

THE INDIAN EPHEMEROPTERA (MAYFLIES) OF THE SUB-ORDER EPHEMEROIDEA.

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(Plates IV & V.)

INTRODUCTION.

The study of this interesting group of insects was suggested to me by Dr. Bains Prasad, Director, Zoological Survey of India, with a view to continue the work of my friend and colleague Dr. B. Chopra, whose paper on the Palingeniidae and Polymitarcidae of the sub-order Ephemeroidea was published in 1927.¹ The Mayfly material of the Indian Museum has in the meantime been increased by collections made by the Officers of the Zoological Survey of India and I am therefore obliged to include in this paper references to Palingeniid and Polymitarcid species already dealt with by Chopra, together with the description of a new species of the genus *Anagenesia*. This paper deals with all the Indian representatives of the sub-order Ephemeroidea so far as was possible with the material available. I have, however, not so far seen any material of the family Potamanthidae.

I have, as was done by Chopra, preferred to follow Comstock and Needham's notation of wing venation throughout my work. I have also adopted Ridgway's nomenclature in describing colouration. As is usual in this group, slide mounts of certain appendages of the specimens that I have seen have been made. These are deposited in the collections of the Zoological Survey of India.

I am much obliged to Dr. Bains Prasad, Director, Zoological Survey of India, for his kind guidance and generous help in preparing this paper for the press. I wish to express my grateful thanks to Dr. B. Chopra for his notes and figures on the two new species of *Ephemera*, viz., *E. diffusa* and *E. annandalei*, as also on some other Ephemerid species dealt with in this paper. I have, however, re-examined the specimens that are in the collections of the Zoological Survey of India on which Chopra based his descriptions of the two new species and have made a few alterations and additions to his descriptions and figures. Some of the specimens are, however, in a rather damaged condition. My best thanks are also due to Dr. F. H. Gravely for his kindness in loaning me the Madras Museum material for study and to my assistant, Mr. G. Mathai, for general help rendered in the course of my work. Babu Subodh Mondul, one of the talented artists of the Zoological Survey of India, executed under my supervision some of the illustrations of this paper.

¹ Chopra, B.—*Rec. Ind. Mus.* XXIX, pp. 91-138 (1927).

SYSTEMATIC ACCOUNT.

Suborder EPHEMEROIDEA.

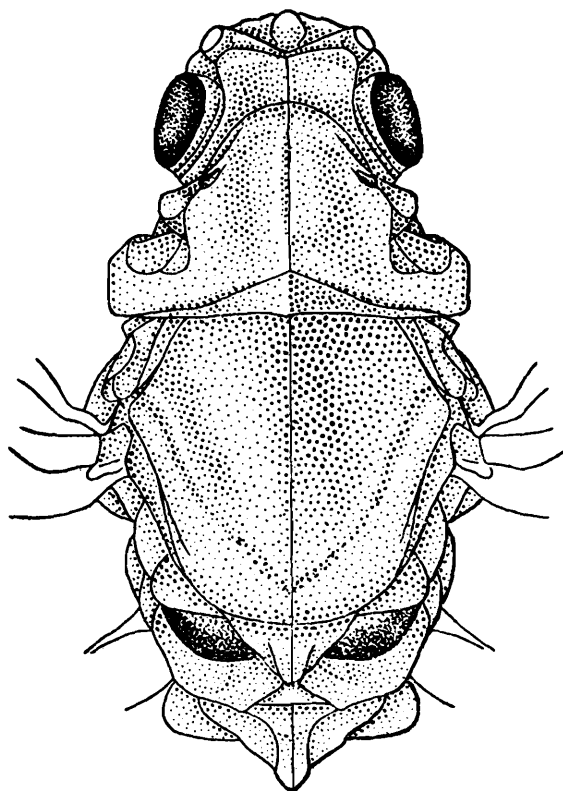
Family PALINGENIIDAE.

Anagenesia lontona, sp. nov.

(Plate IV, figs. 1-3.)

This species is represented in the Indian Museum collection by a single pinned female specimen from Lonton, Upper Burma, collected by Dr. B. Chopra; the specimen is in a fairly good state of preservation.

Imago ♀ (*dried*).—The general colouration of the body varies from walnut brown to vandyke brown. The head is pitch black; the eyes are also black, encircled basally with dark brown; the ocelli are light brown encircled with black; the lateral ocelli are connected by fine shallow grooves meeting in the middle. The pronotum is well developed, and of a vandyke brown colour except at the sides and at the posterior margins which are somewhat lighter. The anterior corners of pronotum are deeply notched. The mesonotum is slate black, robust, bearing two obliquely running shallow grooves forming a V. The metanotum is more or less of the same colour as the pronotum (Text-fig. 1). The dorsum of abdomen is walnut brown except the last three



TEXT-FIG. 1.—*Anagenesia lontona*, sp. nov.
Head and thorax of female, dorsal view: $\times 8$.

segments, which are vandyke brown and more convex than the anterior segments. Segments 3 to 7 bear blackish gray semicircular markings; the free ends of the arches are directed forwards close to the

posterior margins of the preceding segments. The posterior margin of the last abdominal segment is deeply notched in the middle and the rudimentary median caudal seta is visible from above. The venter of thorax is more or less concolourous with the dorsum but that of the abdomen is considerably lighter and the posterior margins of segments, except the last, with pale thick lines.

The wings are dirty-whitish and translucent. The fore-wings are large; the wing venation is typical of the genus; M_1 , however, appears to fork slightly beyond Rs ; there is a single longitudinal vein in the first anal fork; costa, sub-costa, radius and the great cross vein are prominent and dark brown; the rest are cream yellow. The neurotation of hind-wings is typical of the genus; the costal projection near the humeral angle is prominent and is of a dark brown colour; C , Sc , R , M , Cu and the anal veins are well developed; the forking of Rs is not well marked.

The legs are considerably reduced, particularly the first pair. The coxae of the first and second pairs of legs are concolourous with the sternum; the femora, tibiae and tarsi are very much lighter. It is difficult to make out the joints of the fore-tarsus owing to its being greatly shrivelled in the only specimen available. The claws of fore-legs are uniuugiculate. The second and third pairs of legs are more strongly developed, but the tarsi are considerably reduced. The hind-tarsus bears one claw.

The lateral caudal setae are ribbon-like, about half as long as the length of the body and uniformly pubescent; the tips are pointed and brownish; the median seta, as stated before, is rudimentary and is situated in the middle of the notch of the last abdominal segment.

♂ not known.

Length of body 29 mm.; fore-wing 26 mm.; lateral seta 13 mm.

Type specimen.—No. $\frac{963}{H 8}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—Lonton, a small village on the western shore of the Indawgyi Lake, Myitkyina district, Upper Burma, B. Chopra, 18th to 31st October 1926.

The present species is about the darkest in colour of all the Indian species of the genus *Anagenesia* Etn. that I have seen. It is by far the largest species of the genus, being slightly larger than even the males of *A. robusta* (Etn.). It differs from *A. lata* (Walk.) in its very much larger size and dirty-whitish wings. It is easily distinguished from the Bornean species, *A. picta* (Grav.), by the larger size of its body and wings, darker colouration of notum and abdomen and by the characteristic blackish gray semicircular markings on the 3rd to 7th abdominal tergites.

Anagenesia minor (Eaton).

1927. *Anagenesia minor*, Chopra, *Rec. Ind. Mus.* XXIX, p. 113.

I refer to this species a very large number of male specimens, both pinned and in alcohol, from Belgaum district in the Bombay Presidency. *A. minor*, as remarked by Chopra, certainly appears to be a widely distributed species having been previously recorded from Upper Burma, Bengal and Bihar.

Some of the specimens from Belgaum are much smaller than those recorded by Chopra from other localities, the smallest measuring about 14 mm. They, however, very closely resemble the specimens from Saraghat, Bengal. The characteristic feature of the species, *viz.*, the clouding of the dorsum of the posterior segments of the abdomen is quite clear but the general colouration of the specimens is somewhat lighter. The gray clouding of segments 7-9 is continued to other segments but less and less so anteriorly and very much so in the first segment. Specimens, in which the segments of abdomens are telescoped, have the gray clouding as a continuous mid-dorsal gray band. The terminal joints of the genital forceps are distinctly longer than the preceding ones. In all other characters the specimens agree with previous descriptions.

Locality.—Dhupdal and Gokak, Belgaum district, Bombay Presidency, Bani Prashad and H. S. Rao, November 1928 (at light).

Family POLYMITARCIDAE.

Polymitarcys indicus (Pictet).

1927. *Polymitarcys indicus*, Chopra, *Rec. Ind. Mus.* XXIX, p. 124.

I refer to this rather common species a large number of examples from Gokak, Belgaum district, Bombay Presidency, Sarai, Rewa State, and Kamaing, Upper Burma. The large number of specimens from the Bombay Presidency are all females. Specimens of both sexes from Rewa State include a number of male sub-imagos and the specimens from Upper Burma comprise both males and females.

The specimens agree in all respects with previous descriptions. The number of subsidiary veins in the first anal fork of the fore-wing, ranging from 4 to 6, however, is variable. This character, therefore, does not appear to be of any great importance. The genital forceps in specimens from Sarai, Rewa State, are arranged as described by Chopra, the left forcep being more dorsally placed than the left penis lobe. But in one of the male sub-imagos from the same locality it is the right forcep which is more dorsally placed than the left.

There are altogether six male sub-imagos. In all essentials they show great resemblance to the imagos but the colouration of the mesonotum is very much darker than that of the imago. The first pair of legs are very short. Femur with blackish brown streaks on the outside; tibia very robust and a little longer than the femur and has on its inner and outer surfaces a series of closely placed transverse blackish brown lines giving it a characteristic appearance. Tarsus three-fourths as long as tibia, also robust, the five joints decrease in size proximo-distally ending in unequal biunguiculate claws. The second and third pairs of legs are as in the imago but the tarsi are not so much reduced and the segments are quite clear. The second tarsus has three distinct joints and the third four joints ending with biunguiculate claws. Venation as in the adult; six subsidiary veins in the fork of the first anal vein. Genital apparatus as in the imagos but in one example the right forcep appears to be more dorsally placed than the left. One of the specimens has the cast of the skin attached to the posterior end of the body and the first pair of legs in this specimen are as in the adults.

Locality.—Gokak, Belgaum district, Bombay Presidency (at light), B. Prashad and H. S. Rao, November 1928, Sarai (land) 2,700 ft., Rewa State, H. S. Pruthi, February 1927, Kamaing, Myitkyina district, Upper Burma, B. Chopra, November-December 1926, and Mysore, S. India, Gangadaran, November 1925.

Family EPHEMERIDAE.

Ephemera Linn. and *Hexagenia* Walsh. are the only two of the five known genera of the family so far recorded from India. The former comprises ten species including two species described in this paper as new and also *E. fulvata* described by Navas (1935). The genus *Hexagenia* is, so far as I know, represented by a single species *H. indica* described by Chopra (1924).

Genus *Ephemera* Linn.

Ephemera diffusa Chopra, sp. nov.

(Plate IV, figs. 4-9.)

♂ *Imago (in spirit).*—The general colouration of the body is warm sepia to vandyke brown or in some cases burnt umber, with the venter somewhat paler and the dorsum considerably tinged with black.

The head is almost entirely black or rather blackish brown with only a small area in the middle near its posterior end somewhat paler. Another pale circular depression encircles a dark spot above the middle. Eyes are oval in outline with their inner orbits curved, and are separated from one another dorsally by a fairly extensive interspace. The eyes are black and the ocelli slightly lighter. The anterior ocellus is considerably smaller than the paired posterior ones. The antennae are brownish.

The pronotum is long but at its posterior end the breadth exceeds the length. In about its anterior third the pronotum is pale brownish, but the rest of it excluding the margins only is covered by a large quadrilateral patch of vandyke brown. The sides of this quadrilateral patch are almost blackish. The mesonotum is large and is uniformly coloured, vandyke brown to warm sepia; near its posterior extremity it is somewhat blackish. The metanotum is short and is of the same colour as the pronotum.

The dorsum of the abdomen is vandyke brown, with the margins considerably darker than the remaining surface. The apical borders of all the segments are also appreciably darker than the general surface. The characteristic abdominal markings, which are very prominent, are in the form of slightly curved to straight lines of dark vandyke brown on the segments 2-9, on either side of the median line. In the anterior segments the markings are more or less ovalish while in the last three or four segments they are in the form of slightly bent bands. These bands in the posterior segments extend almost completely from the apical to the basal margins but in the anterior somites they are nearer to the basal than the apical margins. The marginal dark bands run from end to end of the abdomen close to the pleura on each side. There is another sub-median band or streak on each side running close and

parallel to the dorsal line. In the anterior segments this is very faint, but becomes more discernible in the posterior segments, where it becomes considerably broader than anteriorly. The sub-median streaks, except in the ninth segment, are lighter in colour than the large lateral patches. It will thus be seen that the colour markings of the abdomen in *Ephemera diffusa* are more or less exactly like those of *Ephemera supposita* as described by Eaton in the *Journal of the Asiatic Society of Bengal*.

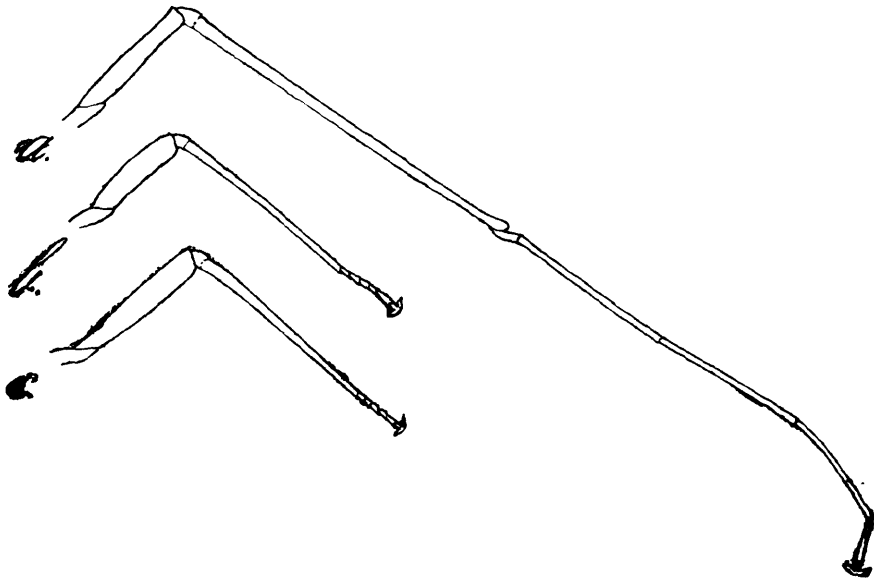
The venter is much lighter than the dorsal surface and there are fairly large and prominent whitish spots on the 9th and the 10th sternites. The prosternum behind the head and the head around the base of the antennae are also whitish.

The fore-wings are perfectly transparent in transmitted light, slightly iridescent, and are of a shade between antique brown and raw umber (nearer the latter than the former); the terminal and the inner margins are slightly darker than the rest of the membrane. The submarginal area is considerably darker. The longitudinal and transverse veins are opaque and of a raw umber colour. The sub-costa and first radial veins are considerably darker than the other longitudinal veins. The usual spotting of the wing is not at all clear perhaps owing to the specimen being in spirit. The spot in the fork of the media may have been present, but there is no trace of any marking on the *Cu*. R_5 a little beyond the forking of *M* has a small circular completely transparent spot which originally may have had pigment around it. There is a similar transparent area on R_2 and *Sc* but they are more proximally situated. The venation is typical of the genus. The costa is well developed; the sub-costa and the first radial are strongly developed. The radial-sector forks well in advance of media, the latter dividing beyond the middle. The cubitus branches quite close to the wing-root, the hinder branch being conspicuously curved near its origin. The first anal is obscurely connected with the cubitus at its base and forms a curve almost similar to that of the posterior branch of *Cu*. A_1 does not give many branches from its inner margin; A_2 is connected at its base to A_1 ; A_3 near the inner margin runs parallel to A_2 .

The hind-wing is concolourous with the fore-wing. The membrane is transparent and is more or less raw umber in colour; near the margins the membrane is much darker. There are no colour spots and the veins are not edged with colour. The costal projection is fairly conspicuous; *Rs* arises from R_1 and is forked quite near the wing base. *M* also divides near the fork of *Rs* and as usual M_3 joins *Cu*. The veins of the inner margin are not very prominent.

The legs, except for some parts of the fore-legs, are somewhat lighter in colour than the body (Text-fig. 2). The tibia of the fore-leg is vandyke brown, but the outer surface of the femur has a number of pale longitudinal streaks. The tarsus is considerably paler than the tibia. The second and third legs are somewhat light umber-brown with darker streaks on the femora. In their structure the legs are more or less typical of the genus. The fore-legs are very long and are about as long as or even longer than the body. The tibia is a little less than 3 times as long as the femur, while the tarsus is 4 times as long. The tarsus

is formed of 4 long, distinct segments and a rudimentary basal joint. The 4 large tarsal segments decrease in size progressively from the first



TEXT-FIG. 2.—*Ephemera diffusa* Chopra, sp. nov.

a. 1st leg of male : $\times 7$; b. 2nd leg of male : $\times 7$; c. 3rd leg of male : $\times 7$.

to the last ; the first is only slightly longer than the second and is almost equal to the third and the fourth joint together ; the 3rd is about twice as long as the 4th. Both the claws are similar. The second leg, the shortest of the three, is only a little shorter than the third. The femora of the 2nd and 3rd legs are of about the same length as that of the 1st ; the tibiae and tarsi of the 2nd and 3rd legs are less than even a third as long as those of the 1st. The tarsi of the last two pairs of legs are small, being about a third of the length of the tibiae. The tarsus is formed of 5 joints, the basal rudimentary segment is also more or less fully differentiated. The tarsal joints are sub-equal, except the ultimate one which is the longest.

The genital apparatus is lodged in a deep concavity of the very short 10th tergite. The forceps are concolourous with the venter. Each forcep is formed of 4 distinct segments. The two terminal segments of each are small, about as long as the basal and less than half as long as the 2nd. The basal segment is stout and the 10th tergite near its origin has a short spine. The second segment has a large prominence on its inner side near the base, is grooved ventrally and has hairs all along the groove. The penultimate and the terminal segments are hairy. The penis lobes are of the same colour as the venter and are proportionately very small in size ; they are lodged in a deep concavity of the 10th sternite, but a thin membrane-like structure covers their basal portions. The lobes are short, stumpy, finger-shaped, distally rounded, each having a sharp spine about as long as the lobe itself lying by its side along the inner margin. The presence of any such spine in connection with the genital apparatus has not been observed in any other mayfly and it is difficult to make any suggestion regarding its function, etc. The spine on the tergite near the base of the forcep is also unusual.

The setae are thin and long and are more or less circular in cross section. The setae in most of the specimens are broken, but the median seta appears to have been almost quite as long as the lateral ones. The setae are vandyke brown in colour, but in some specimens are antique brown especially towards their posterior ends. They are clearly segmented and are uniformly setose.

♂ *Sub-imago (in spirit)*.—This differs from the imago in being much lighter in colour. The wings are pale, dirty whitish with yellowish costal shoulder and brownish (darker near the wing base than distally) sub-costal and first radial veins. The principal veins are light brownish near the root but are milky whitish distally. Except in the sub-costal region most of the transverse veins are whitish and opaque. The dorsum of the abdomen is much lighter in colour than that of the adult but the colour markings in the two are identical. The prothorax is proportionately much shorter than that of the adult.

The legs in the proportion of their component parts resemble those of the female sub-imago more closely than those of the ♂ imago. In the fore-leg the femur is proportionately large and the tarsus is correspondingly reduced. The genital forceps are like those of the adult but the penis lobes are small. The caudal setae are long and have very prominent dark brown joints.

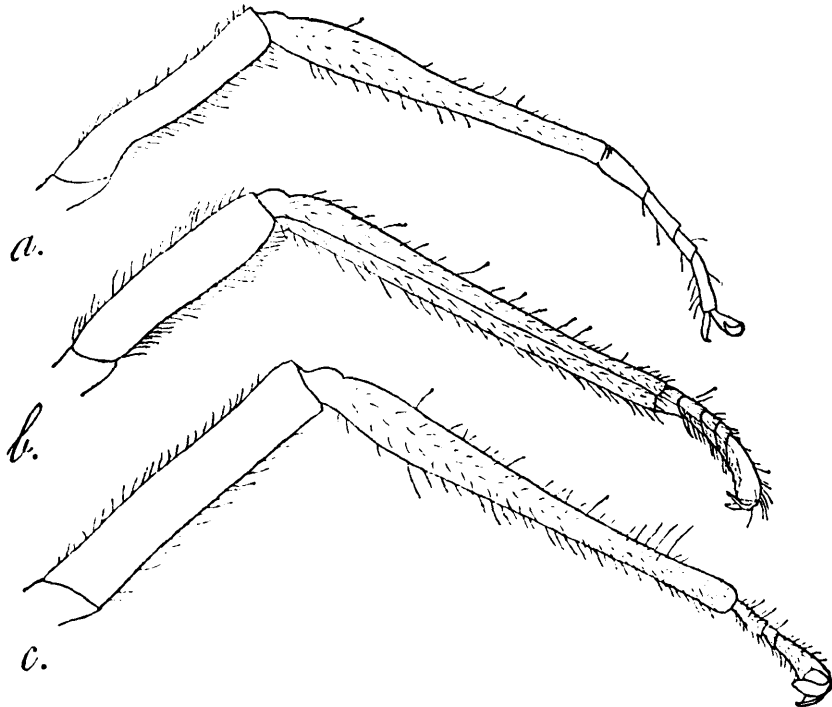
♀ *Sub-imago (in spirit)*.—The body is much paler in colour than that of the male imago. It is raw sienna above in places becoming antique brown to raw umber and is maize yellowish below. The head is dark brown and the eyes are blackish. The pronotum is short and is distinctly transverse. The notum has small irregular short setae of antique brown. The dorsum of the abdomen appears to have the same scheme of colour markings as that of the male but the marginal row of markings is hardly visible. The sub-median and the lateral rows are very well defined. The venter and the sides, as already mentioned, are light maize yellow.

The wings are dull whitish, with a pale tint in certain aspects and the veins are whitish. The sub-marginal area in the fore-wing is grayish. This wing, as compared with that of the male, is slightly longer and narrower, but the venation in the two appears to be more or less identical. The meta-thoracic wing is concolourous with the fore-wing and the venation is exactly like that of the hind-wing of the male.

The legs are more or less of the same colour as the venter (Text-fig. 3). The fore-leg has, however, a dull brownish streak on the femur and another on the tibia. The fore-leg is much shorter than the body; the femur is slightly over $\frac{3}{4}$ as long as the tibia and is somewhat longer than the tarsus. The latter consists of 4 distinct and one indistinct (basal) segments. Of the 4 segments the ultimate is the longest, while the 3rd is the shortest; the first is longer than the 2nd and is considerably shorter than the last. The claw is well developed and the two halves are dissimilar. In the 2nd leg the tibia is twice as long as femur and the tarsus is reduced. Of the 4 distinct segments, the last is by far the longest and the other three are sub-equal. In the last leg the tarsus is further reduced and the segments are not clearly seen.

The setae are dirty whitish with brown joints, which become considerably faded distally.

Along with the specimens described above a large number of cast sub-imaginal skins were also collected. Both sexes are represented



TEXT-FIG. 3.—*Ephemera diffusa* Chopra, sp. nov.

a. 1st leg of female sub-imago : $\times 20$; b. 2nd leg of female sub-imago : $\times 20$; c. 3rd leg of female sub-imago : $\times 20$.

but the females far outnumber the males. The characters briefly mentioned above for male and female sub-imagos are clearly brought out by the specimens. They are transparent, whitish with only certain thoracic parts raw sienna.

Length of body, ♂ imago 10 mm., sub-imago 10.5 mm., skins up to 13 mm., ♀ sub-imago 10.5 mm., skins 11-15 mm., wings ♂ imago 10.5 mm., sub-imago 11 mm., ♀ sub-imago 11 mm.; setae ♂ imago up to 22 mm., sub-imago 16 mm., skins 18 mm., ♀ sub-imago 15 mm., skins up to 13.5 mm.

Nymph not known.

Type specimens.—♂ imago No. $\frac{964}{H8}$, ♂ sub-imago No. $\frac{965}{H8}$, and ♀ sub-imago No. $\frac{966}{H8}$. *Paratypes.*—♂ imagos No. $\frac{969}{H8}$. A fairly large number of cast sub-imaginal skins No. $\frac{970}{H8}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—All the specimens described above were collected by Dr. H. S. Rao in October 1924, sitting on a wall on the bank of the Bhavani river at Bhavani in the Coimbatore district. It is stated by Dr. Rao that the wall was covered with thousands of cast skins of which a few were collected. Also taken at Mettupalliyam, Gravely, 10-vi-1928.

E. diffusa is easily distinguished from *E. immaculata* Eaton¹ by its smaller size and warmer colour and by the penis lobes being shorter. It differs from *E. expectans* (Walk.)² by its more prominent abdominal markings.

¹ Eaton, A. E.—*Trans. Ent. Soc. London*, p. 74 (1871).

² Walker, F.—*ibid.*, 198 (1860).

Ephemera annandalei Chopra, sp. nov.

(Plate V, figs. 1-4.)

A single male specimen in certain respects resembling very closely *E. expectans* (Walk.) is in the collection of the Indian Museum.

♂ probably *Sub-imago* (*in spirit*).—The general colour, as in *E. expectans*, is white but there is considerably more of brown on the dorsal surface. The head is very pale orange yellow, with a few short irregular streaks scattered on it. The eyes are slate gray and the ocelli are white with grayish broad rings at their bases. The pronotum is also pale orange yellow with broad areas along each side suffused with vandyke brown and a distinct fairly broad streak of the same colour on each side. The median area between the streaks is whitish. The mesonotum is mostly whitish but in parts maize yellowish and has two broad curved streaks one on each side. These streaks are continued into broad patches of raw sienna to antique brown. The metanotum is suffused with small brownish spots.

The colour markings of the abdomen are principally very much like those of *E. expectans*, but the streaks are not chocolate but clove brown to blackish brown. The whitish ground surface of the dorsum is much less visible in between the streaks in the present species than in *E. expectans*. In segments 3-9 there are three clearly visible streaks on each side. The sub-median streak is slanting so that it meets its companion of the opposite side at the anterior end of the tergite. The laterals and marginals are more or less straight and run parallel to one another, the latter being quite close to the margin. In the 9th segment these two streaks more or less meet one another so that there appears to be one broad band on each side. In the first two segments the streaks are not differentiated, so that there is a general suffusion of colour. On the 10th tergite there is a blackish square spot on each side in continuation with the side streak and a crescent-shaped arch at the bases of the setae.

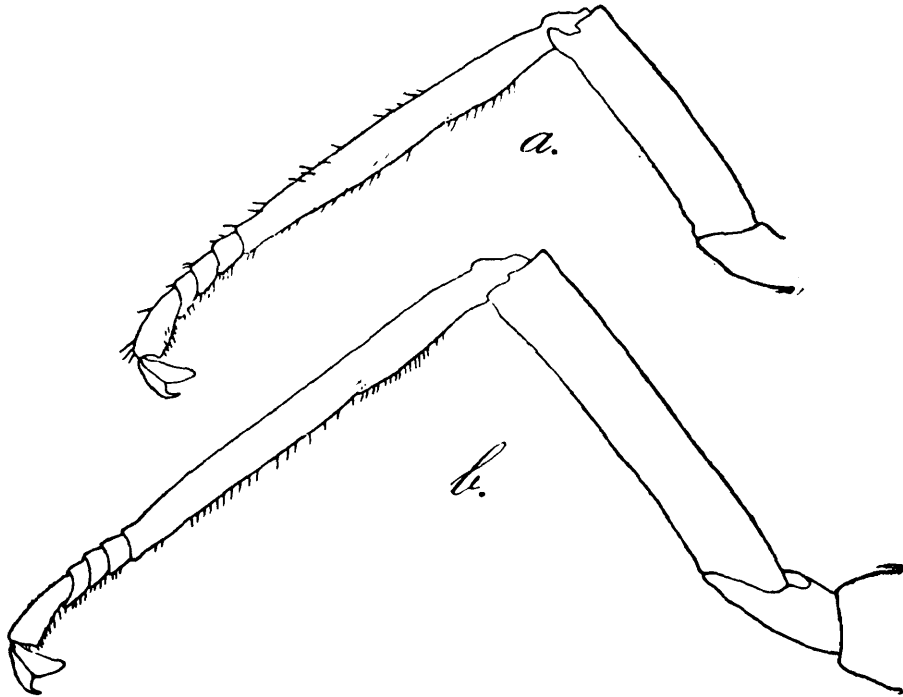
The venter is like that of *E. expectans* there being 2 rows of streaks on the abdomen; those on the 9th being much broader than the others. Between the bases of first legs there is a faint triangular spot. The sides are concolourous with the venter, but in the thorax there is a short streak near the mesothoracic wing-root. On the sides of the abdomen there is a short streak on each segment and some of the spiracles are also encircled with brown.

The wings are dirty-whitish, with the sub-costal area of the fore-wing very pale yellow orange. The membrane is dull but transparent and the longitudinal veins except the *Sc* and *R* are opaque and white. The sub-costa and the first radius are pale yellowish orange. The transverse veins are vandyke brown to warm sepia. There are no transverse veins near the inner margin. At the bifurcation of *M* there is a large and very prominent spot and the other 3 spots are also present in the usual position though considerably smaller than that of *M*. The venation is like that of *E. expectans*, but there are fewer subsidiaries given from *A*₁ to the margin.

The hind-wing is concolourous with the fore-wing and the longitudinal and the transverse veins are also of the same colour. The venation

is typical of the genus and the posterior branch of *M* distinctly arises from *Cu*₁.

The legs are concoloured with the venter and are for the most part devoid of prominent colour markings (Text-fig. 4). In the fore-leg¹



TEXT-FIG. 4.—*Ephemera annandalei* Chopra, sp. nov.

a. 2nd leg of male sub-imago: $\times 22$; b. 3rd leg of male sub-imago: $\times 22$.

the tibia has a longitudinal streak of vandyke brown and one or two of the same colour, but fainter, are present on the femur. The coxa of the 3rd leg has a dark brownish spot on its anterior surface. The fore-tarsi of both the sides are broken but the fore-tibia (as is the case in all sub-imagos) is comparatively shorter, being only slightly longer than the femur. In the 2nd and 3rd legs the tibia is much longer than the femur and the 3 basal joints of the tarsus are sub-equal while the terminal is the longest; a 5th rudimentary joint is hardly differentiated.

The genital forcep is of the same colour as the venter and has a very fine brownish streak along the outer margin. Of the 4 segments, of which it is formed, the basal is short and stout and has a prominent rounded projection on the inner side of its posterior extremity. The second joint is the longest, is curved and slightly grooved ventrally, there being hairs all along the sides of this groove. The last two segments are small, but the penultimate is about twice as long as the last. There is a small and faint brownish streak at the junction of the 2nd and 3rd joints. The concavity formed by the 9th sternite to receive the genital apparatus is fairly deep. The penis lobes are short and triangular with the apices very slightly rounded. The spine-like structure near the bases of the forceps is prominent and is a little larger than the penis lobes. It is finger-like and rounded at the base.

¹ The fore-legs are missing from the specimen and I have not been able to trace them from slides either.

The setae are dirty-whitish on the underside with white joinings near the base. On the upper surface and the outer sides the joints are brown and the general surface is also suffused with brown. Somewhat away from the base there is a brownish patch on each segment besides the ring of the same colour. Near the posterior end the setae are rounded and the joints are brown all round. The median seta is almost as long as the lateral.

Length of body 15 mm., fore-wing 13.5 mm., setae 14.5 mm.

♀ *Imago (in spirit)*.—The colouration of the head, thorax and abdomen is like that of the male, though it is slightly less white, being palish. The abdominal markings are also similar, though somewhat brighter. The wings are transparent and iridescent. The dirty-whitish colour of the wing of ♂ is no doubt due to the specimen being a sub-imago. The yellowish orange tint of the longitudinal veins in the costal region is more well marked than in the ♂.

The colouration and structure of the legs are more or less as in ♂. The wing venation is also apparently like that of the ♂.

Setae are as in male, but broken.

Length of the body 15 mm., fore-wing 15 mm., setae broken but appear to be about 14 mm.

Nymphs not known.

Type specimens.—♂ sub-imago No. $\frac{967}{H8}$ and ♀ imago No. $\frac{968}{H8}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—The single male specimen was collected at Shillong (Assam) at an altitude of 4,500 ft. by Dr. N. Annandale in April 1918. The female specimen was collected by Mr. T. B. Fletcher at Shillong in November 1924.

The species superficially resembles *E. expectans*, but may easily be distinguished from it in having a considerably warmer colour and in the dorsum being more profusely and darkly coloured. The wing membrane is not quite as dull and whitish as in *E. expectans*. The markings on the dorsum of the abdomen are also different in the two species. There are fewer subsidiary veins going to the inner margin from A_1 than in *E. expectans* and the spine-like structure on the side of the penis lobe more pointed and finger-like.

Since Dr. B. Chopra wrote the foregoing description of the present species a large number of female imagos both pinned and in alcohol have been collected by him at light from Lonton, Upper Burma. The tibia of the fore-leg in these specimens has dark chocolate brown rings at the proximal and distal ends. The transverse veins of wings are also dark chocolate brown.

There are two more female specimens in spirit from Namkhai river, Kutkai, North Shan States, Burma (4,500 ft.) collected by Dr. H. S. Rao in November, 1926. The specimens are somewhat damaged and the fore-legs in both the specimens are missing. Setae are broken but the wings are in a fairly good condition. I have placed these specimens under this species with some doubt, as the characteristic abdominal markings are not so very prominent and the general appearance is like that of *E. expectans*. They, however, differ from *E. expectans* by their longer bodies and shorter wing expanse.

There are 5 more pinned females from Nyaungbin, Upper Burma, collected by Dr. B. Chopra in November 1926, which closely resemble *E. annandalei* in their general appearance and wing venation but differ like the specimens from Lonton in having the ends of the tibiae of the fore-legs coloured dark chocolate brown. The broader ungues of the second and third claws are also dark brown as in the specimens from Lonton.

I also refer to this species a female specimen (in spirit) from Sagar, Shimoga district, Mysore, collected at light by Dr. H. S. Rao (l. xii. 1928), a specimen from Danster Wah, Bubak, Sind, collected by Dr. B. Prashad and Dr. B. Chopra (21-23. xi. 1927), and three more females (in spirit) from near Harai, altitude 2,700 ft., Rewa State, collected by Dr. H. S. Pruthi (February 1927). From more or less the same locality (Opposite the Camp at Harai, 2,625 ft., Rewa State, March 1927) Dr. H. S. Pruthi also collected a single male. The male specimen is in a fairly good condition and as Chopra described only the ♂ sub-imago, I give below the description of what I consider to be an adult.

♂ *Imago (in spirit)*.—There is only a superficial difference between the adult and the sub-imago in that the general colouration of the former is much darker than that of the latter.

The front portion of the head is damaged but the general structure appears to be the same as in the sub-imago. The thorax is more darkly coloured, approaching umber brown, especially at the sides of the mesonotum.

The abdominal markings are better defined than in the sub-imago but the abdomen appears to be shorter than that of the sub-imago.

The fore-legs are missing in this specimen. The coxae and femora of the second and third pairs of legs are concolourous with the sides of the thorax. The coxae of third pair of legs on their outer surface have a dark brown spot. The tarsi of both the pairs of legs end in biunguiculate claws. Structurally the second and third pairs of legs are very similar to those of the sub-imago.

The wings are clear and transparent, with the sub-costal area light brown. The longitudinal veins, especially the first three, are conspicuously brown. The transverse veins are also brown. The wing venation is similar to that of the sub-imago.

The genital apparatus is lodged in the concavity of the last abdominal segment, and the general structure is similar to that in the sub-imago. Only one lateral seta of a dirty-whitish colour with brownish joints is present in the specimen.

Length of body 13 mm., fore-wing 12 mm., lateral seta 23 mm.

Distribution.—*E. annandalei* has a fairly wide range of distribution, extending from Upper Burma in the east to Sind in the west and as far down south as Mysore in the Peninsula.

***Ephemera immaculata* Eaton.**

(Plate V, figs. 8-11.)

1871. *Ephemera immaculata*, Eaton, *Trans. Ent. Soc. London*, p. 74, pl. iv, fig. 10.

1883. *Ephemera immaculata*, Eaton, *Trans. Linn. Soc. London*, (2), III, p. 72.

1920. *Ephemera immaculata*, Ulmer, *Entomol. Zeitung. Stettin*. LXXXI, p. 109.

1927. *Ephemera immaculata*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 95,

Eaton's description of *E. immaculata* is too inadequate to enable one to recognise it satisfactorily, but as a number of specimens in the Indian Museum agree fairly closely with Eaton's description I have considered it best to identify them with Eaton's species. The specimens are from Bangalore in South India; Eaton's example came from "Cuna".¹ I have also examined a single male from the same locality captured by Dr. Gravely in May 1921 and preserved in the collection of the Madras Museum.

The general colouration of the specimens is somewhat lighter than that described by Eaton, but this may be due to preservation in spirit for a number of years.

The head and the thorax are pale brownish, the latter being darker than the former. The eyes are grayish and the ocelli are white encircled with chestnut brown. Behind the ocelli there are two short, parallel, longitudinal streaks of a chestnut colour not extending to the anterior margin of the pronotum. The thorax is pale brownish with a few darker streaks. The abdomen is dark, and the tips of the segments and the spiracular lines are considerably darker. The penultimate segment of the abdomen is considerably darker than the rest of the abdomen. The venter and the sides are lighter than the dorsal surface. The lateral margins of the penultimate abdominal sternites are streaked with brown.

The legs are more or less concolourous with the venter. The femur of the fore-leg is considerably lighter than the rest of that limb. The tarsi of all the legs are very light, almost pale whitish. The setae are light brownish, somewhat warmer in the proximal portions.

The wings are spotless; the usual spots on *Sc*, *Rs* and near the fork of *M*, so characteristic of the other species are absent. The membrane of the fore-wing is clear and more or less devoid of colour. The coloured veins, however, make it appear somewhat brownish. The veins are raw sienna to antique brown. The cross veins in the sub-marginal area especially towards the base are considerably darker than in the rest of the wing. The venation is more or less typical of the genus. *Rs* forks well in advance of *M*, the latter dividing somewhat about the middle. The disposition of *Cu*, *A* and their branches is very similar to that of *E. diffusa*.

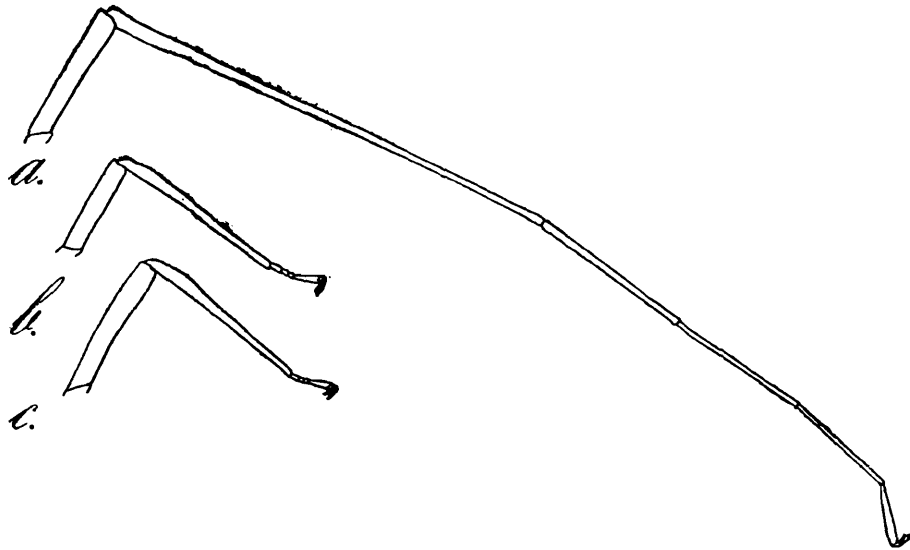
The terminal margin of the hind-wing is coloured raw sienna like the sub-marginal area of the fore-wing. The marginal and sub-marginal areas near the wing root are also lightly tinted. The venation is more or less typical of the genus. The costal projection is very prominent; *Rs* forks near the wing base and the second branch of *M* is joined on to *Cu*. The venation in the hinder portion of the wing, somewhat contrary to rule, is rather well developed, the anals being quite prominent.

The legs are very well developed, those of the first pair being very long (Text-fig. 5). The first legs are broken in all the specimens. The tibiae and the tarsi of the second and the third pairs of legs are reduced.

¹ I have not been able to trace "Cuna", it may probably be a *lapsus calami* for Guna in Gwalior.

The mid-tarsus consists of 5 segments; the first joint is rudimentary and the terminal is by far the longest. The third leg is similar to the second.

The genital apparatus is very like that of *E. diffusa*. The forceps are concolourous with the venter and have the usual structure. The



TEXT-FIG. 5.—*Ephemera immaculata* Eaton.

a. 1st leg of male: $\times 10$; b. 2nd leg of male: $\times 10$; c. 3rd leg of male: $\times 10$.

terminal segment appears slightly shorter than the sub-terminal. A shallow protuberance is visible along the outer side of the base of the second segment. The spine of the 10th sternite near the base of the forceps is fairly well developed. The cup-like concavity of the last sternite formed for the genital apparatus is rather shallow. The penis lobes are finger-shaped structures arising from a quadratic basal area and are proportionately longer than those in *E. diffusa*; the spines on their inner sides are considerably longer than the lobes themselves.

The three setae have the usual structure and are sub-equal in length. They are light brown near their bases, but become lighter distally.

There are no females or nymphs in the collection before me.

Length of body $\text{\textcircled{m}}$ imago up to 12 mm., fore-wing up to 11.5 mm.; setae missing in most of the specimens.

Distribution.—Eaton's type which is stated to be in the Hope Museum, Oxford, came from Cuna, but this is possibly a misprint for Guna in Gwalior. The specimens that I assign to *E. immaculata* are from Bangalore (alt. ca. 3,000 ft.) and most of them were collected by the late Dr. Annandale in October 1910. All these specimens are males. Also taken at Bangalore (alt. ca. 3,000 ft.) by Dr. Gravely in May 1921.

Remarks.—*E. immaculata* as described above seems to resemble the South Indian *E. diffusa* in several respects. It is, however, slightly larger in size and is of a much lighter colour. The wing membrane is very differently coloured, and the male genitalia are very different.

Ephemera expectans (Walker.)

1860. *Potamanthus expectans*, Walker, *Trans. Ent. Soc. London*, (n. s.) V, p. 198.
 1871. *Ephemera expectans*, Eaton, *Trans. Ent. Soc. London*, p. 74.
 1883. *Ephemera expectans*, Eaton, *Trans. Linn. Soc. London*, (2) III, p. 72.
 1913. *Ephemera vedana*, Banks, *Proc. Ent. Soc. Wash.* XV, pp. 137-138.
 1920. *Ephemera expectans*, Ulmer, *Entomol. Zeitung. Stettin.* LXXXI, p. 109.
 1927. *Ephemera expectans*. Lestage, *Ann. Soc. Ent. France* XCVI, p. 95.

♂ *Imago (in spirit)*.—There is a single male specimen from Naukuchia Tal (alt. 4,200 ft.), Kumaon Hills, collected by Dr. S. W. Kemp (5. v. 1911). It agrees with previous descriptions of the species, except for the colouration. This difference, however, may be due to the specimen having been in spirit since 1911. The measurements of this specimen are:—Length of body 13.5 mm., wing 12 mm.

I also refer to this species a large number of rather damaged adult females collected by Dr. B. Chopra (12-15. xi. 1926) from Chaungwa, Upper Burma. These specimens closely agree with Eaton's description in his well known monograph. Their measurements are almost identical with those of the female sub-imagos described by Eaton. I have also seen five male specimens preserved in the Madras Museum and collected by Gangadaran from Mysore in November 1925.

Ephemera supposita Eaton.

(Plate V, figs. 5-7.)

1858. *Potamanthus fasciatus*, Hagen, *Verh. Zool. Bot. Gessells. Wien.* VIII, p. 476.
 1871. *Ephemera fasciata*, Eaton, *Trans. Ent. Soc. London*, pp. 74-75, pl. iv, figs. 11, 11a.
 1883. *Ephemera supposita*, Eaton, *Trans. Linn. Soc. London*, (2), III, pp. 72-73, pl. viii, fig. 12c.
 1891. *Ephemera supposita*, Eaton, *Journ. As. Soc. Bengal*, LX, pp. 409-410.
 1920. *Ephemera supposita*, Ulmer, *Entomol. Zeitung. Stettin.* LXXXI, p. 109.
 1921. *Ephemera supposita*, Ulmer, *Arch. f. Naturg.* LXXXVII, p. 261.
 1924. *Ephemera supposita*, Lestage, *Ann. Soc. Ent. Belgique*, LXIV, p. 39.
 1927. *Ephemera supposita*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 97.

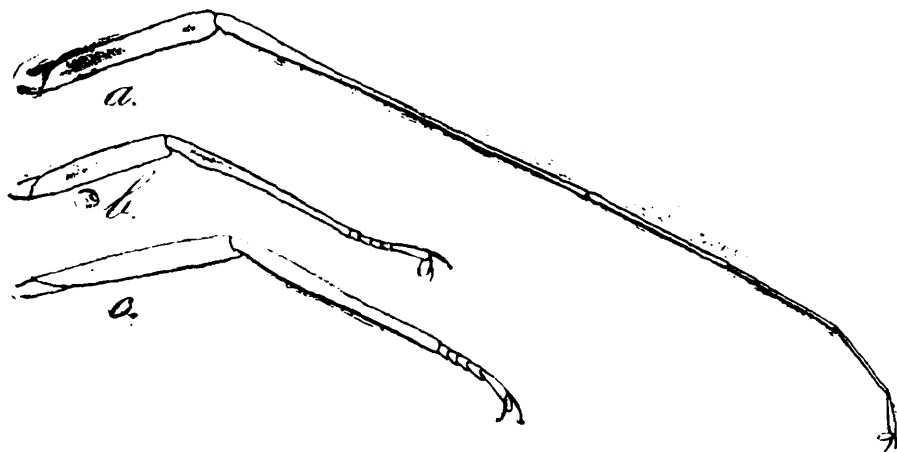
None of the specimens identified by Eaton as *E. supposita* are preserved in the collection of the Indian Museum.

Three pinned males collected in the Malabar district in South India and preserved in the collections of the Madras Government Entomologist at Coimbatore are referred to this species. The 3 specimens, which were examined by Dr. Chopra, the present Government Entomologist at Coimbatore informs me, are not present in his collections. I, however, give below a few notes Dr. Chopra made while examining the specimens together with the figures which were prepared under his supervision.

“ In general colouration the specimens agree closely with the published accounts. The general tint of the dorsum is more of vandyke brown than bistre, but this may be due to the fact that Eaton's examples were, as stated by him, faded. The head is considerably darker than the rest of the body, and there are two dark squarish patches near the posterior margin of the pronotum. The mesonotum is lighter in colour (approaching testaceous) than the abdomen and the metanotum

is in places still lighter. The colour pattern of the abdomen seems to agree closely with Eaton's account. The venter is somewhat lighter than the dorsum.

The fore-legs in two specimens are missing, while only one is present in the third (Text-fig. 6). The femur is brownish, while the tibia,



TEXT-FIG. 6.—*Ephemera supposita* Eaton.

a. 1st leg of male : $\times 9$; b. 2nd leg of male : $\times 9$; c. 3rd leg of male : $\times 9$.

especially towards its distal end, is considerably darker. The tarsus is also dark brown. Hind-legs are much lighter in colour, yellow-umber, as described by Eaton and have the ungues considerably darker.

The setae are umber brown proximally, and the distal parts are yellow. The joints are reddish brown to blackish.

The colouration of the wings is exactly as described by Eaton and the four colour spots described by him are well seen. The venation is quite typical of the genus.

The hind-wing is coloured like the fore-wing. The sub-costal vein is brown. The other longitudinal and cross veins are as in the fore-wing. The terminal margin, as also a part of the inner margin is clouded with grayish colour, very lightly tinted with brown.

The genital forceps are as described by Eaton ; they are dull yellowish in colour (with a slight shade of brown) and the two terminal joints are black.

Length of body, ♂ 17 mm., fore-wing 16.5 mm., setae 39 mm."

I refer to this species 3 specimens (in spirit). They were all collected from Peradeniya, Ceylon, 1,500 ft. by Drs. N. Annandale & F. H. Gravely. Two are males and the third is a female. The female appears to be a sub-imago and is in a damaged condition. One of the males also appears to be a sub-imago. It is 15 mm. long, and in general characters is very similar to previous descriptions.

The female sub-imago is only 13 mm. long. Its general colouration is lighter than that of the ♂ sub-imago.

Locality.—The three pinned specimens that were referred to this species by Dr. B. Chopra were lent to him for examination by the Madras Government Entomologist at Coimbatore. Two of these were collected at Santhanatbod in the Malabar district at an altitude of 2,500 ft. in the month of October 1917. The third specimen came from near a stream at Taliparamba and was captured in October 1908. All the specimens

were dry males and were said to be in quite a good state of preservation. A single male specimen was also collected by Dr. Gravely from Kodaikanal, Palni Hills (alt. *ca.* 6,500—7,500 ft.) in May-June 1926 and is preserved in the Madras Museum. Eaton's specimens were from Rambodde, Ceylon.

Ephemera remensa Eaton.

1891. *Ephemera remensa*, Eaton, *Journ. As. Soc. Bengal*, LX, pp. 410-412.

1920. *Ephemera remensa*, Ulmer, *Ent. Zeitung. Stettin*. LXXXI, p. 109.

1927. *Ephemera remensa*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 96.

Of the five male imagos from Kulu on which Eaton based his description of this species only three pinned specimens are preserved in the collections of the Indian Museum. All the specimens are in a pretty bad condition, the abdomen and the head of one being completely lost and in the other two badly damaged. The wings in the specimen without the abdomen and the head are, however, in a good state of preservation. In the spirit collection there are a few fragments of another specimen, including a portion of the male genital apparatus and a leg.

Typespecimens.—Nos. $\frac{6942-43}{1}$, $\frac{6946}{1}$ and $\frac{6948}{1}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—Kulu, Western Himalayas.

Ephemera consors Eaton.

1891. *Ephemera consors*, Eaton, *Journ. As. Soc. Bengal*, LX, pp. 412-413.

1920. *Ephemera consors*, Ulmer, *Ent. Zeitung. Stettin*. LXXXI, p. 109.

1927. *Ephemera consors*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 99.

Of the two ♂ imagos and two ♀ sub-imagos from the Indian Museum on which Eaton based his description of the species only one male imago and one female sub-imago (both pinned) are available in the Indian Museum collections. The specimens are in a very poor condition, the sub-imago having lost its abdomen completely. The imago too possesses only a portion of the abdomen. The wings in both the specimens are, however, in good condition and so are some of the legs.

Typespecimens.—Nos. $\frac{5852}{5}$ and $\frac{5855}{2}$, Zoological Survey of India (*Ind. Mus.*).

Locality.—Kulu, Western Himalayas.

Ephemera pulcherrima Eaton.

1892. *Ephemera pulcherrima*, Eaton, *Trans. Ent. Soc. London*, pp. 185-186.

1927. *Ephemera pulcherrima*, Lestage, *Ann. Soc. Ent. France*, XCVI, p. 99.

I have not so far seen any specimen belonging to this species. From Eaton's description, which is fairly detailed, the species appears to resemble *E. annandalei* described in this paper as new. Eaton's species is, however, much smaller, measuring 12 mm. in length while *E. annandalei* is 15 mm. long. The single female on which Eaton based his description is probably in the British Museum, and came from Tenasserim Valley.

Genus **Hexagenia** Walsh.**Hexagenia indica** Chopra.

1924. *Hexagenia indica*, Chopra, *Rec. Ind. Mus.* XXVI, pp. 416-418.

H. indica is the only species of the genus *Hexagenia* Walsh. so far described from India. There are altogether eleven specimens belonging to this species in the Indian Museum collections. All the specimens are females, the male being unknown, and two of them are pinned. The specimens were collected by the late Dr. Annandale on the surface of the Chilka Lake off Barkuda Id. in August 1919.

Family POTAMANTHIDAE.

Of the seven known genera of the family only four, *viz.*, *Potamanthus* Pict., *Rhoenanthus* Etn., *Rhoenanthodes* Lest. and *Potamanthodes* Ulm. have so far been recorded from India. A useful key is provided by Lestage in his "Contribution a L'Etude des Larves des Ephemeropteres" for recognising the genera and species. As stated in the introduction, I have not so far seen any mayflies belonging to this family.

Genus **Potamanthus** Pictet.**Potamanthus subcostalis** Navas.

1932. *Potamanthus subcostalis*, Navas, *Rev. Acad. Cienc. Zaragoza*, XV, pp. 17-18.

This species appears to have been described from females only and the locality is given as Khandala (Bombay).

Genus **Rhoenanthus** Eaton.**Rhoenanthus posticus** Bks.

1914. *Rhoenanthus posticus*, Banks, *Proc. Acad. Nat. Sc. Philadelph.* LXVI, p. 613.

1930. *Rhoenanthus posticus*, Lestage, *Mem. Soc. Ent. Belgique*, XXIII, p. 131.

This species described by Banks was recorded from Kandy, Ceylon.

Genus **Rhoenanthodes** Lestage.**Rhoenanthodes amabilis** (Eaton).

1892. *Rhoenanthus amabilis*, Eaton, *Trans. Ent. Soc. London*, pp. 188-189.

1925. *Rhoenanthus amabilis*, Ulmer, *Arch. f. Naturg.* XCI, heft V, p. 100.

1930. *Rhoenanthodes amabilis*, Lestage, *Mem. Soc. Ent. Belgique*, XXIII, p. 136.

This species was originally described by Eaton under the genus *Rhoenanthus* from a single ♂ imago (dried) collected from the Tenasserim Valley. Lestage has, however, created a new genus *Rhoenanthodes* to accommodate this species and has redescribed it. The species, as Lestage redescribed it, is also known to occur in China and Tonkin.

Genus **Potamanthodes** Ulmer.**Potamanthodes formosus** (Eaton).

1892. *Potamanthus formosus*, Eaton, *Trans. Ent. Soc. London*, pp. 186-188.

1919. *Potamanthodes formosus*, Ulmer, *Arch. f. Naturg.* LXXXV, heft XI, p. 11.

1925. *Potamanthodes formosus*, Ulmer, *Arch. f. Naturg.* XCI, heft V, p. 98.

1930. *Potamanthodes formosus*, Lestage, *Mem. Soc. Ent. Belgique*, XXIII, p. 139.

Eaton based his description of the species on dried male and female imagos. Ulmer in 1920 redescribed the species and referred it to his new genus *Potamanthodes*. Eaton's specimens came from the Tenasserim Valley and the species has since been recorded from Japan, China, Tonkin and Formosa.

The following is a list of Indian Ephemeroptera of the sub-order Ephemeroidea which have been described in journals I have not been able to consult and specimens of which I have not so far seen :

Family Palingeniidae.—*Anagenesia birmanica* Navas, *Mem. Accad. Nuovi Lincei* (2), XVI, p. 954, 1932 (Burma).

Family Polymitarcidae.—*Polymitarcys birmanus* Navas, *Mem. Pont. Accad. Sci.* (2), XVII, p. 87, 1933 (Burma).

Family Ephemeridae.—*Ephemera fulvata* Navas, *Broteria Ci. Nat.*, XXXI, pp. 100-101, 1935. (Lonawla near Khandala, Bombay).

REFERENCE TO LITERATURE.

[The following list is supplementary to the bibliography published by Chopra in 1927.]

- Chopra, B., 1924.—The Ephemeroptera of Barkuda Island. *Rec. Ind. Mus.* XXVI, pp. 416-418.
- Chopra, B., 1927.—The Indian Ephemeroptera. *Rec. Ind. Mus.* XXIX, pp. 91-138, pls. viii-x.
- Hora, S. L., 1929.—Swarming of Ephemeroptera and lunar periodicity. *Journ. As. Soc. Bengal*, XXIII, pp. 339-341.
- Lestage, J. A., 1927.—Une *Ephemera* nouvelle du Tonkin et tableau des espèces de la faune orientale. *Ann. Soc. Ent. France*, XCVI, pp. 93-100.
- Lestage, J. A., 1930.—Contribution à l'Etude des Larves des Ephemeropteres—Le groupe Potamanthidien. *Mem. Soc. Ent. Belgique*, XXIII, pp. 73-146.
- Navas, R. P. L., 1932.—Comunicaciones Entomologicas. *Rev. Acad. Cienc. Zaragoza*, XV, p. 17.
- Navas, R. P. L., 1932.—“Description of *Anagenesia birmanica* sp. nov. from Burma” *Mem. Accad. Nuovi Lincei* (2), XVI, p. 945.
- Navas, R. P. L., 1933.—“Description of *Polymitarcys birmanus* sp. nov. from Burma” *Mem. Pont. Accad. Sci.* (2), XVII, p. 87.
- Navas, R. P. L., 1935.—“Description of *Ephemera fulvata* sp. nov. from Bombay” *Broteria Ci. Nat.* XXXI, pp. 100-101.
- Needham, J. G., Traver, J. R. and Hsu, Y. C., 1935.—“The Biology of May-flies” (New York).
- Ulmer, G. 1930.—Key to the genera of Ephemerida. *Peking Nat. Hist. Bull.* IV, pp. 1-18.
- Ulmer, G., 1932.—Bemerkungen über die seit 1920 neu aufgestellten Gattungen der Ephemeropteren. *Stettin. Entomol. Zeitung*, XCIII, pp. 204-219.
- Ulmer, G., 1933.—Revised key to the genera of Ephemeroptera. *Peking Nat. Hist. Bull.* VII, pp. 195-218, pls. i-ii.