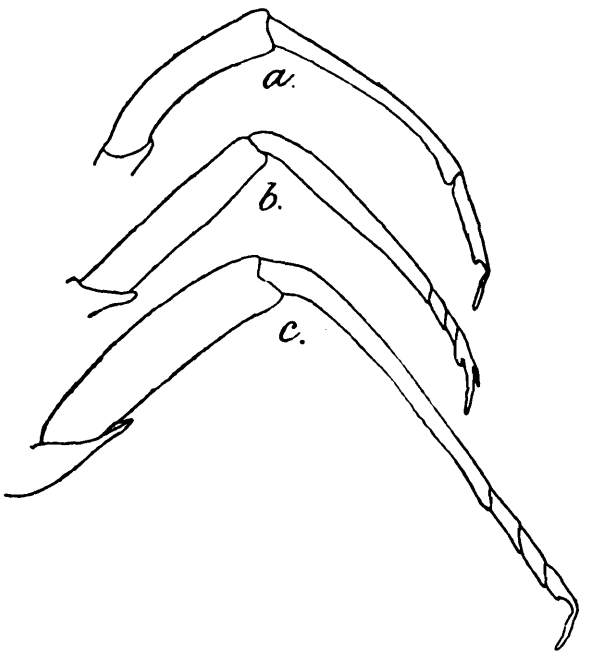
The legs are concolorous with the venter, except those of the first pair, which are somewhat warmer in colour and have thin streaks of a dark brownish colour on their outer sides. The tarsi are almost completely encircled with brown, while the tibiae are also extensively coloured. The tail setae are whitish in colour, while the wings are dirty whitish, with the veins white. The costal margin of the fore-wings and the first three longitudinal veins, together with the great cross vein, are light grayish violet.

The venation is like that of the male. The subcosta is well displayed and the radius is strong and prominent. The radial sector is forked well in advance of the media, and the latter is forked a little before the middle of the wing. The cubitus is not distinctly forked, and the intercalary vein enclosed in the " cubital fork " arises in this case from the base. The third cubital branch (Cu_2) is grafted to the first anal near its base. In the first anal area there are six subsidiary veins, from the last of which there are several curved somewhat S-shaped veins going to the wing margin. The second and the third anal veins are fairly well developed. As usual in the genus there is a very large number of cross veins, which give the wing a mat-like appearance.

In the hind-wing the radial sector vein branches quite close to the wing base, and the media, as in the fore-wing, forks before the middle. The cubitus is considerably reduced, and its three branches cannot be made out. The anal area is reduced. The costal projection is very prominent.

The legs show a great deal of reduction. The fore-legs are considerably shorter than the hind-legs, and of the three pairs these are the least developed. In the fore-tarsus no distinct segments are discernible;

there is apparently only one long joint, followed by a poorly-developed claw. In the tarsi of the second and third pairs of legs two well-defined segments besides the claw can be seen.



Text.-fig. 16.—*Polymitarcys indicus* (Pictet).
Legs of female, second and third tarsi slightly diagrammatic ; all drawn to same magnification : ×20.
a. 1st leg. *b*. 2nd leg. *c*. 3rd leg.

Masses of eggs of a light buff-yellow colour are seen sticking to the posterior sternites of some of the specimens. The eggs are not clustered together in bodies of any regular shape, as in the case of the following species (*vide infra*, p. 132, also pl. X, figs. 5, 6), but they form irregular masses. Each egg is an ovalish structure slightly less than half as broad as long with the polar knob or the "micropylar apparatus," as Miss Morgan calls it, well developed. There is no prominent sculpturing of the chorion. In eggs that have been rendered transparent large granules are seen aggregated near the centre.

The Indian specimens of *Polymitarcys indicus* are somewhat smaller in size than those described by Ulmer. The males are about 9 mm. long, while the females are 1—2 mm. longer. The wings in the male are 9—10 and those of the female 12—14 mm. long. The setae in the male are 22 ; in the female the lateral ones are 11—13, while the median seta is 7—8 mm. long.

The nymphs of this species are not known.

Locality.—A large number of female imagos were collected by the late Dr. N. Annandale at the East Bank Railway Station on the Sone River in Bihar on 14th November, 1914. The insects were attracted to the light of a railway carriage. The two pinned males that I have seen belong to the Pusa collection and were collected by Mr. T. B. Fletcher, also at light in a railway carriage on the Sone River between Arrah and Patna Stations on 9th October, 1922. The third male specimen was recently (March, 1925) found by Dr. S. L. Hora of the Zoological Survey of India, floating down the Dhaleswari River at Katlicherra in

South Cachar, Assam. This specimen is very much crumpled and is preserved in alcohol.

Though the males and females of this form were collected at different places and at different times I have no doubt that they are referrable to the same species. The two localities in Bihar from which Dr. Annandale and Mr. Fletcher collected these insects are quite close to one another. The colouration of the male and female differs considerably, but that is the case in several other mayflies also, and has already been noticed by Ulmer with regard to this species. The wings in the two sexes are identical.

Owing to the kindness of Drs. Maidl and Zerny of the Vienna Museum it has been possible for me to examine Pictet's type-specimen of this species. This specimen, which is still in a fairly good state of preservation, resembles exactly in almost every detail the Indian examples of this species. The colour is somewhat faded in the type, and neither the violet lines on the pronotum, nor the five streaks on the mesonotum, mentioned by Ulmer, can now be made out. The grayish violet bands on the abdomen, which is strongly telescoped, the violet colour of the costal region of the fore-wing, the blackish streaks on the fore-legs and in fact most other characters are exactly as I have described them above. There is, however, one difference between the Indian examples and the Vienna specimen. In the latter the hind wing has [illegible] fore-wing has four subsidiary veins on the right side and five on the left, in my examples there are six on both sides. Ulmer has described " 4 bis 5, selten 6 Längsadern " in his specimens. This character, therefore, appears to be variable, and consequently not of any great importance.

Ulmer's figure and description of the genitalia of the male do not agree with my specimens. The last segment of the genital forceps, shown in Ulmer's figure, seems to be divided in two in the Indian forms, and the indistinct, partly chitinized articulation between the basal and the penultimate joint is present in my specimens in a different position. The forcep of the European *P. virgo* (Oliver), as figured by Eaton (1883, pl. vi, fig. 10 *a.*), and of other species is, however, formed of four distinct segments and is very much like that of the Indian specimens of the present species. It seems to me likely that the figure given by Ulmer is not quite correct in this respect, as the number of segments forming the genital forceps is generally very constant for all species of a genus. The position of the indistinct and partly chitinized articulation does not appear to be of any great importance, for the tendency to the formation of such articulations seems to be present in both cases. Further, the penis lobes in my examples are not quite as sharp apically as those shown in Ulmer's illustration, but, as mentioned above, this is probably due to the fact that Ulmer's figure is based on dried material, while mine is drawn from an example preserved in spirit. In the two pinned specimens that I have seen the penis lobes are pointed, though not to quite so great an extent as is shown in Ulmer's figure.

As already remarked by Ulmer (1924b), *Polymitarcys indicus* appears to be a very variable spceies with regard to the number and arrangement of the subsidiary veins enclosed in the first anal area. The first anal vein forks near its base and there are usually 4—6 subsidiary veins

enclosed in this fork. In the type-specimen there are five such veins on the left side and only four well-developed ones on the right; Banks has described only four veins in his *Anagenesia greeni* from Ceylon, while Ulmer has mentioned the number as four to five, sometimes six. From Lestage's account it appears there were only three subsidiary veins enclosed in the first anal fork of his specimens. Three intercalary veins is an unusually small number, but Lestage's brief description is not quite clear on this point. In all the specimens that I have examined there are six veins enclosed in the anal fork.

Polymitarcys indicus was hitherto known to occur in the "East Indies" (Pictet), Ceylon (Walker and Banks), Java (Ulmer, 1913), Indo-China (Lestage) and Sunda Islands and the Philippines (Ulmer, 1924b). The record of occurrence of this species in India, though not very remarkable, extends its range considerably. In India the species is so far known chiefly from the Sone River, Bihar, though one specimen was collected in Assam also. It seems probable, however, that this insect has a wider distribution in India[1] than these records would show, and in time is likely to be collected in other parts of the country also.

Polymitarcys annandalei, sp. nov.

(Plate X. figs. 2—6).

The present species is represented in the Indian Museum collection by about half a dozen imagos preserved in spirit. All the specimens are females and are in a good state of preservation.

Female imago (in spirit).—The general colouration of the body is dirty whitish, with the head and thorax somewhat warmer in colour. The head on its dorsal surface is light cream, with a short transverse fuscous streak in its anterior region between the ocelli. The eyes are blackish and the ocelli are broadly encircled with dark blackish-brown. There is also a thin, and in some specimens very faint, dark streak running longitudinally in the middle line and the area behind the median ocellus is somewhat fuscous. The pronotum is lighter than the head, and is ivory yellow. It has also a narrow fuscous streak running transversely just behind the anterior margin. The mesonotum is much warmer in colour than the head or the pronotum and is cream coloured. There are the usual dark lines on the mesonotum, and a streak darker than the rest runs longitudinally in the median line, and is continued on the metanotum. The dorsum of the abdomen is dirty whitish to ivory yellow, but the masses of eggs inside give it a buff yellow colour. Each tergite along its posterior margin has a faint brownish to dark grayish-brown broad streak, which is produced anteriorly in the median line so as to form a broad band running longitudinally almost from end to end of the

[1] Quite recently (9th October, 1926) I collected this species in very large numbers in Burma. I was travelling in a railway train near Pegu at about 8 in the evening and a swarm of these insects, no doubt attracted by bright light, flew right into the carriage. They were in such large numbers that they seemed to fill the whole carriage. On switching off the lights they fell down on the floor and the seats and were later picked up almost half dead. As usual with such swarms the females outnumbered the males.

The species is now, therefore, known to occur in Burma, Assam and Bihar. There seems little doubt that it will be met with in Bengal also.

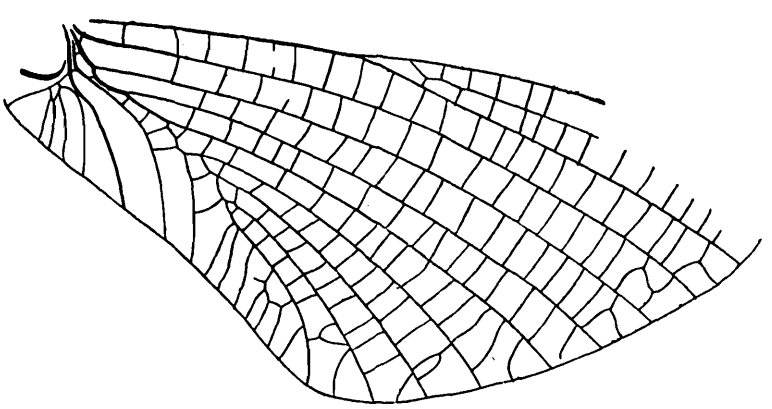
dorsum. The last two or three tergites are warmer than the rest. The venter and sides are dirty whitish, except in the thoracic region where the sternites are ivory yellow.

The legs are more or less concolorous with the venter. In the fore-leg the femur has on its dorsal surface a number of inconspicuous fuscous streaks running longitudinally, and the tibia and tarsus are also more or less similarly marked.

The setae are whitish.

The wings are dirty whitish, with most of the veins in opaque view whitish. The costal region, especially the pterostigmatal area, is considerably warmer than the rest of the wing, except a small region along the terminal margin behind the third anal vein, which is of the same colour. The costal, subcostal and the radial veins are cream coloured. The wing membrane has a mottled appearance on account of the presence of faint spots in the cells formed by the crossing of veins. Except in the anterior region of the wing almost every cell has a small spot in its middle. The spots are only very slightly warmer in colour than the wing membrance and are consequently inconspicuous. In some of the specimens this mottling is very faint.

The shape of the fore-wing is somewhat different from that of the preceding species. The inner margin is proportionately longer, while the terminal is correspondingly shorter. The anal angle is also less defined, and is broadly rounded. The venation is, however, typical of the genus. The subcosta is well displayed, the radial sector forks well in advance of the media, which branches a little before the middle of the wing and the cubitus does not form a definite fork at all, its anterior branch arising separately near the base of the media, while the two posterior ones, which are more or less equally developed, join the first anal a little below the base. The fork formed by the latter contains in some examples four intercalary veins and in others five. When there are four veins enclosed in the anal fork instead of five the curved transverse veins going from the last of these to the wing margin are more prominent and better



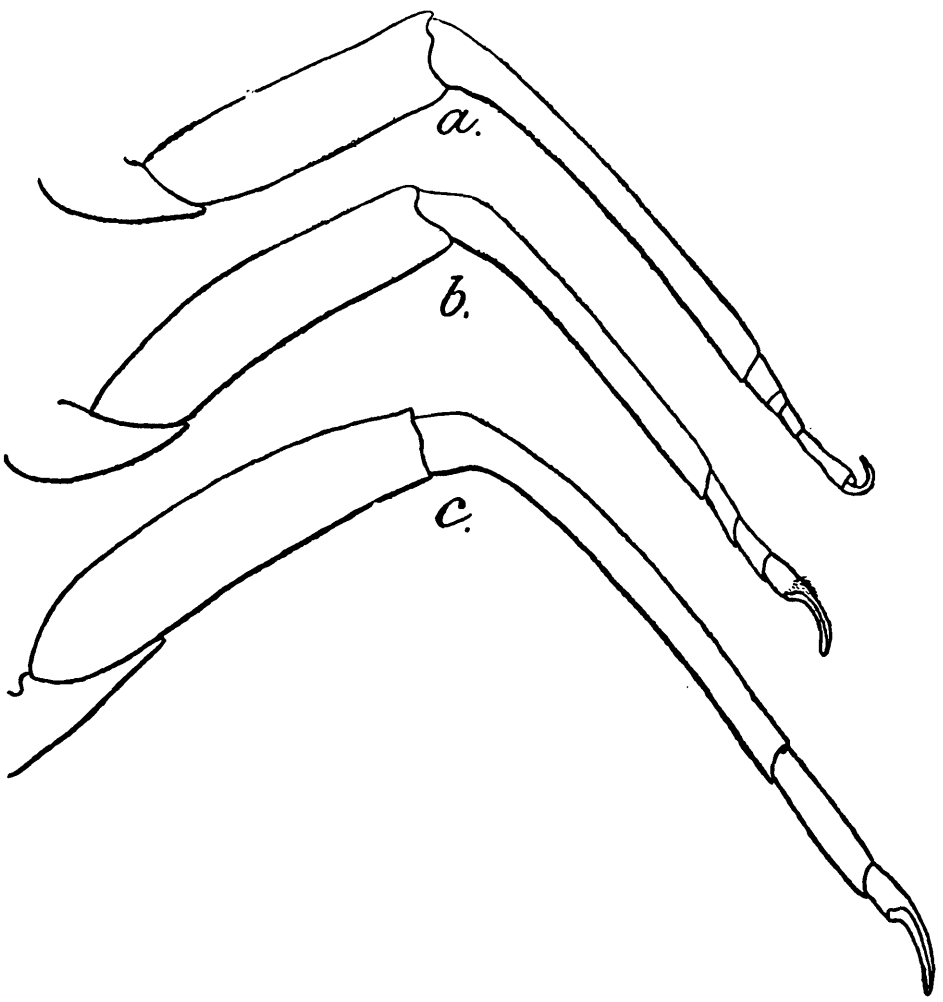
TEXT-FIG. 17.—*Polymitarcys annandalei*, sp. nov.

Posterior region of a fore-wing, showing four subsidiary veins enclosed in the first anal fork: × 8.

developed. The wing has a closely reticulated appearance on account of the large number of transverse veins.

The hind-wing is similar to that of the preceding species, and the membrane does not present a spotted appearance. The costal projection is highly developed.

The legs are extremely reduced. The fore-legs are of about the same size as the middle ones and are distinctly smaller than the hind-legs. The femur and the radius are well developed in all the legs, but the tarsus shows great reduction, especially in the last pair of legs. In the fore-tarsus four segments can be more or less clearly made out, of which the second is the shortest and the fourth the longest. The first is a little shorter than the second and the third put together. In the mid-tarsus only three segments can be distinguished, while in the tarsus of the last lag only two segments are discernible. The claws are well developed and appear to be double.



TEXT-FIG. 18.—*Polymitarcys annandalei*, sp. nov.
Legs of female, tarsi somewhat diagrammatic; all drawn to same magnification: ×34.
a. 1st leg. *b*. 2nd leg. *c*. 3rd leg.

The setae have the usual structure.

Masses of eggs are seen through the transparent walls of the abdomen and are of a buff-yellowish colour. The eggs are grouped together in elongate oval masses, two of which are seen protruding out of the genital openings in some of the specimens. In most cases the abdomen is sharply bent upwards at the seventh segment so as to enlarge the paired

openings of the oviducts and thus provide an easy exit for the large egg-masses. This condition is exactly like that shown by Needham[1] for *Polymitarcys albus* Say. Each egg is oval in shape, with the apex somewhat truncate, and the " micropylar apparatus " well developed. The eggs are proportionately longer than those of *P. indicus*. The chorion is sculptured and presents a strikingly scaly appearance. Inside the granules are arranged more or less like those in the eggs of the preceding species.

The male is not known.

The nymphs are not known.

Polymitarcys annandalei is somewhat larger than the preceding species, the female reaching up to a length of 14 mm., with the fore-wing of the same length. The outer setae are 12 mm. long and the median 10.

Type-specimens.—9222/H_2, Zoological Survey of India (*Ind. Mus.*).

Locality.—All the specimens of this species in the collection of the Indian Museum were collected by the late Dr. N. Annandale and Dr. F. Gravely at Chakradharpur on the Sanjai River in Chota Nagpur in February, 1918. The insects were captured at light at the edge of the river.

P. annandalei can be easily distinguished from *P. indicus* by its paler body and larger size. In this species the body is dirty whitish, while in the female of *P. indicus* the prevailing colour is brownish yellow. Further the wing in *P. annandalei* is faintly spotted, while that of Pictet's species has no spots, but has the costal region coloured violet. Also there are six intercalary veins in the first anal fork in the wing of *P. indicus*, while in the Chota Nagpur form the number of such veins does not exceed five. The eggs in the two forms are also somewhat different.

Polymitarcys sp. Eaton.

(Plate X, fig. 7).

1892. *Polymitarcys* sp., Eaton, *Journ. As. Soc. Bengal* LX, p.408.
1924. *Polymitarcys indicus*, Ulmer, *Treubia* VI, pp. 32-34 (*partim*).

A single pinned female example, labelled in Eaton's handwriting as *Polymitarcys* sp., is preserved in the collection of the Indian Museum. The specimen is now in a very poor condition, but from an examination of the one complete fore-wing that still exists it is clearly seen to be different from Pictet's *P. indicus*. From the drawing of the fore-wing that I am giving here the difference in the arrangement of the various veins between the present species and Pictet's *P. indicus* will be readily seen. There are only four subsidiary veins in the first anal fork. The shape of the wing is different from that of *P. indicus*, and the costal region is not violet, but a shade of yellowish brown approaching raw sienna. The dorsum also is somewhat differently coloured, there being more of a brownish tint in Eaton's example than in *P. indicus*.

The wing of *P.* sp. in its shape and the disposition of its veins somewhat resembles that of *P. annandalei*, but the costal region is differently

[1] Needham, *Bull. U. S. Bur. Fish. Washington* XXXVI, pl. lxxvii, fig. 26 (1917, 18).

tinted in the two and the membrane is not spotted in the former. The colouration of the body is also different in the two species.

As mentioned by Eaton this specimen probably belongs to an undescribed species, but, owing to the inadequacy of the material, it is best not to give it a specific name.

The specimen is from Raneeganj in West Bengal.

Genus **Povilla** Navás.

1912. *Povilla*, Navás, *Rev. Zool. Afric.* I, pp. 401-403.
1919. *Povilla*, Ulmer, *Arch. Naturgesch.* LXXXV, Heft 11, pp. 5, 6.
1920. *Povilla*, Ulmer, *Stettin. Entomol. Zeitung* LXXXI, p. 107.
1922. *Asthenopus*, Lestage, *Ann. Soc. Ent. Belgique* LXII, pp. 142—148 (*partim*).
1924. *Povilla*, Ulmer, *Treubia* VI, pp. 34-37.

The history of the genus *Povilla* has been described by Lestage in the work cited above. Navás created this genus for an insect from the Congo, considering it to be closely similar to *Campsurus*, but differing from it in having greatly reduced legs and a peculiar neuration in the anal region of the fore-wing. Ulmer in 1919 added one more species to the genus from Siam and Cambodge and Lestage (1922) described another under the name of *Asthenopus corporaali* from Java, which, however, appears to be a true *Povilla*. Thus the genus now includes three species, *P. adusta* Navás, the genotype, originally described from the Congo, but now known to occur more extensively in Africa (Ulmer, 1915), *P. cambodjensis* Ulmer, from Siam, etc., and *P. corporaali* (Lestage) originally from Java, but now recorded by me from India also.

The remarkable diversity in the venation of the fore-wing, and especially in its anal area, that exists in the different members of the family Polymitarcidae has been already referred to, and this diversity has given rise to doubts regarding the validity of the genus *Povilla*. Lestage (1922) in his well-reasoned " Notes sur les genres *Asthenopus-Povilla* " combined the two genera under the older name *Asthenopus*, considering that the definition of *Asthenopus* Eaton (revived by Ulmer) was broad enough to include the species described as *Povilla*. He also noticed the strong peculiarity of the two intercalary veins enclosed in the anal fork, but he does not seem to have given this character its due importance. In all the species described as *Povilla* the two intercalary veins arise at about the same level, the anterior one from the first anal, and the posterior from the second anal vein. This character is found in no other genus of Polymitarcidae ; in *Asthenopus* the two veins in question arise in quite a simple manner from the first anal vein. Besides this the penis lobes are said to be different in the two genera. For these reasons, among others, Ulmer (1924b) was, in my opinion, quite justified in changing the genus of Lestage's species from *Asthenopus* to *Povilla*.

From India the genus is so far known from a single species, represented by a single female specimen, collected in Assam. The genus has, however, a wide range, having been met with in Africa and the Oriental Region.

Povilla corporaali (Lestage) ?

(Plate X, figs. 8—11).

1922. *Asthenopus corporaali*, Lestage, *Ann. Soc. Ent. Belgique* LXII, p. 145.
1924. *Povilla corporaali*, Ulmer, *Treubia* VI, pp. 34-37.

I have examined a single female pinned specimen of this remarkable insect, preserved in the collection of the Forest Research Institute, Dehra Dun. The specimen is not in a perfect state of preservation as parts of the abdomen have been eaten away, probably by cabinet pests. The wings, legs and all the essential parts are, however, present in an undamaged condition.

My specimen agrees in most particulars with the descriptions published by Lestage and Ulmer, and a few important differences that do exist may possibly be due to the bad condition of my specimen. The most important difference seems to me to be in the colouration of the body and wings and in the different shape of the pronotum.

In the specimen that I have examined the dorsum is dark brownish-black, with the notum considerably lighter than the rest of the body, it being brownish. The head is almost pitch black, with the exception of a small portion between the eyes, which is brown. The eyes are black, oval in outline, and, as shown in the figure (plate X, fig. 8), are very remotely placed. The ocelli are whitish encircled with black, and the median ocellus is smaller than the lateral ones. The posterior margin of the head is black. The pronotum is very short and broad, being considerably shorter than the head. A fairly conspicuous median ridge (running longitudinally) divides the pronotum in two equal halves, and another transverse ridge just behind the anterior margin cuts off a small anterior segment and a larger posterior one. As shown in the illustration the pronotum, as seen from above, is pointed at the sides in a forwardly direction. It is fuscous to clove brown in colour, suffused with very fine spots of black in the median region. The lateral regions are more brown than black, and there is a black streak along the posterior margin. The mesonotum is considerably paler in colour than the pronotum and is amber brown. It has a few streaks of blackish brown, and the posterior spine is blackish. The metanotum has the same ground colour as the mesonotum, though it has more black suffused on it than the latter.

The abdomen is in a considerably damaged condition. The ground colour appears to have been a dark shade of brown, something like blackish brown, but in most places it is uniformly fuscous-black to sooty black. The posterior one or two tergites are slightly paler in colour than the rest of the abdomen. The last two tergites in my specimen are somewhat telescoped in those preceding them and thus appear to be very small. The last segment ends broadly, so that the abdomen has a distinctly truncate appearance (plate X, fig. 11).

The sides and the venter are dirty whitish to very pale yellowish in colour. The sternum is light brownish, and some of the abdominal sternites have a transverse dark streak, bluish in colour, a little behind the middle of each segment. There are no stripes on the last three sternites, and those on some of the anterior ones are faint.[1]

[1] The abdomen being damaged it is difficult to make out all these characters distinctly.

The legs are very greatly reduced and are like those described and figured by Ulmer.

The fore-wing as described by previous writers is bi-coloured and presents a very characteristic appearance. The basal half of the wing is of a very dark colour, while the other half is dirty whitish and transparent. It is very difficult to describe the colour of the basal portion accurately, for it does not resemble even approximately any of the numerous shades given in Ridgway's book. It, however, comes nearest to Hay's maroon, or some shade of chocolate, but in certain lights has a distinct purplish shade. The coloured area covers about half of the membrane, and extends more anteriorly on the inner margin. Its disposition and extent is clearly shown in the illustration (plate X, fig. 9). All the longitudinal veins are blackish. The venation is like that described by Lestage and Ulmer. The radial sector forks near the base, but well in advance of the media. The latter branches so close to the wing base that it has no stem and the intercalary vein M_2 is only a little shorter than the posterior branch M_3. The cubitus does not appear to branch at all, and its posterior branch (Cu_2) is grafted on to the first anal. The two intercalaries in the first anal area are as figured by Ulmer or as described by him and Lestage. The venation is fully brought out in the figure that I have given, and it is not necessary to describe it in detail.

The hind-wing (plate X, fig. 10) is dirty whitish and transparent, but near the costal projection the membrane is dark brownish (purplish ?).

The setae are greatly reduced, and the median seta is considerably shorter than the lateral ones. They are dirty whitish in colour.

No males of this species are so far known.

The nymphs are not known.

Locality.—The single female pinned specimen of this species that I have seen is in the collection of the Forest Research Institute at Dehra Dun. It was collected in Assam. As already mentioned the specimen has been damaged by cabinet pests, parts of the mesonotum and the abdomen having been eaten away. The colour also appears to have undergone some change.

From the figure of a complete wing that I am giving for the first time, it will be seen that the species does not belong to the genus under which Lestage originally included it. Though my specimen differs considerably from Lestage's and Ulmer's accounts of this species, I have, however, thought it best not to describe it as a new species, firstly because there are many points of resemblance between the two and secondly because the material at my disposal is far from adequate. The chief difference lies in the fact that the colour of the coloured portion of the fore-wing is not " intensiv dunkelviolett " (Ulmer, p. 35) or " violacé très foncé " (Lestage, p. 146), but is a shade of dark brown. The extent of the coloured area, as seen from my illustration, is also somewhat different from what has been described by Lestage and Ulmer. The membrane of the hind-wing in my specimen is dirty whitish and transparent except for a small portion near the costal projection, while in examples examined by Lestage and Ulmer it is bicoloured like that of the mesothoracic wing. The colouration of the abdomen also differs

from the published accounts and the prothorax has also a somewhat different shape.

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EXPLANATION OF PLATE VIII.

Palingenia orientalis, sp. nov.

FIG. 1.—Head and prothorax of male, dorsal view : ×8.
FIG. 2.—Hind-wing of male : ×3½.
FIG. 3.—Genital forcep : ×11.

Anagenesia lata (Walker).

FIG. 4.—Head and prothorax of male, dorsal view : ×8.
FIG. 5.—Hind-wing of male : ×5.
FIG. 6.—Genitalia of male, ventral view : ×16.

Anagenesia robusta Eaton.

FIG. 7.—Fore-wing[1] of female : ×4.
FIG. 8.—Hind-wing of male : ×4.
FIG. 9.—Abdomen of female, dorsal view : ×4.
FIG. 10.—Genitalia of male, ventral view : ×12.

Anagenesia minor Eaton.

FIG. 11.—Egg : ×150.

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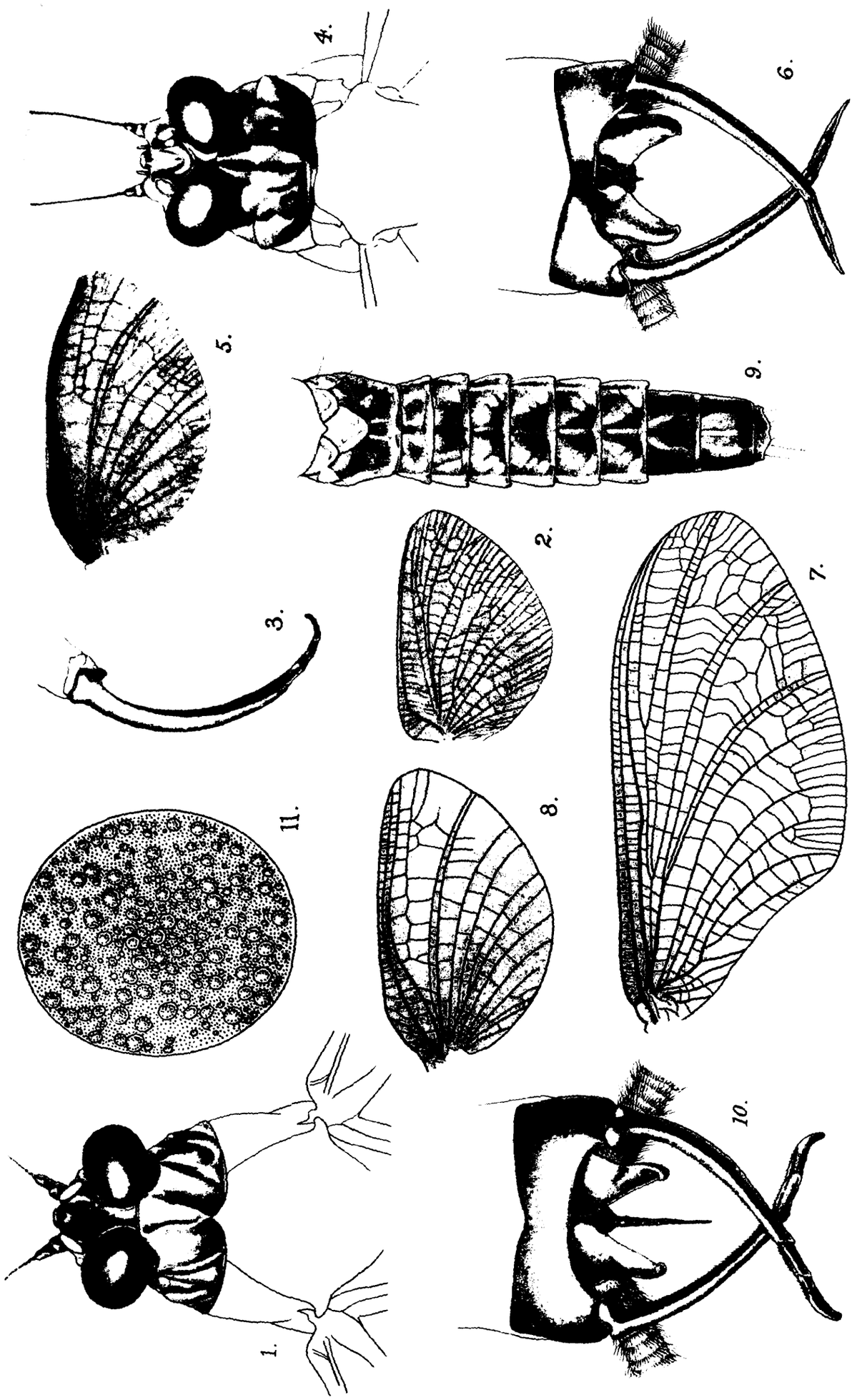
[1] The subcosta in this figure is not shown concealed in a fold of the membrane.



INDIAN EPHEMEROPTERA.

EXPLANATION OF PLATE IX.

Anagenesia minor Eaton.

FIG. 1.—Fore-wing[1] of male : ×4.
FIG. 2.—Hind-wing of male : ×4.
FIG. 3.—Abdomen of female, dorsal view : ×4.
FIG. 4.—Genitalia of male, ventral view : ×12.

Anagenesia picta Gravely.

FIG. 5.—Hind-wing of male : ×4.
FIG. 6.—Genitalia of male, ventral view : ×9.

Polymitarcys indicus (Pictet).

FIG. 7.—Head and prothorax of male,[2] dorsal view : ×18.
FIG. 8.—Fore-wing of female : ×5.
FIG. 9.—Hind-wing of female : ×10.
FIG. 10.—Abdomen of female, dorsal view : ×12.
FIG. 11.—Genitalia of male,[3] ventral view : ×36.

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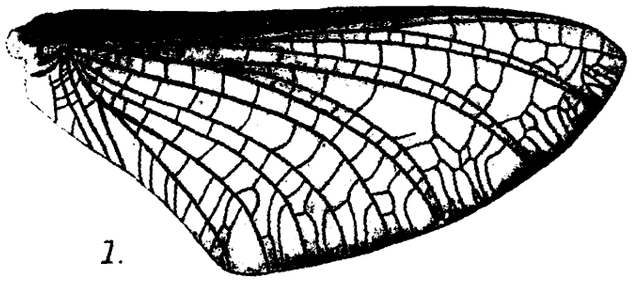
[1] The subcosta in this figure is not shown quite as much concealed as it is in the natural condition.
[2] This figure is drawn from one of the Bihar specimens.
[3] This figure is drawn from the Assam specimen.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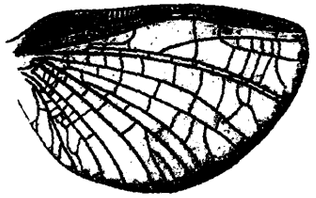
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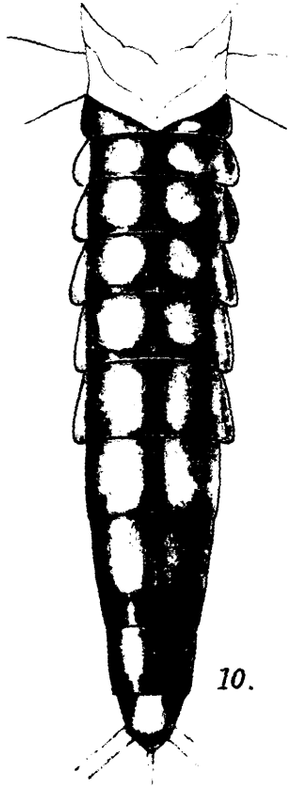
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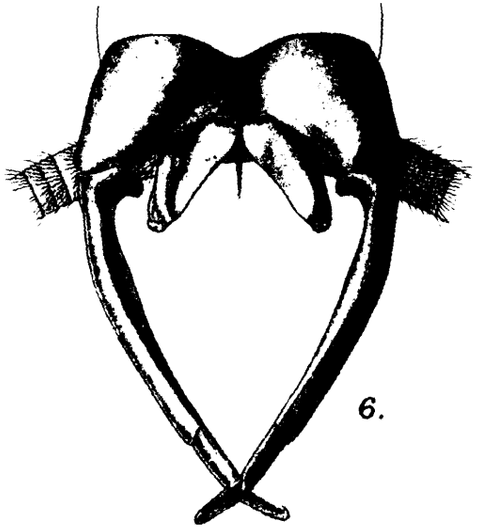
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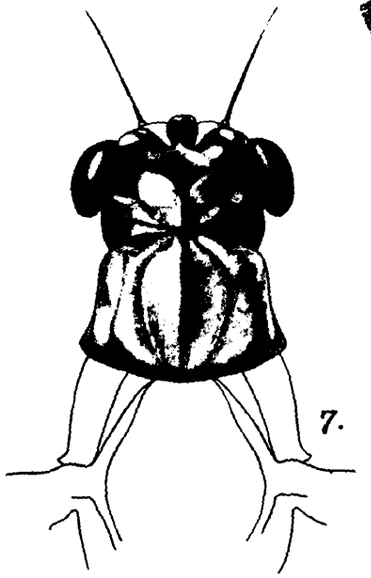
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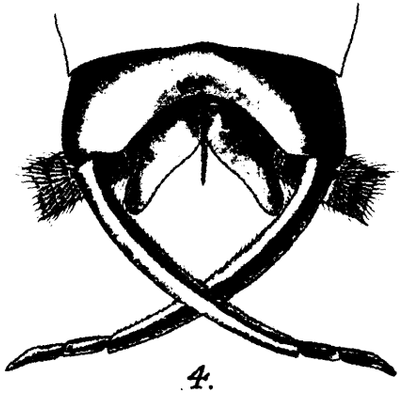
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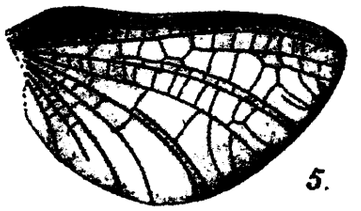
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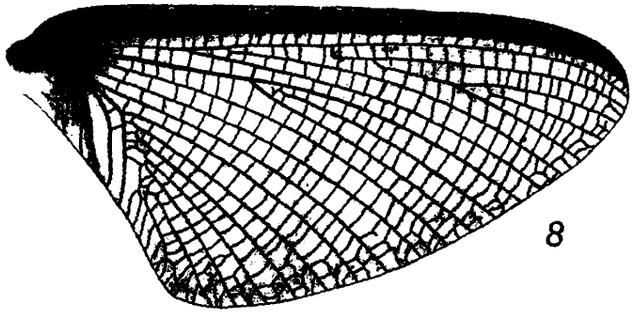
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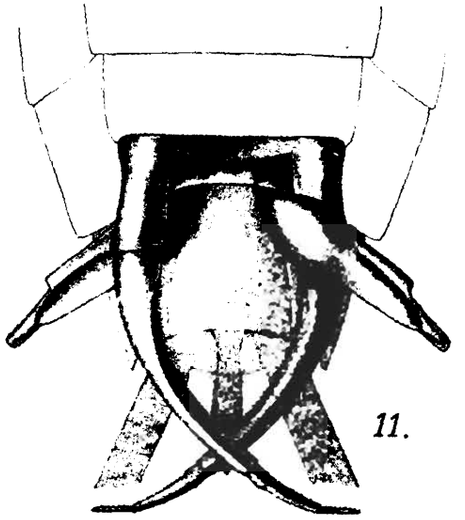
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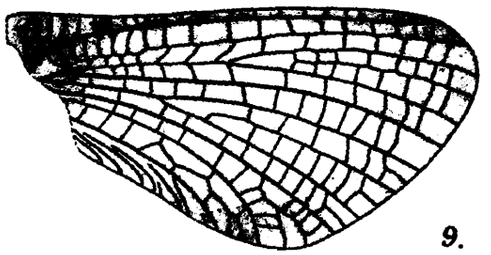
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3.

INDIAN EPHEMEROPTERA.

EXPLANATION OF PLATE X.

Polymitarcys indicus (Pictet).

FIG. 1.—Egg : × 200.

Polymitarcys annandalei, sp. nov.

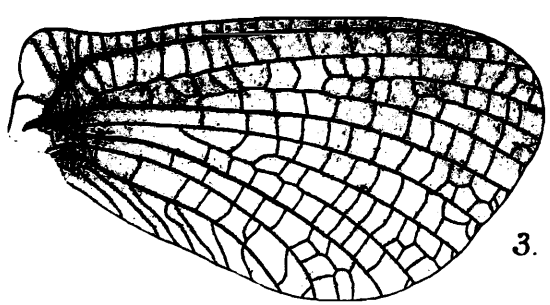
FIG. 2.—Fore-wing of female : × 5.
FIG. 3.—Hind-wing of female : × 10.
FIG. 4.—Abdomen of female, dorsal view : × 6.
FIG. 5.—An egg-mass : × 16.
FIG. 6.—Egg : × 200.

Polymitarcys sp. Eaton.

FIG. 7.—Fore-wing of female : × 8.

Povilla corporaali (Lestage).

FIG. 8.—Head and prothorax of female, dorsal view : × 5.
FIG. 9.—Fore-wing of female : × 3½.
FIG. 10.—Hind-wing of female : × 3½.
FIG. 11.—Abdomen of female, dorsal view : × 6.



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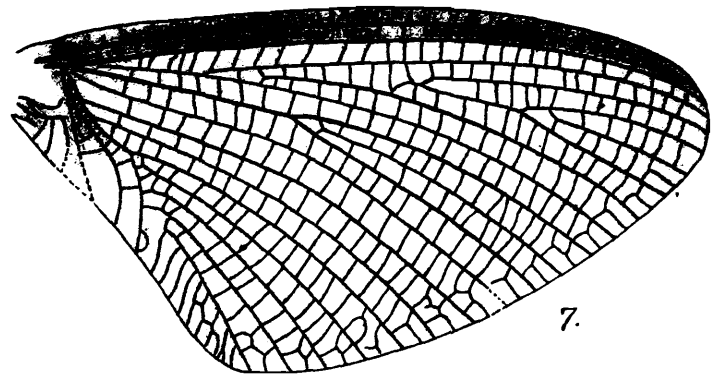

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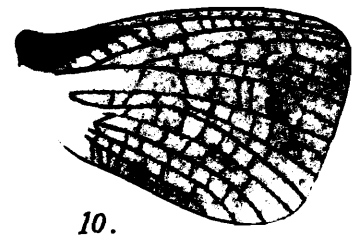

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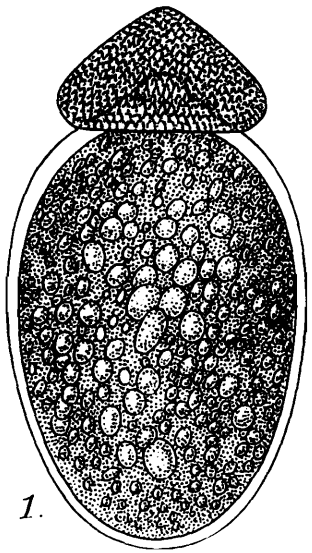

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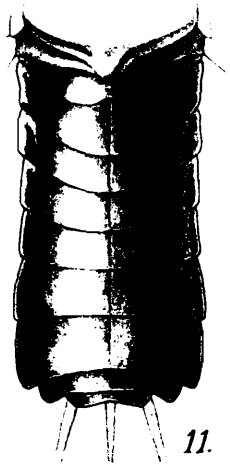

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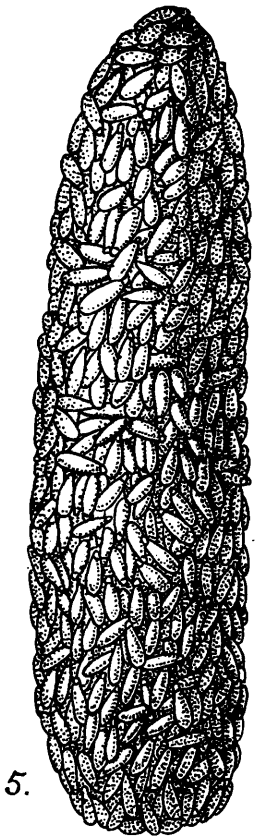

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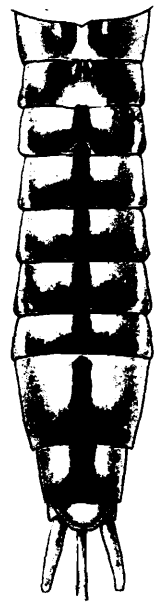

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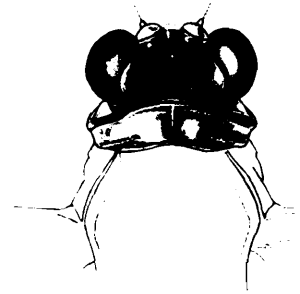

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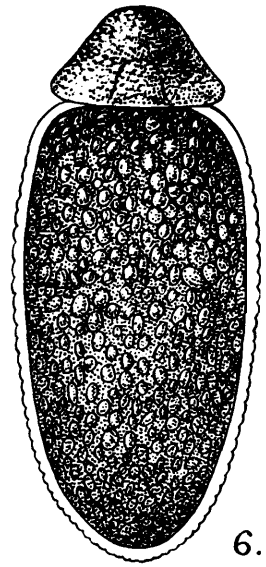

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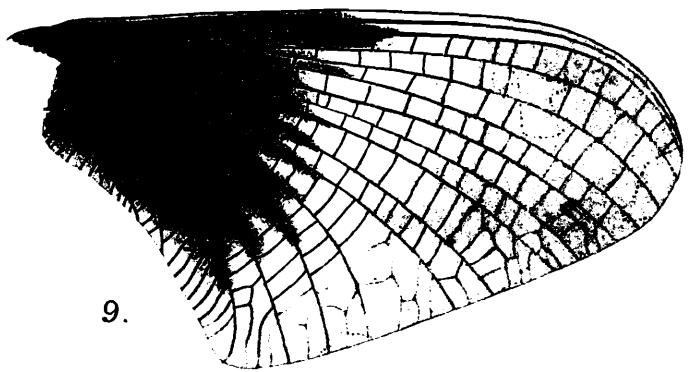

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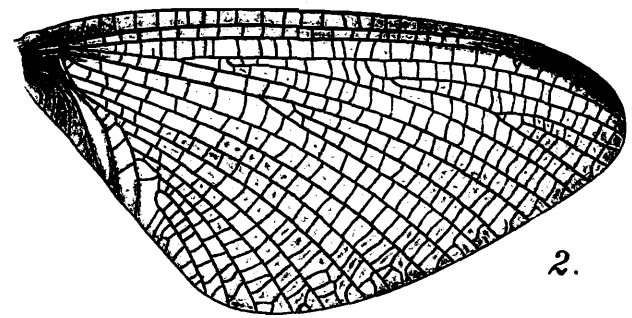


2.

INDIAN EPHEMEROPTERA.

ON A NEW TREMATODE *OPISTHORCHIS PEDICELLATA*, SP. NOV. FROM THE INDIAN SILUROID FISHES *RITA RITA* AND *BAGARIUS YARRELLII* WITH A KEY TO THE SPECIES OF THE GENUS.

By S. C. VERMA, *M.Sc., LL.B., Zoology Department, University of Allahabad.*

(Plates XI, XII.)

INTRODUCTION AND HABITS.

Opisthorchis pedicellata, sp. nov.

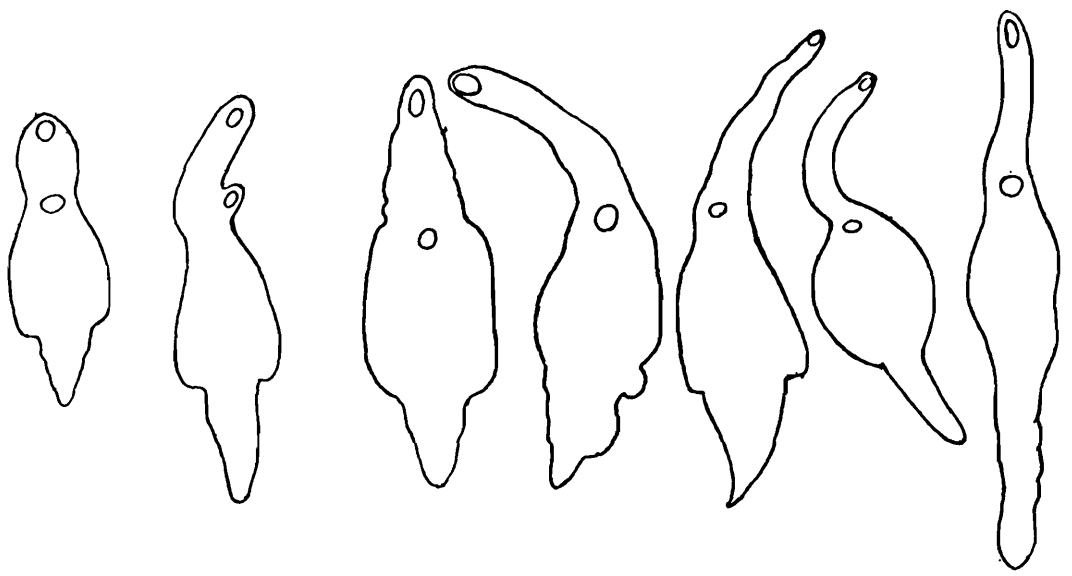
This species, apart from its remarkable anatomical features, is of great interest for it is only the second species of the genus known from fishes, and also the second to be described from India. The very brief description of the only adult piscine species, *O. piscicola* (Odhner 1902), that has hitherto been recorded does not appear to have attracted the attention of such well-known subsequent writers on Helminthology as Lühe (1909), Stephens (1916) and Brumpt (1922), for none of them has mentioned the occurrence of the genus *Opisthorchis* in fishes.

The present species was first encountered in the early winter of 1924 in the gall-bladder of three out of four Siluroid fishes of the species *Rita rita* (=*Rita buchanani* Day), obtained from the rivers Ganges and Jumna. Subsequently, about fifty more fishes were examined from time to time but only fifty per cent of them were found infected with this trematode. The worms are common in larger examples, of fifteen to twenty inches length, but in fishes of smaller size (less than 10-12 inches long) they are rare. The number of parasites in a host is very variable. Some were found infected with a single adult fluke, while others had two, four or eight each ; one example had as many as twelve (large mature forms 4, small mature 2, very small immature 6), and another as many as twenty-nine (large mature 2, small mature 7, very small immature 20). It is interesting to note that younger forms were obtained only from those fishes that were caught in the rivers in September, after the rains had stopped. Owing to their transparency, minute size and capacity of considerable elongation these immature specimens are apt to be missed in a cursory examination of the bladder contents.

In the course of last year about half a dozen specimens of another fish, *Bagarius yarrellii* Sykes (=*Pimelodus bagarius* Ham. Buch.), of similar habits to *Rita rita*, were examined and every one of them carried a varying number of these parasites in the gall-bladder which, in these fishes, is closely attached to the duodenum. Apart from these two fishes I have had an opportunity of examining most of the local fishes, but so far I have not been able to obtain this fluke from any other species.

The worms are either attached to the thin membranous walls of the gall-bladder or keep moving about freely in the fluid contents by expanding and contracting their bodies in different planes. When placed in nutritive solutions or in water the movements and alterations of the body-form can be easily studied (*vide* text-fig. 1). At times the whole body is so much elongated that the worm looks like a nematode, but more often it is either the neck or the posterior region alone that is

drawn out to a considerable extent. At one moment the body is completely straightened out but at another it is bent upon itself, being often produced in the region of the ventral sucker into a distinct protuberance or pedicel. In this respect this trematode very much resembles *Allacanthocasmus varius* (Van Cleave 1922) which, "in spite of the fact that body musculature is not excessively developed," displays "both in the living and the preserved condition the results of unusual powers of generalised and localised contraction."



Text-fig. 1.—Outline sketches showing alterations in body-form of a living example of *Opisthorchis pedicellata.*

An attempt was made to keep examples alive, outside the host, at the temperature of the laboratory in various nutritive solutions which were changed every alternate day. The degree of success attained in these operations can be gathered from Table I, A and B.

TABLE I.

A. Mid-winter (December and January); temperature of Lab. 65°-70° F.

Nutritive solutions used.	Tap water.	Normal salt solution.	Dilute egg albumen.	Dilute yolk of egg.	Mix. of 20 per cent yolk and normal salt sol. 1 : 1.	Mix. of albumen and normal salt sol. 1 : 2.	Mix. of 0·5 per cent sugar sol. and normal salt sol. 1 : 1.
No. of trematodes kept.	2	4	2	2	4	3	3
No. of days trematodes lived.	2 days	2,5 days 2,6 days	2 days	1,20 hrs. 1,2 days	2,4 days 1,5 days 1,8 days	1,1 day 2,2 days	1,1 day 2,2 days

B. Mid-summer (May and June); temperature of Lab. 110° F.

Nutritive solutions used.	Tap water.	Bile.	Normal salt sol.	Mix. of 20 per cent yolk and normal salt sol.
No. of trematodes kept	2	1	2	2
No. of days trematodes lived.	6 hrs.	8 hrs.	4 days	4 days

From the above table it is manifest that in summer none could survive beyond four days, whereas in winter some remained alive for six to eight days. This species is therefore more tenacious of life than *Tremiorchis ranarum* (Mehra and Negi 1926); but while the latter lived longest in a mixture of white of egg and salt solution, my species thrived best in a weak solution of yolk in normal salt solution. While agreeing with the above named authors that these parasites can live outside the body of the host on fluid food for a number of days, attempts are being made to discover some peptonised or other media in which they may be cultured under laboratory conditions. It may thus eventually prove possible to rear immature forms into adult flukes outside the body of the host if suitable conditions are provided.

EXTERNAL FEATURES.

The trematodes are small worms measuring 5-9 mm. in a state of ordinary contraction. Their proper dimensions in life are difficult to obtain owing to the constant contraction and expansion of body both in length as well as breadth, hence the measurements here given are generally from preserved specimens. An adult individual of average size, which measured 7 mm. in length after fixation, when alive showed the following dimensions :—

At maximum elongation—length of body 12·7 mm., greatest breadth 0·83 mm.

At maximum contraction—length of body 6·3 mm., greatest breadth 1·66 mm.

This would show that when fully elongated it is twice as long and half as broad as when it is fully contracted.

TABLE II.

Dimensions in mm. of adult specimens of O. pedicellata fixed without pressure.

Length.	Breadth in region of ventral sucker.	Greatest breadth in front of ovary.	Distance of ventral sucker from anterior end.	Diameter of oral sucker.	Diameter of ventral sucker.	Diameter of pharynx.
4·5	0·32	1·10	1·04	0·13	0·17	0·06
5·6	0·59	0·93	1·84	0·17	0·25	0·09
6·0	0·64	1·20	1·80	0·24	0·33	0·15
6·0	0·62	1·12	1·90	0·23	0·32	0·14
6·5	0·71	1·25	2·14	0·25	0·33	0·16

The trematodes were best killed in the expanded state in hot corrosive sublimate or in warm methylated spirit actively shaken for a few minutes. As soon as they appeared to be motionless the worms were removed to the desired fixative. Measurements given in the above table are of worms preserved in this way, and are taken from vertical and horizontal sections, and whole mounts. Specimens, which after flattening between two glass slides were fixed in Bouin's fluid or hot alcohol, were

mounted entire. Various stains were used, but the best results were obtained by alum carmine and borax carmine. Table III shows the dimensions of full-grown worms fixed and mounted after flattening, and table IV of small immature flukes treated in the same way.

TABLE III.

Dimensions in mm. of adult specimens of O. pedicellata fixed after flattening.

Length.	Breadth in region of ventral sucker.	Greatest breadth in region of ovary.	Distance of ventral sucker from anterior end.	Diameter of oral sucker.	Diameter of ventral sucker.	Diameter of pharynx.
7·0	0·94	1·25	2·16	0·24	0·29	0·13
9·0	1·20	1·40	3·10	0·32	0·39	0·16
9·5	1·12	1·50	2·60	0·26	0·33	0·15
10·0	1·28	1·50	3·50	0·30	0·40	0·15
10·5	0·96	1·60	3·40	0·35	0·45	0·18
12·8	1·45	2·0	3·30	0·38	0·47	0·19

TABLE IV.

Dimensions in mm. of immature specimens of O. pedicellata from balsam mounts.

Length.	Breadth at anterior end.	Breadth in region of ventral sucker.	Greatest breadth in region of ovary.	Distance of ventral sucker from anterior end.	Diameter of oral sucker.	Diameter of ventral sucker.
0·640	0·112	0·140	0·180	0·38	0·096	0·064
0·960	0·114	0·176	0·208	0·61	0·120	0·096
1·008	0·114	0·224	0·358	0·65	0·128	0·112
1·010	0·160	0·190	0·240	0·59	0·128	0·112
2·000	0·176	0·240	0·360	1·09	0·128	0·176

Opisthorchis pedicellata is therefore a much longer form than *O. piscicola*, *O. obsequeus* and *O. caninus*; it is also somewhat larger than *O. interruptus* and *O. lancea*, but is decidedly shorter than *O. viverrini*, *O. longissimus*, *O. noverca*, *O. simulans*, *O. entzi* and *O. felineus*. In Table V, I have given the characteristics of the principal species of the genus.

In life the immature forms are white in colour and quite transparent; mature ones are, however, less transparent, the middle portions of their bodies appearing yellowish-brown owing to the innumerable eggs contained in the uterine coils. The body of the present species, unlike that of most of the other species of the genus, is more or less distinctly divisible both in the adult and young conditions into three regions, a narrow cylindrically-built neck extending up to the ventral sucker, a median broader and dorso-ventrally flattened body proper, which

ends with its widest part in the region of the ovary, and a small and abruptly tapering hinder part, in which are lodged the two testes. The surface of the body, in mature as well as in young forms, is more or less uniformly covered with minute closely-set spines arranged in regular rows encircling the body. The spines are more numerous round the anterior sucker and the neck, and in fully-grown individuals the posterior end bears comparatively few spines excepting in the immediate vicinity of the genital pore. The spines are minute structures not more than 0·025 mm. long but can easily be seen under the low power of a microscope.

The oral and ventral suckers are nearly circular in outline, being slightly elongated in a transverse or an oblique direction. The ventral sucker in mature flukes is decidedly larger than the oral, having a mean diameter in uncompressed specimens of 0·28 mm. (Table II) and in flattened mounts of 0·39 mm. (Table III). The oral sucker is 0·204 mm. in diameter in uncompressed specimens and 0·308 mm. in flattened specimens of average size. The oral sucker, therefore, bears to the ventral a ratio of 2 : 3 in normal specimens, and of 3 : 4 in flattened mounts. But in immature flukes the two suckers are either of the same size (*vide* Table IV, last example), or the condition is reversed, the ventral sucker being decidedly smaller than the oral (*vide* Table IV, first four examples). In fact the younger the specimen the greater is the relative size of the oral sucker. In addition to this difference in the young and the adult stages there also exists a considerable difference in the relative position of the ventral sucker. In mature individuals it is situated at about the end of the anterior third of the body, but in immature ones it lies clearly behind the middle of the body as can be judged from the distance of the acetabulum from the anterior end given in tables II-IV and Pl. XI, figs. 1 and 2. This is due to the more rapid growth of the acetabulum and post-acetabular regions during the period of maturity, as has also been observed in *Margeana californiensis* (Cort 1919-20) and in *Mesocoelium sociale* (Lühe) [Sewell 1920]. The oral sucker lies at the anterior end of the body directed towards the ventral surface and has well-developed muscular walls.

The genital opening lies in the median line immediately in front of the ventral sucker. There is a short but rather wide genital atrium into which open both male and female ducts. The aperture of Laurer's canal cannot be made out in entire mounts owing to its minute size, but it is readily seen in sections, and particularly well in vertical ones, as a narrow pore lined by cuticle situated in the middle line on the dorsal surface of the body (*vide* Pl. XII, fig. 8).

The region of the ventral sucker together with the genital opening is capable of being protruded ventrally in a short process or pedicel, as is also the case in *O. caninus* Barker (=*Paropisthorchis* Stephens 1912) and *Psilochasmus oxyurus* (Lühe 1909) and certain other trematodes. A living distome of this species moving about in the nutritive solution often exhibits this pedicel projecting from the ventral region of the body, and if fixed in this condition it will show a curved pedicelled appearance. The creation, therefore, of a separate genus "*Paropisthorchis*" (Stephens 1912, as mentioned in a Animal Para-

sites of Man" 1916, p. 255) for the form described by Barker as *O. caninus* does not appear to be justifiable[1].

INTERNAL ANATOMY.

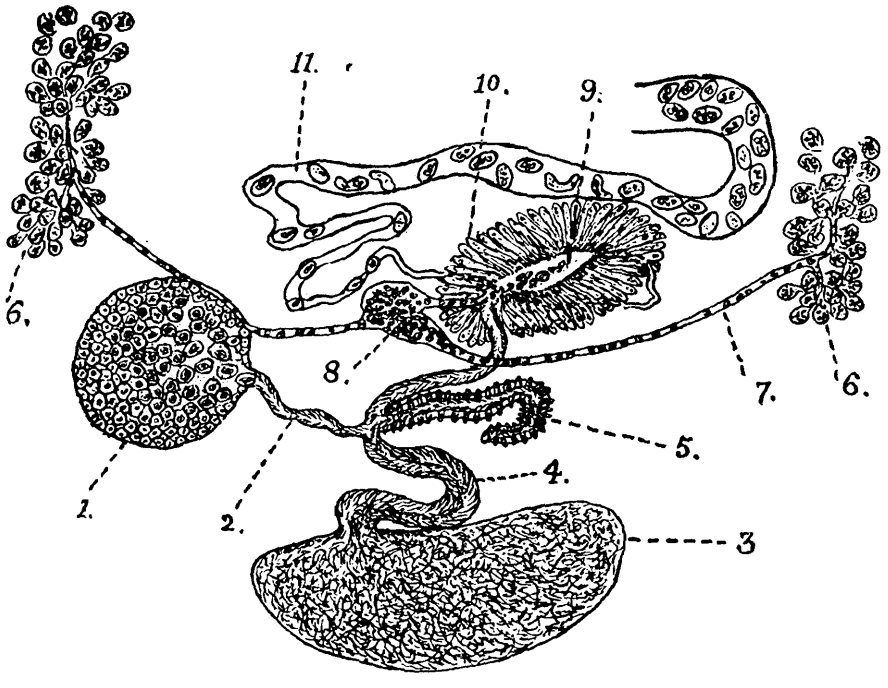
Alimentary System.—The mouth is subterminal and lies as usual at the bottom of the anterior sucker. It opens into a distinct thin-walled prepharynx which is followed by a thick-walled muscular, spherical pharynx having an average diameter of 0·13 to 0·19 mm. The pharynx leads into a narrow tubular oesophagus whose length varies from one to three times the diameter of the pharynx according to the degree of contraction of the part, but usually it is about one and a half times as long as the pharynx. The oesophagus is continued into the intestine which immediately bifurcates into two wider lateral caeca. The intestinal caeca are nearly straight tubes, with very faintly crenated walls, that run parallel to one another and terminate near the hinder end of the body in the vicinity of the terminal portion of the posterior testis; the left caecum is slightly shorter than the right one.

Reproductive System.—The principal genital organs all lie in the posterior fifth of the body, the two testes occupying the hindermost region. The posterior testis reaches to within 0·1 to 0·16 mm. of the hinder extremity: it is the larger of the two and is divided into 3 to 5 lobes occurring one behind the other. Its dimensions in mature specimens vary from 0·4 mm. to 0·56 mm. in length and from 0·192 mm. to 0·354 mm. in breadth. The anterior testis is roughly triangular in shape in surface view, and has its anterior arm slightly depressed backwards owing to the pressure of the large receptaculum seminis in front. It is also lobulated into three to five lobes and is usually displaced towards the left side, so that the right anterior margin of the posterior testis is in many cases flush with the posterior surface of the anterior testis and sometimes extends forwards even beyond it. In immature specimens both the testes are more or less circular in outline with clear lobes and are separated from one another by the thickness of the excretory bladder. This peculiar position of the testes, placed somewhat obliquely one behind the other in close proximity and partly alongside, is a characteristic feature of the species (*vide* Pl. XI, fig. I). The number of testicular lobes is not invariable as has also been observed in *O. obsequeus* (Nicoll 1914). The vasa efferentia arise as delicate tubes from the antero-lateral surface of the testes. They run forwards independently of one another to about the commencement of the posterior third of the body and then, approaching one another towards the middle line, come to lie side by side. After running together for some distance they unite to form a very small, inconspicuous (20 μ to 30 μ long) vas deferens, opening into the seminal vesicle. The vasa efferentia can be traced in transverse sections as minute ducts situated internally to the dorsal body-wall of the animal, but they are difficult to see in entire

[1] The author is collecting more specimens of this genus as he is of opinion that this pedicel may be present in some other forms also though, hitherto, not detected, as in many cases the specimens were not examined alive. Even if it were not so, he thinks that this characteristic is not of sufficient importance to warrant the creation of a separate genus; it is at best a sub-generic character. It is intended to discuss this further in another paper in which the author proposes to revise this and some other allied genera.

mounts unless very carefully differentiated. The seminal vesicle is a long coiled thin-walled tube full of sperms, occupying the space between the coils of the uterus. It commences about the middle of the body, runs straight for a little distance, then becomes twisted into several coils, and finally takes a more or less sinuous course along the right side of the ventral sucker, beyond which it turns inwards and slightly backwards to open into the genital atrium on a short muscular papilla, which probably functions as the copulatory organ (*vide* Pl. XII, fig. 4). A cirrus sac is absent—a feature common to all species of the genus—and no prostatic gland or cells appear to be present in this species.

The ovary is rounded or pear-shaped in outline but in some specimens its posterior surface is somewhat depressed in the vicinity of the seminal receptacle. It is situated invariably to the right of the middle line and nearer the ventral than the dorsal surface at a distance of about one-fifth the body length from the hinder extremity. The oviduct arises from the mid-dorsal surface of the ovary and running a short distance inwards joins the duct of the seminal receptacle, into which also opens Laurer's canal from the opposite side. The receptaculum seminis is a prominent oval structure (with its anterior margin concave in some preparations), placed somewhat obliquely between the ovary and the anterior testis. The duct of the receptaculum is a thin-walled wide tube (0·18 to 0·25 mm. broad). It originates from its anterior margin and passes a little dorsalwards towards the ovary, then turns to the left and soon takes another turn to the right forming a depressed



TEXT-FIG. 2.—Diagrammatic view of female genitalia of *Opisthorchis pedicellata*. 1. Ovary; 2. Oviduct; 3. Seminal receptacle; 4. Duct of receptacle; 5. Laurer's canal; 6. Vitelline gland; 7. Vitelline duct; 8. Yolk-sac; 9. Ootype; 10. Shell-gland; 11. Uterus.

S-shaped loop before it meets the oviduct and Laurer's canal (*vide* text-fig. 2 and Pl. XII, fig. 7). The epithelial lining of the receptaculum does not appear to be ciliated, but that of the duct is strongly so, and the cilia are directed mostly towards the receptaculum. From its

junction with the duct of the receptaculum seminis Laurer's canal takes a short course to the left ; it then bends towards the dorsal surface where it opens by a minute pore lined by cuticle which is continuous with that of the outer surface. The whole of Laurer's canal, with the exception of the cuticular external aperture, is lined with outwardly directed cilia which are only about half as large as those of the duct of the seminal receptacle. The canal is only 0·012 to 0·016 mm. thick, and the lumen is very narrow owing to the comparatively thick wall provided with powerful circular muscle-fibres.

The oviduct, beyond its junction with Laurer's canal and the duct of the seminal receptacle, continues its course towards the left ; it then turns anteriorly and after crossing the left vitelline duct is joined by a short duct from the vitelline reservoir lying to its right. It soon enters the ootype on its dorsal aspect. The ootype is slightly dilated and is surrounded by prominent elongated shell-glands of the usual type, arranged radially round it. On the side opposite to that from which it receives the oviduct the ootype opens into a narrow duct which takes a backward turn before it abruptly broadens out as a transversly coiled uterus full of eggs, filling up the space between the ovary and the ventral sucker. In full-grown individuals the uterine coils form eighteen to twenty-four convolutions and are characteristically opisthorchid in character, touching but rarely overlapping the gut diverticula and never extending anteriorly beyond the ventral sucker. Its outgoing portion, the vagina, runs obliquely forwards along the left side of the ventral sucker as a narrower wavy tube with eggs arranged in single file, and passing forwards, beyond the genital aperture and the male duct, it turns backwards towards the middle line to open into the short but spacious genital atrium lying just in front of the sucker. The eggs are oval in outline and measure 30 μ by 16 μ in size. Their colour is at first white, but in the anterior half of the uterus they are distinctly reddish-brown and give the characteristic tinge to that part of the body in the living worm.

The yolk-glands occupy the lateral areas, beginning in the region of the ventral sucker and terminating at about the level of the ovary. They never extend behind the ovary and are confined to the dorsal and ventral surfaces of the body, lying partly to the outer side of the intestinal caeca and partly overlapping them. Both vitellaria consist of eight groups of follicles the hinder ones of which usually run together forming more or less continuous bands. The transverse vitelline duct of each side leaves the gland in front of the last group of acini, and runs inwards and backwards to open independently into a small but prominent vitelline reservoir or yolk-sac referred to above (*vide* Pl. XII, fig. 6). Text-figure 2 gives a dagrammatic sketch of the female genitalia.

Excretory system.—A detailed study was made of the excretory system because no complete description of it is given in any species of this genus. It was studied mainly from young living specimens that had not yet developed the uterine coils and the eggs. The conclusions thus arrived at were verified independently by careful examination of permanent mounts of both vertical and transverse sections. The excretory bladder is clearly visible in younger specimens as an elongated

S-shaped structure running between the two testes and bifurcating behind the receptaculum seminis into a longer left and a shorter right horn or cornua. It continues backwards into a short narrow duct which opens to the outside by a terminal excretory pore surrounded by somewhat larger spines than those present on the adjacent parts of the body surface. Each horn of the bladder receives along its hinder outer margin a common collecting tube which runs obliquely outwards and after crossing the intestinal caecum continues forwards as a convoluted duct parallel to it. In the region of the prepharynx the collecting tube bends backwards and receives its first collecting tubule or branch (1) which appears to be connected by transverse connections with its fellow of the opposite side, and gives off one main branch towards the anterior side and another posteriorly. The main duct then continues backwards parallel to its ascending arm as a tube of gradually decreasing calibre to the posterior extremity of the worm, and receives in its course five more accessory collecting tubules (2-6) as indicated in Plate XI, figure 3. From each of these six accessory collecting tubules are given off two capillaries of the first order, which again divide into secondary and tertiary capillaries and end ultimately in flame cells. The latter were observed distinctly by means of an oil immersion microscope (Leitz. Eye-piece III, Objective 1/12 N.) in a permanent preparation made from a specimen that had been left in water after fixation for a very long time and from portions of which the cuticle could be easily removed by means of a fine brush. A diagram of the arrangement of the finer capillaries originating from flame cells is given in Plate XII, figure 5 which is drawn to scale as indicated.

The excretory system therefore consists of a Y-shaped bladder having unequal arms with curved stem and a pair of laterally placed collecting tubes, each consisting of an ascending portion receiving six accessory collecting tubules and a descending portion which ultimately opens into the bladder. The system therefore bears great resemblance to that of *Distomum tereticolle* (Rudolphi) described and figured by A. Looss (1894).

SYSTEMATIC POSITION AND DIAGNOSTIC CHARACTERS.

From the foregoing description it will be seen that in the topographic relationships of its organs this fluke conforms closely to the diagnosis of the genus *Opisthorchis* Blanchard 1895 ; but in possessing a retractile pedicel which carries on it the ventral sucker and probably also the genital pore it resembles the genus *Paropisthorchis*. As has already been pointed out, this character in itself does not appear to me to be sufficient ground for the creation of a separate genus, particularly as Stephens (1916, p. 255) admits that in all other structural features his genus agrees with *Opisthorchis*. Apart from the brief description given of this genus by Stephens in the book referred to above, I have not been able to find any reference to his paper published in 1912, in which he creates this genus ; nor has the genus been taken cognisance of by Skrjabin (1913) in his important paper in which he gives diagnoses of the genera of the family Opisthorchidae. As my species is structurally much more opisthorchid than *O.* (=*Paropisthorchis*) *caninus* (Barker) I propose

for the present, to place it in the more stable genus *Opisthorchis* under the name *O. pedicellata.*

In Table V I have compared the diagnostic features of this trematode with other species of *Opisthorchis* including the closely allied form *Opisthorchis* (=*Amphimerus*) *noverca* and *Opisthorchis* (=*Paropisthorchis*) *caninus*. It can be seen from this table that the new species, in the possession of cuticular spines, resembles *O. viverrini*, *O. piscicola*, *O.* (=*Amphimerus*) *noverca* and *O.* (=*Paropisthorchis*) *caninus* and differs from the rest. It approaches the last named species in having in common with it the short pedicel—a structure that may be present in some other forms also. But apart from this and other features it can be readily differentiated from :—

(i) *O. viverrini* by the ratio in the size of the two suckers, and by its simple undivided ovary.

(ii) *O. piscicola*, the other piscine species, by the relatively larger size of its body, of the two suckers and of the vitellaria ; also by its undivided ovary and the more posterior position of the ventral sucker in the body.

(iii) *O. noverca* by its smaller size, by the relative size of the two suckers, the more posterior position of the ovary and the ventral sucker in the body, and above all in having no post-ovarial portion of the vitellaria.

(iv) *O. caninus* by the reverse ratio in the size of the two suckers, by the presence of a prepharynx and a much longer oesophagus, and the more posterior position of the genital opening and the ventral sucker.

KEY TO THE SPECIES INCLUDED IN TABLE V.

A.	Body armed with spines	B.
	Body unarmed with spines	F.
B.	Ovary simple, not divided into lobes ..	*O. pedicellata*, n. sp. (14).
	Ovary not simple, divided into lobes	C.
C.	Oral sucker equal to or less than the ventral ..	D.
	Oral sucker larger than the ventral	E.
D.	Oral sucker equal in size to ventral	*O. viverrini* (4).
	Oral sucker smaller in size than ventral	*O. piscicola* (9).
E.	Vitellaria extend far behind ovary	*O. noverca* (10).
	Vitellaria end in region of ovary	*O. caninus* (12).
F.	Oral sucker smaller than ventral	G.
	Oral sucker equal to (or nearly so) or larger in size than ventral	M.
G.	Testes lobed	H.
	Testes not at all lobed	*O. pseudofelineus* (7).
H.	Testes lobed deeply, almost dendritic	*O. obsequeus* (13).
	Testes lobed but not deeply	K.
K.	Vitellaria disproportionate in size, one half much longer than the other	*O. entzi* (11).
	Vitellaria proportionate in size	L.
L.	Vitellaria long, extend far behind ovary	*O. lancea* (1).
	Vitellaria short, do not extend behind ovary ..	*O. longissimus* (2).
M.	Oral sucker equal (or nearly so) to ventral	N.
	Oral sucker larger than ventral	O.
N.	Ovary simple or but slightly lobed ; length of eggs 30 μ	*O. felineus* (3).
	Ovary usually three lobed ; length of eggs 20 μ .	*O. geminus* (6).
O.	Ovary multilobed ; vitellaria short, never extend behind ovary	*O. simulans* (5).
	Ovary not lobed, vitellaria long, extending far behind ovary	*O. interruptus* (8).

The number in brackets after the name of a species refers to its position in Table V.

The type-slide and specimen are deposited in the collection of the Zoological Survey of India, at the Indian Museum, Calcutta. No. W 1376/1.

I have great pleasure in recording my thanks to two members of my department, to Mr. R. S. Das for directing my attention to this worm, and to Dr. H. R. Mehra for occasional advice, and also to Major R. B. Seymour Sewell, I.M.S., Director, Zoological Survey of India, for having gone through the manuscript and for correcting it before publication.

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TABLE V.

Showing Characteristics of the Species of the Genus Opisthorchis and Allied Forms.

Species.	Host.	Size and shape of body.
1. *O. lancea* Diesing 1856 (Weski 1900).	" *Delphinus tacuschi* " (*stanotucuxi*, Gray) (gall-bladder).	5·5—12·5 by 1·0—2·8 : neck and body lancet-shaped, margin behind ventral sucker undulating.
2. *O. longissimus* Linstow 1883.	*Botaurus* (*Ardea*) *stellaris* (liver).	20·0 by 1·0 : very long, cylindrical, posteriorly rounded.
3. *O. felineus* Rivolta 1885	man, cat, dog, fox, glutton and seal (liver, gall-bladder, bile and pancreatic duct).	8—11 by 1·5—2·0 : flat, with a conical neck (varies according to contraction).
4. *O. viverrini* Poirier 1886	man and civet cats (gall-bladder, bile duct and intestine).	closely resembles *O. felineus*.
5. *O. simulans* Looss 1896 (1910).	*Pernis apivorous* and *Anas penelope* (gall-bladder) ; *A. boschas* and *Fulix cristata*, young ones (liver).	7·0 by 1·15 (15—16 by 1—1·5) : very long, pointed posteriorly.
6. *O. geminus* Looss 1896 (1910).	*Milvus parasiticus* (liver and bile duct).	7—8 by 1·3 : thin, long, rounded posteriorly.
7. *O. pseudofelineus* Ward 1900.	cat (gall-bladder and liver)	10—13 by 1·5 : like *O. felineus* but somewhat longer and narrower.
8. *O. interruptus* Braun 1902.	*Alcedo viridirufa* (intestine)	7—8 by 0·5—0·7 : elongated, band-shaped, posterior end broad ; margin behind ventral sucker undulating.
9. *O. piscicola* Odhner 1902.	*Gymnarchus niloticus* (gall-bladder).	3—4 by 0·5 : strongly tapering in front.
10. *O.* (=*Amphimerus*) *noverca*, Braun 1903 (Barker 1911).	man, dog and American fox (liver and bile duct).	9—12 by 2·5 : lanceolate, more elongated in front.
11. *O. entzi* Ratz 1903 ..	*Ardea purpurea* (gall-bladder).	like that of *O. longissimus* but more pointed, anteriorly lancet-shaped.
12. *O.* (=*Paropisthorchis*) *caninus* Barker 1911, Stephens 1912.	dog (liver) ..	2·75—5·75 by 1·5 : oval ventro-dorsally concavo-convex.
13. *O. obsequeus* Nicoll 1914.	*Hieracidea berigora* and *H. orientalis* (liver).	2·6—5·1 by 0·8—1·0 : flattened, with crenated edges ; a knob-like tip frequently projecting from posterior end.
14. *O. pedicellata*, sp. nov. 1927.	*Rita rita* and *Bagarius yarrellii*—India (gall-bladder).	5—9 by 1·0—1·5 (average 7 by 1·25) (varies according to contraction) ; divisible into three regions.

Showing Characteristics of the Species of the Genus Opisthorchis and Allied Forms—contd.

Cuticle.	Size and ratio of suckers (oral : ventral).	Nature and position of ventral sucker.
1. unarmed	0·47 by 0·51 : 0·5 by 1·2 1 : 1·5	from less than one and a half times to twice as big as oral; at ⅓rd of body length from anterior end.
2. unarmed	0·28 : 0·34 1 : 1·2	slightly larger than oral; in anterior ⅛th of body length.
3. unarmed ..	0·25 : 0·25 1 : 1	of same size as oral; at ¼th to ⅛th of body length from anterior end.
4. armed; spines small, pointed	1 : 1	of same size as oral; as in *O. felineus*.
5. unarmed	0·5 : 0·2 1 : 0·4	less than half the size of oral; at ⅓rd to ⅕th of body length from anterior end.
6. unarmed	0·17 : 0·17 1 : 1	nearly as big as oral; just behind ¼th of body length from anterior end.
7. unarmed ..	0·2 : 0·33 (approximate, from fig.) 1 : 1·65	little more than one and a half times as big as oral; in anterior ¼th of body length.
8. unarmed	0·25 by 0·26 : 0·135 1 : 0·52	nearly half the size of oral, oblique; at ⅕th to ⅙th of body length from anterior end.
9. armed, spines minute	0·19 by 0·22 : 0·026 by 0·3 1 : 1·4	nearly one and a half times as big as oral; transversely oval; at end of ⅛th of body length from anterior end.
10. armed, spines, small ..	0·45 by 0·75 : 0·35 (approximate, from fig.) 1 : 0·4—0·7	nearly half the size of oral; at ⅙th of body length from anterior end.
11. **	**	**
12. armed, uniformly spiny except on pedicel	0·28 : 0·176 1 : 0·63	more than half as big as oral; at ⅛th of body length from anterior end; on a short pedicel.
13. unarmed	0·16 by 0·20 : 0·26 1 : 1·3—1·6	about one and a half times as big as oral; at ⅓rd of body length from anterior end.
14. armed, more or less uniformly spiny, spines minute (0·025)	0·204 by 0·308 : 0·28 by 0·39 1 : 1·3—1·5	in adult—about one and a half times as big as oral; at end of ⅓rd of body length from anterior end. in young—as big as or smaller than oral; behind middle of body on a short pedicel.

Showing Characteristics of the Species of the Genus Opisthorchis and Allied Forms—contd.

Prepharynx.	Pharynx.	Oesophagus.	Intestinal caeca.
1. absent ..	muscular, about half the size of oral sucker	short, slightly smaller than pharynx	rather wide, reach almost to posterior end.
2. not noticed, (probably absent)	slightly smaller than oral sucker	almost as big as oral sucker	do not quite reach posterior end.
3. absent ..	close behind oral sucker and about $\frac{2}{3}$rd its size.	hardly any longer than pharynx	reach almost to posterior end.
4. ..	....	as in *O. felineus* ..	extend to posterior end.
5. absent	close behind oral sucker and about $\frac{3}{5}$th its size	as long as pharynx	reach almost to posterior end.
6. absent ..	feebly developed, minute (dia. 0·1)	more than twice as long as pharynx, length 0·25	reach almost to posterior end, ends turned inwards.
7. absent ..	not prominent and smaller than oral sucker	small, nearly as long as pharynx	extend to posterior end.
8. probably absent or indistinct	close behind oral sucker and about half its size	as long as pharynx	wider than oesophagus; one slightly longer than the other, extending to posterior end.
9. not observed	less than half the size of oral sucker (dia. 0·08)	not described ..	*
10. probably absent	close behind oral sucker and about half its size	very short, half as long as pharynx	do not reach posterior end.
11. **	**	**	**
12. absent ..	close behind oral sucker and smaller than it (size 0·224 by 0·184)	minute, 0·04 in length	do not reach posterior end.
13. absent ..	close behind oral sucker and smaller than it (dia. 0·12)	almost one and a half times as long as pharynx	almost reach posterior end; inner walls crenated, ends turned inwards.
14. distinct, thin-walled	nearly half the size of oral sucker (dia. 0·13—0·19)	prominent, one to three, usually one and a half times as long as pharynx	almost reach posterior end, walls very feebly crenated.

Showing Characteristics of the Species of the Genus Opisthorchis and Allied Forms—contd.

Excretory system.	Testes.
1. bladder very long ; main trunk S-shaped between the two testes but behind them straight, its narrow horns run forwards between uterine loops and gut forks	roundish, anterior 4 posterior 5 lobed, in hinder third of body, oblique ; post testicular space large.
2. not observed	roundish, anterior 5 posterior 6 lobed, in hinder fourth of body in median line.
3. bladder elongated S-shaped, forked in front of anterior testis	roundish, anterior 4 posterior 5 lobed, in hinder fourth of body, oblique.
4.	in hinder fourth of body.
5. bladder forked just behind ovary, elongated	elongated, spheroidal (dia. 0·6), or partly rounded, partly irregularly shaped ; in hinder fourth of body in median line.
6. bladder elongated S-shaped ; forks short, at level of seminal receptacle	roundish, anterior 4 posterior 5 lobed, in hinder fourth of body, oblique.
7. bladder very long and curved.	ovoid, obliquely or transversely elongated ; in hinder fourth of body in median line.
8. bladder very long, S-shaped between the testes but hinder portion straight ; horns not indicated	anterior 4 posterior little lobed, roundish ; post testicular space 0·7—0·8.
9. *	slightly lobed, lie in median line close behind ovary.
10. bladder narrow, elongated, Y-shaped, bifurcates a short distance behind middle of ovary	anterior roundish, posterior distinctly lobed ; at commencement of last third of body ; post testicular space about $\frac{1}{8}$th body length.
11. **	**
12. bladder narrow, S-shaped, confined to last third of body ; horns very short	usually ovoid, though may be regularly lobed, oblique ; in last third of body.
13. bladder sinuous ; horns short and lie just behind ovary	deeply lobed, almost dendritic ; anterior 5 posterior 4 lobed.
14. bladder with two unequal horns and S-shaped stem whose hinder part is nearly straight ; principal collecting tube on each side consists of an ascending and a descending portion	shape variable ; in young, circular in outline ; in adult, ovoid or elongated ; lobes 3-5 but never deep ; post testicular space 0·1—0·16.

Showing Characteristics of the Species of the Genus Opisthorchis and Allied Forms—contd.

Vesicula seminalis.	Ovary.
1. very short, formed a little distance behind ventral sucker	simple, small, mostly biscuit-shaped ; at commencement of last third of body.
2. long ; wavy in front, sinuous behind ..	many lobed, median ; at end of third fourth of body.
3. not described, in figure narrow and indistinct	simple or slightly lobed, median, transverse ; at end of second third of body.
4.	many lobed ; at commencement of hinder fourth of body.
5. rather short, rarely sinuous ; maximum dia. 0·1	irregular in outline, faintly lobed ; behind commencement of posterior third of body.
6. voluminous, forming many transverse coils ; maximum dia. 0·1	usually three lobed, almost median ; near end of third fourth of body.
6. long, convoluted ; indistinct in figure	simple, pear-shaped, median ; within posterior third of body.
8. not observed	simple, elongated oval, transverse diameter equal to that of testes ; at commencement of last third of body.
9.	more or less single-notched.
10. not observed	slightly lobed, median ; just behind middle of body between horns of excretory bladder.
11. **	**
12. coils close and displace uterus to left ..	irregular in outline, six to eight lobed ; in front of last third of body.
13. short, highly convoluted ; extends beyond ventral sucker for about 0·3	usually irregular with three deep lobes ; at $\frac{1}{3}$rd of body length from hinder end.
14. long thin-walled, coiled ; anteriorly extends a little beyond genital pore	rounded or pear-shaped, simple, to right side of middle line ; at $\frac{1}{7}$th to $\frac{1}{8}$th of body length from hinder end.

Showing Characteristics of the Species of the Genus Opisthorchis and Allied Forms—contd.

Vitellaria.	Shell-gland.
1. outside gut forks ; from near the termination of gut forks to a little distance behind ventral sucker : ant-ovarial portion as long as post-ovarial	not visible in permanent preparations.
2. overlapping gut forks ; in third fourth of body, from in front of shell gland to half way between ovary and ventral sucker	prominent, median, extends in front of ovary.
3. outside gut forks ; in central third of body, from level of ovary to some distance behind ventral sucker	diffuse ; at same level as ovary.
4. as in *O. felineus*	as in *O. felineus*.
5. usually outside gut forks, close together ; in third fourth of body, from level of ovary to midway between it and ventral sucker	not prominent, near ovary.
6. outside gut forks ; from hinder margin of ovary to some distance behind ventral sucker	not prominent, near ovary.
7. usually outside gut forks ; from front margin of hinder testis to end of first third of body ; ant-ovarial portion much longer than post-ovarial	distinct, extends in front of ovary.
8. overlapping gut forks ; from posterior testis to $\frac{1}{8}$th of body length behind ventral sucker : ant-ovarial portion a little longer than post-ovarial	not observed.
9. extend from hinder border of ovary to commencement of middle third of body	*
10. well outside gut forks ; from posterior testis to behind ventral sucker : ant-ovarial portion equal to post-ovarial	....
11. disproportionately developed, one half always longer than the other	**
12. entirely outside gut forks ; acini distinct from one another ; from ovary or front testis to region of ventral sucker	extensive, diffuse, in region of ovary.
13. entirely outside gut forks ; from middle or front border of anterior testis to region of ventral sucker	not observed.
14. overlapping gut forks ; from ovary to region of ventral sucker ; groups of acini often merge into one another	large, rather compact, to left of ovary.

Showing Characteristics of the Species of the Genus Opisthorchis and Allied Forms—contd.

Receptaculum seminis	Laurer's canal.	Uterus.	Genital pore.	Eggs.
1. between horns of excretory bladder; small spindle shaped, oblique	not observed	loops narrow, not filling the middle field	as usual in genus	0·029—0·033 by 0·012—0·014.
2. between ovary and anterior testis; large, ovoid, median and elongated in the long axis	not observed ..	extensively convoluted; rarely overlapping gut forks	as usual in genus	0·026 by 0·015.
3. close behind ovary; large, pear shaped or retort shaped, well in advance of front testis	present ..	convolutions occupy central field, rarely touching gut forks	as usual in genus	0·030 by 0·011 operculated.
4. as in *O. felineus*	....	as in *O. felineus*	..	..
5. behind ovary; small, oblique	rather short and broad, external opening in front of anterior testis, in mid-dorsal line	anteriorly loops narrow and wavy, posteriorly they fill up space between gut forks	on anterior border of ventral sucker	0·028 by 0·018 operculated.
6. close behind ovary and equal to it in size; curved and saccular	rather long and narrow; external opening in region of seminal receptacle	extensively convoluted, filling up space between gut forks	as usual in genus	0·02 by 0·01 operculated.
7. close to one side of ovary; large, oblique, fills up space between ovary and anterior testis	long, narrow, external opening in advance of anterior testis	extensively convoluted throughout its length	male and female apertures side by side (fig. Stiles) ?	..
8. close behind ovary and smaller than it; roundish or pear shaped	not observed ..	convolutions hardly cross central field, at times oblique.	as usual in genus	0·023 by 0·01 darkish.
9. *	*	*	*	0·021 by 0·011.
10. ..		convolutions barely spread beyond central field	as usual in genus	0·034 by 0·019—0·021.
11. **	**	**	**	**
12. dorso-lateral to posterior ovarian lobe; globular	from end of receptacle takes a single curve medially backwards	convolutions often overlap gut forks	on apex of a pedicel; surrounded with scales	..
13. alongside and slightly behind ovary; pear shaped, of moderate size	not observed ..	convolutions 14 to 16, occasionally touch gut forks	as usual in genus	0·028 by 0·0155.
14. between ovary and anterior testis; large, oval and oblique	somewhat S-shaped, narrow, external opening minute and cuticular	convolutions 18-24, only at times overlap gut forks	on a protrusible pedicel; along with ventral sucker	0·030 by 0·016 brown.

* In these " respects it agrees with the diagnosis given by Looss of the genus and sub-family."
** Complete description of this species published in *Allatt. Kozl*, II, Budapest, is not available to the Author.

EXPLANATION OF PLATE XI.

FIG. 1.—Ventral view of *O. pedicellata* (adult), × 25.

FIG. 2.—Ventral view of *O. pedicellata* (young), × 55.

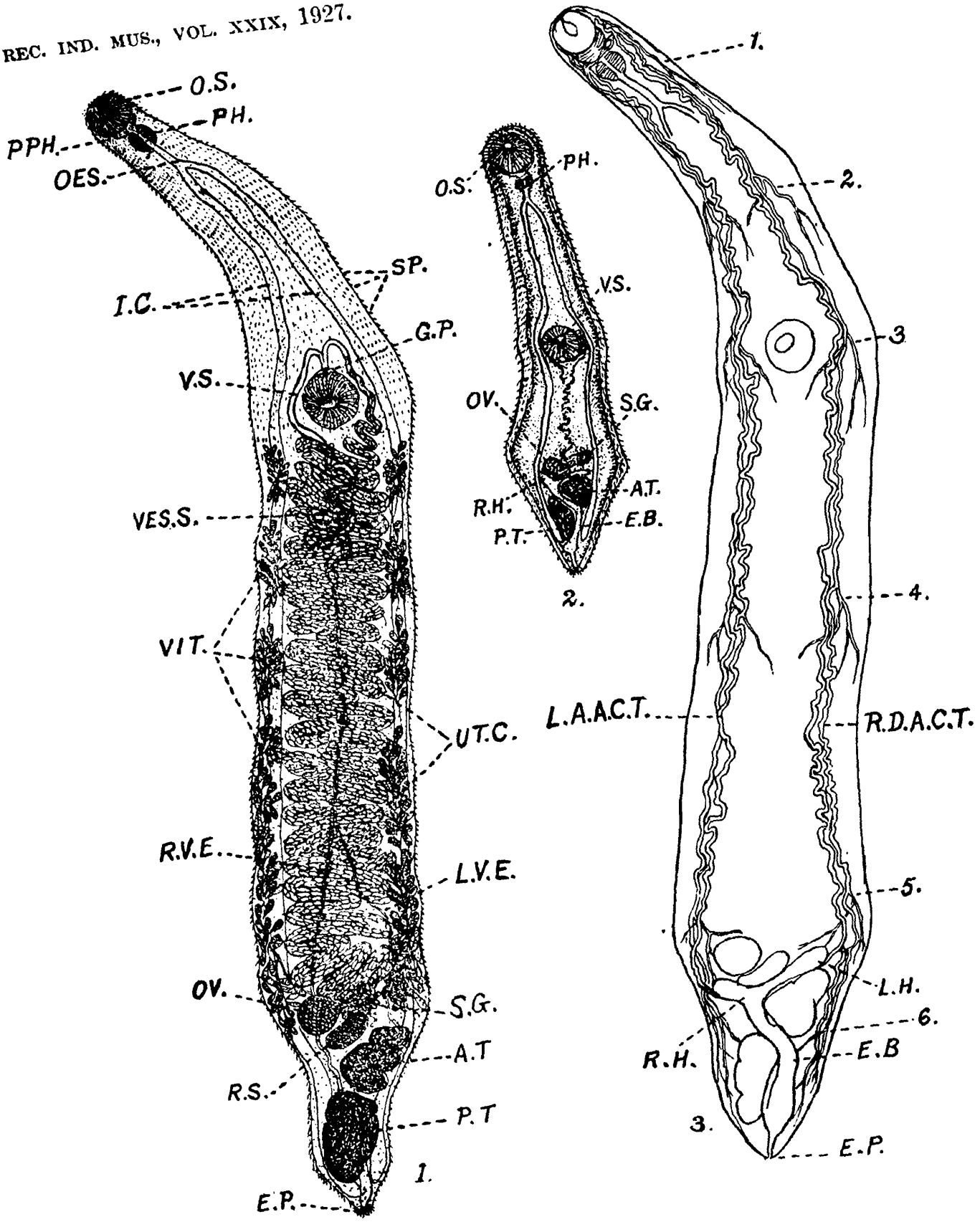
FIG. 3.—Diagram of excretory system of *O. pedicellata*, × 25.

All figures, with the exception of fig. 3, were drawn with the aid of Spencer's Electric Drawing Apparatus.

EXPLANATION OF LETTERING.

A. T., anterior testis; CU., cuticle; D. R. S., duct of receptaculum seminalis; E. B., excretory bladder; E. P., excretory pore; F. C., flame cells; G. P. genital pore; G. S., genital sinus; I. C., intestinal caeca; L. A. A. C. T., left ascending arm of collecting tube; L. C., Laurer's canal; L. H., left horn of excretory bladder; L. V. E., left vasa efferentia; M. D., male duct; M. P., muscular papilla; OD., oviduct; OES., oesophagus; O. L. C., opening of Laurer's canal; O. S., oral sucker; OT., ootype; OV., ovary; PH., pharynx; PPH., prepharynx; P. T., posterior testis; R. D. A. C. T., right descending arm of collecting tube; R. H., right horn of excretory bladder; R. S., receptaculum seminalis; R. V. E., right vasa efferentia; R. VIT. D., right vitelline duct; S. G., shell gland; SP., spines; U. C., uterine coils; VAG., vagina; VIT., vitellaria; VIT. R., vitelline reservoir; V. S., ventral sucker; VES. S., vesicula seminalis; 1-6, accessory collecting tubules.

REC. IND. MUS., VOL. XXIX, 1927.



Opisthorchis pedicellata, sp. nov.

EXPLANATION OF PLATE XII.

FIG. 4.—Vertical longitudinal section through genital pore of *O. pedicellata*, in part only, × 250.

FIG. 5.—View of excretory capillaries, slightly diagrammatic, × 500.

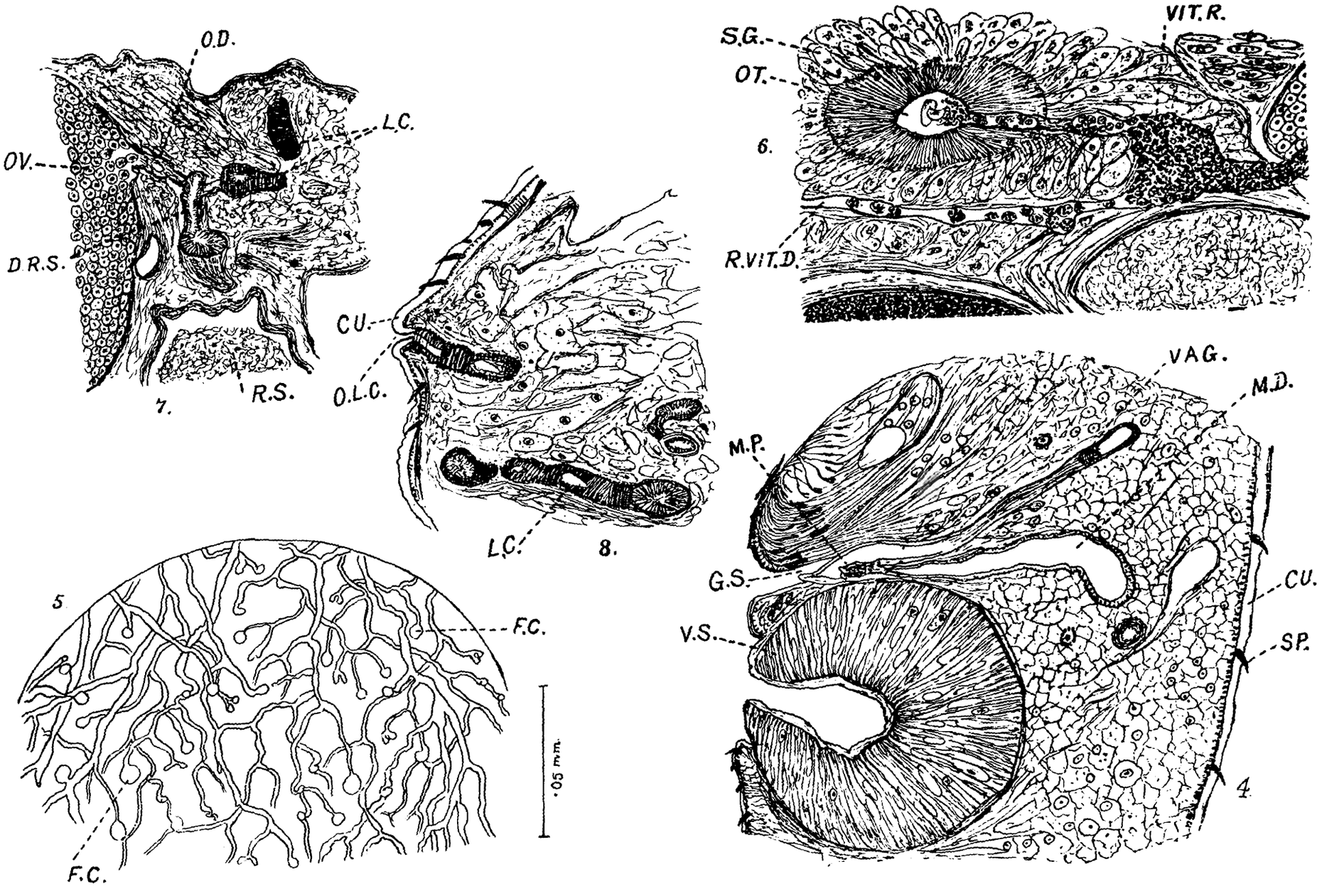
FIG. 6.—Vertical horizontal section in the region of vitelline reservoir and shell gland, in part only, × 300.

FIG. 7.—Transverse section, somewhat oblique, passing through junction of Laurer's canal and oviduct, × 250.

FIG. 8.—Vertical longitudinal section passing through external opening of Laurer's canal, × 300.

All figures were drawn with the aid of Spencer's Electric Drawing Apparatus.

For explanation of lettering see Explanation of plate XI.



Opisthorchis pedicellata, sp. nov.

ZUR KENNTNIS DER MIKROFAUNA VON BRITISCH INDIEN.

I. Ostracoda.

Von W. Klie. (*Bremerhaven*).

Durch freundliche Vermittlung von Herrn Dr. P. A. Chappuis erhielt ich eine Anzahl von Proben mit Süsswasserostracoden aus Britisch Ostindien die vom Zoological Survey of India gesammelt worden waren. Bis auf eine, die der Vollständigkeit wegen am Schluss mit berücksichtigt werden soll, entstammen sie Moospolstern und Algenwatten, einem Lebensraum, der bisher nur selten auf das Vorkommen von Muschelkrebsen untersucht worden ist. Da in mehreren Fällen nur Larven der frühsten Entwicklungsstufen vorlagen, liessen sich leider nicht alle mir zur Bearbeitung eingesandten Tiere bestimmen. Wenn also auch die Ausbeute im Ganzen nur gering ist, so bietet sie doch insofern ein besonderes Interesse, als zwei neue Arten festgestellt werden konnten, bei denen die Rückbildung der Schwimmborsten der zweiten Antennen zu dem Schluss berechtigt, dass wir es nicht mit zufälligen Gästen, sondern mit typischen Bewohnern der geschilderten Standorte zu tun haben, umsomehr, als beide an weit von einander entfernten Fundorten gesammelt worden sind.

Gattung **Stenocypris** G. O. Sars.

Stenocypris sewelli, nov. spec.

Fundorte: Simla, St. 1 (W. Himalayas, 6-7000 ft.), August-September 1925. Moos an Steinen eines Wasserfalls in einem kleinen Fluss. coll. *Dr. B. Chopra.*

Bhagsunath (Upper Dharmsala, Kangra Valley, Punjab), 4. VI. 1926. Moospolster. coll. *Dr. S. L. Hora.*

Cheerapunji (Khasi Hills, Assam), 1. X. 1926. Algen in einem felsigen Flussbett. coll. *Major R. B. S. Sewell.*

Darjiling: Near milestone 16½ from Darjiling on the Teesta-Darjiling road, 21. XII. 26. Moospolster. coll. *Dr. S. L. Hora.*

Beschreibung des Weibchens.

Schale.

Die Schalen sind dünn, zart und durchscheinend und haben, soweit nach der Einwirkung des als Konservierungsmittel benutzten Alkohols noch ein Urteil darüber möglich ist, eine schwach bläulichgrüne Färbung mit einem Hauch von Perlmutterglanz. Sie sind mässig behaart, an den Enden am stärksten, und zwar am Vorderende dichter und kürzer als am Hinterende. In der Seitenansicht erscheinen sie langgestreckt, ihre Länge ist etwas grösser als die doppelte Höhe. Die grösste Höhe liegt etwas hinter der Mitte, von dort fällt der Oberrand nach vorn sehr sanft geneight und zunächst fast gerade, nach hinten dage-

gen ziemlich stei ab. Das Hinterende ist infolgedessen schmal, das Vorderende dagegen breit gerundet. Der Unterrand ist vor der Mitte schwach eingebuchtet, vor dieser Einbuchtung, in der Mundgegend,

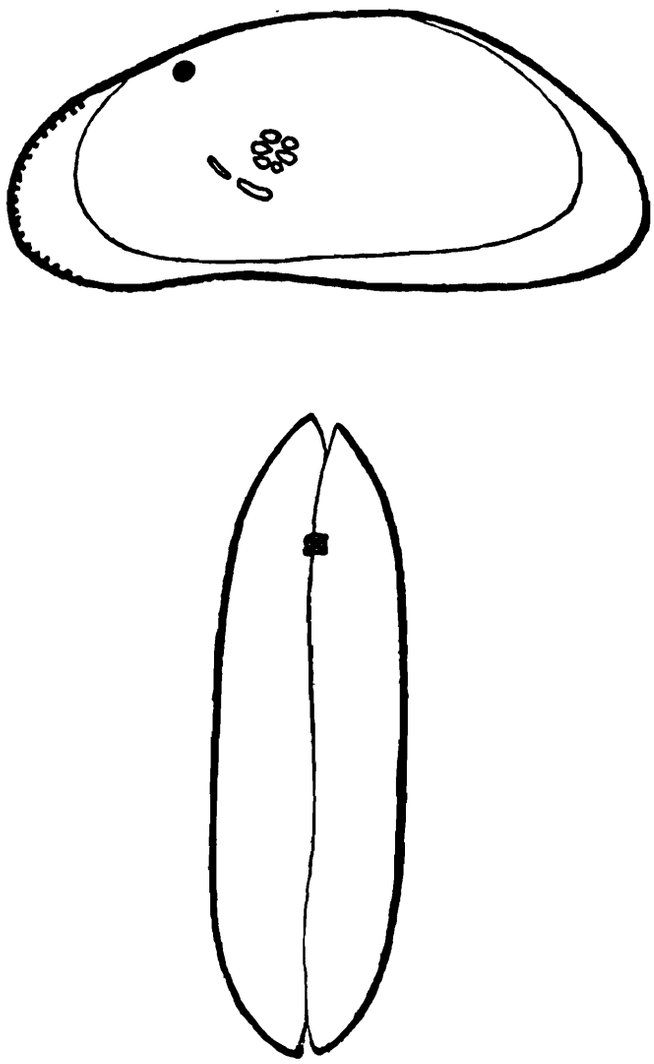


Fig. 1.—*Stenocypris sewelli*, n. sp. Seitenansicht der linken Schale und Ansicht von oben.

findet sich eine schwache, aber deutliche Vorwölbung. Eine ganz schwache, kaum merkliche Einsenkung liegt am oberen Vorderrande über der Augengegend. Der am Vorder- und Hinterende weit vom Schalenrande zurücktretende Innenrand verläuft in den Schalenrändern entsprechend geschwungener Krümmung, wobei er sich dem Unterrande in der Gegend der Einbuchtung am meisten nähert. Eine radiäre Streifung ist nur im Bereiche des Vorderrandes in schwacher Ausprägung nachweisbar. Vor den eine Bossette bildenden Schliessmuskeleindrücken finden sich die Eindrücke der Mandibularmuskeln als zwei langgestreckte Flecke verschiedener Breite. In der Ansicht von oben sind die Ränder der Schalenhälften annähernd parallel, beide Enden sind gerundet, das Hinterende jedoch breiter als das Vorderende. Die linke Schale überragt vorn und hinten die rechte nur wenig. Die Schalen erscheinen auch in dieser Ansicht sehr schlank, da die Breite von der Länge um mehr als das dreifache übertroffen wird.

Gliedmassen.

Bei der ersten Antenne, deren vier letzte Glieder nicht länger als breit sind, während bei dem ihnen vorhergehenden die Länge das Doppelte der Breite beträgt, erreichen die Endborsten des letzten Gliedes eine Länge, die die Gesamtlänge der Antenne übertrifft.

Bei der zweiten Antenne sind die Klauen aussergewöhnlich kurz und kräftig, die längsten erreichen kaum die Länge des vorletzten Gliedes. Der am Grunde mit einer Borste verschmolzene Sinneskolben des End-

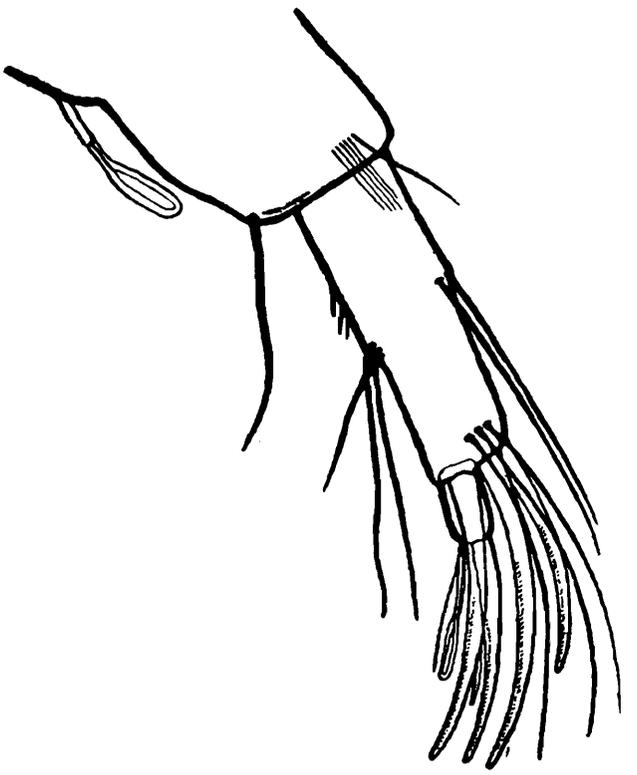


FIG. 2.—*Stenocypris sewelli*, n. sp. Endteil der zweiten Antenne.

gliedes ist fast doppelt so lang als dieses Glied selbst. Die fünf Schwimmborsten sind äusserst fein und zart, ihre Spitzen erreichen kaum das erste Drittel der Länge des folgenden Gliedes, nur die sechste (vordere Tastborste) ist etwas kräftiger und um die Hälfte länger.

Mandibel nebst Taster ohne Besonderheiten.

Die beiden verstärkten Borsten am dritten Kaufortsatz der Maxille sind schwach, aber deutlich gezähnt.

Erstes und zweites Fusspaar ohne Besonderheiten.

Der Putzfuss ist schlank, das vorletzte Glied trägt in der Mitte des Aussenrandes eine im Endteil schwach gekniete Borste. Das letzte Glied ist mit einer kleinen, stark gebogenen Klaue versehen. Die Endklaue ist sehr kräftig entwickelt, sie zeigt deutlich eine Sonderung in Grund- und Endteil, beide sind gekrümmt, der erste Abschnitt hauptsächlich am Grunde, der letzte am Ende. Die Sonderung von Grund- und Endteil, sowie die Ausbildung des Endhakens unterliegt zuweilen Abänderung en ; doch ist der Absatz in der Mitte der Klaue und die Krümmung der Spitze, wenn auch in manchen Fällen minder deutlich als in der beigegebenen Abbildung, regelmässig ausgeprägter als bei

St. malcolmsoni, die in dieser Beziehung der neuen Art am nächsten steht.

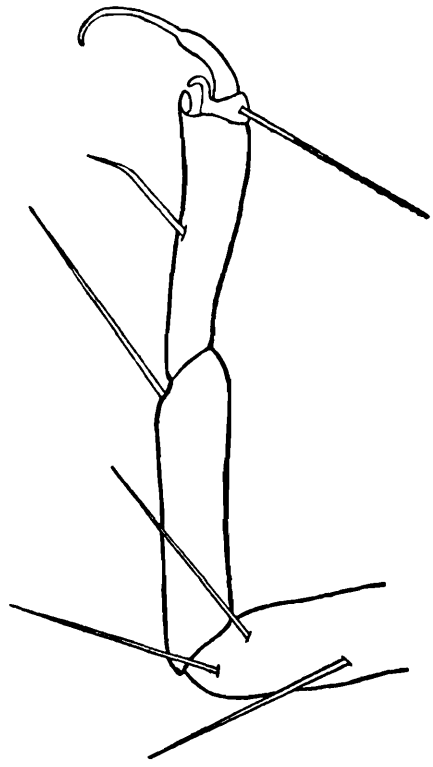


Fig. 3.—*Stenocypris sewelli*, n. sp. Putzfuss.

Die für die Gattung *Stenocypris* kennzeichnende ungleiche Entwicklung der Furkaläste tritt bei der neuen Art nicht so auffällig hervor wie bei den übrigen. Sie beschränkt sich in der Hauptsache auf die Bedornung des Hinterrandes, während der Stamm selbst links nur wenig schwächer ausgebildet ist als rechts. Auch die Bedornung der Klauen, die sich bei der grossen auf die halbe, bei der kleinen auf die ganze Länge erstreckt, sowie die Entwicklung der vorderen Borste, die die Länge der grossen Endklaue erreicht, ist rechts und links übereinstimmend. Die Bedornung der Hinterränder, die übrigens in ihren Einzelheiten nicht bei allen Stücken gleich ist, nimmt rechts fast die ganze distale Hälfte des Hinterrandes in Anspruch, während sie sich links mit viel schwächeren Zähnen nur über ein Fünftel bis ein Viertel der Länge des Hinterrandes erstreckt. Im ganzen ist die Furka der neuen Art kurz und gedrungen, da sie ausserdem breit und nicht gekrümmt ist, erscheint sie vergleichsweise plump.

Männchen unbekannt.

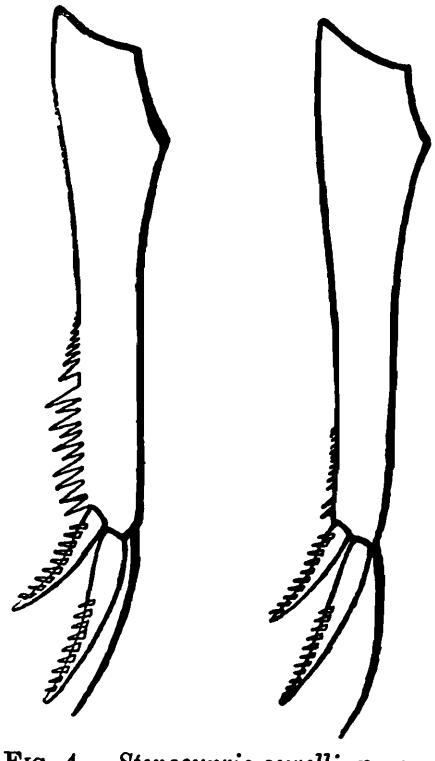


Fig. 4.—*Stenocypris sewelli*, n. sp. Furkaläste beider Körperhälften.

Masse: Länge 1·2—1·5 mm. Höhe 0·53—0·65 mm. Breite 0·37—0·43 mm.

Bemerkungen.

Die Arten der Gattung *Stenocypris* sind im Süsswasser der Inseln und der Randgebiete der den Indischen Ozean einschliessenden Festländer nicht selten, doch scheinen sie streng auf das angegebene Gebiet beschränkt zu sein. Die kleinsten Arten messen nämlich etwa 1·5 mm., die Mehrzahl ist zwischen 2 und 3 mm. gross, einige wenige erreichen sogar 4 mm. Länge und darüber, und Muschelkrebse von solcher Grösse pflegen auch dem Nichtspezialisten aufzufallen. Wenn also aus anderen Gegenden bisher keine *Stenocypris* Arten gemeldet worden sind, so hat das wahrscheinlich seinen Grund darin, dass die Gattung dort tatsächlich fehlt. Zur Verteilung der einzelnen Arten auf das Gebiet vergleiche

man die im wesentlichen nach den Angaben von G. W. Müller (1912) entworfene Verbreitungskarte.

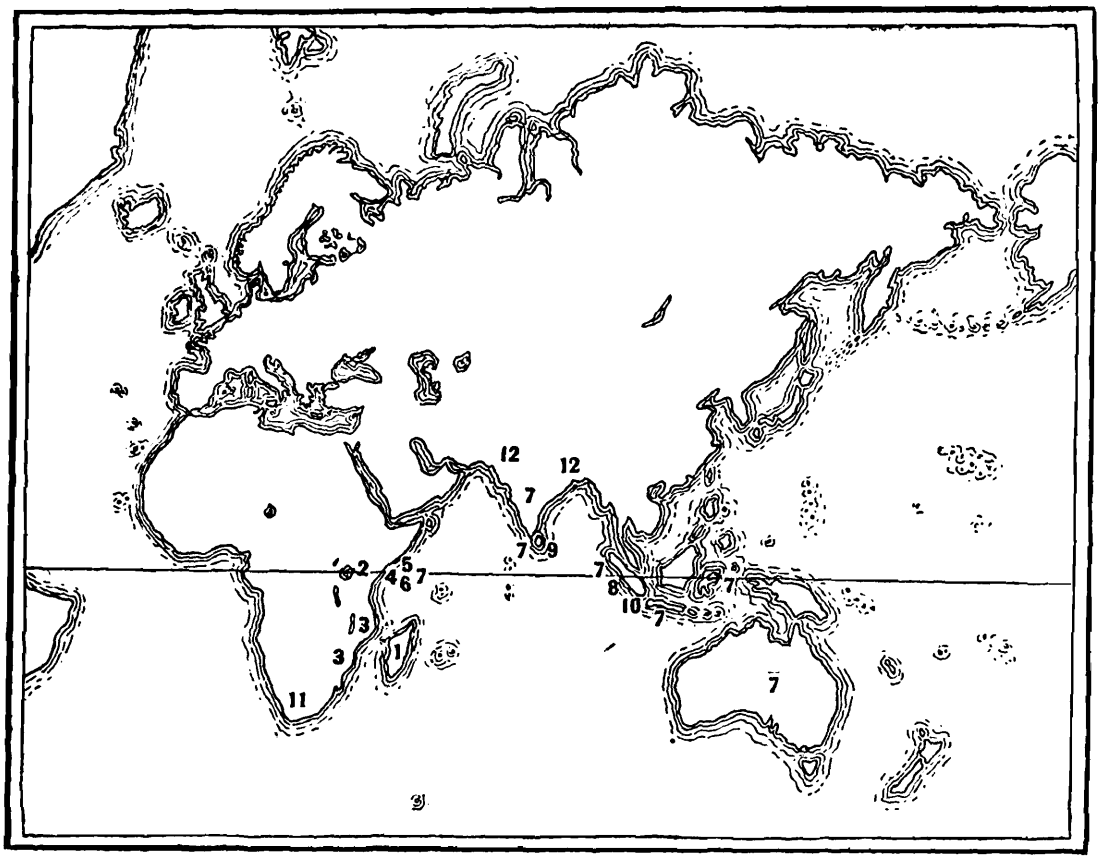


FIG. 5.—Verbreitungskarte für die Gattung *Stenocypris*.

1. *St. sinuata* G. W. Müller.
2. *St. exsiccata* Vavra.
3. *St. aldabrae* G. W. Müller.
4. *St. cultrata* G. W. Müller.
5. *St. acuta* Vavra.
6. *St. fontinalis* Vavra.
7. *St. malcolmsoni* (Brady).
8. *St. derupta* Vavra.
9. *St. ceylonica* Daday.
10. *St. bimucronata* Vavra.
11. *St. ametra* G. W. Müller.
12. *St. sewelli*, n. sp.

Stenocypris malcolmsoni (Brady), die weitest vertreitete, also anpassungsfähigste Art (sie ist sogar schon ein ständiger Bewohner europäischer Warmhäuser, ich besitze Exemplare aus Basel und Lunz), hat auch den Uebergang zum Leben in Moospolstern zu vollziehen vermocht, wie Menzel (1923) gezeigt hat. Sie gehört natürlich nicht zu der Tiergesellschaft, die für häufig austrocknende und starkem Temperaturwechsel unterliegende Mooskrusten charakteristisch ist, aus Menzels Darstellung geht vielmehr hervor, dass es sich um nur ausnahmsweise trocken liegende Moospolster in annähernd gleichmässig temperierter Lage handelt. Aehnliche oekologische Verhältnisse scheinen bei dem für die neue Art angegebenen Fundort vorzuliegen. Doch ist bemerkenswert, dass es sich bei ihr offenbar nicht um ein gelegentliches, durch besondere Gunst der Umstände veranlasstes Vordringen einer sonst auf dauernde Gewässer angewiesenen Art in einen neuen Lebensraum handelt. Nach dem Befund an den Schwimmborsten der zweiten Antenne, die sich nur in einer der Rückbildungsstufe von manchen Quellenostracoden entsprechenden Entwicklung vorfinden, muss vielmehr gefolgert werden, dass die die Steine des Bachbetts überkleidenden Moose und Algen nicht aussergewöhnliche und zufällige

Standorte der Art sind, vielmehr ist anzunehmen, dass sie hier an ihrem normalen Aufenthaltsorte gesammelt wurde. Auch die ausserordentliche Gedrungenheit der Endklauen, sowie die starke Entwicklung des Sinneskolbens am Endgliede der zweiten Antenne weist darauf hin, dass das in Moospolstern allein mögliche Klettern und Kriechen die dem Tiere gemässe Bewegungsart ist. Beiläufig soll in diesem Zusammenhange noch bemerkt werden, dass also, da ganz zweifellos eine echte *Stenocypris* vorliegt, die Bestimmung in der Gattungsdiagnose von Vávra (1894) " die Schwimmborsten erreichen die Spitze der Endklauen " gestrichen werden muss.

Es wurde schon bemerkt, dass die untersuchten Proben keine Männchen enthielten. Der Schluss auf rein parthenogenetische Fortpflanzungsweise ist damit aber noch keineswegs gerechtfertigt. Zwar sind gerade bei der am besten bekannten Art, bei *St. malcolmsoni*, bisher noch niemals Männchen gefunden worden, eine ganze Reihe von Arten dagegen ist amphigon. Wie sehr unsere diesbezüglichen Erfahrungen vom Zufall abhängen beweist *St. ametra* G. W. Müller, von der bis jetzt nur das Männchen bekannt ist.

Gattung **Cypridopsis** G. S. Brady.

Cypridopsis horai, nov. spec.

Fundorte : Tiloknath (Kangra Valley, Punjab), 24. V. 1926. Moospolster. coll. *Dr. S. L. Hora.*

Darjiling : Near milestone 16½ from Darjiling on the Teesta-Darjiling road, 21. XII. 26. Moospolster. coll. *Dr. S. L. Hora.*

Beschreibung des Weibchens.

Schale.

Die Schalen sind mässig fest, ihre Oberfläche ist mit zerstreut stehenden Porenkanälen ziemlich gleichmässig bedeckt, randständige Porenkanäle finden sich nur im vorderen und hinteren Abschnitt des Unterrandes. Die mir vorliegenden, in Alkohol konservierten Exemplare sahen gelblichbraungrau aus. In der Seitenansicht erscheint der Rückenrand mit kaum hervortretender Ecke dicht vor der Mitte gleichmässig gewölbt ; beide Enden sind gerundet ; der Unterrand ist fast gerade, nur in der Mundgegend weist er eine deutliche Vorwölbung auf. Die Höhe ist nur wenig grösser als die halbe Länge. Die Ansicht von oben zeigt fast parallele Seitenränder, die sich vorn und hinten in annähernd gleichmässiger Rundung zusammenschliessen ; die rechte Schale überragt die linke an beiden Enden.

Gliedmassen.

Bei den ersten, verhältnismässig kurzen Antennen sind Grundteil (Glied 1+2) und Endteil (Glied 3—7) von ungefähr gleicher Länge ; die längsten Borsten erreichen die anderthalbfache Länge der Antenne.

Die zweite Antenne ist gleichfalls kurz und gedrungen, ihre Endklauen, von denen sich besonders die vordere des vorletzter Gliedes durch ihre Stärke auszeichnet, sind kräftig. Von den Schwimmborsten erreichen nur die längsten die Mitte des vorletzten Gliedes.

Mandibel nebst Taster von gewöhnlichem Bau.

Bei der Maxille ist das Endglied des Tasters lang und schmal, der dritte Kaufortsatz trägt zwei ungefiederte, zahnartig verstärkte Borsten.

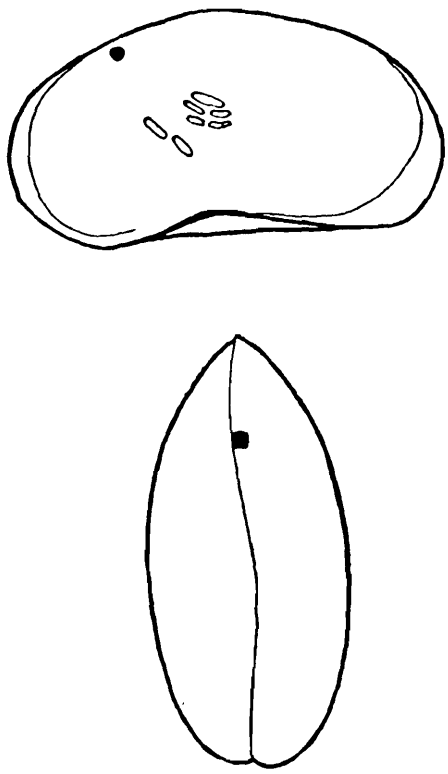


FIG. 6.—*Cypridopsis horai*, n. sp. Seitenansicht der linken Schale und Ansicht von oben.

Die Atemplatte des ersten Thoraxbeines hat zwei Strahlen.

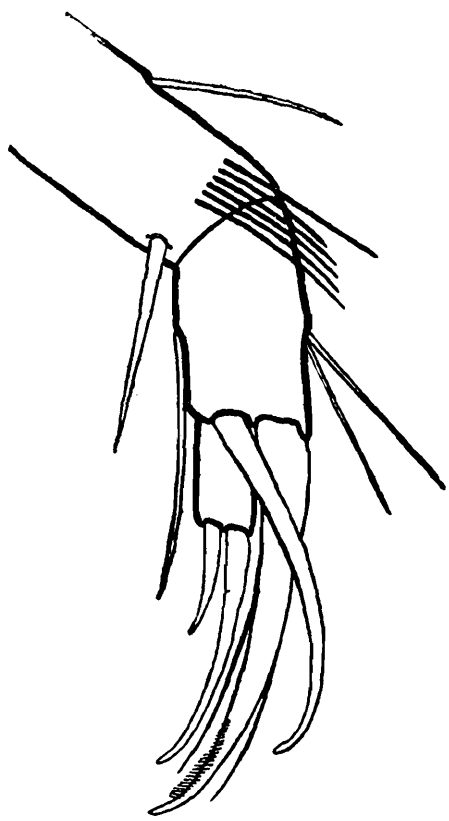


FIG. 7.—*Cypridopsis horai*, n. sp. Endteil der zweiten Antenne.

Das zweite Bein ist bei verhältnismässiger Kürze stark gebaut, Borsten und Endklaue sind kräftig.

Putzfuss ohne Abweichungen von der Norm.

Bei der Furka ist die Geissel deutlich abgesetzt, sie ist ungefähr um die Hälfte länger als der Stamm. Die gut entwickelte hintere Klaue (Bezeichnung nach Wolf, 1920) ist im letzten Drittel in einem halben rechten Winkel nach aufwärts gekrümmt.

Masse: Länge 0·44 mm. Höhe 0·23 mm. Breite 0·21 mm.

Männchen unbekannt.

Bemerkungen.

Die Abgrenzung der Genera bei den Cyprinae mit geisselförmiger Furka ist von jeher mit Schwierigkeiten verbunden gewesen. G. O. Sars (1925) hat versucht, durch Wiederaufnahme der Gattungen *Pionocypris* Brady & Norman und *Cypridopsella* Kaufmann eine befriedigende Lösung zu finden. Mir will jedoch scheinen, als ob wir die hierher gehörenden Arten noch nicht ausreichend kennen, um eine den Verwandtschaftsverhältnissen gerecht werdende Gruppierung schon jetzt vornehmen zu können. Ich benutze deshalb die von Alm (1915) vorgeschlagene Zweiteilung des Genus *Cypridopsis* in die beiden Untergattungen *Cypridopsis* s. str. und *Potamocypris*. Sie sind in ihren typischen Vertretern durch die Symmetrieverhältnisse der Schalen und die Gestalt des Endgliedes des Maxillartasters ausreichend gekennzeichnet. Berücksichtigt man nur diese beiden Merkmale, so können Zweifel über die Zugehörigkeit eigentlich nur bei *C. subterranea* Wolf entstehen, die der Ungleichheit der Schalenhälften wegen zu *Potamocypris*, zu stellen wäre, der gestreckten Form des Endgliedes des Maxillartasters nach aber von ihrem Entdecker der Gattung *Cypridopsis* zugewiesen worden ist. Von Umwelteinflüssen stark beeinflussbar und daher als Gattungsmerkmal nicht zu verwenden ist der Ausbildungsgrad der Schwimmborsten der zweiten Antennen. Gut entwickelte Schwimmborsten finden sich bei der Untergattung *Cypridopsis* zurückgebildete bei *Potamocypris*, doch gilt diese Unterscheidung nur ganz im allgemeinen und bedarf mehr facher Einschränkungen. *Cypridopsis subterranea* Wolf, als strittig bereits erwähnt, würde sich der Beschaffenheit der Schwimmborsten wegen besser der Gattung *Potamocypris* einfügen, da aber die Rückbildung derselben offensichtlich durch die Lebensweise in unterirdischen Spaltengewässern erworben worden ist, wird man die Art besser bei der Untergattung *Cypridopsis* belassen. In diesem Merkmal weicht die oben beschriebene neue Art gleichfalls von den bisher bekannten Vertretern des Subgenus *Cypridopsis* ab, aber auch hier, bei einem Moosbewohner, ist diese Rückbildung unschwer als durch den Einfluss der Umwelt bedingt zu erklären. Uebrigens ist diese Abweichung die einzige; der Beschaffenheit der Schalenhälften nach gehört sie unzweifelhaft zu *Cypridopsis*, und, da die rechte Schale die linke umgreift, sogar in der von Sars stark eingeengten Abgrenzung des Gattungsbegriffs.

Fig. 8.—*Cypridopsis horai*, n. sp. Furka.

Gattung **Cypria** Zenker.

Cypria javana G. W. Müller.

Fundort: Calicut, Sumpfgewässer. coll. *Dr. B. Sundara Raj.*

G. W. Müller (1906) hat diese Art nach den von Kraepelin bei Tjitajam auf Java gesammelten Exemplaren aufgestellt, andere Fundorte sind meines Wissens bis jetzt nicht bekannt geworden. Die Art ist eine der kleinsten ihrer Gattung, G. W. Müller gibt für das Weibchen 0·54—0·57 mm. und für das Männchen 0·48 mm. an. Ich habe an den mir vorliegenden drei weiblichen Exemplaren, die noch keine Eier trugen, also trotz Erreichung der Reife wohl noch nicht ihre volle Grösse erlangt haben mochten, folgende Masse festgestellt: Länge 450μ, Höhe 276μ, Breite 207μ. Die Art ist vornehmlich kenntlich an dem Vorhandensein einer Borste an der Grenze des dritten und vierten verschmolzenen Gliedes des Putzfusses und an der aussergewöhnlich langen Hinterrandborste der Furka: Merkmale, die bei den untersuchten Exemplaren in typischer Ausbildung erkannt werden konnten.

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