

II. THE INDIAN SPECIES OF PAPATACI FLY (*PHLEBOTOMUS*)

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INTRODUCTION.

The importance of the genus *Phlebotomus* from a medical point of view has recently been demonstrated by Grassi and others so far as southern Europe is concerned, and there can be little doubt that in India too fevers of a certain type are carried by these flies, which, in common with several others, are commonly known as "sand-flies" in this country. The descriptions of the species described below are based on specimens in the collection of the Indian Museum, some of which have been sent me by Mr. F. M. Howlett, Second Imperial Zoologist; but I have been able to examine all the species except *P. papatasi* in a living condition. The types of all the species except *P. papatasi* and *P. perturbans* are preserved in the Indian Museum. My thanks are due to Mr. E. Brunetti for much assistance.

The study of the material at my disposal has convinced me of the necessity of *not* relying solely on pinned specimens in examining minute and delicate insects such as *Phlebotomus*. Not only do certain structures shrivel and become distorted when dried, but it is impossible to make out the exact arrangement of others without proper examination under a high power of the microscope. So delicate, for example, is the venation of the wing of some species of *Phlebotomus* that its details cannot be seen unless the wing is dealt with in the manner in which any similar organ belonging to any animal but an insect would be dealt with, that is to say, unless it is mounted on a glass slide under a cover-slip in a suitable medium, after having been artificially stained. Pinned specimens even of *Phlebotomus* are valuable, as showing the natural colour and appearance of the insect; but specimens preserved in spirit are much more valuable, as enabling structural characters to be investigated with greater ease and surety.

As Mr. Howlett is working at the habits of the Indian *Phlebotomi*,¹ I need only say that specimens are to be found in the corners of bathrooms during the day and round the lamp at night; but a few hints as to their collection and preservation

¹ For full details regarding one Indian species (*viz.*, *P. papatasi*) see Grassi's "Ricerche sui Flebotomi" in the memoirs of the Italian Society of Science (1907) and also Doerr, Franz and Taussig's *Das Pappatacifeber* (Leipzig and Vienna, 1909).

may be useful. The most satisfactory method, so far as my experience goes, is the following :—Take a small glass tube full of strong spirit and a fine camel's hair brush. Dip the latter in the spirit and lightly touch the *Phlebotomus* as it rests on a wall or table. It will adhere to the brush and may then be washed off in the spirit, in which it may be permanently preserved.

Dried specimens should be pinned in the same way as mosquitoes, but, owing to their small size, this is a difficult process. Specimens packed loose in a pill box with tissue paper crumpled up not too tightly are, however, useful, provided that there is a considerable number of them.

When the specimens preserved in spirit have to be examined, they may be carefully removed to a watch-glass and examined superficially under a low power of the microscope. After such details have been made out as can be made out in this way, a specimen should be removed to a small stoppered bottle of absolute alcohol,¹ care being taken that it is not allowed to dry up during the process and that the stopper is not left out of the bottle of absolute alcohol longer than is necessary.

After the *Phlebotomus* has remained in absolute alcohol for about half an hour it should be removed to a watch-glass containing oil of cloves, in which it must be left until it is quite transparent. Important details can often be made out while it is in this watch-glass, for the point of view can be readily altered. Finally the specimen should be mounted in canada balsam under a thin cover-slip in the ordinary way. It will then be possible to study the general form and also such structures as the antennæ, limbs and genitalia with comparative ease.

To render the wings fit for detailed study, however, it is necessary to stain them artificially. While the specimen is in spirit in a watch-glass they should be snipped off at the base by a fine pair of scissors and carefully transferred to some preparation of hæmalum or hæmatoxylin. I find Ehrlich's acid hæmatoxylin, Delafield's hæmatoxylin and Mayer's hæmalum all good for the purpose. Although these stains are rapid in their action, it is as well to leave the wing in them for about twenty-four hours. After this it should be washed in tap-water, removed to 70 % spirit, in which it need only remain for a few minutes, and then to absolute alcohol. Finally it should be cleared in oil of cloves and mounted in canada balsam. Owing to the toughness of the wings, in spite of their apparent delicacy, it is not necessary to pass them through different strengths of alcohol in the process of dehydration.

¹ In the damp climate of many parts of India absolute alcohol absorbs atmospheric moisture with great rapidity ; but this may be remedied by keeping the bottom of the bottle in which the absolute alcohol is stored covered with a layer of burnt (*i.e.*, dehydrated) copper sulphate. The copper sulphate in this condition is white ; when it begins to turn green in the alcohol, it is clear that the alcohol is absorbing water, which is again being absorbed by the copper sulphate. In this case the alcohol should be poured off and freshly burnt copper sulphate placed in it ; or the old powder may be removed, burnt again and replaced.

LIST OF KNOWN SPECIES OF *PHLEBOTOMUS*
AND OF PAPERS IN WHICH THEY ARE
DESCRIBED.

SPECIES.

<i>Europe.</i>	<i>Phlebotomus papatasi</i> , Scopoli (1, 9) (S. Europe).
	,, <i>minutus</i> , Rondani (2)
	,, <i>mascittii</i> , Grassi (10) (Italy).
	,, <i>tipuliformis</i> , Meunier (5, 6) (fossil in Baltic amber).
<i>America.</i>	,, <i>vexator</i> , Coquillet (8) (Maryland).
	,, <i>cruciatus</i> , ,, (8) (Guatemala).
<i>Africa.</i>	,, <i>duboscqui</i> , Neveu-Lemaire (7) (Soudan).
<i>Asia.</i>	,, <i>papatasi</i> , Scopoli (15) (Northern India; ? Java).
	,, <i>himalayensis</i> , sp. nov. (lower Himalayas).
	,, <i>malabaricus</i> , sp. nov. (Travancore, S. India).
	,, <i>perturbans</i> , Meijere (15) (Java; base of Eastern Himalayas).
	,, <i>babu</i> , sp. nov. (plains of India).
	,, <i>major</i> , sp. nov. (outer Himalayas; Paresnath, W Bengal).
	,, <i>argentipes</i> , Annandale and Brunetti (11) (p'ains of India).

LITERATURE.

1. 1786. Scopoli: *Deliciæ faunæ et floræ insubricæ*, etc. [*P. papatasi* described.]
2. 1843. Rondani: *Ann. Soc. ent. France* (11), vol. i, p. 263. [*P. minutus* described and *P. papatasi* redescribed.]
3. 1864. Loew: *Fauna Austriaca*, Dipt. 11, p. 630. [A general description of the genus.]
4. 1903. Kertész: "Psychodidæ" in *Katalog der Palaarktischen Dipteren*, i. [A bibliography of the genus.]
5. 1905. Meunier: *Ann. Mus. Hung.*, iii, p. 254. [*P. tipuliformis* described.]
6. 1906. ,, *Naturaliste*, p. 103. [*P. tipuliformis* described as a type of a new genus (*Phlebotomiella*) I think unnecessarily.]
7. 1906. Neveu-Lemaire: *Bull. Soc. zool. France*, xxxi, p. 64. [*P. duboscqui* described.]
8. 1907. Coquil et: *Ent. News*, Philadelphia, Pa., p. 101. [*P. vexator* and *P. cruciatus* described.]

9. 1907. Grassi: *Mem. d. Soc. ital. d. Sci.* (iii), xiv, p. 353. [*P. papatasi* fully redescribed with many figures.]
10. 1908. Grassi: *Att. Reale Accad. Lincei* (v), vol. xvii, fasc. 12, 2nd senestre, p. 68. [*P. mascittii* described.]
11. 1908. Annandale: *Rec. Ind. Mus.*, vol. ii, p. 101. [*P. argentipes* described.]
12. 1909. Doerr, Franz and Taussig: *Das Pappataciefieber* (Leipzig and Vienna).
13. 1909. Austen: *African Bloodsucking Flies*, pl. i, fig. 4 (B. M., London). [*P. duboscqui* figured.]
14. 1909. Annandale: *Nature*, vol. 81, p. 518. [*P. papatasi* recorded from India.]
15. 1909. Meijere: "Blutsaugende Micro-Dipteren," *Tijd. voor Entom.*, vol. lii, p. 191. [*P. perturbans* and *P. angustipennis* (synonym of *P. papatasi*?) described.]

TAXONOMIC POSITION OF *PHLEBOTOMUS* AND ITS SPECIES.

FAMILY PSYCHODIDÆ.

Small Nematocera with relatively large wings, which are densely covered with scales or hairs. At least six longitudinal veins present in addition to the costal (anterior border) and sub-costal; cross-veins few in number, often practically invisible, absent from the distal part of the wing.

Subfamily Phlebotominæ.

Psychodidæ in which the second longitudinal vein has either two or three branches, which arise at a considerable distance from the point at which the main branch of the vein is joined to the third longitudinal vein. Female devoid of a horny ovipositor; the external genitalia of the male consisting of at least three pairs of appendages in addition to an intromittent organ. Genera—*Phlebotomus*, **Nemopalpus*, *Sycorax*, *Trichomyia*, *Eatonisca*, *Diplonema*.*

Subfamily Psychodinæ.

Psychodidæ in which the lowest of the three branches of the second longitudinal vein always present is very distinct from the two upper ones, and joins the middle branch at a point nearer the base of the wing than the apex. Females with a horny ovipositor consisting of two longitudinal valves; external genitalia of the male consisting of two pairs of appendages. Genera—*Psychoda*, **Pericoma*.*

The genera whose names are marked with a * are known to occur in India. They may be distinguished as follows:—

PHLEBOTOMINÆ—

A. Wings broadly heart-shaped, densely covered with scales; mouth not forming a proboscis

Diplonema.

B. Wings relatively narrow, devoid of scales except at the base; mouth parts forming a proboscis

Phlebotomus.

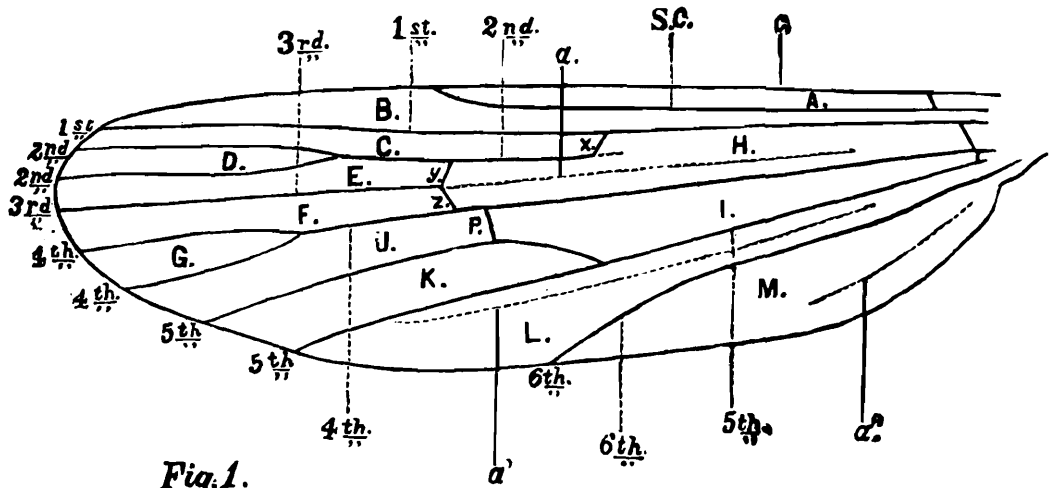


Fig. 1.

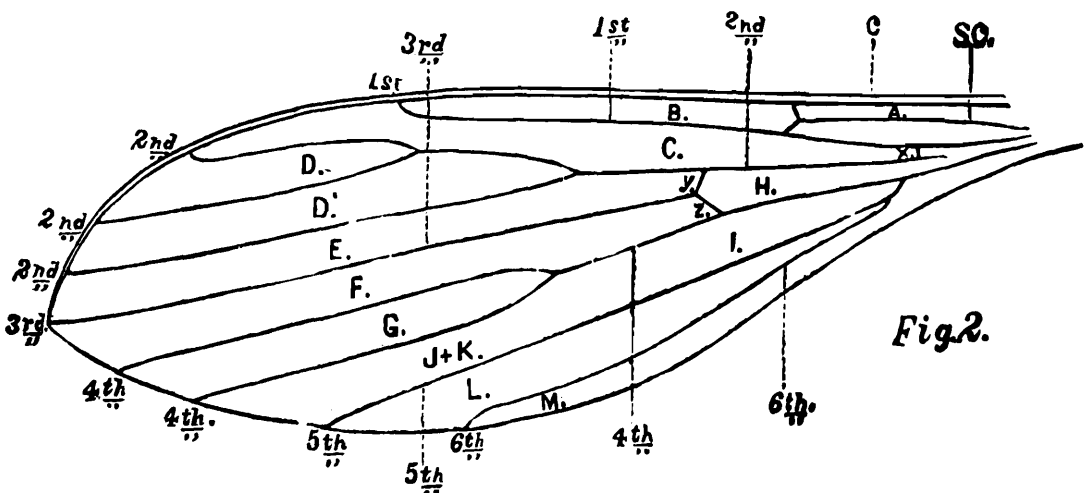


Fig. 2.

FIG. 1.—Wing of *Culex* (after Theobald). FIG. 2.—Wing of *Phlebotomus*.

c., costal vein; s.c., subcostal; 1st to 6th, first to sixth longitudinal veins; a, a', and a'', incassations (a' called by Austen the 6th vein, a'' the 8th); y., supernumerary cross-vein; z., mid cross-vein; P., posterior cross-vein; A., costal cell; B., subcostal cell; C., marginal cell; D., first submarginal cell; E., second submarginal cell; F., first posterior cell; G., second posterior cell; J., third posterior cell; K., anal cell; H., first basal cell; I., second basal cell; L., auxiliary; M., spurious cell.

PSYCHODINÆ—

A. The third longitudinal vein runs to the apex of the wing, dividing the wing into two approximately equal halves

Psychoda.

B. The third longitudinal vein terminates distally at a point below the apex of the wing

Pericoma.

Wing— *Some Diagnostic Characters.*

There is some dispute as to the proper nomenclature of the venation of the wing of the Psychodidæ; but I think it will be sufficient for the purposes of this paper if I compare the wing of *Phlebotomus* with that of the Culicidæ, for not only are the Psychodidæ (and especially *Phlebotomus*) closely allied to that family, but more attention has perhaps been paid to the anatomy of the Culicidæ in recent years than to that of any other group of Diptera. I have therefore reproduced the figure of the wing of *Culex* (fig. 1) given by Theobald in the first volume (p. 18) of his *Monograph of the Culicidæ* side by side with one of the wing of *Phlebotomus* (fig. 2) on which the same lettering is used.

In accordance with Theobald's figure and with the views of many diptero'ogists, the thickened anterior or upper border of the wing is called the costa, while the short parallel vein running immediately below it is called the subcosta. The first parallel vein that reaches the distal margin of the wing is known as the first longitudinal, those posterior to it being numbered in numerical succession. In both genera six longitudinal veins can be distinguished.

The subcosta in *Culex* turns upwards at the tip and joins the costa, while in *Phlebotomus* it turns downwards and joins the first longitudinal. This is a point that will be considered later when the cross-veins are discussed. There is no radical difference as regards the first longitudinal in the two genera except that in the Psychodid it turns upwards at the tip and so assumes a superficial resemblance to the subcosta in *Culex*, in which it turns downwards. In *Culex* the second longitudinal forks once, while in *Phlebotomus* it forks twice. In both genera the third longitudinal is simple and practically straight; it is much longer in the Psychodid than in *Culex*. The fourth longitudinal is once forked in both genera, but the fifth is simple in *Phlebotomus* and bears a branch in *Culex*; in both genera the sixth longitudinal is simple and directed downwards at the distal end.

The cross-veins are easily detected in *Culex*, but in *Phlebotomus* they are very difficult to see owing to their extreme delicacy. In stained preparations, however, their exact position can be detected, at any rate in some specimens. The most noticeable difference as regards them is that while in *Culex* the more important cross-veins are situated on the distal part of the wing, in *Phlebotomus* they are confined entirely to the proximal part. Considering first the anterior half of the wing, we find in *Culex* a minute cross-vein (the "humeral" cross-vein, not numbered or lettered in the diagrams) joining the subcosta to the costa. In *Culex* it is situated near the base of the wing, while in *Phlebotomus* it is practically at the distal end of the very short subcosta, which therefore appears to be forked. A careful examination shows, however, that the lower branch of the apparent fork is really in continuity with the main stem of the vein, while the cross-vein proceeds

from it at a distinct angle. In *Phlebotomus* this cross-vein is of extreme delicacy and, unlike the other veins, it is not provided with a double line of hairs. It can only be seen after prolonged staining of the wing, and even then is faint and indistinct. The next transverse vein that is apparent joins the base of the second longitudinal to the first and is marked x in the diagrams; it is further from the base of the wing in *Culex* than it is in *Phlebotomus*. Strictly speaking this is not a distinct vein but an upturned portion of the lower vein. The base of the third longitudinal in both genera ends in a small fork, one branch joining the vein to the second longitudinal, the other to the fourth. The former branch is called by Theobald the supernumerary cross-vein, the latter the mid cross-vein. In *Phlebotomus*, however, the lower branch appears to be in actual continuity with the vein, while the upper one joins it at an angle. This is more distinct in some species than in others. In *Culex* the fourth and sixth longitudinals do not appear to be joined together at the base; but in *Phlebotomus* the fifth arises from the base of the sixth, as can be seen distinctly in some species, while it is connected with the fourth by a short cross-vein close to its base.

The venation of *Phlebotomus*, taking into consideration the above facts, may therefore be said to resemble that of *Culex* in some essential points, but to differ from it mainly in the fact that the cross-veins are extremely delicate and are situated exclusively on the proximal part of the wing.

From a systematic point of view, as regards specific differentiation, the most important feature in the venation is the relative proportions between the length of the upper branch of the second longitudinal, the distance between the two forks of this vein, and that between the proximal fork and the point at which the vein is joined by the mid cross-vein to the third longitudinal.

In *Phlebotomus*, but not in some of its allies (e.g., *Diplonema*), the wing is almost devoid of scales, a few of which occur at the extreme base on the costal and lower borders and on those veins which reach the base. Each vein except the small cross-vein that joins the subcostal to the costal, bears a double row of fine hairs, and the edge of the wing is deeply fringed with longer hairs.

External genitalia—

The visible female genitalia in *Phlebotomus* are simple in structure, consisting of two pairs (a superior and an inferior pair) of compressed, more or less leaf-like appendages covered with sensory hairs. They offer in their shape and proportions features of diagnostic importance but become shrivelled and distorted in dried specimens. There is no horny ovipositor such as is found in *Psychoda* and *Pericoma*.

The male genitalia are far more complicated and of much greater systematic importance. It is possible, moreover, to trace their specific differences even in specimens which have been dried, but even such specimens should be mounted in canada balsam for

a proper examination. It is difficult to homologize the different appendages exactly with those of other Diptera, because in all families great differences, often of no more than specific value, occur in different species. It is better, therefore, not to use technical terms in describing these appendages. In the male

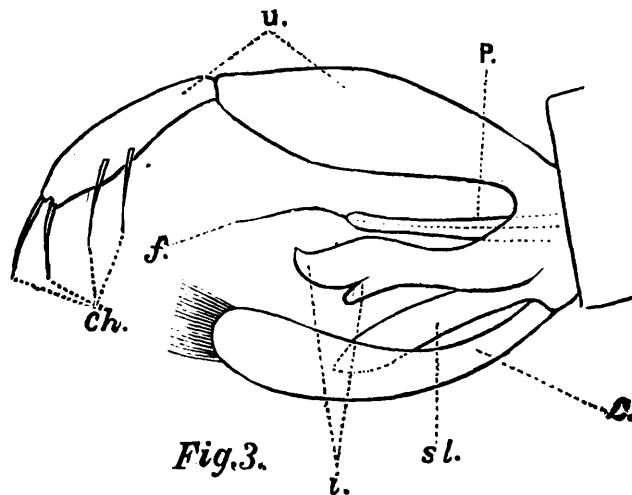
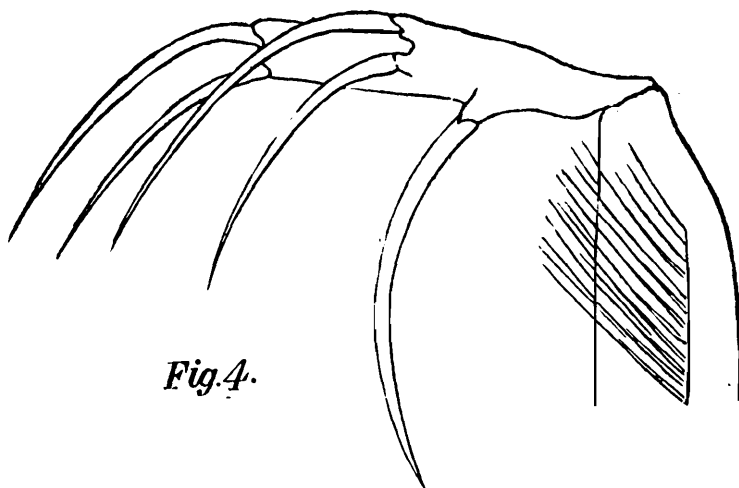


Diagram of the external male genitalia of *Phlebotomus*: u., upper or superior appendage; ch., chætæ; f., genital filament; i., intermediate appendage; P., intromittent organ; s.l., subgenital lamella; L., lower or inferior appendage.

genitalia of *Phlebotomus* five pairs of organs can be distinguished. They are shown in the accompanying diagram (fig. 3) which is a generalized sketch of the whole apparatus as seen from the right side and does not represent the organs of any one species. The



Distal joint of superior male appendage of *P. argentipes*, showing the chætæ.

uppermost appendage has two joints, the posterior (distal) of which bears a varying number of stout chætæ (fig. 4). The form, position and number of these chætæ are valuable diagnostic points. The intermediate appendage is morphologically a branch of the superior one but has often more than one lobe. The inferior appendage

never has more than one joint, but is often elbowed; it arises from a subgenital plate, which represents the last somite of the abdomen. This subgenital plate, which is highly developed in some Psychodidæ, is very inconspicuous in *Phlebotomus*, owing rather to its membranous nature than to its small size. In dried specimens it disappears almost completely. The intromittent organ, which lies between the two intermediate appendages, consists of a pair of slender, compressed chitinous valves, between which a pair of long, slender, chitinous filaments can be protruded.

Head—

The head in *Phlebotomus* is small and round but the anterior part is produced into a more or less cylindrical rostrum, which overhangs the mouth parts above. The eyes are large, invariably dark in colour and more or less emarginate opposite the base of the antennæ. The antennæ are long and filiform, having normally sixteen joints, two of which form the scape. They show great individual variation as regards the proportions of the joints and also differ as regards the exact outline of the last few distal joints in the two sexes. The sexual differences are, however, small. The palpi are generally stated to have four joints. In fresh specimens, however, a minute basal joint can sometimes be distinguished. This joint is often difficult to see and appears to be imperfectly separated from the others. Including it the number of the joints is five.

For an account of the mouth parts Grassi may be consulted. They do not appear to present features of merely diagnostic interest and closely resemble those of *Culex* in general structure.

THE INDIAN SPECIES OF *PHLEBOTOMUS*.

Table of the Indian species of Phlebotomus.

1. Length 2 mm. Dorsum of thorax dark, sides yellowish. Wing with the posterior border much more strongly arched than the anterior; the anterior branch of the second longitudinal vein longer than either the distance between the two forks of the vein or that between the posterior fork and the mid cross-vein; the latter distance shorter than that between the two forks *P. argentipecs.*
2. Length 3.375 mm. Colour an almost uniform golden grey. Wing with the posterior border much more strongly arched than the anterior; the anterior branch of the second vein longer than either the distance between the two forks of the vein or that between the posterior fork and the mid cross-vein; the distance between the two forks shorter than

- that between the posterior fork and the mid cross-vein *P. major.*
3. Length 2.5-3 mm. Colour dark greyish brown. Wing with the posterior margin as a rule more strongly arched than the anterior; the length of the anterior branch of the second vein, the distance between the two forks and that between the posterior fork and the mid cross-vein subequal *P. perturbans.*
4. Length 2.5 mm. Colour dark brown with a purplish tinge. Wing with the posterior margin hardly more strongly arched than the anterior; the anterior branch of the second vein four times as long as the distance between the two forks, which is much shorter than that between the posterior fork and the mid cross-vein *P. malabaricus*
5. Length 1.5 mm. Colour silvery grey. Wing narrow, as a rule divided into two almost equal and similar halves by the third longitudinal vein; the anterior branch of the second vein shorter than either the distance between the two forks or that between the posterior fork and the mid cross-vein; the two latter distances being nearly equal *P. babu.*
6. Length 2 mm. Colour yellowish grey. Wing narrow, divided into two equal and similar halves by the third longitudinal vein; the anterior branch of the second vein nearly three times as long as the distance between the two forks, twice as long as that between the posterior fork and the mid cross-vein *P. himalayensis.*
7. Length 2.5 mm. Colour yellowish grey. Wing narrow, but with the posterior margin as a rule more strongly arched than the anterior; the anterior branch of the second vein nearly twice as long as the distance between the two forks, equal to that between the posterior fork and the mid cross-vein *P. papatasi.*

Phlebotomus argentipes, Annandale and Brunetti. (Pl. iv, fig. 3, wing, and pl. vi, fig. 6, male genitalia.)

P. argentipes, Annandale, *Rec. Ind. Mus.*, ii, p. 101, fig. (1908).

Size and proportions.—Total length in well-preserved specimens 2 mm. Length of wing 1.75 mm.; greatest breadth of wing 0.5 mm. Hind leg about twice as long as the head and body; the femur less than half as long as the tibia and distinctly shorter than the first joint of the tarsus, which is longer than the remaining joints together.

Colour.—Head (except eyes, which are black) and abdomen brown; dorsum of thorax dark brown or blackish; sides of thorax, coxæ and trochanters yellowish; legs, antennæ and palpi grey; the whole (especially the legs) exhibiting a strong silvery refulgence. Wings smoke-grey, with a strong bluish iridescence on the disk and a general silvery refulgence.

Head.—Rostrum elongate, sausage-shaped, ovoid as seen from above. Eyes distinctly emarginate on their internal upper border, narrowly separated. Antennæ with 14 joints in the flagellum, all of which are more or less elongate and each of which bears three or four somewhat irregular verticels of stiff, fine hairs; the proximal joint of the scape clearly separated from the head, rather slender, short; distal joint subspherical, bearing a circle of suberect, narrow, spatulate, curved scales and (alternating with and below the scales) another of stiff bristles. Palpi with five joints; the basal joint short, the second joint more than half as long as the third, which is as long as the fourth and fifth together.

Thorax.—The dorsum is covered with long, stiff, upright, curved hairs

Abdomen slender and cylindrical in both sexes, considerably shorter than the wings, covered with rather slender curved hairs of irregular length but never very long or stout.

Wings bluntly pointed; the posterior border much more strongly curved than the anterior. The anterior branch of the second longitudinal vein much longer than the distance between its base and the second fork; the stem of the vein between the second fork and the mid cross-vein slightly longer than the distance between the two forks; the posterior fork nearly on a level with the fork of the fourth vein.

External genitalia.—(♀) The superior appendages somewhat widely separated from the inferior, which are small, pointed and claw-shaped. (♂) All the appendages long and apparent. The inferior appendages somewhat slender, laterally compressed, longer than the basal joint of the superior appendages, obliquely truncated, devoid of spines, covered with stout hairs, which form a dense brush at the tip of the appendage; a distinct elbow not far from the base of the appendage; the intermediate appendages small, consisting of a stout, bluntly pointed dorsal lobe and a small ventral lobe which is a minute, pointed process bearing a bunch of bristles at the tip and attached to the ventral margin of the dorsal lobe. The superior appendage with the distal joint considerably shorter than the proximal one, bearing five stout, pointed chætæ, each nearly as long as the joint, arranged as follows:—a single chæta at a point about a third of the length of the joint from the base, a pair of slightly unequal chætæ near the middle of the joint, and a terminal equal pair. The proximal joint slightly longer than the last apparent segment of the abdomen. Intromittent organs relatively long, ensiform, consisting of two slender, pointed lateral valves, between which a pair of long filaments can be protruded.

This species is easily distinguished, except in the case of females distended with blood, from all other Indian forms by the strong contrast in colour between the dorsal surface and the sides of the thorax. It is a very common species in Calcutta at all times of the year, but only occasionally. Often it seems to disappear for a time (a few weeks or days) and then to reappear again in large numbers. It is commonly found in dark corners of bathrooms and basements in houses and round the lamp at night, and has the habit of biting people's ankles under the dinner table.

Distribution.—Probably all over the plains of India. I have examined specimens from Calcutta (all times of year), Rajmahal (July, February), Asansol (*Paiva*, February) and Pusa (*Howlett*) in Bengal, and from several localities in the coastal districts of Travancore (November).

Phlebotomus major, sp. nov. (Pl. v, fig. 4, wing, and pl. vi, fig. 4, male genitalia.)

Phlebotomus sp., *Giles, Gnats or Mosquitoes* (2nd. ed.), p. 5, fig. 2 (1902).

Size and proportions.—Total length 3.375 mm. Length of wing 2.75 mm., greatest breadth 1 mm. Hind leg two-and-a-half times as long as the head and body; its femur less than half as long as the tibia and considerably shorter than the first joint of the tarsus, which is longer than the remaining joints together.

Colour.—A uniform golden grey with very strong silvery lights; the disk of the wings with a bluish iridescence; eyes black; legs sometimes darker than abdomen.

Head.—Rostrum somewhat conical, short, truncated in front. Eyes widely separated, emarginate above. Antennæ with the two joints of the scape subspherical; those of the flagellum elongate, slender, densely covered with soft hairs. Palpi with five joints; the basal joint very short, the second, third and fourth subequal, shorter than the fifth.

Thorax much as in *P. argentipes*.

Abdomen long and slender, clothed with long recumbent hairs and with tufts of longer, upright ones on the dorsal surface.

Wings rather narrower than in *P. argentipes*, pointed, with the posterior border much more strongly arched than the anterior. The anterior branch of the second longitudinal vein much longer than the distance between the two forks, which is considerably shorter than the distance between the second fork and the mid cross-vein; the second fork slightly nearer the base of the wing than that of the fourth longitudinal vein.

External genitalia.—(♂) Superior and inferior appendages similar to those of *P. argentipes* except that they are more slender and elongate, the basal joint of the superior appendage being nearly twice as long as the last apparent joint of the abdomen; intermediate appendages devoid of a ventral lobe; valves of the intromittent organs slender and blunt; genital filaments well developed.

This species is closely allied to *P. argentipes*, from which it is easily distinguished by its larger size, uniform golden colour, more elongate tarsi and male genitalia.

Distribution.—Outer Himalayas from the base up to 7,000 or 8,000 feet. Paresnath Hill, Western Bengal. I have examined specimens from Naini Tal and Bowali (Kumaon), Kurseong (Darjiling district), the Nepal Terai, and Paresnath Hill (Chota Nagpur). The fauna of this hill, which is separated by about 180 miles from the foot-hills of Nepal, the nearest part of the Himalayas, has a distinctly Himalayan facies, and I think that *P. major* may be regarded as the Himalayan representative of *P. argentipes*. All the specimens of the former species that I have taken myself have been taken at light in the evening. The only one I saw on Paresnath (a male) was taken at an altitude of 4,300 feet in April. The species appears to be common at Naini Tal and Kurseong and probably also at Simla in May and June. Dr. A. D. Imms took specimens at Bowali in July.

Phlebotomus perturbans, Meijere. (Pl. v, fig. 3, wing, and pl. vi, figs. 5, 5a, 5b, male genitalia.)

P. perturbans, Meijere, *Tijdschr. v. Ent.*, vol. lii, p. 201, pl. 12, fig. 13 (1909).

Size and proportions.—Total length 2.5–3 mm. Length of wing 3.25 mm.; greatest breadth of wing 0.7 mm. Hind leg $2\frac{1}{4}$ times as long as head and thorax; the femur a little more than half as long as the tibia, slightly longer than the first joint of the tarsus, which is distinctly shorter than the other joints together.

Colour.—Thorax, abdomen, femora, tibiæ, tarsi and antennæ brown, with the usual silvery lights; head (including palpi and proboscis), coxæ and trochanters yellowish; eyes black.

Head.—Rostrum short and thick, rounded at the tip. Antennæ with the basal joint of the flagellum not much longer than the second; the second joint of the scape bearing a circle of curved scales. Palpi long, with five joints; the fifth joint the longest; the second and third much longer than the fourth; the first very short.

Thorax much as in *P. argentipes*, except that the hairs are shorter.

Abdomen relatively shorter than in *P. major*, clothed with recumbent hairs and with a few upright curved ones on both the dorsal and the ventral surfaces.

Wing bluntly pointed, with the posterior border not much more strongly arched than the anterior. The length of the anterior branch of the second longitudinal vein, the distance between the two forks of this vein and that between the posterior fork and the mid cross-vein subequal; the fork of the fourth longitudinal distinctly nearer the tip of the wing than the posterior fork of the second longitudinal.

Genitalia.—(♀) The superior appendage considerably larger than the inferior, both leaf-like and rounded at the tip.

(♂) Inferior appendage shorter than the basal joint of the superior appendage, slender, bearing at the tip a bunch of long, stout bristles. Intermediate appendage without a ventral lobe, slender, pointed, with the tip curved. Superior appendage very long, the distal joint much shorter than the proximal, bearing four chætæ, which are less than half as long as the joint and are arranged in two pairs—an equal pair at the tip and one in which the two chætæ are not equal on the inner surface about half way along the joint; the proximal chætæ are blunt, the distal ones pointed. Intromittent organ very slender, the valves rounded at the tip; the genital filaments well developed.

This species is easily distinguished from all the other Indian forms I have seen except *P. malabaricus* (to which it bears a close superficial resemblance) by its dark brownish colour. It is abundant in the jungles at the base of the Eastern Himalayas at the beginning of the rains. Large numbers flew to my light in the forest bungalow at Sukna (alt. 500 feet) near the Darjiling Himalayan Railway on the evenings of July 1st, 2nd and 3rd, 1908. I have not seen it elsewhere.

Distribution.—Base of the Eastern Himalayas (Darjiling district); Java.

Phlebotomus malabaricus, sp. nov. (Pl. v, fig. 1, head, fig. 2, wing; and pl. vi, fig. 1, male genitalia.)

Size and proportions.—Total length 2.5 mm. Length of wing 2 mm., greatest breadth 0.5 mm. Hind leg $1\frac{1}{2}$ times as long as the thorax and abdomen; the femur nearly $\frac{3}{4}$ the length of the tibia, $1\frac{2}{3}$ that of the first joint of the tarsus, which is $\frac{3}{4}$ that of the remaining joints together.

Colour.—Thorax, abdomen and legs (except coxæ and trochanters) brown with a tinge of purple and with the usual silvery lights; wings purplish, strongly iridescent; head, coxæ and trochanters pale brown; eyes black.

Head.—Rostrum short, rounded in front. Antennæ normal; the second joint of the scape pear-shaped, with several circles of hairs and scales; the first joint of the flagellum much longer than the second. Palpi long, with five joints; the basal joint very short, the second shorter than the third or fourth; third and fourth joints subequal, together shorter than the fifth.

Thorax densely covered with upright curved hairs.

Abdomen covered with recumbent hairs.

Wings pointed; the posterior border not much more strongly arched than the anterior. The anterior branch of the second longitudinal vein very long, about four times as long as the distance between the two forks of the vein, which is much shorter than that between the posterior fork and the mid cross-vein; the fork of the fourth longitudinal almost level with the posterior fork of the second.

Genitalia.—(♀) Much as in *P. perturbans*. (♂) Inferior appendage slender, cylindrical, slightly shorter than the basal

joint of the superior appendage, bearing at its tip (in addition to a bunch of fine bristles) seven minute, conical, chitinous spines. Intermediate appendage without a ventral branch; the dorsal branch resembling that of *P. perturbans*. Superior appendage with the distal joint less than half as long as the proximal one, bearing four chætæ, each of which is as long as the joint; one pair of chætæ is situated at the tip of the appendage and the other a short distance nearer the base of the joint. Intromittent organ long and slender; the apices of the valves club-shaped; genital filaments well developed.

This species is closely related to *P. perturbans*, the place of which it takes in the jungles at the base of the Western Ghats in Travancore, where I took numerous specimens at light in November, 1908. The anterior branch of the second longitudinal vein, however, is much longer than it is in *P. perturbans* and the legs are shorter, while the chætæ of the male genitalia are much better developed.

Distribution.—Travancore, S. India, below the western slopes of the Western Ghats. I took specimens at Nedumangad, Pallode and Maddathorai in November.

Phlebotomus babu, sp. nov. (Pl. iv, fig. 1, wing, and pl. vi, figs. 3, 3a, male genitalia.)

Phlebotomus sp., Howlett, in Maxwell-Lefroy's *Indian Insect Life*, p. 559, fig. 358 (1909).

Size and proportions.—Total length 2.5 mm. Length of wing 1.75 mm., greatest breadth of wing 0.25 mm. Hind leg rather less than twice as long as the thorax and abdomen; the femur slightly shorter than the tibia, which is more than twice as long as the first joint of the tarsus; the first joint of the tarsus less than half as long as the femur, shorter than the remaining joints together by half of its own length.

Colour.—Silvery grey; the fringes on the wings, the thorax and abdomen appear in certain lights to be darker than the wings themselves and the limbs: the usual silvery lights present.

Head.—Rostrum prominent, somewhat arched. Antennæ with the second joint of the scape bearing several rows of flat scales; the joints of the flagellum normal. Palpi with four joints; the first three subequal, short; the fourth nearly as long as these three together.

Thorax less tumid above than in *P. argentipes*.

Abdomen rather short, clothed in close-set upright hairs of different lengths and with a dense fringe of upwardly curved hairs running along each side of the abdomen near the ventral surface.

Wings narrow, pointed, the posterior border hardly more strongly arched than the anterior, the third longitudinal vein dividing the wing into two nearly equal and similar halves. The anterior branch of the second vein not much shorter than the second branch, shorter than the distance between the two forks of

the vein or the distance between the posterior fork and the mid cross-vein; the two latter distances nearly equal; the posterior fork nearer the base of the wing than the fork of the fourth vein.

Genitalia.—(♀) The superior appendage long and narrow, somewhat curved; the inferior appendage less than half as long, straight. (♂) The inferior appendage club-shaped, distinctly elbowed, about as long as the basal joint of the superior appendage, bearing (in addition to slender bristles) several chitinous spines at the tip and on the ventral surface. Intermediate appendage short, blunt, with the ventral lobe represented by a short process on its ventral margin. The superior appendage with the basal joint stout, about twice as long as the distal joint, which bears four pointed equal or subequal chætæ; the chætæ rather longer than the joint, situated two at the tip and two a short distance from it.

This species is the smallest with which I am acquainted. It is frequently found together with *P. argentipes*, from which it is easily distinguished by its smaller size, narrower wings and uniform grey colour; I have taken it also with *P. malabaricus*. In habits it resembles *P. argentipes*, than which it appears to be somewhat more common.

Distribution.—Probably all over the plains of India. I have examined specimens from Rawalpindi (*C. W. Mason*, September); from Allahabad (*A. D. Imms*, October); from Rajmahal on the Ganges (July); from Asansol (February, *Paiva*); from Purneah and Pusa (*Howlett*) in Northern Bengal; Calcutta (all times of year) and Port Canning, Lower Bengal; Puri, Orissa; Rambha in the north-east of Madras (March); Trivandrum, Pallode and Maddathorai, Travancore (November), and Igatpuri in the Western Ghats, Bombay (November).

Phlebotomus himalayensis, sp. nov. (Pl. iv, fig. 2, wing, and pl. vj, fig. 7, male genitalia.)

Size.—Total length 2.25 mm. Length of wing 1.5 mm.; greatest breadth of wing 0.4 mm.

Colour.—Yellowish grey with the usual silvery lights; the dorsum of the thorax slightly darker than the sides.

Head.—Rostrum rounded at the tip, stout and elongated. Antennæ normal, with two circles of flat scales and one of flattened hairs on the second joint of scape. Palpi with five joints; the fifth the longest.

Thorax and abdomen as in *P. babu*.

Wing narrow, obtusely pointed, the posterior margin slightly more strongly arched than the anterior; the anterior branch of the second longitudinal vein not much shorter than the second branch, at least four times as long as the distance between the two forks, which is about half as long as that between the posterior fork and the mid cross-vein; the posterior fork and the fork of

the fourth longitudinal almost level, the former being slightly nearer the tip of the wing than the latter.

Genitalia.—(♀). Appendages short and broad, the superior not much longer than the inferior. (♂) Inferior appendage slender, distinctly elbowed, rounded and slightly clubbed at the tip, nearly as long as basal joint of superior appendages, devoid of chitinous spines. Intermediate appendages simple, pointed, curved downwards at the tip. Superior appendages with the distal joint about half as long as the proximal, bearing at the tip three pointed chætæ, each of which is slightly shorter than the joint. Intromittent organ with two elongate, slender valves, which are truncated at the tip.

This species resembles *P. babu* in general appearance but is somewhat larger and yellower. The wing is easily distinguished from that of *P. babu* by the great length of the anterior branch of the second longitudinal vein. *P. himalayensis* frequently occurs together with *P. major*, just as *P. babu* does with *P. argentipes*.

Distribution.—The Himalayas between 4,000 and 7,000 feet. I have examined specimens from Naini Tal and Bowali in Kumaon (A. D. Imms, R. E. Lloyd) and Kurseong (Darjiling district). It is apparently common in both districts in May, June and July.

Phlebotomus papatasi, Scopoli. (Pl. iv, fig. 4, wing, and pl. vi, fig. 2, male genitalia.)

P. papatasi, Grassi, *Mem. d. soc. ital. d. Sci.* (iii), xiv, p. 353 (1907).
Phlebotomus sp. (♂ genitalia), Howlett, in Maxwell-Lefroy's *Indian Insect Life*, p. 560, fig. 359 (1909).

? *P. angustipennis*, Meijere, *Tijdschr. v. Ent.*, vol. lii, p. 202, pl. 12, fig. 14 (1909).

Size and proportions.—Total length 2.5 mm. Length of wing 2.25 mm.; greatest breadth 0.4 mm. Hind leg more than twice as long as thorax and abdomen; the femur a little less than $\frac{3}{4}$ the length of the tibia, which is nearly twice the length of the first joint of the tarsus; the first joint of the tarsus in the anterior legs distinctly shorter than the remaining joints together.

Colour pale yellowish grey.

Head.—Rostrum somewhat slender. Antennæ normal; the basal joint slender, the second joint of the scape subspherical, with a circle of scales and two of flattened hairs.

Palpi with (?) five joints; the basal joint indistinct, the second, third and fifth subequal, each longer than the fourth.

Thorax and abdomen offering no apparent peculiarities.

Wings narrow, pointed, with the posterior border markedly more arched than the anterior. The anterior branch of the second longitudinal vein much shorter than the second branch; the former longer than the distance between the two forks, shorter than that between the posterior fork and the mid cross-vein; the posterior fork slightly nearer the base of the wing than the fork of the fourth longitudinal.

Genitalia.—(♀) The superior and inferior appendages short, subequal. (♂) Inferior appendages slender, shorter than the basal joint of the superior appendages, bearing about six short chitinous spines at the tip. Intermediate appendages with three lobes, the proximal lobe slender, curved, filiform; the middle lobe longer than either of the other two, slender, arched, with a fringe of hairs on the concave posterior margin; the distal lobe concave above, pointed, clothed with fine hairs. The superior appendage with the distal joint rather longer than the proximal one, bearing five short, blunt chætæ, three at the tip (the middle one being shorter than that at either side of it) and two, one nearer the base than the other, on the middle part of the joint. The intromittent organ very short, pointed, the genital filaments well developed.

By the kindness of Dr. J. H. Ashworth, I have been able to compare Indian specimens with specimens from S. Europe (see *Nature*, vol. 81, p. 518, 1909).

Meijere's *P. angustipennis*, so far as is shown by his figure of the wing and his brief description, only differs from *P. papatasi* as regards the outline of the posterior border of the wing and the longitudinal vein adjacent to it. In some species (e.g., *P. babu*) this is a variable character.¹

Distribution.—Southern Europe and Northern India (plains); ? N. Africa. I have seen a number of specimens from Rawalpindi (collected by Mr. C. W. Mason in September) and a single male from Pusa, Bihar, Northern Bengal (*Howlett*). The Rawalpindi specimens were accompanied by specimens of *P. babu* and were for the most part infected by a parasitic fungus.

The importance of this species from a medical point of view is expounded in Doerr, Franz and Taussig's *Das Pappatacifeber* (1909):

¹ It would perhaps be more correct to say that this part of the wing is peculiarly liable to distortion in preserved specimens. A comparison of the different figures of the wing of *P. papatasi* that have been published proves very considerable apparent variation in this respect.