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Contributors

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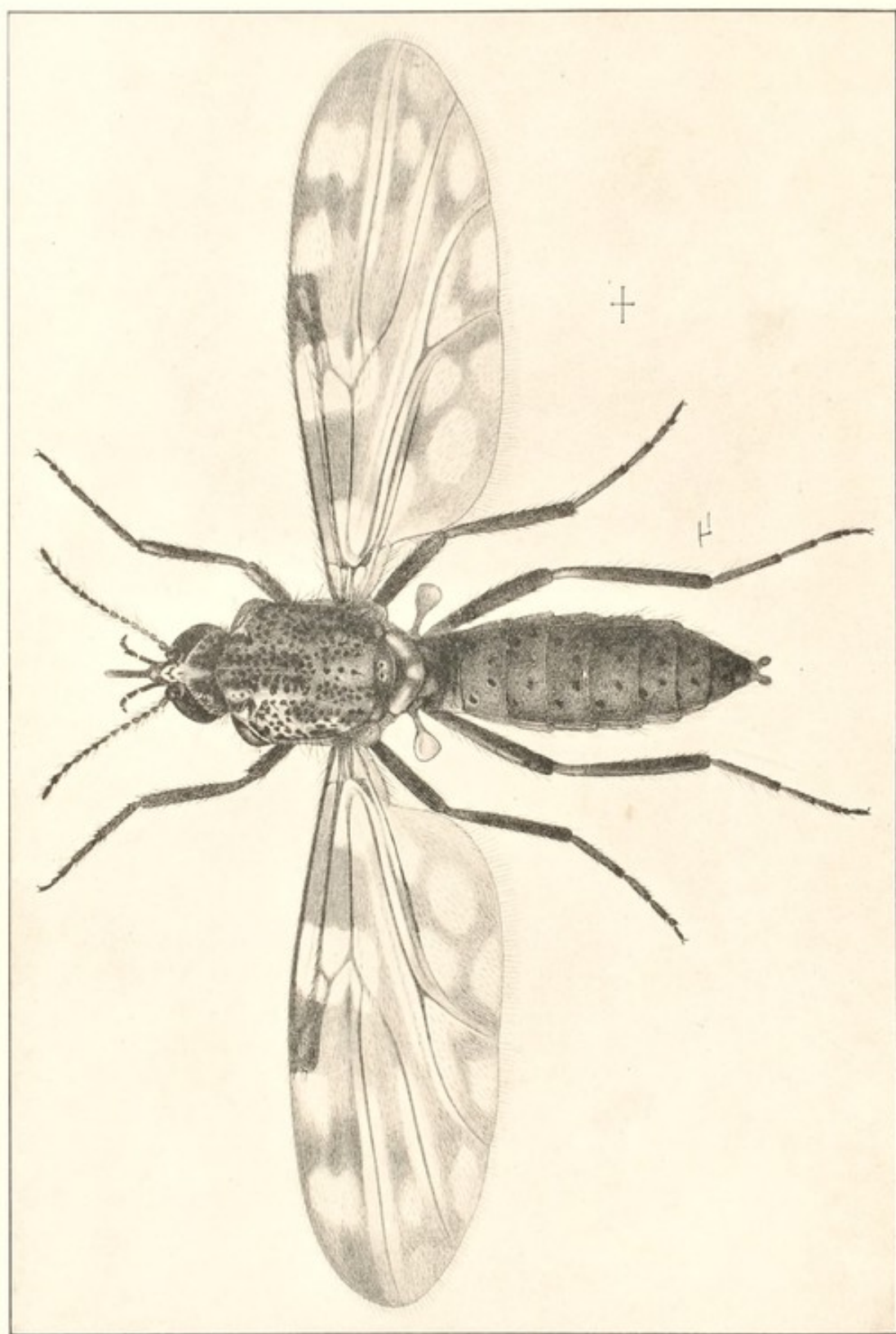


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Culicoides nubeculosus (Female)

BRITISH BLOOD-SUCKING FLIES

BY

F. W. EDWARDS, Sc.D., F.R.S., H. OLDROYD, M.A.
and J. SMART, Ph.D.

DEPARTMENT OF ENTOMOLOGY

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PREFACE

IN the year 1906 the Trustees of the British Museum published a volume entitled "Illustrations of British Blood-sucking Flies," consisting of coloured plates, reproduced from enlarged drawings made by Mr. A. J. Engel Terzi, with accompanying notes by the late Major E. E. Austen.

The utility of this volume was proved by the fact that the edition was exhausted within a few years. By 1921 continued demands for the work and the extent to which fresh data relative to the subject of the book had been accumulated, made the preparation of a second edition desirable. This was arranged for, and drawings for twelve new coloured plates were prepared by Mr. Terzi and completed in 1923. Unfortunately Major Austen's duties as Deputy-Keeper and subsequently as Keeper of the Department of Entomology prevented him from completing the text to accompany these plates; it was hoped that he might be able to do this after his retirement, but again other work prevented him.

The text of the volume now issued has been compiled by Dr. F. W. Edwards, Mr. H. Oldroyd and Dr. J. Smart. The whole-plate illustrations already prepared have been supplemented by a large number of text-figures in order to illustrate more fully the distinctions between the various species; in addition, keys have been included for the determination of all the British species of the blood-sucking groups. It is believed that these features will increase the value of the work to students.

The manuscript left by the late Major Austen dealt only with the Tabanidae. It has been freely drawn upon by Mr. Oldroyd in his account of the species of this family, but has at the same time been revised and re-written in accordance with recent discoveries.

As in the earlier work, the aim in this edition has been to provide in the simplest manner information of interest to non-specialists; technical terms are so far as possible avoided, and no attempt has been made to give full descriptions of the insects, while in the Nematocera, the males (which do not suck blood) have been omitted from consideration. A brief summary has, however, been included of the known facts regarding the habits, life-history, and distribution in Britain of every blood-sucking fly known to occur within these islands.

*British Museum (Natural History),
S. Kensington,
10th May, 1939.*

N. D. RILEY,
*Keeper,
Department of Entomology.*

INTRODUCTION

THE habit, found amongst certain Diptera, of piercing the skin of man and other warm blooded animals and sucking blood is a highly specialised one. The mouth-parts of the more primitive insects such as grasshoppers and cock-roaches are of a simple biting type adapted for chewing vegetable matter which, after being reduced to a suitable size, is swallowed in a solid state. Adult Diptera have deserted this mode of feeding on solid matter in favour of one which allows them to suck up fluids or finely divided substances such as pollen, and their mouth parts are modified accordingly.

All the three sub-orders of the Diptera contain species which attack man or other warm blooded animals for the purpose of feeding upon their blood. The sub-order Nematocera comprises about fourteen families of which three are notorious for the attacks that some of their members make in their attempts to obtain blood meals. These families are the Culicidae (Mosquitoes, p. 1), the Ceratopogonidae (Midges, p. 25), and the Simuliidae (Black-flies, p. 50). Another family, Psychodidae (Moth Flies), includes one blood-sucking genus, *Phlebotomus* (not British). In the Culicidae and Simuliidae the blood-sucking habit is general, but in the Ceratopogonidae it is confined to a few genera, only one of which (*Culicoides*) is British. In the sub-order Brachycera it is confined in Britain to the Tabanidae (Horse-flies, p. 67), though the Rhagionidae include blood-sucking members in America and Australia. Many other Brachycera, such as Asilidae (Robber-flies) and Empididae, have their mouth parts in the shape of a formidable beak but these flies prey upon insects and other arthropods, and do not attack warm blooded animals. The third sub-order of the Diptera, the Cyclorrhapha, has blood-sucking species in four families. These are the Muscidae ("Flies"), where the habit is confined to one sub-family, the Stomoxydinae (Biting Flies, p. 115), the Hippoboscidae (Louse Flies, p. 118), the Nycteribidae and the Streblidae (Bat Flies, p. 124); the last mentioned family does not occur, however, in the British Isles. The last three are relatively small families of truly parasitic insects and, as far as is known, blood-sucking is universal amongst them.

The blood-sucking habit in the Nematocera and Brachycera (families Culicidae, Ceratopogonidae, Simuliidae and Tabanidae) is found amongst the females only. While there are some species that can, and do, produce fertile eggs without having partaken of a blood meal the number of eggs produced on these occasions is small. Development of the normal number of eggs and their subsequent deposition apparently takes place only after the females have taken a satisfactory meal of blood. There is also a considerable amount of evidence showing that the blood meal itself is taken by the female fly only after she has copulated with a male and thus more or less assured the fertility of her eggs. The males are probably nectar feeders.

In a generalised insect the mouth parts consist of the labium, a pair of maxillae, a pair of mandibles and the labrum. The hypopharynx is a tongue-like projection on the floor of the mouth on which is situated the opening of the salivary duct. In blood-sucking Diptera the hypopharynx and the labrum are produced into awl-like structures which together form a tube up which the blood is sucked when they are inserted into the skin of the victim. Coagulation of the blood and consequent blocking of the mouth parts is apparently prevented by the salivary secretion which is poured into the wound.

In the Nematocera and the Brachycera the wound is cut by the mandibles and the maxillae, both of which are usually furnished with serrate cutting edges, and are inserted into the wound together with the labium and hypopharynx. The labium is soft and fleshy and is not inserted into the wound; its function is to protect the cutting and sucking parts and to guide and support them when they are brought into use. The size and delicacy of the various parts varies; in the Culicidae they are very elongate and extremely delicate while in the Tabanidae they are short and quite stout. In the males the mouth-parts are constructed on the same lines but the degree to which they are developed as cutting appliances is much less than in the females, as would be expected from their non blood-sucking habits.

In the Cyclorrhapha the mandibles and the maxillae are completely atrophied, no trace of them can be seen, and the actual cutting of the wound is performed by the labium. In the blood-sucking Cyclorrhapha the labium is in the form of a horny stylet and it is actually inserted into the wound. The tip of the labium is rasp like and it is grooved above to accommodate the elongated labrum and hypopharynx.

The males of the cyclorrhaphous blood-sucking species take blood as well as the females. It is possible amongst them to trace the development of the blood-sucking habit and the correlated evolution of piercing mouth parts. Starting with species having normal mouth parts, which are attracted to wounds and suck up the blood oozing from them, the chain leads through species (not found in the British Isles) which are able to scratch the skin with their labium till the blood oozes and can be sucked up, to the species (mentioned in this book) which actually bite and penetrate the skin in their quest for blood.

Blood-sucking flies take more than one blood meal in the course of their lives, and are thus liable to transmit disease from one person or animal to another. The subject is a complex one that cannot be entered into here but it gives these insects a tremendous importance in the Tropics and some other parts of the globe. Certain diseases, such as malaria and sleeping sickness, cannot be transmitted naturally in any other way than through the agency of a blood-sucking fly, a mosquito in the case of malaria and the Tse-tse fly in the case of sleeping sickness. So far as is known they are of relatively little importance in this respect in the British Isles but notes on their status will be found in the sections of this book dealing with the separate families.

In the introduction to the first edition of this work it was stated that of the eight (or nine) groups of Diptera, of which some members have developed the blood-sucking habit, seven occur in Britain, and that of the total of about 2,700

known species of British Diptera, 74 were blood-suckers (actual or potential). The first statement remains true, but naturally the intervening 32 years have brought considerable increases in knowledge of our native fauna, so that the numbers in the second statement need revision, and should be given as about 5,200 and 117 respectively. The increases in the numbers of known British species in the blood-sucking families are as follows :

		Known in 1906	1939
Nematocera (gnats and midges)	{ Culicidae	16	29
	{ Ceratopogonidae (Culicoides)	(12 ?)	29
	{ Simuliidae	(12 ?)	19
Brachycera (horse-flies)	Tabanidae	22	28
Cyclorrhapha ("flies")	{ Muscidae	3	3
	{ Hippoboscidae	6	9
	{ Nycteribiidae	2	2

More important than the increase in the numbers of known British species is the increase in our knowledge of them. For example, in 1906 the life-histories of only 8 of the 16 Culicidae were known, and those only partially ; in 1939 the life-histories of all the 29 species are known, for the most part in considerable detail.

In this work the nomenclature of the Tabanidae has been revised where necessary and one new name has been introduced (*T. verralli*, p. 103). New names have also been proposed for seven species of midges of the genus *Culicoides*: *C. brunnicans* (p. 43), *cubitalis* (p. 40), *delta* (p. 48), *fagineus* (p. 148), *grisescens* (p. 146), *simulator* (p. 40), and *truncorum* (p. 41).

It is not necessary to give a complete account of our knowledge of the British blood-sucking flies in an introductory work such as the present one, nor indeed would this be possible within the limits of a single volume, but for the benefit of those who may wish to follow up the subject in greater detail a short bibliography is given at the end of the account of each family.

The authors wish to express their thanks to Drs. B. M. Hobby and H. Scott, and to Messrs. H. Britten, J. E. Collin, P. Freeman, E. Rivenhall Goffe and J. F. Marshall, who have materially assisted in the production of this work by the submission of specimens for study and by reading sections of the proofs and suggesting improvements in the text.

NEMATOCERA

By F. W. Edwards, Sc.D., F.R.S.

Family

CULICIDAE*

(GNATS OR MOSQUITOES)

THE terms gnat and mosquito are synonymous, and refer to long-legged, two-winged flies which possess in the female sex a set of long piercing mouth-parts enclosed in a flexible sheath or proboscis, and are further distinguished by having a special type of wing-venation. Many other small flies are similar in size and build, and are often loosely designated "gnats," but differ from mosquitoes either in lacking the piercing mouth-parts or in having a quite different arrangement of the veins on the wings. All mosquitoes require water, more or less stagnant, for their development. Male mosquitoes do not bite; they differ from the females in having feathery antennae.

The structure and life-history of mosquitoes, and their role in the spread of human disease, have been so frequently described in text-books and popular works that it seems superfluous to give any general account of them here.

The British species of mosquitoes are twenty-nine in number, and are placed in six genera; ecologically they may be referred to the following four groups:

- A. Domestic species (hibernating in buildings):
Anopheles maculipennis, *Theobaldia annulata*, *Culex pipiens* and *C. molestus*.
- B. Salt-marsh species (breeding on or near coasts):
Aedes detritus, *A. caspius*, *A. dorsalis*.
- C. Arboreal species (breeding in tree-holes):
Anopheles plumbeus, *Aedes geniculatus*, *Orthopodomyia pulchripalpis*.
- D. Rural species (non-domestic, breeding in ground-waters usually away from coasts): all the remaining species.

The obvious distinctions between the various species are briefly summarised in the following key, which has been based, as far as possible, on features of colouring and pattern which are easily visible to the naked eye or under a hand lens. It is probable that this arrangement will be more convenient to a beginner

* The information in this section has been almost entirely compiled from Mr. J. F. Marshall's book on The British Mosquitoes, published by the Trustees of the British Museum in July 1938, some paragraphs being copied more or less verbatim. Readers are referred to this work for further details regarding our British Culicidae as well as for information regarding suitable control measures. A brief account will also be found in the sixpenny pamphlet "British Mosquitoes and their Control" (British Museum (Nat. Hist.) Economic Series No. 4A). The nomenclature of the species adopted here is that of Mr. Marshall's book, and for the sake of uniformity with that work the species are arranged in the same order.

than one in which the species are first allocated to their respective natural genera.

The species of the "domestic" group differ markedly not only in their external appearance, but also in their "piping" when in flight. The female *A. maculipennis* in flight produces a note which varies in pitch from middle C to E flat, according to whether the insect has fed or not; that of *T. annulata* varies similarly from A to B, and that of *C. pipiens* is a third higher (D'). In each case the note of the male is much higher than that of the female.

The family Culicidae includes two other small groups of gnat-like insects in addition to the mosquitoes. As the species of these groups do not suck blood they are not dealt with in this work, but those interested will find accounts of them in papers by Edwards (1920, 1921, 1930), Martini (1929), and Peus (1934).

KEY FOR IDENTIFICATION OF BRITISH MOSQUITOES.*

(Females only)

1. Palpi as long as proboscis; abdomen without scales (*Anopheles*) 2
 Palpi much shorter than proboscis; abdomen covered with scales 5
2. Wings spotted *An. maculipennis*
 Wings unspotted 3
3. Thorax uniform, brown; head without frontal tuft *An. algeriensis*
 Thorax darker at sides (as seen from above); head with frontal tuft of white scales 4
4. Body brown *An. claviger*
 Body black *An. plumbeus*
5. Tarsi with pale rings (usually conspicuous, but may be narrow and rather faint) 6
 Tarsi entirely dark 19
6. Wings with small dark spots; large species 7
 Wings without dark spots 9
7. Pale rings near tip of each femur and in *middle* of first tarsal segment of each leg 8
 Such rings absent *Th. alaskaensis*
8. Abdomen with conspicuous white bands *Th. annulata*
 Abdomen not distinctly banded, suffused with yellow *Th. subochrea*
9. Tarsal rings spreading across the joints 10
 Tarsal rings confined to the base of each segment 15
10. Black-and-white insect; thorax with narrow sharply defined white lines .. *O. pulchripalpis*
 Ornament otherwise 11
11. Abdomen with transverse pale bands only; thorax without conspicuous ornament 12
 Abdomen with median longitudinal pale stripe 14
12. Proboscis all dark *Th. morsitans*
 Proboscis pale beneath in middle 13
13. Yellowish rings at all tarsal joints *Th. fumipennis*
 Rings at last two tarsal joints of hind leg inconspicuous or absent *Th. litorea*
14. Thorax fawn-coloured with two narrow white lines *Aed. caspius*
 Thorax with broad dark brown stripe, on each side of which is a broad ashy-white area *Aed. dorsalis*
15. First segment of hind tarsus with a pale ring in middle: wing-scales rather broad
 *Taen. richiardii*
 Such a ring absent; wing-scales mostly narrow 16
16. Abdomen mainly yellow, unbanded *Aed. flavescens*
 Abdomen distinctly banded 17

* In using this key it must be remembered that the ornamentation of mosquitoes is due to a covering of scales of different colours. When these scales are rubbed off (as very easily happens) the insect may appear quite different, and identification is not an easy matter.

- | | |
|--|--|
| 17. Thorax yellowish towards sides above | <i>Aed. annulipes</i> |
| Thorax darker..... | 18 |
| 18. Pale bands of abdomen of uniform width | <i>Aed. cantans</i> |
| Pale bands of abdomen constricted in middle | <i>Aed. vexans</i> |
| 19. Abdomen tapering; claws toothed | 20 |
| Abdomen blunt; claws simple..... | 27 |
| 20. Abdomen unbanded | 21 |
| Abdomen with complete transverse pale bands..... | 22 |
| 21. Thorax ornate, knees silvery | <i>Aed. geniculatus</i> |
| Thorax dull reddish-brown, knees dark | <i>Aed. cinereus</i> |
| 22. Abdomen with tendency to have a median longitudinal pale stripe, indicated at least towards tip | <i>Aed. rusticus</i> |
| Abdomen without trace of such stripe | 23 |
| 23. Abdominal bands (at least the last few) narrowed in middle, their posterior margins \wedge -shaped | <i>Aed. punctor</i> |
| Abdominal bands not narrowed in middle | 24 |
| 24. Fore and mid femora conspicuously sprinkled with pale scales in front..... | 25 |
| Fore and mid femora with only a few pale scales in front | 26 |
| 25. Dark parts of abdomen with scattered pale scales | <i>Aed. detritus</i> |
| Dark parts of abdomen without scattered pale scales | <i>Aed. leucomelas</i> |
| 26. Hind tibia with a white stripe on outer side | <i>Aed. sticticus</i> |
| Hind tibia without such stripe | <i>Aed. communis</i> |
| 27. Pale bands of abdomen on anterior borders of segments | <i>C. pipiens</i> and <i>C. molestus</i> |
| Pale bands of abdomen on posterior borders of segments | <i>C. apicalis</i> |

Genus ANOPHELES Meigen

The British mosquitoes of this genus may be distinguished (in the female sex) from all those of other genera by several easily recognised peculiarities: (1) the proboscis has a trifid appearance owing to the fact that the palpi which lie on each side of it are of about the same length as the proboscis itself, whereas in all the other genera of mosquitoes they are much shorter; (2) the abdomen is devoid of scales, and so lacks any definite ornament, such as white bands or spots, whereas in all the other genera the abdomen is completely clothed with scales which form a more or less conspicuous ornament; (3) the legs are of almost hair-like slenderness, besides being all dark; (4) the insects rest with the body at an angle with the surface.

In the early stages there are equally striking features in which *Anopheles* differs from other mosquitoes. The eggs are always laid on the surface of water, on which they float during the short period which elapses before the hatching of the larvae; they are deposited singly, not in boat-shaped masses as in *Theobaldia* and *Culex*, and obtain their buoyancy by means of a pair of air-chambers or floats situated one on each side. The larvae feed at, instead of below, the surface of the water,* and occupy a horizontal position instead of a more or less vertical one as in other genera of mosquitoes.

The genus *Anopheles*, which comprises the malaria-carrying mosquitoes, has four representatives in this country.

* It is because of this fact that *Anopheles* larvae can be destroyed by a fine arsenical dust-spray which settles on the surface of the water and which they eat. Such dust-sprays, containing "Paris-Green," are now very widely used in anti-malaria measures, but they have no effect on the larvae of non-malarial mosquitoes (*Culex* and *Aedes*).

Anopheles maculipennis Meigen

(Plate 4)

Anopheles maculipennis may be recognised easily by the presence of small dark spots on the wings, these spots being formed by the aggregation of scales in certain positions. The only other mosquitoes occurring in Britain which exhibit similar wing-spots are *Theobaldia annulata* and its immediate relatives ; these are sometimes confused with *A. maculipennis*, but apart from generic differences which are obvious on a careful examination, *A. maculipennis* differs conspicuously from *Theobaldia* in its uniformly dark legs.

Few insects have been more closely studied than *A. maculipennis*, which, being the chief malaria-carrying mosquito of Europe, now has an immense literature devoted to it. It is now known that this species exists in Europe in several distinct varieties or subspecies, which, though closely similar in general appearance, exhibit very important biological differences, for example in their breeding habits and method of over-wintering. Of these varieties or subspecies two have been recognised as occurring in Britain ; *A. maculipennis messeae* and *A. maculipennis atroparvus*. No constant differences have yet been discovered by which the adults of these two varieties may be distinguished, but there are small distinctions in the larvae and eggs, of which the most obvious is in the egg-pattern, the upper surface of the egg in *A. m. messeae* being checkered grey with two dark bars, that of *A. m. atroparvus* having quite irregular dark markings ; moreover the lateral floats of the eggs in *A. m. messeae* are equal to half the total length of the egg and rough, in *A. m. atroparvus* less than half the total length of the egg and smooth. It is thus possible to distinguish individual female specimens if eggs can be obtained from them.

A. maculipennis is very widely distributed in the British Isles, having been recorded from every county of England and from as far north as Morayshire in Scotland, as well as from Ireland. Further research is needed, however, before the distribution of the two varieties can be stated.

Anopheles maculipennis messeae Falleroni

This subspecies is probably the form of *A. maculipennis* most commonly found in inland districts in this country ; it has been found also in some sea-side localities.

In *A. m. messeae* the males and larvae die off at the approach of autumn, while the fat-body of the females becomes highly developed, providing a store of nutriment for the insects, which pass the winter in a completely torpid condition in cool outhouses, cellars or lofts. The females emerge from hibernation in April, and the adults of the first new brood of the year are hatched about the end of May, two or three more generations following during the summer. Breeding places are to be found in collections of clean fresh (non-salt) water with plenty of vegetation, such as permanent ponds and the weedy margins of slow-moving streams ; small tanks may also be used, especially if much green algae is present in the water.

Females of *A. m. messeae* attack both human beings and domestic animals (usually indoors and at night), but where sufficient numbers of animals are present it is usually "effectively deviated" from man.

A. m. messeae requires a rather large space in which the mating swarms of the males may gather, hence it is difficult to breed in captivity.

Anopheles maculipennis atroparvus Van Thiel

This subspecies is by far the more abundant of the two in coastal and estuarine marshes, but is not absolutely confined to such areas in Britain, having been found, for example, at Windsor, Berks., and at Chobham, Surrey.

In *A. m. atroparvus* the males die off in autumn and females gradually suspend sexual activity as early as August; unlike the females of *A. m. messeae*, however, they continue to frequent warm places, do not develop such a large fat-body, and only pass into a state of partial hibernation, installing themselves in comparatively warm farm buildings or dwellings (especially those which are dark and ill-ventilated) and taking meals of blood occasionally during the winter. The larvae are usually to be found in brackish water, of varying degrees of salinity up to one-third that of sea-water. It is thought that the males do not form mating swarms as in *A. m. messeae*; in any case this subspecies will breed readily in small cages.

The former prevalence of malaria (ague) in flat coastal districts of England must have been due to invasion of dwellings by this subspecies, and the explanation of the disappearance of the disease is considered to be that improvements in housing conditions in the last half-century have rendered human habitations unsuitable for hibernating quarters for the *Anopheles* and so practically severed the connection between *A. m. atroparvus* and man.

Anopheles claviger Meigen

(*A. bifurcatus* Meigen) (Plate 3)

The uniformly dark wings of this species provide a sufficient distinction from *Anopheles maculipennis*, but in order to discriminate between it and our other two native *Anopheles*, a somewhat closer inspection is necessary. In *A. claviger* the general tint of the body is a moderately dark brown; the thorax when viewed from above appears dark velvety-brown at the sides, lighter brown in a broad stripe down the middle,* this stripe being clothed with short golden-yellow hairs (which, however, are easily denuded and so not always noticeable); on the front margin of the thorax is a rather indefinite tuft of creamy-white scales, and on the crown of the head is a more conspicuous tuft of purer white scales.*

In most country districts of Britain *A. claviger* is probably the commonest Anopheline mosquito, though it may not be so much in evidence as *A. maculipennis*, as it is not very often seen indoors. It has been found wherever searched

* These features are not well shown on the plate.

for in England and Wales, and there are many records from Scotland and Ireland; indeed, from Scotland there are far more records of this species than of *A. maculipennis*, the most northerly being from Lochinver, Sutherland.

The life-history of *A. claviger* is very different from that of *A. maculipennis*, largely owing to the fact that the winter is passed in the larval instead of in the adult stage. Females as well as males die at the approach of winter, and from the beginning of November until the end of February only larvae are to be found. Wintering larvae are mostly half-grown, but a proportion of small and nearly full-grown larvae is usually also present, so that it appears that the growth of the larva is arrested at whatever stage it has reached by the end of October. The larvae are resistant to cold and have been found to survive even after being frozen for many days in blocks of ice. In a mild spring the larvae complete their development by the end of February, and adults may be hatched early in March, though the end of this month is the usual time for the first brood to appear. Shute has observed that adults of the first generation usually avail themselves of the warmth and food provided by pig-sties, while those of the succeeding generations live amongst vegetation. The female lays about 200 eggs at a time, and several generations are produced during the summer, the shortest time needed for a complete life-cycle being about three weeks in warm weather.

A. claviger breeds in waters of a more or less permanent character, for the most part in shady situations (in contrast with *A. maculipennis*, which prefers more sun); especially in weedy pools, ditches, and the weedy margins of lakes where these are sheltered by trees, also in greenhouse and other tanks. The larvae have been found in brackish water with a salinity up to one-third that of sea-water.

A. claviger bites man readily in the open near its breeding places, but comparatively seldom indoors. A somewhat unusual record is one by C. Bonne, a Dutch mosquito specialist, who took a female *A. claviger* biting indoors by a gas-fire at Mill Hill on 18th October, 1935 (a late date for this species).

Anopheles algeriensis Theobald

This is a brownish insect very much resembling *A. claviger*, from which it may be distinguished most readily by the fact that the thorax is of a more uniform brown, the sides not appearing obviously darker than the middle part when the insect is viewed from above; the small hairs on the thorax are less numerous, more evenly spread, and somewhat darker than in *A. claviger*; also, there are no tufts of white scales either on the front of the thorax or on the crown of the head. This last feature provides a distinction from *A. plumbeus* and *A. maculipennis* as well as from *A. claviger*.

A. algeriensis, so far as our present knowledge goes, has an extremely local distribution in Britain, having been found in only two districts in Norfolk—the neighbourhood of Hickling Broad and at Foulton, near Stoke Ferry; in these localities it was very abundant in August 1932. It is to be expected that

it will also be found when searched for in other parts of the Broads district, but it seems worth noting that the surveys recently made of the fauna of Wicken Fen failed to reveal its presence in that locality in spite of the fact that the conditions there are very similar to those which obtain at Hickling.

The life-history of *A. algeriensis* is not yet known in detail, but it has been suggested that it may differ from our other three species in having only one generation in the year the adults of which appear in the warmest month. It would be of great interest if some resident in the Norfolk Broads would put this suggestion to the test.

Another point in which *A. algeriensis* differs from our other British *Anopheles* is in its attitude of rest; when settled on a vertical surface the body is held practically parallel with the surface instead of at a distinct angle.

Females of *A. algeriensis* were found to bite readily in calm dull weather both at dusk and dawn, but only in the open or in tents: none could be found in pig-sties or in buildings. Larvae were found in extensive shallow puddles among thick sedge on the marshes adjoining Hickling Broad; none were seen in the open weedy ditches dissecting the marshes, though these ditches harboured plenty of *A. claviger* larvae.

Anopheles plumbeus Stephens

(Plate 2)

The name of this mosquito indicates one of its most obvious distinguishing features, the leaden-grey colour of much of the upper surface of the thorax. It is a much darker insect than *A. claviger*, the general naked-eye appearance being almost black. The thorax when seen from above appears blackish at the sides, the broad grey median stripe being clothed with white hairs, which are longer and denser towards the front, where they form a rather conspicuous tuft; there is also a conspicuous white tuft on the crown of the head (not shown clearly enough in the plate). The wings are more densely scaled and blacker in appearance than in *A. claviger* or *A. algeriensis*, which like the present species have no dark spots on the wings.

The distribution of *A. plumbeus* in Britain is conditioned by the presence of large trees which can form rot-holes. Subject to this limitation it is found throughout Britain and in Ireland, and has occurred as far north as Skibo Castle, Sutherlandshire. It is naturally commonest in wooded districts.

A. plumbeus is unique among British Anopheline mosquitoes in breeding almost exclusively in the water which collects in rot-holes in trees. The larvae may often be found in large numbers in the larger rot-holes in such trees as beech, elm, sycamore and horse-chestnut, especially when these holes are capable of holding a fair volume of water for a sufficient time for it to become dark brown in colour through dissolved tannin; the smaller holes, and those in forks and among roots, which only retain water for shorter periods, are less suitable breeding-places for this species. Exceptionally the larvae may also be found in water-butts or tanks, but never in ponds or ditches like those of the other species of the genus. The food of the larvae appears to consist largely

of the remains of insects which fall into the water and are drowned. Larvae have been found in all stages of development in every month of the year, and it is in the larval stage that the winter is passed; adults occur from April to October, and there are probably several overlapping broods during the summer.

A. plumbeus bites persistently in the shade near its breeding-places during the day, and not infrequently enters houses and bites the occupants at dusk. The bite may be painful. It has been found experimentally that this species can efficiently carry the parasite of benign tertian malaria.

Genus *AËDES* Meigen

This genus includes about half the known species of British mosquitoes. These may usually be distinguished without much difficulty from the other species by the fact that the abdomen of the female is more or less pointed, with a pair of small processes (cerci) projecting distinctly at the tip, but this feature is not very noticeable in two species (*A. cinereus* and *A. geniculatus*). Another characteristic more absolutely diagnostic of female *Aëdes* in Britain is the form of the claws: on at least the front and middle legs of all the species the two claws have each a small tooth in the middle (readily seen under the low power of the microscope), this tooth being absent in all the species of other genera.

Aëdes also exhibits peculiarities in its life-history distinguishing it from most other genera of mosquitoes. The eggs are laid singly either on dry ground or at least above water-level, and are capable of surviving long periods of dessication; in the case of some species occurring in desert or semi-desert regions they can certainly remain viable for several years, and then hatch within a day or so of being washed into puddles by heavy rain. Nearly all *Aëdes* larvae are found in temporary collections of water, their occurrence in permanent pools or lakes being unusual. Most of the species living in temperate regions have only one annual brood which is hatched in the spring or early summer, but the adults may live for several months; in no case, however, do the adults of either sex survive the winter.

The genus *Aëdes* includes among its several hundreds of species one which is of immense importance to humanity owing to its role in the spread of yellow fever. This species, *Aëdes aegypti* (formerly known as *Stegomyia fasciata*, *Aëdes calopus*, or *Aëdes argenteus*) occurs almost throughout the tropical and subtropical parts of the world, but is not a native of Britain. On one occasion two larvae were found in a tree-hole in Epping Forest and mosquitoes hatched from them in a laboratory. The find was duly recorded in print, but it is fairly certain that the occurrence of these specimens was in some way accidental—rumour even suggests that they may have been “planted” by students in order to provide a “surprise packet” for an enthusiastic investigator.

Aëdes cinereus Meigen

This is the duller-coloured and least ornamented of all the British Culicine mosquitoes, but for this very reason should not be difficult of recognition; it

is the only species occurring with us which has at the same time no pale rings on the legs, no transverse pale bands on the abdomen, and no markings on the thorax. The thorax is reddish-brown, the abdomen dark brown above, with a stripe of yellowish scales running the whole length on each side. It is rather smaller than most of our other Culicines, the average length of the wing being about 4-4.5 mm.

A. cinereus is a common species in many parts of Britain, especially in the more low-lying districts; it has been recorded from many counties in the south and east of England, as well as from Glamorganshire and several localities in the lowlands of Scotland. In the Broads district of Norfolk and Suffolk it is particularly abundant.

The most characteristic breeding places of *A. cinereus* are riverside marshes and flooded meadows, but the larvae are sometimes found also in woodland pools. The adults first appear in June and may remain on the wing until September; eggs are laid during this period, but do not hatch until the following April, the larvae taking about two months to develop. There is thus of necessity only one generation in the year.

Where it is abundant *A. cinereus* is often a very troublesome insect.

Dr. Gunnar Olin, in Sweden in the summer of 1938, found specimens of *A. cinereus* infected with tularaemia (an infectious disease of rodents, which can also attack man).

***Aedes geniculatus* Olivier**

(Plate 10)

The silvery-white knees, to which the specific name of this species alludes, provide one of its most distinctive features; this, taken in conjunction with the pattern of black and white scales on the thorax, well represented in the accompanying plate, will serve to distinguish it from several other woodland species of the genus *Aedes* with which it might be confused. Another striking characteristic is the blue-black colour of the upper surface of the abdomen, which has conspicuous silvery-white spots along the sides, but no transverse white bands such as are to be seen in most of the other species. The legs are blue-black, with the hind femora extensively white.

A. geniculatus is common in most parts of England where there are suitable large trees, but at present there are no records of its occurrence in Wales, Scotland or Ireland; this may be in part due to the fact that few persons have attempted to find it, but it seems certain that it does not extend nearly so far north as its common associate *Anopheles plumbeus*.

This is the only species of *Aedes* as yet found in this country which breeds exclusively in the water which collects in holes in trees. As in the case of *Anopheles plumbeus* the larvae are found chiefly in those rot-holes which contain brown tanninised water, but they also occur in smaller holes and forks between trunks which contain clear rain-water. The larvae may be found (though usually in small numbers) throughout the winter, but are most numerous in the early summer months. Adults occur from April to September, being

most numerous in June. Eggs are laid on the sides of the cavity above the water-level, so that when the supply of water in the hole is replenished by rain they are washed down and hatch. The winter is probably passed mainly in the egg stage as the larvae are able to survive only brief periods of frost. It is uncertain whether more than one complete life-cycle is passed through during the year; the apparent succession of broods during the summer may be due to irregularities of rate of growth in the larvae or (as is known to happen in some species of this genus) to delay in hatching of a proportion of the eggs of one batch.

A. geniculatus can inflict a severe bite and is often troublesome in well-timbered districts.

***Aedes rusticus* Rossi**

(Plate 9)

This is a rather larger insect than the others of the dark-legged group of the genus *Aedes*, the average wing-length being about 6·65 mm. as against 5 mm. in *A. punctor* or *A. detritus*. There is some variation in the ornamentation of the body; in many specimens the abdomen of the female shows a more or less complete median longitudinal stripe of yellowish scales, but in other examples this stripe is apparent only on the last few segments and may be reduced to a slight widening of the transverse pale bands (which are present in all cases). The front half of the thorax shows in perfect specimens a pair of rather narrow black stripes separated and bordered by golden-brown scales. The sides of the thorax (pleurae) are more densely scaly than usual, and a feature distinguishing this species from all other members of the genus in Britain is that the scales on the "posterior pronotum" (immediately below each shoulder) are all very broad.

A. rusticus is a woodland species common in many parts of England and Wales; in Scotland it has been found at Dingwall, Cromarty. The adults appear chiefly in April and May, less commonly in June and July.

The larvae of *A. rusticus* are found for the most part in ditches or woodland pools which are bordered with deciduous hedges or trees, such pools being usually bottomed with dead leaves, upon which the larvae feed. The eggs may hatch, and the larvae grow to maturity, at any time during the winter, but pupation does not occur until late in March.

Although *A. rusticus* will bite readily enough in the neighbourhood of its breeding places, there do not appear to be any records of its causing serious annoyance, perhaps because other woodland species are usually more abundant.

***Aedes punctor* Kirby**

(Plate 8)

This species, at one time more commonly known under the name *A. nemorosus*, is the only member of the dark-legged group of the genus *Aedes* in which the pale transverse bands of the abdomen (or at least those on the last few

segments) are constricted in the middle so that their margins form an inverted V. The vestiture of the thorax is rather variable in colour; usually it is light brown with a single broad median stripe of dark brown, but often this stripe may be absent, or the whole of the back of the thorax may be dark brown; occasionally the stripe may be double, or the scales at the sides may be whitish. The scales of the wings are entirely dark, and there is no sprinkling of white scales on the dark parts of the legs and abdomen.

A. punctor is an abundant species in many parts of Britain; it occurs almost throughout England and Scotland, but is specially associated with sandy and gravelly districts, and with moorlands with heather, birch and coniferous woods. It is therefore more abundant towards the north. Adults first appear in April and may be found throughout the summer.

The females of *A. punctor* deposit their eggs in dry hollows where water is likely to collect during the winter, either on open heaths or in woods; the eggs are laid above the level of any water that may be temporarily present in the summer. The larvae hatch when the pools are flooded during the late autumn or winter and pupate in the following March. Larvae are sometimes also found during the summer months; it is thought that these have derived from eggs, the hatching of which had been delayed, and not that they represent a second generation.

A. punctor attacks human beings fiercely in the neighbourhood of its breeding-places (for example, in the southern outskirts of London) and has sometimes been taken biting indoors in houses in the vicinity.

***Aedes sticticus* Meigen**

This is very similar to *A. punctor* and *A. communis*, resembling the latter in having the pale bands of the abdomen of even width, but differing from both in the scaling of the mesonotum, which is blackish in the middle, whitish at the sides (somewhat as in *A. geniculatus*, though the contrast in colours is less sharp), and in having a whitish stripe on the outer side of the hind tibia.

A. sticticus is a scarce insect in Britain. It was first recorded from Scotland by Stephens under the name *Culex concinnus*; since then it has been found once in Perthshire, once in Westmorland, and on a few occasions in the New Forest.

According to continental observers *A. sticticus* breeds in open or partly shaded temporary pools; the winter is passed in the egg stage, and there may be one or more summer generations if the breeding areas become re-flooded. The adults are said to travel considerable distances from their breeding places, often causing widespread annoyance.

***Aedes communis* De Geer**

This is very similar to *A. punctor*, but the pale bands of the abdomen are of even width and the front half of the thorax shows two narrow dark stripes. It has only once been found in Britain, in a wood near Strelley, Notts., in September 1922. The life history in Europe is similar to that of *A. punctor*.

***Aedes detritus* Haliday**

(Plate 7)

Although included among the dark-legged species of the genus *Aedes*, *A. detritus* has in fact rather pale legs, owing to the more or less copious sprinkling of white scales among the black ones, except towards the tips of the tarsi; there is usually also a considerable sprinkling of white scales on the dark parts of the abdomen and on the wings. This "pepper-and-salt" appearance is usually a sufficient indication of the identity of the species. The thorax is uniformly brown, without the dark median stripe characteristic of *A. punctor*; the pale bands of the abdomen are usually of even width.

A. detritus is a very abundant species on all the low-lying coasts of Britain. It may extend some distance up our estuaries, but is not found far from tidal water except in the brine district of Worcestershire.* Adults have been collected in every month of the year, though they are most abundant in summer.

The eggs of *A. detritus* are deposited amidst the vegetation of coastal marshes; they are able to retain their vitality for at least a year (probably much longer), whether dry or submerged, and some of them hatch on each successive occasion that the marshes are flooded by an exceptionally high tide either directly or by water percolating through a sea-wall. Hence, in areas which are subject to alternate flooding and drying, fresh stocks of larvae are periodically produced, the greatest numbers after the highest tides. The larvae are able to stand a very high degree of salinity (very much greater than that of sea-water), with the important result that mosquito production in coastal districts is able to continue unchecked through periods of drought. Apart from the fact that all the eggs do not hatch at once, it is almost certain that in *A. detritus* several complete life-cycles may be passed through during the year, and in hot weather the period required for one of these cycles may be as short as a fortnight.

Females of *A. detritus* are vicious and persistent biters, and have been ascertained to have a flight-range of at least four miles; the species is therefore a source of widespread and serious annoyance in coastal districts.

***Aedes leucomelas* Meigen**

This is very similar to *A. detritus*, but lacks the sprinkling of pale scales on the dark parts of the abdomen. It has only once been found in Britain, at Widmerpool, Notts., in May 1919.

A. leucomelas is common on the coasts of Germany and Denmark, and also in central Europe. The larvae occur mainly if not solely in brackish water.

***Aedes caspius* Pallas**

(Plate 6)

The bright fawn-coloured thorax, with two rather narrow white stripes running its whole length, is highly characteristic of this species; in addition it

* Since this was written the species has been found on Wood Walton Fen, Hunts.

may be distinguished from all other British *Aedes* except *A. dorsalis* by the markings of the legs, the hind tarsi having pale cream-coloured rings embracing the joints, with the last segment entirely cream-coloured. The scales of the head are mostly bright fawn-coloured like those of the thorax, with a conspicuous white spot in front; the abdomen of the female is dark brown above, with a median yellowish stripe, transverse yellowish bands across the junctions of the segments, and with lateral white spots; the wings have a copious sprinkling of pale scales among the dark ones. Variations from this typical ornament are frequent; the white stripes of the thorax may be very narrow or absent, the general tint of the thorax may be lighter or darker, and the yellowish scales of the abdomen may be more numerous or the median stripe interrupted.

A. caspius is in the main a coastal insect, commonly associated with *A. detritus*, and occurring with that species on all the low-lying coasts of England and Wales, and also inland in the neighbourhood of Droitwich; unlike *A. detritus*, however, it extends up the Thames estuary as far as London, and in some seasons is abundant in some of the London suburbs. Adults have been collected in April, June and July, but are commoner in August and September.

The life-history of *A. caspius* is in general similar to that of *A. detritus*, the larvae occurring together in salt marshes and several broods being produced during the summer. However, *A. caspius* differs from *A. detritus* in two noteworthy respects: in the first place it is not confined to salt or brackish water, having been found breeding on several occasions in fresh-water pools on commons near London and also in sewage beds; secondly, the winter appears to be passed exclusively in the egg stage, the first larvae appearing in April. As is the case with *A. detritus*, the females certainly fly for considerable distances (at least several miles) from their breeding places, though not so far as was formerly supposed.

A. caspius shares with *A. detritus* the responsibility for causing widespread annoyance in English coastal districts, being apparently more abundant than its associate on the East coast, but less so on the south coast. It is also extremely troublesome in some seasons in the southern suburbs of London, sometimes entering houses to bite.

***Aedes dorsalis* Meigen**

In leg-markings and some other respects this resembles *A. caspius*, but the two are very easily separated if their scaly vestiture has not been denuded. In *A. dorsalis* the thorax has a broad dark brown median stripe and dark brown areas on each side, separated from the median stripe by broad areas of ashy-white scales; the median stripe and transverse bands of the abdomen are white instead of yellowish and the dark scales almost black; also the wings are less evenly sprinkled with pale scales, some of the veins being almost entirely dark.

A. dorsalis, like *A. detritus*, is in Britain a purely coastal species, but so far it has not been found in many localities, these being in the counties of Dorset, Essex, Norfolk, Westmorland, and the Isle of Man (Ramsey). On the heaths around Poole Harbour it has been recorded as biting fiercely.

The life-history of *A. dorsalis*, so far as known, is similar to that of its close relative *A. caspius*, but larvae have not been found in fresh water in this country. The winter is apparently passed in the egg stage; Marshall records that of a batch of eggs obtained in the early summer of 1935, some hatched on immersion ten days after being laid, others, after having been preserved dry (on moist filter-paper) for a year.

A. dorsalis is widely distributed in Europe, North Asia and North America, chiefly in coastal or saline districts. It is one of several species of *Aedes* which have recently been shown experimentally to be capable of transmitting the virus of encephalomyelitis in horses in the United States.

***Aedes flavescens* Müller**

This is one of four species of *Aedes* which have conspicuous white rings on the tarsi of the hind legs, these rings being confined to the bases of the segments and not embracing the joints. From the other three species of this group *A. flavescens* is sharply distinguished by the colouring of the body, the thorax being dark golden-brown and the abdomen mainly covered with straw-yellow scales, with indications of interrupted median and lateral black stripes; the scales on some of the wing-veins are predominantly yellow, on others predominantly dark; the first segment of the hind tarsus is yellow, except for the narrow basal white ring and a still narrower black ring at the tip.

A. flavescens is at present considered one of the most local of the British mosquitoes, having been obtained so far in only two localities—the Isle of Sheppey and Walton-on-Naze. Both discoveries were due to P. G. Shute, who found the larvae in deep ditches containing slightly brackish water and situated not far behind the sea wall in open marshy country.

According to the investigations of Wesenberg-Lund in Denmark and Hearle in Canada (where this species also occurs) *A. flavescens* has one annual generation; the eggs are laid in low-lying places amongst reeds or sedge; they become submerged during the winter, the larvae hatch in February or March, and the adults are on the wing towards the end of May. The life-history of the species in Britain appears to be similar.

***Aedes annulipes* Meigen**

This is in most respects similar to *A. cantans*, differing (in the female sex) in the following particulars: pale scales of thorax, abdomen, wings and femora and tibiae yellow instead of white; scales of thorax mainly golden brown, with a broad darker brown median stripe; transverse pale bands of abdomen and white rings of tarsi broader.

A. annulipes is a rather local species in Britain, but has been recorded from many localities in the south-east and midlands of England, the most northerly being Austwick (N.-W. Yorks). It is very abundant and troublesome in some localities in the fens and broads.

A. annulipes breeds in open or only partly shaded situations, typically among reeds or sedge with willow and other bushes forming "carr," as at Wicken and Wood Walton fens, and apparently always in fresh water. Adults hatch late in April (usually somewhat later than *A. cantans*) and may remain on the wing until September. Eggs laid during the summer do not hatch (even if submerged) until early the following year.

***Aedes cantans* Meigen**

(Plate 5)

From the two nearly related species with white rings at the bases of the hind tarsal segments, *A. flavescens* and *A. annulipes*, *A. cantans* is distinguished by its darker colour: the thorax is dark brown, usually with a pair of small patches of pale scales; the abdomen is largely blackish above, though usually with narrow transverse white bands; and the legs are more extensively dark, the white tarsal rings being narrower. The wings have scattered pale scales (variable in quantity) which are white, not yellowish, and the pale scales of the legs are also white.

A. cantans is recorded from rather more localities in England than *A. annulipes*, though there are at present no records from Wales, or Ireland, and the only Scottish record is of females from Dingwall, Cromarty.*

In contrast with *A. annulipes*, *A. cantans* is definitely a woodland species, its breeding places being temporary pools which are well shaded. At Hayling Island, the removal of bushes and overhanging trees from around a prolific breeding place of *A. cantans* resulted in the entire disappearance of the larvae for a long period. When, however, the bushes were allowed to grow again the water became reinfested with larvae. Adults are hatched in April and live on (or are supplemented by fresh hatchings) through the summer until September. Eggs laid in the summer do not hatch until the following February or March (even if submerged in the autumn), and even then some remain unhatched so that if the breeding pools become dried out in the spring, summer rains may result in a fresh supply of larvae hatching (from the previous season's eggs) to replace those which had failed to mature through drought.

***Aedes vexans* Meigen**

In general this species is very similar to *A. cantans*, though the two are not nearly related, as is clearly shown by the structure of the male genitalia and larvae. Apart from its usually smaller size *A. vexans* may be distinguished from *A. cantans* by having the pale transverse bands of the abdomen constricted in the middle and the scales of the wings all dark; the white rings of the tarsi are narrower and less conspicuous than in the other species.

The few records of *A. vexans* in Britain seem to be of a sporadic nature and suggest that the species may not be a permanent native with us;

* These differ in some respects from English females of *A. cantans* and it is possible that they may represent another species. There are two or three closely allied Continental species which have not yet been recognised as occurring in Britain.

Marshall suggests that "dry-laid" eggs might perhaps be accidentally imported from the continent and subsequently introduced into suitable water. The species has occurred in the following counties: Sussex, Hants, Middlesex, Herts., Oxon., Cambs., Suffolk, Merioneth. In September, 1927, it constituted a plague at Finchley, London, this being the only occasion when it has been noted in numbers in this country.

According to European observers, *A. vexans* breeds principally in flooded meadows and other temporary collections of water, preferably in open, sunlit situations. The adults bite persistently in the day-time, being often the cause of serious and widespread annoyance both to men and beasts, so much so, in some districts, that agricultural operations have to be carried on chiefly at night, and cattle kept under cover throughout the day.

Experiments on the flight-range of *A. vexans* have been made in North America by Marlatt (1934), who recovered marked individuals at distances of 4 to 5 miles from the place of liberation within 10 days. The same experiments served to demonstrate the length of life of individual mosquitoes; some were aged 104 days when re-captured.

Genus THEOBALDIA Schrank

The chief diagnostic feature of this genus is the presence of a row of yellow hairs immediately in front of the anterior thoracic spiracle, but this feature is only obvious to a trained eye and cannot be seen without magnification. Apart from this the species of *Theobaldia* may be distinguished from those of *Aedes* by their blunt abdomen and simple claws and from those of *Culex* by their larger size and ornamentation.

The six British species fall into two groups representing two very distinct subgenera. The species of these two groups are not only dissimilar in ornament, but also in life-history: those of the first group (typified by *T. annulata*) resemble *Culex* in that their eggs are deposited in the form of rafts on the surface of water and that several generations are produced during the year; those of the second group (typified by *T. fumipennis*) resemble *Aedes* in that the eggs are laid singly on dry ground, while the species have only one annual generation.

The only one of the six species that is of any practical importance (on account of being a nuisance) is *T. annulata*.

Theobaldia annulata Schrank

(Plate 13)

Among the species liable to be found indoors in Britain, *Theobaldia annulata* is both the largest and the most ornamental. It is quite half as large again as the common house-gnat (*Culex pipiens*), and is not greatly exceeded in size by any blood-sucking mosquito in the world. Its wings exhibit four or five small dark spots, formed by aggregations of scales, in the same positions as in *Anopheles maculipennis*, and confusion between the two species is possible on this account, but *T. annulata* may at once be recognised by the many white rings on the legs; not only is there a conspicuous white ring at the base of each

tarsal segment (as in *Aedes cantans* and related species), but the first of these segments on each leg has a second white ring in the middle, and there is a whitish ring near the tip of each femur. The abdomen has a distinct transverse white band on each segment, and also a median longitudinal white mark on the second segment.

T. annulata, though not usually nearly so abundant as *Culex*, is a common insect throughout Britain.

The breeding places of *T. annulata* are varied, the larvae being found in stagnant ponds, ditches, water-butts, tanks and other collections of water alike in open or shaded situations, especially when the water is contaminated with manure; they may occur in brackish water with a salinity up to one-third that of sea-water. Females have been found hibernating in cellars, attics, outbuildings occupied by domestic animals, stacks of wood and hollow trees. The hibernation, however, is incomplete, and any short spell of mild weather in the winter may induce the insects to leave their hiding-places, feed, and deposit their egg-rafts. On this account larvae as well as adults may be found at any time, though as in the case of the other hibernating species the majority of females lay their first batch of eggs in April or May. Several generations (that is at least two) are passed through during the year, the last main batch of adults being produced in October.

T. annulata inflicts a more painful bite than most of the other British mosquitoes, usually indoors and at night. The after-effects of the bite are also liable to be distressing, and it is not at all unusual for extensive swelling, sometimes needing medical attention, to follow an attack by this insect; but as in the case of other biting insects the severity of such effects seems to depend more on the idiosyncrasies of the victim than on those of the aggressor. To avoid risks, it is desirable to destroy any specimens of this insect found in bedrooms.

Theobaldia subochrea Edwards

The chief distinction of this species from *T. annulata* is its generally lighter colour, the thorax being a lighter reddish brown and the abdomen being suffused to a greater or less extent with yellow scales, the pale bands being yellowish and often ill-defined.

The life history and habits of *T. subochrea* are quite similar to those of *T. annulata*.

In Britain, *T. subochrea* is a much more local insect than *T. annulata*, and except for odd specimens taken in London and at Letchworth is confined to the neighbourhood of the sea-coast (as is usually the case also in Europe). County records include Dorset, Hants, Sussex, Kent and Yorks.

Theobaldia alaskaensis Ludlow

This species differs from *T. annulata* chiefly in the absence of pale rings from the femora and the presence of only one pale ring on the first segment of each tarsus (the median pale ring being absent).

According to available records *T. alaskaensis* seems to be not uncommon in Scotland, in both the lowlands and the highlands. In England it has only been taken (and that sparingly) in Cumberland, Westmorland, and North-West Yorkshire.

Nothing is at present known regarding the life-history or habits of *T. alaskaensis* in this country.

Theobaldia fumipennis Stephens

In this species the conspicuous markings characteristic of *T. annulata* and its allies are lacking: there are no spots on the wings and no short white stripe on the second abdominal segment; the pale rings on the legs are so much less conspicuous that the insect might at first sight be mistaken for a large *Culex pipiens*, owing to its general brown colouring and banded abdomen; in *T. fumipennis*, however, there are definite though not very broad pale rings on all the tarsi, these rings being yellowish in colour and spreading across both sides of each of the joints. The thorax shows four narrow lines of pale scales. The scales on the middle third of the proboscis are mainly pale except on the upper surface.

T. fumipennis is locally common throughout Britain, having been recorded from as far north as Inveran in Sutherland, but is easily overlooked owing to its inoffensiveness: there is no record of the females biting human beings or domestic animals or even of entering houses; they will not feed on blood in the laboratory, neither have any blood-fed females ever been captured.

The eggs of *T. fumipennis* are laid singly or in small groups either in dried-up hollows or above the water-level in partly-filled ones; they hatch in the early winter and often become full-grown by November, changing to pupae in the following spring. The adults hatch in April and may be found on the wing until September.

Theobaldia morsitans Theobald

This closely resembles *T. fumipennis*, differing most obviously (in the female sex) in having the proboscis almost entirely dark below as well as above.

T. morsitans is as widely distributed in England as *T. fumipennis*, and in most districts it is the commoner insect; it has been found also in Wales and Ireland, but there appear to be no well-authenticated records at present from Scotland.

The habits and life history of *T. morsitans* are similar to those of *T. fumipennis*; the name *morsitans* is inappropriate as there are no certain records of its biting in this country.

Theobaldia litorea Shute

This is extremely similar to *T. fumipennis* and *T. morsitans*, differing (in the female sex) from the former chiefly in the more indistinct tarsal rings, and from the latter in having the proboscis largely pale beneath in the middle.

T. litorea is a much more local insect than either of its two allies; most of

the records of its occurrence are from the south and east coast (Dorset, Hants, Kent, Essex) and it has also been found near Belfast and in the fens near Cambridge.

In habits and life-history, *T. litorca* resembles *T. fumipennis* and *T. morsitans*.

Genus CULEX Linnaeus

The one positive feature of the genus *Culex*, by which it may be distinguished, in the adult state, from other genera of mosquitoes, is the presence of a pair of small hairy pads (pulvilli) between the claws, but as even some entomologists find this character rather difficult to appreciate, it is not to be expected that the layman, for whom these notes are intended, will readily recognise the genus by this means. An easier means of diagnosing our common *Culex* is by the negative distinction of the absence of any striking ornament.

Culex is mainly a genus of the tropics and subtropics, only a very few species extending into northern Europe, of which we have two (or three, if *C. molestus* be admitted as a distinct species) in Britain. In all cases the eggs are deposited in rafts on the surface of water, and there are two or more generations in the year.

Culex pipiens Linnaeus and **C. molestus** Forskål

(The House-gnats) (Plate 14)

The house-gnats are rather dull-coloured insects lacking any very striking peculiarities. Nevertheless their identification is rarely a matter of any difficulty because, apart from the highly-ornamented *Theobaldia annulata*, they are the only culicine mosquitoes commonly found indoors in this country. Doubt is only likely to occur regarding the identity of specimens found out of doors, which might easily be confused with dark-legged species of the genus *Aedes*, such as *A. punctor* or *A. detritus*. From these species house-gnats may usually be known at a glance by the more reddish-brown tint of the body, due partly to the colour of the scales, but more to the paler tint of the almost bare sides of the thorax. A more careful examination will show that in *Culex* the abdomen is blunt-tipped, and the upper fork-cell of the wing has a very short stem, this latter feature being diagnostic. The upper surface of the abdomen is mainly dark brown, each segment having a creamy-white band at the base.

Until recently it was supposed that the common house-gnats of this country belonged to a single species, *Culex pipiens*, but intensive research has now established the fact that there are two distinct forms (Marshall and Staley, 1935). These two forms have been treated by Marshall (1938) as distinct species, *C. pipiens* Linnaeus and *C. molestus* Forskål, and for the sake of consistency the same procedure is adopted here. There are, however, several reasons for regarding them as varieties or subspecies only, as has been done by Jobling (1938), who uses the names *C. pipiens pipiens* and *C. pipiens molestus*. Points in favour of this latter terminology are: (a) the two forms have been shown to be capable of inter-breeding in the laboratory (though it is still uncertain to what extent the hybrids are fertile); (b) there are no constant

differences between the two in the structure of the genitalia ; (c) the distinctions are of the same order as those between *Anopheles maculipennis atroparvus* and *A. m. messeae*, which have hitherto been treated as races or varieties and not as species. On the other hand, Marshall points out that : (a) Weyer has shown that *molestus*, but not *pipiens*, will interbreed with the tropical *C. fatigans* Wied. ; (b) close similarity or even identity in genitalic structure is no proof of identity of species, as is demonstrated, for example, by *Theobaldia morsitans* and *T. fumipennis* ; (c) different strains of *C. molestus* will not interbreed, and these strains are perhaps comparable with the races (*atroparvus*, *messeae*, etc.) of *A. maculipennis*.

The distinctions between *C. pipiens* and *C. molestus* are most readily appreciated in the larval stage and in the male sex, the larva (in all four growth-stages) having a shorter siphon and shorter anal papillae and the male shorter palpi in *C. molestus* than in *C. pipiens*. The females of the two cannot always be distinguished with absolute certainty, the most reliable distinction, according to Marshall, being in the colour of the scales on the under surface of the abdomen ; in *C. pipiens* these scales are mostly cream-coloured, but there is always a small patch of black scales in the middle, and usually another on each posterior corner of each segment, whereas in *C. molestus* the scales are either all cream-coloured or with small median black spots but no lateral black spots. Marshall also states that when adults of *C. pipiens* and *C. molestus* are viewed side by side, the former species is distinguishable by the darker brown colour of the abdominal tergites and the more obvious pale spots at the tips of the femora and tibiae. Much more important than the very small morphological differences between the two species are the differences in habits and life-history as described below.

***Culex pipiens* Linnaeus**

This species is abundant throughout the British Isles, and is probably to be found in every house in country districts, often in very large numbers, but is very much less in evidence in towns. It is one of the three common British mosquitoes of which the females hibernate, passing the winter in a torpid state in cool but more or less frost-free cellars, out-houses, caves, mine-adits or similar places. They emerge from hibernation in April and commence egg-laying in May. Two or more generations are passed through during the summer, and by the beginning of September the species has reached its peak in numbers and in favourable years is very abundant. The mean autumn temperature, however, is not sufficient to allow breeding to continue in nature—though in the laboratory with somewhat higher temperature and increased illumination it has been found possible to induce the insects to continue breeding through the winter. During September females begin to enter sheltered places for hibernation ; males and larvae do not survive much if at all beyond the end of October.

The characteristic breeding-places of *C. pipiens* are rain-water butts, tubs on allotment gardens, and puddles and ditches about farms, also pond-margins

and sometimes wells; though normally living in fresh and fairly clear water the larvae can accommodate themselves to salinity up to half that of sea-water and to a considerable degree of pollution.

It is commonly stated that the female of this species requires a feed of blood before she can lay fertile eggs. This blood-meal is generally obtained from birds (including poultry), sometimes from rodents or even from frogs, but rarely if ever from man. The man-ignoring propensity of *C. pipiens* may be regarded as definitely established by numerous laboratory experiments which have shown that it is a matter of great difficulty or even impossibility to induce females of this species to feed on a human subject, and that in spite of the vast numbers which are to be found in houses in this country no proof of their biting is forthcoming; in all cases where complaints of mosquitoes biting indoors have been investigated the offenders have been shown to be either the allied *C. molestus* or some other species such as *Theobaldia annulata*.

As an alternative or supplement to the blood-meal, *C. pipiens* sometimes takes honey from flowers, and Myers has recorded a remarkable case of its feeding on milk in separating-pans, sitting on the creamy surface and piercing this to obtain the skim-milk beneath. Whether milk would be an adequate alternative to blood as an egg-producing meal is a point which has not been investigated. Food taken by the female in autumn, whether in the form of blood or not, is stored in the fat-body for consumption during hibernation.

C. pipiens is unable to mate in small confined spaces; mating takes place in the open during the swarming of the males. Autumn mated females store the sperms in their spermathecae for use in the spring when, after the first blood-meal, development of the eggs takes place.

Culex molestus Forskål

In striking contrast with *C. pipiens*, *C. molestus* is only very sporadically distributed in Britain; apart from a number of occurrences in London its presence has only been established in two seaside places—Hull and Hayling Island, and suspected in another seaside town—Harwich. The fact that it has only been found in or near sea-ports suggests that it may not be a permanent native but is introduced sporadically by shipping. It is abundant in southern Europe, but in France and Germany, as in Britain, it is much less widely distributed and occurs chiefly in towns. It is thus even more strictly domestic than *C. pipiens*, but it does not hibernate so completely.

C. molestus has been the subject of detailed laboratory researches during the last few years in this country as well as on the continent. It has been shown to be capable of mating in small confined spaces (even in jars) and of producing fertile and viable eggs without any food having been taken by the adult, also of passing through its whole life-history, even for several successive generations, in complete darkness. It is less resistant to low temperatures than *C. pipiens*, but on the other hand its larvae can stand a greater degree of pollution of the water in their breeding-places, and even thrive better in highly contaminated and turbid water.

Most of the records of *C. molestus* in this country are of adults only, so that little can be said regarding its natural breeding-places. In France, however, it is said to be specially addicted to cess-pools and septic tanks, though it does occur in other types of breeding place such as those more favoured by *C. pipiens*:

Paradoxically, although *C. molestus* is capable of carrying on its existence without a blood-meal, it is far more bloodthirsty than *C. pipiens*; it not only feeds on birds but also attacks man very readily—usually indoors and at night.

From the now established fact that house-gnats exist in two distinct forms, one man-biting and one man-ignoring, a conclusion of practical importance may be drawn: that is, that in this country control measures against them are entirely unnecessary unless the (fortunately very localised) *C. molestus* is present.

***Culex apicalis* Adams**

Apart from the two common house-gnats, this is the only member of the genus *Culex* occurring in these islands. It is similar in appearance to *C. pipiens*, but may be distinguished very readily by the position of the white bands of the abdomen, which are placed on the hind instead of the front margin of each segment. The species is rare in Britain; a few examples have been captured in the highlands of Scotland and single larvae have been taken at Hayling (Hants) and Easthampstead (Berks).

C. apicalis is widely distributed in Europe and North America, its breeding places being similar to those of *C. pipiens*. The females do not hibernate in dwellings, but have been found doing so in crevices between stones; they do not attack warm-blooded vertebrates, but have been observed biting frogs and snakes, as is the case with some other nearly related species in other parts of the world.

Genus ORTHOPODOMYIA Theobald

The unusually short fourth segment of the front tarsus is regarded as the most important diagnostic feature distinguishing female mosquitoes of this genus from others, but the single British species is more easily recognised by its peculiar and conspicuous ornament.

The species of *Orthopodomyia* are few in number and mostly tropical in distribution. All of them breed either in tree-holes or in the water collected in the axils of leaves of various plants, and none of them is known to bite man.

***Orthopodomyia pulchripalpis* Rondani**

(Plate 12)

This is, perhaps, the most handsome of all our native mosquitoes. The beautiful pattern of the thorax, consisting of sharply defined fine white lines on a dull black ground, should make its identity quite unmistakeable, while further distinctive features are the white band across the middle of the proboscis and the sharply contrasted black and white colouring of the whole body; the broad white rings on the hind tarsi spread across the joints.

All the examples of this insect taken in England have been reared from

larvae ; it is a remarkable fact that it has never been seen on the wing and was not known to occur with us until the discovery of its larvae in Epping Forest in 1920. The available records suggest that it has a very local distribution, as it has so far been found only in a few places in London and the home counties, and at Cambridge and Hayling Island, but when searched for it will probably be found to be widely spread in the south and midlands of England.

O. pulchripalpis breeds exclusively in the water which collects in holes in trees, and chiefly in those holes which contain a fair volume of water for a considerable period of the year, the water being dark brown in colour. There is probably only one generation in the year. The species has been kept under observation at the Molteno Institute, Cambridge, a supply being maintained in a hollow tree-trunk set up in the grounds. The observations made have been thus summarised by Tate :

“ Larvae of *O. pulchripalpis* are usually present all the year round, and are especially abundant in July and August. The fourth-instar larvae may over-winter in the reservoir, and even if these larvae are brought indoors and kept in a warm room they will not pupate until the following spring. Although the imagines live for several weeks in captivity if fed on raisins or apple they do not breed. The females, in captivity, would not bite man, birds, toads or invertebrates such as earth-worms or slugs.”

Genus TAENIORHYNCHUS Lynch

The species of this genus have the abdomen of the female blunt-tipped and the claws simple as in *Theobaldia* and *Culex*, the chief distinctions from these genera (so far as the adult female is concerned) being in microscopic details. The genus, however, is sharply distinguished from other mosquito genera by the remarkable adaptations of the larvae for aquatic life, as noted in the account of the single British species which follows.

Taeniorhynchus richiardii Ficalbi

(Plate 11)

In general naked-eye appearance there is nothing strikingly distinctive about this insect, its size and tawny-brown colour reminding one very much of *Culex pipiens*, the common house-gnat ; abraded examples of these two species might indeed be very easily confused. The distinctive features of *T. richiardii* are, however, quite easily appreciated, especially if the insect be examined under a hand-lens. The upper surface of the abdomen lacks transverse white bands ; the tarsi are ringed—even though somewhat inconspicuously—with creamy-white, the first segment having a ring in the middle as well as one at the base, the others at the base only ; and the veins of the wings are clothed with scales which are unusually broad, many of them being pale in colour while others are dark, giving the wing a peppered appearance.

T. richiardii is locally common in England, having been found in most of the counties where collectors have searched for it and occurring as far north as Durham, as well as in Belfast, County Down and County Wicklow in Ireland ; at present, however, there are no records for Wales or Scotland.

The life-history of *T. richiardi* is of exceptional interest. The larvae and pupae, like those of all other mosquitoes, live in water and breathe air, but instead of rising to the surface to breathe they obtain their oxygen from the roots of water-plants. The adaptations of the larvae for this purpose are highly remarkable; organs of attachment and piercing, which include a saw-like structure, are developed from the valves at the tip of the breathing-tube, and in addition to this, special air-storage-sacks are formed as appendages to the tracheal trunks. The pupae also have their breathing horns specially modified for piercing the plant rootlets, so that, like the larvae, they can remain in the mud at the bottom of the water, only rising to the surface when the adult fly is ready to hatch. There is probably only one generation in the year; the flies may be found from May to September, but are most abundant in July when the main brood is hatched. The eggs are fastened together in the form of rafts which float on the surface of the water; the larvae when quite young breathe at the surface, but soon descend and take up their positions on the plant roots. The winter is passed in the larval state; the young larvae remain half-grown until the spring, when they complete their development.

Females of this species attack man readily, and where they are abundant may be very troublesome; they bite at night, and are rarely active till it is almost or quite dark; they not infrequently enter houses, and according to Shute are likely to enter bedrooms during the night and to depart, gorged with the blood of the occupants, before daybreak, with the result that other harmless insects (such, perhaps, as *Culex pipiens*) are liable to become objects of suspicion.

REFERENCES

- EDWARDS, F. W. and JAMES, S. P. 1925. British Mosquitoes and their Control. British Museum (Natural History). Economic Series No. 4A, 28 pp.
- EDWARDS, F. W. 1920. The British Chaoborinae and Dixinae. Ent. Mo. Mag. (3), **61**, 264-270.
- EDWARDS, F. W. 1921. A new species of *Dixa* from Sussex. Ent. Mo. Mag. (3), **7**, 57.
- EDWARDS, F. W. 1930. The British species of *Chaoborus* and *Mochlonyx*. Ent. Mo. Mag., **66**, 163-165.
- JOBLING, B. 1938. On two subspecies of *Culex pipiens* L. Trans. R. Ent. Soc. London, **87**, 193-216.
- MARLATT, C. L. 1933. Report of Chief of Bureau of Entomology, Washington, D.C.
- MARSHALL, J. F. and STALEY, J. 1937. Some notes regarding the morphological and biological differentiation of *Culex pipiens* Linnaeus and *Culex molestus* Forskål. Proc. R. Ent. Soc. (A), **12**, 17-26.
- MARSHALL, J. F. 1938. The British Mosquitoes. British Museum (Nat. Hist.), 341 pp., 20 pls. [Gives full account with extensive bibliography.]
- MARTINI, E. 1929-30. Culicidae. In Lindner's "Die Fliegen der Palaarkt. Region."
- PEUS, F. 1934. Zur Kenntnis der Larven und Puppen der Chaoborinae (Corethrinae auct.) Arch. Hydrobiol., **27**, 641-668.
- SHUTE, P. G. 1933. The life-history and habits of British Mosquitoes in relation to their control by antilarval operations. J. Trop. Med. Hyg., **36**, 83-88.

Family
CERATOPOGONIDAE

(BITING MIDGES; in North America known as PUNKIES or sometimes as SANDFLIES.)

THE small flies which comprise this family were, until somewhat recently, included with other non-biting flies in the larger family Chironomidae, the two groups having many features in common; the separation, however, is now generally agreed upon and is both convenient and natural, the biting midges having in fact rather more in common with the Simuliidae than with the Chironomidae. As in the case of the Simuliidae, the females of all Ceratopogonidae possess well-developed biting mouth-parts, including a pair of toothed mandibles which work on the "scissors" principle; such structures are absent in the Chironomidae. The flies are all small or minute in size, usually of slender build, with the wings superposed over the back when at rest. The males (which do not bite) resemble those of Culicidae and Chironomidae and differ from those of Simuliidae in having bushy antennae. The wing-venation is of a simplified type and on a rather uniform plan throughout the family (as described briefly below under the genus *Culicoides*).

In Britain nearly 150 species of Ceratopogonidae are known to exist. Fortunately the great majority of these do not use their mandibles for the purpose of obtaining animal blood. Nearly half of them are known or believed to subsist by capturing and devouring other small insects; many more feed, so far as known, mainly or solely upon flower juices. Of those which do suck blood some members of the genus *Forcipomyia* attack only smooth, juicy caterpillars, others pierce the wing-veins of butterflies, moths, lace-wing flies or dragon-flies; others, in America, attack stick insects; one European species of the genus *Atrichopogon* confines its diet to the blood of oil-beetles, and another species of the same genus in South India has been found sucking mealy-bugs. Probably future research will reveal a still greater variety of feeding-habits in the family. The habit of sucking the blood of mammals or birds has only been definitely established as occurring in three genera of this family, *Culicoides*, *Lasiohelea*, and *Leptoconops* (including the allied *Holoconops*); of these only the first-named occurs in Britain.

The Ceratopogonidae are almost as diverse in their life-histories as in the feeding-habits of the adults, and there is great variation even among members of the same genus.

Genus *CULICOIDES* Latreille*

The members of this genus are distinguished from others of the family by a number of small details of structure which are for the most part only appreciable under a fairly high magnification. Of these the following are the most important: (1) the presence near the front margin of the thorax of two small

* For an account of the genitalia of the British species see Appendix A (p. 129).

pits, which are sharply defined, with their surface smoother than that of the rest of the thorax ; (2) the absence of a hairy pad (empodium) between the claws, which are equal in size and without teeth ; (3) the presence (at least in all the British species) of two types of hairs on the wings—a dense microscopic pubescence covering the whole surface, and longer and less dense hairs which are variable in quantity in the different species, sometimes clothing only the outer part of the wing ; (4) the fact that the costa (the thickened front margin) ends at about three-fifths of the wing's length. In addition an obvious feature distinguishing *most* species of *Culicoides* from *most* other Ceratopogonidae is the presence of spots or clouds on the wings.

The venation is characteristic of the family. The veins towards the front margin are much stouter than the others, and enclose two small areas known as the *first* and *second radial cells* ; a larger and more elongate enclosed area

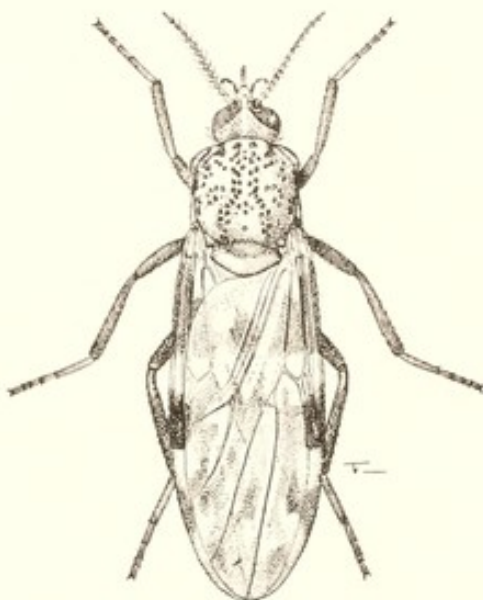


FIG. 1.—A biting midge (*Culicoides nubeculosus* Mg.) in resting position.

extending from the base to the middle of the wing is the *basal cell*, limited outwardly by the *cross-vein*. The more slender veins in the field of the wing form two forks, the *median fork* ending in the wing-tip, and the shorter *cubital fork* ending on the posterior margin. These features are illustrated in the diagram accompanying the key to species (fig. 2, p. 30).

The first description of the life-history of a species of *Culicoides* was published as long ago as 1713, by W. Derham, Rector of Upminster in Essex, in his work entitled "Physico-Theology : or a demonstration of the being and attributes of God, from His Works of Creation," and dedicated to the then Archbishop of Canterbury. This account deserves quotation, and is as follows :

"For an Instance of Insects endued with a Spear, I shall, for its peculiarity, pitch upon one of the smallest, if not the very smallest of all of the Gnat-kind, which I call *Culex minimus nigricans maculatus sanguisuga*

Among us in *Essex* they are called *Nidiots*, by *Mouffet Midges*.^{*} It is about $\frac{1}{16}$ of an inch, or somewhat more long with short *antennae*, plain in the female, in the male feather'd, somewhat like a Bottle-brush. It is spotted with blackish spots, especially on the wings, which extend a little beyond the Body. It comes from a little slender Eel-like Worm, of a dirty white Colour, swimming in stagnating Waters by a wrigling Motion, as in fig. 5.

"Its *Aurelia* [pupa] is small, with a black Head, little short Horns, a spotted, slender rough Belly, *Vid. Fig. 6*. It lies quietly on the top of the Water, now and then gently wagging itself this way, and that.

"These Gnats are greedy Blood-suckers, and very troublesome where numerous, as they are in some places near the *Thames*, particularly in the Breach-waters that have lately befallen near us, in the Parish of Dagenham; where I found them so vexatious, that I was glad to get out of those Marshes. Yea, I have seen Horses so stung with them, that they have had drops of Blood all over their Bodies, where they were wounded by them." †

Exactly two hundred years elapsed before a more precise description than that of Derham was published of the larva and pupa of any species of *Culicoides*.‡ In the year 1913 Patton published an illustrated account of the life-history of an Indian species, and at the same time Lutz published some account of his observations on *Culicoides* in Brazil. Shortly afterwards descriptions were published by Rieth (1915) and Goetghebuer (1919) of some of the European species, and by Carter, Ingram and Macfie (1920) of a number of African species. More recently Thienemann (1928) and Mayer (1934) have summarised our knowledge—still rather scanty and incomplete—of the life-histories of the European species.

The eggs of *Culicoides* are cigar-shaped or sometimes banana-shaped, dark in colour, and laid singly or in small groups; in some species at least they are capable of withstanding prolonged periods of dryness. The larvae, which in the larger species attain a maximum length of about 9 mm., are provided with an oval pale brownish head and a long, smooth, dull whitish or translucent body which terminates in a few hairs; they progress with a snake-like motion. As in all members of this family, respiration is entirely cuticular, spiracles being absent. Though the larvae of most species of *Culicoides* are normally aquatic, it was shown by Ingram and Macfie that even these aquatic larvae can survive for at least six days in moist situations where no free water is present; moreover, some species (*e.g.* *C. vexans*) appear to pass their whole existence in moist soil, and others in moist decaying vegetable matter without any appreciable content of water; Tokunaga has recorded a Japanese species (*C. arakawae*) as breeding in the dung of the poultry which it attacks. The aquatic species spend the greater part of their time buried in the fine mud at the bottom, with

* This refers to Mouffet's *Insectorum sive Minimorum Animalium Theatrum* (1634), said to be the first zoological work published in England. On p. 82 of this book Mouffet refers to small blood-sucking gnats popularly known as "midges" in England, but gives no details of interest.

† Quoted from p. 192 of the second edition, dated 1716.

‡ Heeger, in 1856, described a larva purporting to be that of *C. varius* Winn., but inspection of his figures shows that he had one of the Cecidomyiidae before him.

the front part of the body protruding. They are most commonly found in mud that is rich in confervae, or among mats of filamentous green algae. The duration of larval life varies with climatic conditions and with the species; in the case of the salt marsh species of North America, Dove, Hall and Hull (1932) concluded that the larvae live for at least six months if not for a whole year, and that they flourished best at rather low temperatures. For most of the European species precise data on this subject are not available.

The pupae are provided with small breathing-horns on the thorax, and rows of spines on the abdomen; they are capable of very little movement, merely turning the end of the abdomen about like the chrysalis of a moth; usually they may be found floating passively on the surface of the water; they breathe air and are incapable of surviving long submersion in water. The duration of the pupal stage is from three to seven days.

Species of *Culicoides* are found in most parts of the world, except (apparently) in Patagonia and New Zealand, and the blood-sucking habit appears to be universal, birds as well as mammals being attacked. There appear to be no records at present of attacks by midges on reptiles or amphibia, but an interesting variation of the blood-sucking habit is found in an Oriental species (*C. anophelis*) which obtains its food from the body of a gorged mosquito instead of directly from a mammalian host.

In some countries the annoyance caused by midges is extremely serious, and deaths have even been attributed to their bites (as in Belgium, reported by Goetghebuer, 1919), though it is probable that in such cases the real cause of death was blood-poisoning by subsequent infection of a scratch.

Considering the abundance and ferocity of many midges, it is perhaps surprising that there is as yet little evidence incriminating them in the spread of disease. Evidence has however accumulated in recent years showing that species of *Culicoides* are intermediate hosts of certain filarial worms which pass part of their life in the blood of mammals.

Dyce Sharp showed, in 1928, that *C. austeni* Carter and *C. grahmi* Austen are hosts of the worm *Filaria perstans* Manson, in West Africa; the young stage of this worm is very common in the blood of man, gorilla and chimpanzee in the Cameroons and the Congo basin, but it is not known to cause any serious pathological developments in man. J. J. C. Buckley, in 1933-4, demonstrated the similar part played in St. Vincent by *C. furens* Poey in conveying the worm *Filaria ozzardi* Manson, a common human blood-parasite in the West Indies and Central America. In the same year, 1933, J. S. Steward, working in Herefordshire, succeeded in establishing that the worm *Onchocerca cervicalis* Railliet and Henry is transmitted by *C. nubeculosus* Mg., and probably by some other species of *Culicoides*; this worm is the principal cause of nuchal disease (fistulous withers and poll-evil) in horses; it occurs also in America, where it has been suggested that it may be transmitted by *C. furens* Poey.

The irritation and annoyance caused by the attacks of midges is often so great as to constitute a serious problem. Their numbers are in some countries sufficient to make outdoor work impossible, and they may seriously interfere with tourist business at seaside resorts. It has been suggested that their

abundance on the coasts of Florida and other southern states of North America has been largely the cause of the lack of early development of these areas; and also that the backward condition of croft farming in western Scotland may be partly due to their pernicious activities. Certain it is that they constitute a major pest in parts of Scotland as well as in the West Indies.

As in the case of mosquitoes, the effect of the bites varies with different victims as well as with the species of midge; on some persons the disagreeable sensations caused by the bites are transitory, the only after-effect being a small red spot on the skin, but on others (especially women) weals are raised which may cause great discomfort for two or three days. B. Jobling (1928), who is evidently a susceptible subject, thus summarises the effects upon himself of the bites of three species of *Culicoides*:

"The intense irritation caused by the bite of *Culicoides* begins at the moment of piercing, and lasts from one to several days according to the species. Scratching the skin increases the irritation as well as the size of the swelling and prolongs their duration. Moreover, by scratching, it is very easy to tear the skin from the swelling; the resulting sore heals much more slowly than a sore produced by an accidental cut or scratch, being also liable to bacterial infection. The irritation and swelling caused by the bite of *C. pulicaris* is of very short duration and in many cases disappears on the following day, whereas the bite of *C. vexans*, and more particularly of *C. obsoletus*, produces a more intense irritation, which may last more than a week, the swelling being very distinct on the second and in many cases even the third day after the bite."

Jobling further remarks that "if the lesion is moistened and rubbed with a crystal of sodium carbonate, the irritation ceases in a few seconds, and does not recur. Furthermore, the swelling also subsides very rapidly. The same result is obtained even if the application is not made till twenty-four hours have elapsed."

Owing to the nature of the life-histories of most of the species, and the incompleteness of our present knowledge, few practical suggestions as to control measures can be made at the present time. In Britain the species most susceptible of control by direct attack would appear to be *C. nubeculosus*, which could presumably be dealt with effectively by drainage or chemical treatment of farm-yard manure-heaps, but the more universally annoying species (such as *C. obsoletus* and *C. impunctatus*) are not so susceptible. Suggestions for control of salt-marsh species (which are the most serious offenders in North America and the West Indies, but not, so far as our present information goes, in Britain) have been made by Dove, Hall and Hull (1932) and Myers (1933). These workers found that control is possible by drainage, as the midges do not breed in any great numbers in those ditches which have a free flow of tidal water and whose edges are kept straight. These authors also found that the flight-range of the salt-marsh species is less than half a mile, an important consideration when questions of control arise. In the case of the common British species it is thought—though without experimental basis—that the flight-range does not as a rule exceed a few hundred yards from the breeding places. Nevertheless

it must be noted that in 1938, in the course of investigations regarding the aerial drift of small insects, A. C. Hardy obtained several specimens of *C. pulicaris* over the middle of the North Sea.

Whether or not control is feasible, some form of protection from the attacks of *Culicoides* is often highly desirable if not essential. Screening is difficult owing to the minute size of the insects, but some form of mask provided with a respirator might sometimes be used with advantage by out-door workers. Smudges and repellants are much used by holiday-makers. In regard to the former, tobacco smoke is usually helpful, but R. L. Coe has found that a more efficient alternative in keeping a tent clear of midges is the smoke from burning incense. A great variety of repellants has been suggested for application to the skin or hair, but most of them are transitory in their effects, and some are unsuitable for general use. The following are among those recommended :

(a) A mixture of oil of lavender, 1 part, and elder-flower water, 20 parts.

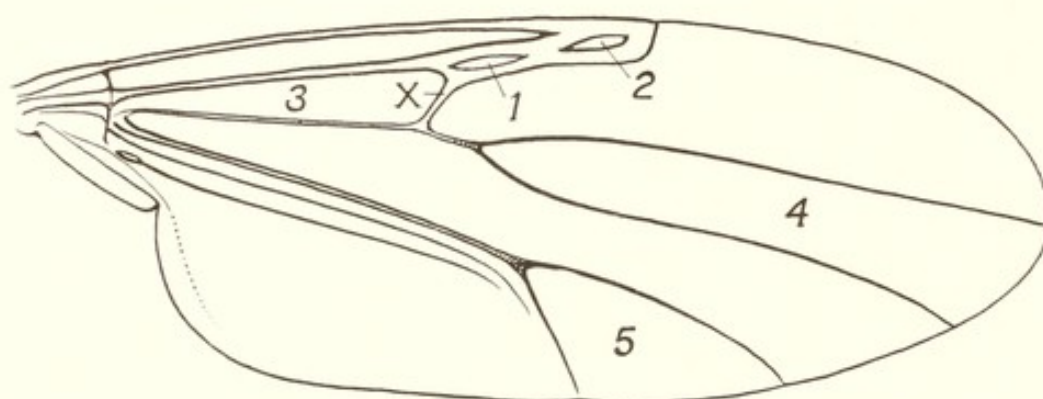


FIG. 2.—Diagram of wing of a biting midge (*Culicoides*). 1 and 2, first and second radial cells. 3, basal cell. 4, median fork. 5, cubital fork. x, cross-vein.

(Recommended by a writer in *Home Gardening*, May 1928 ; said to be very efficacious, one application lasting a whole evening).

(b) Oil of pennyroyal (recommended by J. G. Myers in West Indies).

(c) A mixture of oil of thyme, 1 part, concentrated extract of pyrethrum flowers in mineral oil, 2 parts, and castor or olive oil, 5 parts (recommended by C. Graham MacNay in *Canadian Entomologist*, August 1938).

(d) Oil of white birch is effective, but its odour is unpleasant.

(e) Citronella, 1 oz., liquid petroleum, 4 oz. (recommended by R. Matheson as least injurious to the skin).

(f) Oil of cassia, 1 oz., brown oil of camphor, 2 oz., lanoline 3 oz., paraffin wax to stiffen (recommended by Bacot and Talbot 1919 ; confirmed by A. W. McKenny Hughes).

The British species of *Culicoides* were reviewed by Edwards in 1926, 14 being then recognised as distinct. This number has now been increased to 27, mainly by the separation of similar forms which the revision undertaken in connection with the present work showed to have been confused. These 27 species may be distinguished by the following key :

KEY TO BRITISH SPECIES OF CULICOIDES (FEMALES)*

1. Wings either unmarked or with a single dark spot on the front margin and no additional pale areas 2
 Wings with light spots on a dark ground or numerous dark spots on a light ground (markings may be faint) 10
2. Wings scarcely 1 mm. in length and nearly bare *chiopterus* Mg.
 Wings longer and hairy nearly all over 3
3. Body black, wings milk-white 4
 Body brownish or mouse-grey, wings creamy-white or greyish 6
4. Large species (wing about 2.5 mm.) ; wing with a deep black spot on middle of front margin 5
 Small species (wing 1.3 mm.) ; no definite dark spot on wing *heliophilus* Edw.
5. Thorax greyish about shoulders, otherwise black and unmarked ; halteres yellow. *stigma* Mg.
 Thorax with three confluent black stripes on a greyish ground, and numerous black dots on shoulders ; halteres black *parroti* Kieff.
6. Wings creamy-white, often with black hair over radial cells 7
 Wings uniformly greyish 9
7. Legs dark 8
 Legs pale *albicans* Winn.
8. Black hair on wings almost confined to radial cells *vexans* Staeg.
 Black hair tending to extend in a patch below radial cells *brunnicans* sp. n.
9. Larger (wing 1.5-2 mm.) *cunctans* Winn.
 Smaller (wing 1 mm.) *pumilus* Winn.
10. Thorax with numerous dark brown dots, at bases of hairs 11
 Thorax otherwise, markings larger if present 14
11. Wings with grey clouds on a pale ground ; a dark spot in cubital fork 12
 Wings with roundish pale spots on a dark ground ; a pale spot in cubital fork 13
12. Legs mainly blackish *nubeculosus* Mg.
 Legs pale *riethi* Kieff.
13. A dark spot by cross-vein ; the lower branch of cubital fork pale *circumscriptus* Kieff.
 No dark spot over cross vein ; lower branch of cubital fork dark *salinarius* Kieff.
14. Wings with second radial cell entirely or (*pictipennis*) mainly dark, and with pale markings on a dark ground, surface hairy 15
 Wings with second radial cell mainly pale, and with dark markings on a pale ground, or else largely bare 21
15. Wings with two pale spots on front border, none round tip 16
 Wings with pale areas round tip in addition to those on front margin 18
16. Hairs present in basal cell *fascipennis* Staeg.
 No hairs in basal cell 17
17. Thorax brownish, scutellum paler *pallidicornis* Kieff. ; *cubitalis* sp. n.
 Thorax dark brown, including scutellum *odiatius* Austen
18. Median fork dark except at tip *truncorum* sp. n. ; *simulator* sp. n.
 Median fork with a pale spot in or near base 19
19. Thorax with conspicuous markings *odibilis* Austen
 Thorax unmarked 20
20. Tip of second radial cell pale ; spot in median fork level with the one above it. *pictipennis* Staeg.
 Second radial cell all dark ; spot in median fork extending more distally than the one above it *maritimus* Kieff.
21. Wings bare except at tip 22
 Wings hairy on the distal half or more 23

* This key is also applicable in the main to males, if it be remembered that in that sex the pale areas on the wings are usually more extensive, and the amount of hair is less. Two additional species, recognised during the printing of this book, are described on pp. 146-8.

22. Smaller (wing barely 1 mm.), wing-markings very faint *chiopterus* Mg.
 Larger (wing about 1.4 mm.), wing-markings less faint *obsoletus* Mg.
 23. No spot in cubital fork 24
 A small separate dark spot in cubital fork 25
 24. Smaller (wing about 1.5 mm.), thorax unmarked *impunctatus* Goet.
 Larger (wing about 2 mm.), thorax with markings *delta* sp. n.
 25. Two dark marks in median fork, one near base *halophilus* Kieff.
 Only one dark mark in median fork, towards tip *pulicaris* L.

Culicoides stigma Meigen

(Fig. 3)

This is one of the most easily recognised species of *Culicoides*, having the body mainly sooty-black and the wings milky-white, with a single deep black spot in the middle of the front margin. The thorax exhibits no definite pattern, though it has some ill-defined greyish areas on the shoulders and posteriorly; the legs are blackish and the halteres yellow.

C. stigma is one of the largest species of the genus, having an average wing-length of 2.5 mm.

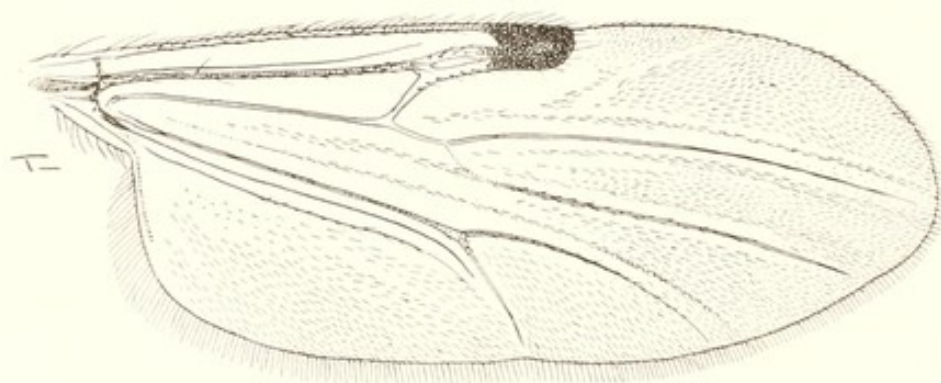


FIG. 3.—*Culicoides stigma* Mg. Wing of ♀.

In the south of England *C. stigma* is a decidedly uncommon insect; the very small number of specimens in the British Museum are from the counties of Herts., Middlesex, Devon and Notts. It may be commoner in the north as Mr. H. Britten has taken numerous examples in and around Manchester. Dates of capture are mostly in May and June, with one record in September.

Some specimens were taken biting at sunset, the bite being painful. Some of the specimens from Manchester were reared from larvae found among floating green algae at the edge of a small pond.

Culicoides parroti Kieffer

This strikingly distinct species might be confused with *C. stigma* on account of its milk-white wings with a single deep black spot occupying the second radial cell, but a glance under a lens is sufficient to separate the two. The thorax of *C. parroti* is mainly light greyish, with numerous small blackish dots

on the shoulders and three rather irregular blackish stripes, which tend to fuse, the lateral stripes being abbreviated in front; the halteres are mainly blackish, with only the tip yellowish.

C. parroti is one of the rarest of our British *Culicoides*; the first British specimens were obtained by H. Britten near Manchester in May 1922, and it has also been recorded from Herefordshire by J. S. Steward.

The specimens from Manchester were reared from larvae found among floating green algae at the edge of a small pond, in company with larvae of *C. stigma*; those from Herefordshire were taken feeding on a horse.

Outside Britain *C. parroti* has been recorded from Algeria and Turkey; the original specimens were taken feeding on a donkey.

***Culicoides nubeculosus* Meigen**

(Fig. 4 and Plate 1)

The grey pattern on the wings, with a conspicuous black area covering the radial cells and a second darker area beyond this, together with the stippling of

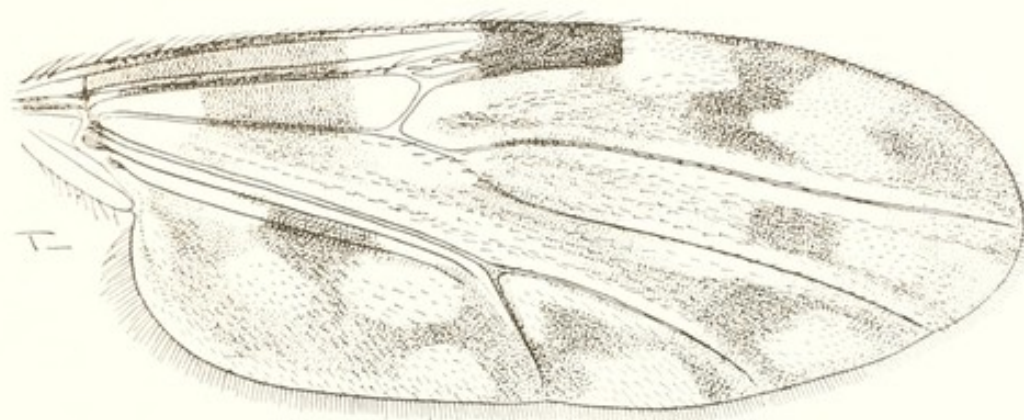


FIG. 4.—*Culicoides nubeculosus* Mg. Wing of ♀.

dark brown dots on the thorax, are characters which will sufficiently distinguish this species from all others of the genus in Britain except the very similar *C. riethi*. For the separation of these two a closer inspection is necessary, but obvious diagnostic features are to be found in the thorax and wings. In *C. nubeculosus* the dark dots on the mesonotum are rather larger and tend to run together; the scutellum is yellowish at the sides, but largely dark in the middle, the dark area including a yellowish or greyish spot in the middle of the posterior margin; the wings are rather densely hairy over most of the surface, some hairs being present in the area below the radial cells. The dark markings of the wings are usually rather diffuse, as shown in fig. 4, but may be more sharply defined (as in a series of specimens from Warcham Heath); in the latter case it is difficult to distinguish between *C. nubeculosus* and *C. puncticollis*.

C. nubeculosus is one of the largest species of the genus, having an average wing-length in the female sex of 2.5 mm.

In Britain *C. nubeculosus* is widely distributed, but decidedly local. It is sometimes abundant about farms, having been taken in such situations in

numerous localities extending to as far north as Ayrshire. It occurs throughout the summer.

As might be expected from its larger size, the bite of *C. nubeculosus* is more painful (at the time of infliction) than that of most of the other species, and when numerous it may be a serious pest; for example, Mr. L. C. Curtis in sending specimens of this species for identification in May 1930, stated that it was so troublesome at a sewage farm at Burnham, Essex, that the farm hands were unable to work. According to J. S. Steward, it feeds in the largest numbers between 10.30 a.m. and 1.0 p.m., and in bright sunshine, but also in smaller numbers at any time of the day. It attacks horses chiefly on the under side of the body.

C. nubeculosus was discovered by Steward (1933) to act as host to the worm *Onchocerca cervicalis* (Railliet and Henry), the parasite giving rise to fistulous withers and poll-evil in horses. The development of the worm was followed in the tissues of the midge.

Larvae of *C. nubeculosus* have been found in the liquid running from farm-yard manure heaps, or in green slime rich in organic matter, but details of its life-history have not been worked out.

Culicoides riethi Kieffer

This species needs comparison only with *C. nubeculosus*, which it rather closely resembles. The main distinctions are to be found in the male genitalia, but *C. riethi* may also be distinguished from *C. nubeculosus* by the following points:—Dark dots on mesonotum smaller and not tending to fuse; scutellum mainly yellowish, the dark area in the middle smaller and not including a paler spot; legs not nearly so dark; wings less densely hairy, no hairs on the space below radial cells; palpi differing in shape, the second segment less swollen and relatively shorter; size a little smaller; average wing-length scarcely over 2 mm.

C. riethi, as far as known at present, is confined to coastal marshes. British records of it are as follows:

NORFOLK: Blakeney Point, 19 vii. 1920 (*J. E. Collin*); Waxham, viii. 1932 (*F. W. Edwards*).

SUFFOLK: Aldeburgh, 17 ix. 1907 (*J. E. Collin*).

ESSEX: Gravesend, 20 vii. 1907 (*J. W. Yerbury*).

SOMERSET: Burnham-on-Sea? (*W. H. Thorpe*, 1927).

The larvae are recorded by continental observers as occurring in salt water, presumably on the muddy margins of tidal creeks and pools. On account of the peculiar habitat, it is probable that the specimen reared from a larva found in a pool near low tide level at Burnham-on-Sea, April 1927, by W. H. Thorpe, was this species and not *C. nubeculosus*, as recorded at the time.

Culicoides puncticollis Becker

(Fig. 5)

This is another close ally of *C. nubeculosus*, differing from that species and also from *C. riethi* in the better definition of the dark markings of the wings,

which (when seen by reflected light) show up more clearly on the milky-white background; the spot at the tip of the wing is well separated from the small one preceding it on the costal margin, as well as from the small spot at the tip of the lower branch of the median fork, whereas in both the other species these spots are usually more or less connected by a dark suffusion. As in *C. riethi* the legs are mainly pale, but as in *C. nubeculosus* the dark patch in the middle of the scutellum usually includes a small greyish spot.



FIG. 5.—*Culicoides puncticollis* Beck. Wing of ♀.

C. puncticollis is a common and widely spread species in the Mediterranean region. It cannot definitely be stated to be a British insect, but it may possibly occur with us; it is described and figured here because there is a specimen (without any data as to its origin) in the old Hope-Westwood British collection in the Oxford Museum.

It may be that *C. riethi* and *C. puncticollis* are merely northern and southern forms of the same species, in which case the earlier name *puncticollis* should be used.

***Culicoides salinarius* Kieffer**

(Fig. 6)

This species and the closely related *C. circumscriptus* resemble *C. nubeculosus* and *C. riethi* in having the back of the thorax "stippled" with numerous dark brown dots, but differ strikingly from them in the ornamentation of the wings, which instead of a suffused grey pattern on a pale ground are provided with numerous well-defined pale spots on a grey ground, and with only one spot darker than the ground colour, this covering the two radial cells; in addition the wings are hairy right to the base, whereas in the other pair of species the base of the wing is more or less extensively bare. In *C. salinarius* the cross-vein is pale (occupying the centre of a large pale spot), the spot near the outer end of the median fork is



FIG. 6.—*Culicoides salinarius* Kieff. Wing of ♀.

markedly smaller than those above and below it, and the lower branch of the cubital fork is entirely dark.

C. salinarius (as now re-defined) has not hitherto been recorded as British; it is, however, represented in the British Museum by three specimens: CROMARTY: Dingwall, vii. 1909, 1 ♂, 1 ♀ (*J. J. F. X. King*); and HERTS.: Harpenden, 7 vi. 1934, 1 ♀ taken in light trap (*C. B. Williams*). It seems likely that it will be found to occur at various points along our coasts; it is recognised on the continent as associated with brackish water. The Harpenden specimen had presumably strayed from the coast.

***Culicoides circumscriptus* Kieffer**

(Fig. 7)

The points differentiating this species from *C. salinarius* are small, but definite. They are to be found in the wing-markings; in *C. circumscriptus* there is a small dark spot adjoining the cross-vein, forming a small "bull's-eye" centre to a large pale spot; the pale spot near the outer end of the median

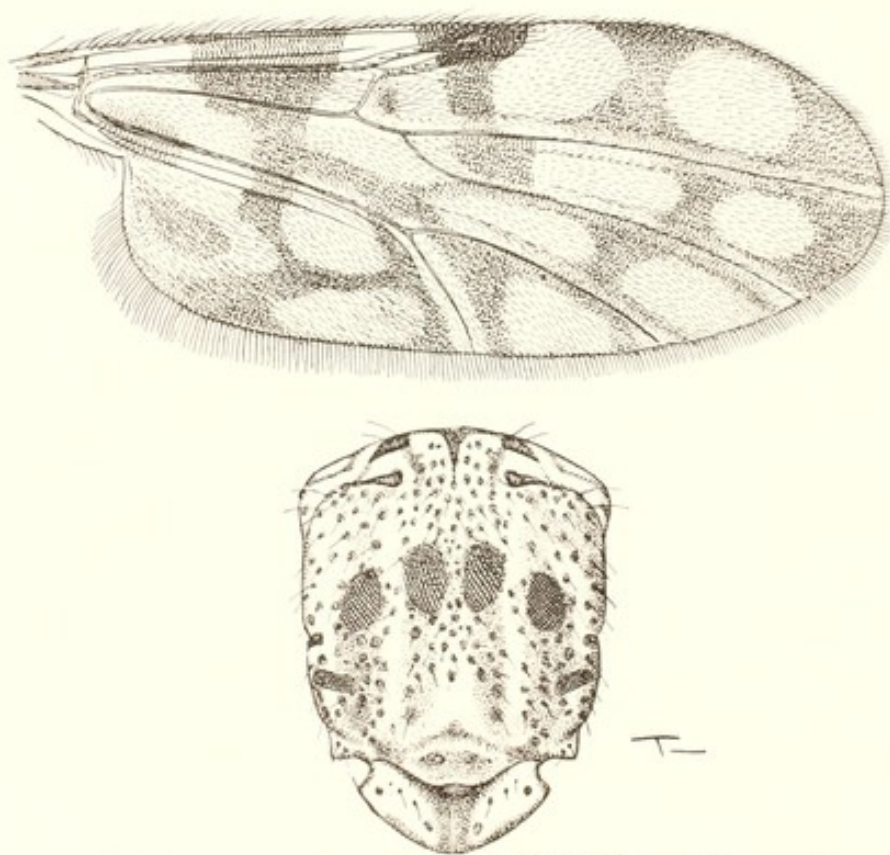


FIG. 7.—*Culicoides circumscriptus* Kieff. Wing and thorax of ♀

fork is fairly large and more or less confluent with the spots above and below it; the tips of the branches of the median fork are more extensively pale, and the lower branch of the cubital fork lies wholly within a narrow pale streak. The markings of the thorax are rather variable; some specimens show, in addition to the small dark spots, six larger or smaller rounded dark spots in

a curved row across the middle; on such specimens Kieffer bestowed the varietal name *pictidorsum*.

C. circumscriptus, like *C. salinarius* and *C. riethi*, is essentially a coastal insect; in Britain it has been found at the following seaside localities: NORFOLK, Waxham; SUFFOLK, Orford; ESSEX, Frinton; CARNARVON, Llandwrog. In addition a female specimen (doubtless a straggler) was taken on a window in the Natural History Museum, South Kensington.

Culicoides odibilis Austen

(Fig. 8)

The ornamentation of this insect is highly distinctive, the thorax and wing both exhibiting a pattern which is unlike that of any other British species. The ground colour of the wing is dark, with a still darker spot covering the whole of the second radial cell, on each side of which is a pale spot; four more roundish pale spots are situated on the distal margin of the wing between the veins, these spots usually quite small, at least in the female; a small oval pale spot is situated in the base of the median fork and another near the base of the upper branch of this fork. The whole wing is hairy. The markings of the thorax include a median stripe which extends from the front margin and is usually fairly broad and connected with other irregular dark marks.



FIG. 8.—*Culicoides odibilis* Austen. Wing of ♀.

C. odibilis does not appear to be a common species anywhere in Britain, but it is widely distributed, having been found in the counties of HERTS.: Harpenden, Letchworth; CAMBS.: Cambridge; CHESHIRE: Broadheath; CUMBERLAND: Skirwith; and CROMARTY: Dingwall.

Dates of capture range from May 22nd to August 28th.

There are no definite records of *C. odibilis* biting in this country, and in any case it is probably nowhere sufficiently abundant to cause serious trouble.

The larvae have been found living in association with *C. pulicaris* in mud at the margin of a cattle pond.

Culicoides pictipennis Staeger

(Fig. 9)

This belongs to a small group of similar species characterised by having the thorax uniformly brown or greyish, without definite markings, and the

wings greyish with a number of round or oval pale spots occupying much of the surface, with one not very conspicuous dark spot on the radial cells. From the other members of this group *C. pictipennis* may be distinguished by the fact that the pale spot beyond the middle of the front margin of the wing includes the tip of the second radial cell, the three spots round the tip of the wing are large or small but not removed from the margin, and there is a rather large oval spot within the median fork, near its base, this spot and the one above it being on the same level.

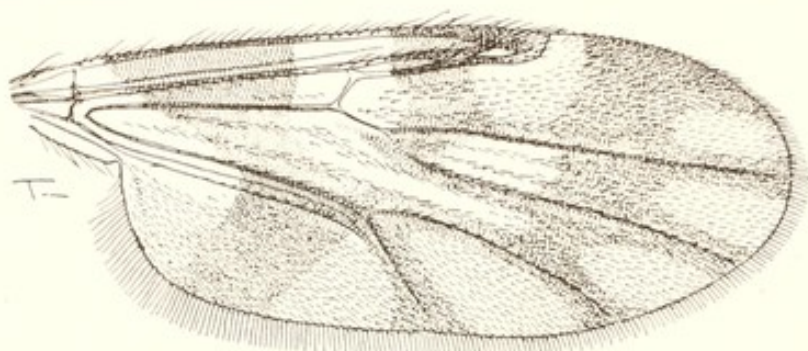


FIG. 9.—*Culicoides pictipennis* Staeg. Wing of ♀.

British records of *C. pictipennis* are rather few; they include the following: HERTS.: Letchworth, Knebworth. MIDDLESEX: Harrow. HUNTS.: Wood Walton Fen. CAMBS.: Cambridge. ARRAN: Corriegills. Dates of capture range from April 18th to June 3rd.

There are at present no definite records of blood-sucking by this species. One of the specimens from Knebworth was reared from a larva found in a woodland pool in company with larvae of *Aedes cantans* Mg.

***Culicoides maritimus* Kieffer.**

(Fig. 10)

This very much resembles *C. pictipennis*, but shows two quite definite points of distinction in the wing-markings: the second radial cell is entirely dark, the pale spot in the middle of the front margin of the wing lying just



FIG. 10.—*Culicoides maritimus* Kieff. Wing of ♀.

beyond and beneath it; and the oval pale spot near the base of the median fork extends further out, lying very obviously nearer the tip of the wing than the pale spot immediately above it.

C. maritimus has not hitherto been recognised as a British insect, but there are specimens in the British Museum from SUFFOLK: Orford, 27 vi. 08 (*J. J. F. X. King*); Lincs.: coast near Holbeach, biting, 6 vi. 39 (*F. W. Edwards*); and HANTS: Portsmouth, 18 iv. 34 (*Miss L. Selwood*). Those from the last-named locality were reared from larvae found in salt water.

***Culicoides fascipennis* Staeger**

(Fig. 11)

Several allied but distinct species have hitherto been confused under the name *C. fascipennis* in this country. All of them are similar in appearance, the thorax being devoid of markings and the wing being greyish with only two (not very conspicuous) whitish spots, placed one on each side of the darkened radial cells; the first spot is longer than broad, extending at least over the cross vein, whereas the second spot is usually much smaller.

The female of the true *C. fascipennis* may be distinguished from the others which have been confused with it by having the first white spot on the wing forming a more definite transverse band which is continued below the stem of the cubital fork by a small (and very faint) round pale spot; also, more definitely, by the fact that fairly numerous hairs are present in the basal cell of the wing. In the male these distinctions are less well marked as the pale markings are less definite and the basal cell includes at most three or four hairs, but the wings are very definitely more hairy than in the male of *C. pallidicornis*, especially in the cubital fork. The thorax in both sexes is rather dark greyish, and the legs are darkened. In size *C. fascipennis* is slightly larger than the other species of the group, the wing-length averaging 1.7 mm.



FIG. 11.—*Culicoides fascipennis* Staeg. Wing of ♀.

C. fascipennis as now diagnosed is apparently uncommon in Britain, but specimens from the following localities are in the British Museum:—CROMARTY: Dingwall. NAIRN: Nairn. DUNBARTON: Luss. PERTH: Rannoch. HANTS: New Forest. All were collected by the late Mr. J. J. F. X. King, mostly in July.

The nearly related American species *C. biguttatus* Coq. has been found in large numbers, gorged with blood, in the nests of crows and magpies.

***Culicoides pallidicornis* Kieffer**

This is one of the species which have been confused with *C. fascipennis*. In the female sex it may be distinguished from *C. fascipennis* by having the basal cell of the wing quite bare, and the first white spot of the wing rather smaller; there is no trace of a pale spot below the end of the stem of the cubital fork or between the branches of this fork; the thorax is usually of a rather

light reddish-brown tint, with the scutellum yellowish, and the size is smaller than in *C. fascipennis* (average wing-length about 1.4 mm.). The male of *C. pallidicornis* differs from *C. fascipennis* in the much less hairy wings, the cubital fork being entirely bare or with only a very few hairs.

C. pallidicornis is apparently a common and widely distributed species in Britain; the British Museum collection includes examples from the following counties:—DEVON, GLAMORGAN, SALOP, HERTS., WESTMORLAND, CUMBERLAND, BUTE, CROMARTY. Specimens taken by the late Col. J. W. Yerbury at Dingwall and Porthcawl were labelled "red-handed," and "troublesome biter."

Culicoides odiatus Austen

This was described from two females taken in Palestine which are generally similar to *C. pallidicornis*, but with the thorax very much darker brown, the scutellum as dark as the remainder of the thorax. A female from SALOP (Church Stretton), and a male from S. DEVON (Dartmouth), closely resemble the Palestine type, and are provisionally noted here as perhaps *C. odiatus*, but they may be merely dark specimens of *C. pallidicornis*.

Culicoides cubitalis sp. n.

This species is separated from *C. fascipennis* and its allies chiefly on characters of the male genitalia, as described and figured in the appendix (p. 139). Externally the male very much resembles *C. fascipennis*, and differs definitely from *C. pallidicornis* in having the wing more hairy, with numerous hairs in the cubital fork. The wing has two white patches on the front margin, separated by the blackish spot on the radial cells as in other similar species, but here the two spots are about equal in size and both fairly broad; when the wing is viewed obliquely against a dark background a faint pale streak can be seen between the media and cubitus, and an indistinct pale area on each side of the lower branch of the cubital fork, but there is no trace of pale spots round the apex of the wing. The female of this species has not been identified with certainty; it is probably extremely similar to that of *C. pallidicornis*.

Male specimens, definitely identified as this species by study of mounts of the genitalia, are in the British Museum from the following localities:—HERTS.: Letchworth, viii. 18 (type); Radwell, vi. 18. NORTHUMBERLAND: Crag Lough, viii. 23. ARRAN: Pirnmill and Catacol, vi. 19. CROMARTY: Dingwall, vii. 09. The species is probably as widely spread and common as *C. pallidicornis*.

Culicoides simulator sp. n.

(Fig. 12)

In general appearance this species is somewhat intermediate between *C. pictipennis* and *C. truncorum*, with both of which it agrees in having the thorax uniformly dull brownish (with at most a faintly indicated median dark line), the legs pale, and the wings greyish with pale markings. It further agrees with *C. truncorum*, and differs from *C. pictipennis* in having the second radial

cell entirely dark and no pale spot in the base of the median fork. The main external distinctions from *C. truncorum* are that the pale spots round the apical margin of the wing are larger and more distinct—there is a well-defined pale area before the lower branch of the cubital fork, and the thoracic hair is pale. Apart from this the male genitalia (described and figured in the appendix) are

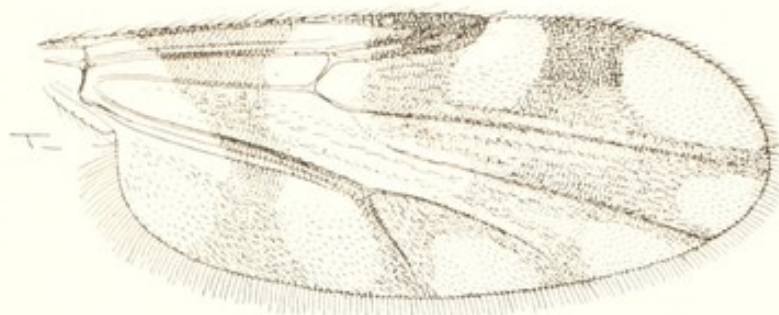


FIG. 12.—*Culicoides simulator* sp. n. Wing of ♀ from Oxford.

quite different from those of *C. truncorum* and resemble those of *C. analis* more closely. For description of genitalia see p. 136.

Only three specimens of this species have been taken up to the present: a male at Knebworth, HERTS., vi. 1922 (type), and a female at OXFORD, 12 vi. 15 (*A. H. Hamm*), and another female at Epsom, SURREY, 15 vii. 36 (*B. Jobling*). In the female from Epsom the pale spots are much smaller than in the one illustrated.

***Culicoides truncorum* sp. n.**

The wing markings of this species will serve to distinguish it without much difficulty from all others of the genus known in Britain except *C. simulator*. As in *C. fascipennis* and related species the wing is mainly greyish, with a rather large whitish spot on the front margin before the radial cells and a smaller one beyond them; it differs from these species in having (in both sexes) ill-defined paler areas on the margin round the tip, between the tips of the veins; these pale areas are not large and are most easily seen when the wing is viewed obliquely against a dark background; the dark spot over the radial cells is much less obvious than in *C. fascipennis*. The thorax is rather light dull brownish in colour, clothed with *dark* hair, and entirely without markings; the legs are almost uniformly pale yellowish-brown. The wing in both sexes is clothed with hair on most of its surface, but the basal cell is bare, as usual. The wing-length in the male is about 1.7 mm., in the female about 2.0 mm. For description of genitalia see p. 139.

C. truncorum is apparently an uncommon insect in Britain; few specimens have been obtained, and most of these have been reared from larvae. The records are as follows:—CAMBS.: Snailwell, vi. 07, 3 ♂, 3 ♀ in British Museum, including type ♂ (others in Mr. Collin's collection), reared from moist debris collected from a very large hollow (not a water-hole) in a chestnut tree (*J. E. Collin*). HERTS.: Letchworth, vi. 17, 1 ♂, and vii. 18, 1 ♀, on window. HANTS: Brockenhurst, v. 06, 1 ♂, 1 ♀ reared from beech wood (*D. Sharp*).

The above records suggest that this species breeds normally in damp rotten

wood ; it is the only species of the genus reported in this country from such a habitat, except that at Snailwell *C. obsoletus* was associated with it. (But see also p. 146.)

***Culicoides vexans* Staeger**

This species may be recognised by its uniformly mouse-grey thorax, blackish abdomen, dark legs and creamy-white wings without definite markings. The wings are uniformly and rather densely clothed with hair which is for the most part creamy-white ; most (but by no means all) specimens have a patch of dark hair covering the radial cells, so that to the naked eye the wing may appear to have a blackish spot in the middle of the costa, though this is never as obvious as in *C. stigma* ; the area of the dark hair may extend below the radial cells, but only to a slight extent. *C. vexans* is a medium-sized midge, a little smaller than the average *C. pulicaris*, with a wing-length of about 2 mm.

In many of the LONDON suburbs, both north-west and south, *C. vexans* is a very abundant species, in some places and seasons far outnumbering the other species of the genus ; it has also been found abundantly in the NEW FOREST and at OXFORD, and there are specimens in the British Museum from HERTS., BEDS., HUNTS., CAMBS., and GLAMORGAN, but confirmation of its occurrence in the North of England and Scotland is desirable. The adults are to be found chiefly at the end of April and during May ; the latest date of capture noted in the British Museum is July 6th

C. vexans is a troublesome species where it is abundant, biting even during the day-time, though chiefly in the evening. The bite is often painful. It is most troublesome out of doors, but will also enter houses to bite, which other *Culicoides* rarely do ; Staeger records it as troublesome in houses in Denmark.

The life-history of *C. vexans* has been investigated by Jobling, who thus summarises his findings :

" It breeds in damp earth round bushes and under big trees, where desiccation of the ground is prevented by overhanging branches. The midge has only one generation a year. From eggs laid in June and kept in the open, the first-stage larvae hatched in October. Further observations on these larvae were then made in the laboratory, and in the following March many midges of both sexes were hatched. The pupal stage is of very short duration, lasting only a few days."

***Culicoides albicans* Winnertz**

This is a dull-coloured insect resembling *C. vexans* in having the thorax uniformly mouse-grey and the wings creamy-white ; the only entirely satisfactory means of distinguishing the two species is by the structure of the male genitalia, but the legs and abdomen of *C. albicans* are paler than those of *C. vexans* and the hair on the radial cells is less obviously dark, or even all pale.

The scanty records at present available of the occurrence of *C. albicans* in Britain indicate that it may largely replace *C. vexans* in the west and north. The following specimens are in the British Museum :

DEVON : Dartmouth, vi. 20, 1 ♀ (*F. W. E.*). YORKS. : Skipwith, vii. 26, 1 ♂ (*F. W. E.*). LANCS. : Cringle Fields, Manchester, 3 ♂, 1 ♀, 31 v. 20 (*H. Britten*). WESTMORLAND : Witherslack, vi. 29, 1 ♀ (*F. W. E.*). DUNBARTON : Luss Glen, vi. 09, 1 ♂, 1 ♀ (*J. J. F. X. King*). ARRAN : Catacol, v. 19, 1 ♀ (*F. W. E.*).

***Culicoides brunnicans* sp. n.**

(Fig. 13)

A study of the male genitalia of the British *Culicoides*, undertaken in connection with this volume, has revealed that, in addition to the true *C. vexans* and *C. albicans* Winn., two other distinct species have hitherto been confused under the name *C. vexans*. For one of these no name appears to be available and the above designation is proposed for it.

C. brunnicans is externally extremely similar to *C. vexans*, which it resembles in its mouse-grey thorax, dark abdomen and legs, and creamy-white wings clothed rather densely with pale hair. The only external differences between the two species at present discovered are in the wings; in *C. brunnicans* the area of dark hair in the middle is more obvious and extensive and not only covers the radial cells but extends below them in a patch spreading nearly half way across the wing; moreover there is a faint and diffuse dark band on the basal half extending from the costa nearly half way across the wing, this



FIG. 13.—*Culicoides brunnicans* sp. n. Wing of ♀.

band being most evident when the wing is viewed under a strong pocket lens very obliquely against a dark background. For description of genitalia see p. 141.

In Britain *C. brunnicans* will probably be found to be common and widely distributed. It certainly occurs commonly in the London district, as well as in some other localities. Specimens from the following places are in the British Museum collection :

MIDDLESEX : Harrow, Stanmore, Northwood, Ealing. HERTS. : Bushey, Knebworth. OXON. : Oxford. SALOP : Snailbeach. N. DEVON : Buck's Mills. Dates of capture range from April 27th to June 8th.

C. brunnicans is found associated with *C. vexans* in the London district and is probably equally annoying; two of the specimens in the Museum are definitely labelled as taken in the act of biting. On Stanmore Common in May, 1916, females were found in swarms at the source of a small stream, which was probably their breeding-place.

Culicoides cunctans Winnertz

This is a little-known species resembling *C. vexans* and *C. albicans*, but differing (according to the original description) in having the hair on the wings grey instead of creamy white; like the two species mentioned it has a mouse-grey thorax and is quite unadorned.

No definite record of the occurrence of this species in Britain has hitherto been published, but the following specimens in the British Museum collection are considered to be most probably *C. cunctans*:

HERTS.: Letchworth, v. 1918, 1 ♂ (*F. W. Edwards*). MIDDLESEX: Edgware, 8 vi. 1926, 1 ♀ (*B. Jobling*). WESTMORLAND: Newby, vi. 1929, 1 ♂ (*F. W. Edwards*). CUMBERLAND: Skirwith, 6 vii. 1927, ♀ (*H. Britten*). CROMARTY: Dingwall, vii. 1909, 3 ♂, 1 ♀ (*J. J. F. X. King*).

Nothing is known of the biting or breeding habits of the species.

Culicoides heliophilus Edwards

Although not possessing a distinctive pattern, this species is not difficult to identify on account of the sooty-black body and milk-white wings. It is only half the size of *C. stigma*, with which it might otherwise be confused owing to its general colouring and the fact that the hair on the radial cells is largely black; in *C. heliophilus*, however, there is no obvious black spot as there is in *C. stigma*. The wing in this species averages 1.3 mm. in length; it is thus markedly smaller than *C. vexans* and related species, from which it is also distinguished by its much darker colour.

C. heliophilus is very common in Scotland and in hilly districts in the north and west of England and has also been found in DORSET, HANTS (New Forest), and ESSEX (Epping Forest), and S.-W. IRELAND (Killarney). It flies chiefly in June.

A peculiarity of this species, in which it differs from most others of the genus found in Britain (except *C. nubeculosus*) is that it is most active during the middle of the day, biting freely in hot sun; it disappears before dusk, when some of the other *Culicoides* are most in evidence. On Dartmoor (and doubtless in other districts where it is abundant) it may be seen flying in swarms round the heads of sheep, to which animals it must be a great source of annoyance.

Nothing is known regarding the life-history of *C. heliophilus*.

Culicoides pumilus Winnertz.

This shares with *C. chiopterus* the distinction of being the smallest species of the genus in Britain, having a wing length of only 1 mm. It resembles *C. cunctans* in being dark in colour with entirely unadorned wings clothed with greyish hair, but apart from its smaller size may be distinguished by having the wing-hair less dense, especially towards the base.

C. pumilus is probably common and widely distributed, but has at present been found in only a few British localities, in HERTS., CAMBS., and DEVON.

There are no British records of blood-sucking by *C. pumilus*, and nothing is known of its life-history. Goetghebuer has recorded it as a blood-sucking species in Belgium.

***Culicoides chiopterus* Meigen.**

This is a very small species without any conspicuous ornamentation; the wings of the female are very faintly clouded, the most obvious dark area being at the junction of the two radial cells, but in the male even this dark marking is absent or very faint, the wings being wholly whitish. From other species with unmarked wings it can easily be separated under the microscope by the fact that the wings have the surface bare of hairs except towards the tip; the wing-length is scarcely 1 mm.

C. chiopterus is probably common and widely distributed in Britain, though at present the only counties from which records are available are HERTS., CAMBS., OXON., and DURHAM. It is probably overlooked owing to its small size, and perhaps through confusion with *C. obsoletus*.

There are no definite records of blood-sucking by this species, but as the female is extremely similar to that of *C. obsoletus* it may be that the two are sometimes confused.

The larvae have been found in the sap running from wounds in elm trees, a habitat which so far as known is not shared by any other species of *Culicoides* in this country.

***Culicoides obsoletus* Meigen.**

(Fig. 14)

The small size and faint grey markings of the wings are usually sufficient to distinguish this species from other biting midges in this country. Except for the still smaller *C. chiopterus* it is the only British species in which the wing is largely bare, the longer hairs being almost confined to the tip. The

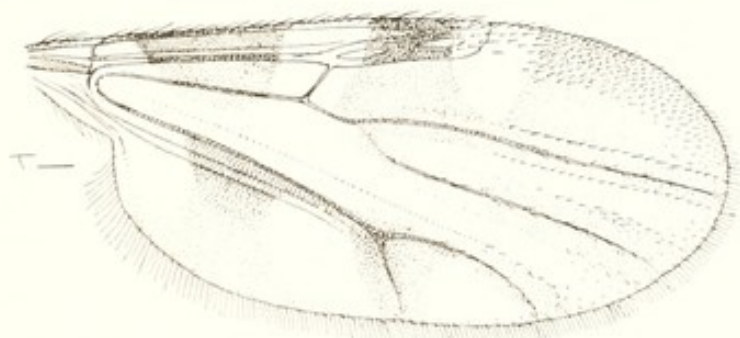


FIG. 14.—*Culicoides obsoletus* Meigen. Wing of ♀.
(Slightly more enlarged than other *Culicoides* wings illustrated here.)

wing has one distinct blackish mark in the middle of the front margin, this occupying the junction between the two radial cells and leaving most of the second radial cell pale; other dark markings on the wings are extensive but much fainter. There are no definite markings on the thorax. The average wing-length is about 1.4 mm.

C. obsoletus is abundant in most parts of Britain, extending as far north as Sutherland, though perhaps more numerous in the south. In bloodthirstiness it is second only to *C. impunctatus*, and everyone living in the country must be only too familiar with its activities on warm summer evenings in the gardens.

Though most abundant in June, *C. obsoletus* may be found throughout the summer, and in a damp autumn is sometimes very numerous again in September and October, a fact which suggests that it has normally at least two broods in the year.

In spite of its abundance the life-history of *C. obsoletus* is still very little known, but it has been reared on a good many occasions and from very various media; in England from rather dry decaying fungi, from damp debris from a tree-hole, and from sheep-dung in fields; on the continent from fungi and also from the muddy edges of springs. Its abundance in gardens and woods suggests that its normal breeding places may be moist decaying vegetable matter, such as accumulations of dead leaves.

***Culicoides pulicaris* Linnaeus**

(Figs. 15, 16)

The precise identity of the midge to which Linnaeus actually applied the name *Culex pulicaris* is to some extent a matter of conjecture, but it was certainly one of the larger *Culicoides*, and the name is now in general use for a common species which has somewhat milky wings clothed with hair on the greater part of their surface and with rather sharply defined dark markings which include three blackish spots on the front margin and a small dark spot in the middle of the cubital fork. The wing-length is rather variable, but averages about 2 mm.

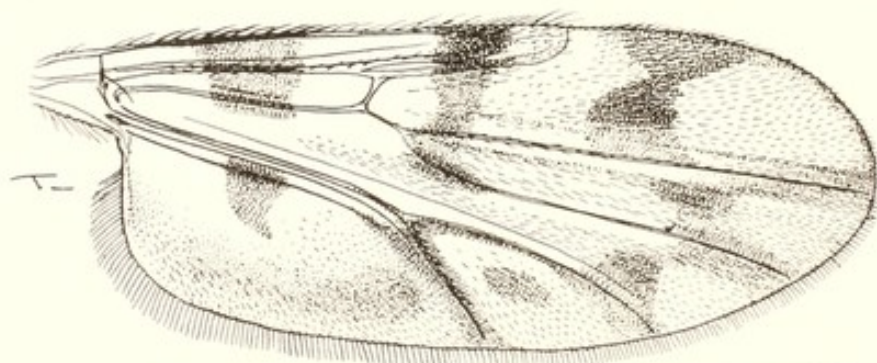


FIG. 15.—*Culicoides pulicaris*, L., typical form. Wing of ♀.

The size and disposition of the dark markings of the wings, and also those of the thorax, is subject to a good deal of variation, but nearly all specimens may be grouped into one or other of two rather distinct varieties, each of which has a lighter form in which the dark markings of the wings are so much reduced that the wings appear mainly white. In the first variety (arbitrarily chosen as representing the typical *C. pulicaris*) the hour-glass shaped dark mark towards the tip of the front margin of the wing is broadest on the fold above the upper branch of the median fork, the two branches of this fork are

dark to the extreme tips, and the thorax is either unmarked or with three small and usually separate dark marks. In the second variety (var. *punctatus* Meigen) the hour-glass shaped mark extends farther across the wing and is broadest above the fold above the upper branch of the median fork, there is a very small pale area at the extreme tip of each of the two branches of this fork, and the thorax usually has three fairly large irregular dark marks which are often partially fused.

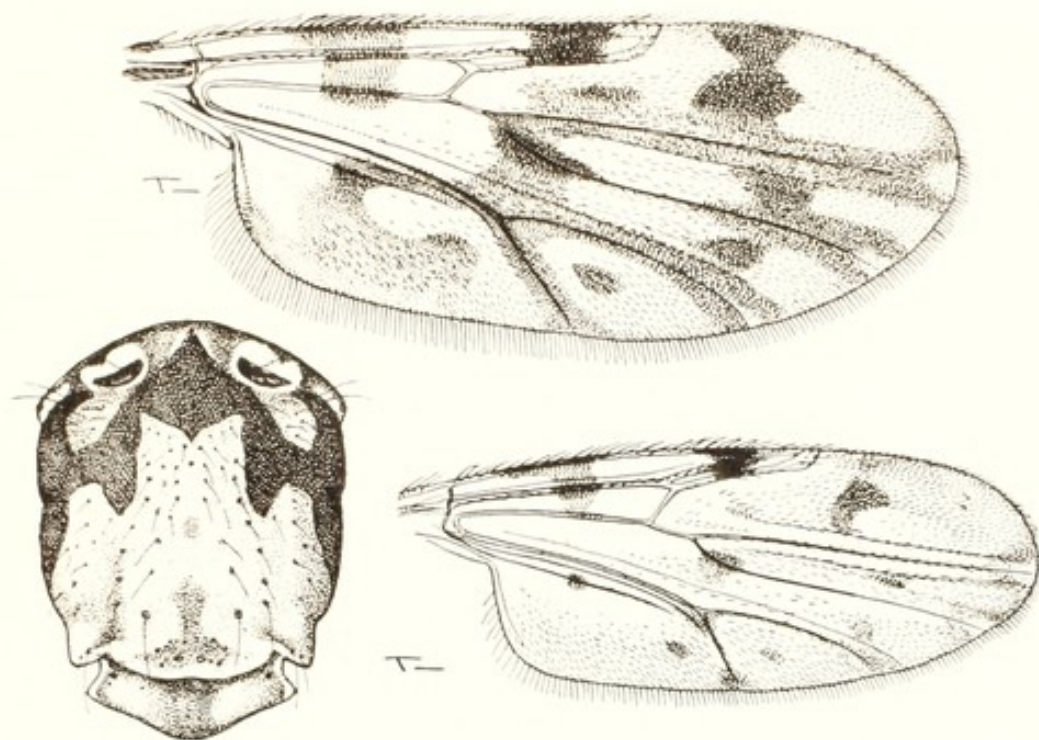


FIG. 16.—*Culicoides pulicaris* L., var. *punctatus* Mg. Wings of ♀, showing variation in size and in extent of dark markings; thorax, showing average type of markings.

C. pulicaris occurs throughout Britain, and though usually less numerous than *C. arcuatus* or *C. obsoletus* it is frequently (especially in moist seasons) sufficiently abundant to be a most troublesome pest. Like most of the other species, it is most abundant and troublesome in the early summer; it is usually most active in the afternoon or evening, though Goetghebuer reports it as troublesome during the middle of the day.

The larvae of *C. pulicaris* have on several occasions been found among floating green algae in ponds.

***Culicoides halophilus* Kieffer**

(Fig. 17)

In most respects this resembles *C. pulicaris*, of which it has been considered a variety. There is, however, a rather definite difference in wing-markings, the median fork containing two dark spots or streaks instead of only one as in *C. pulicaris*; the wing-markings in many specimens are more suffused than in *C. pulicaris*, and there may be a dark suffusion at the tip of the wing above and including the upper branch of the median fork, but this is by no means

always the case. On the average *C. halophilus* is a somewhat smaller insect than *C. pulicaris*, with a wing-length of about 1.8 mm.

In Britain *C. halophilus* has been found only on or near the coast, the

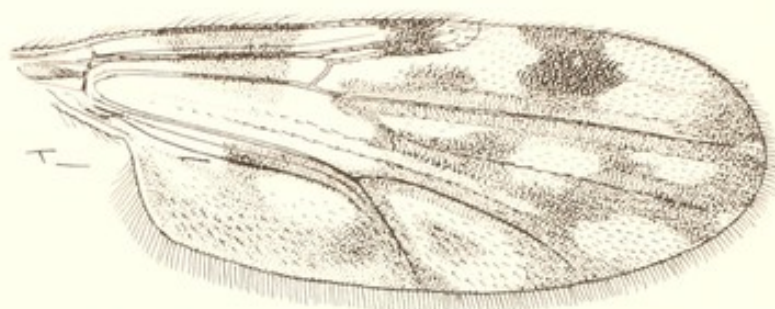


FIG. 17.—*Culicoides halophilus* Kieff. Wing of ♀.

locality records including the following :—DORSET : Goathorn. CARNARVON : Llandwrog. ARRAN : Brodick, Catacol. CROMARTY : Dingwall. ST. KILDA.

***Culicoides delta* sp. n.**

(Fig. 18)

This also has been considered a variety of *C. pulicaris*, which it resembles in size and general appearance, differing as follows :—Pale parts of wing creamy-yellow by reflected light ; no separate dark spot in cubital fork, but dark margin to lower branch of this fork much broader and filling base of fork ; hairs on wing somewhat scantier ; legs darker, the hind tibia without any trace of a yellow ring at base. The wing-markings are almost on the same pattern as in *C. impunctatus*, from which species *C. delta* is chiefly to be dis-

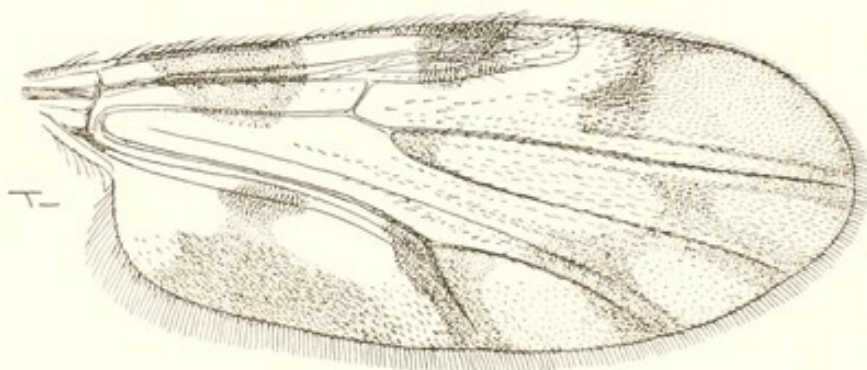


FIG. 18.—*Culicoides delta* sp. n. Wing of ♀.

tinguished by the presence on the thorax of tripartite dark markings shaped somewhat as shown in fig. 16, and by its larger size, the average wing-length being about 2.2 mm. For description of genitalia see p. 145.

British Museum specimens of *C. delta* are from the following localities :—ARRAN : Brodick (types), Catacol, Corriegills, Sannox, v. 19. PERTHSHIRE : Loch Rannoch and Lock Kinardochy, vi. 31 (*F. W. Edwards*).

Culicoides impunctatus Goetghebuer

(Fig. 19)

This is intermediate in size and appearance between *C. obsoletus* and *C. pulicaris*. As in the latter the wing-markings include three distinct dark areas on the front margin (the outermost one being variable in size and shape), but the remaining markings are less sharply defined, there is no dark spot in the cubital fork, and the ground-colour of the wing is not definitely whitish. As in *C. pulicaris* the wing is hairy over the greater part of the surface, except towards the base, but as in *C. obsoletus* there are no dark markings on the thorax. The average wing-length is about 1.6 mm.

C. impunctatus is by far the most abundant species of *Culicoides* in Scotland, "where its presence in conjunction with that of the kilt is said to have given rise to the highland fling." It is almost equally abundant in all the hilly districts of the north and west of England and in Wales; in the south and east it is less abundant, and from some districts (*e.g.* North Hertfordshire) it appears to be absent, though it has been found in some numbers near the Dorset coast and in Epping Forest. As in the case of *C. obsoletus* it is most abundant in June, but occurs throughout the summer except in dry weather.



FIG. 19.—*Culicoides impunctatus* Goet.
Wing of ♀.

Wherever it occurs, *C. impunctatus* is an exceedingly troublesome insect, and in the western highlands of Scotland is a major pest, sometimes rendering outdoor activities impossible, especially during the late afternoon and evening; it will bite all through the night in sultry weather, but is not much in evidence in the middle of the day except in sheltered and shady places.

Nothing is known of the life-history and breeding habits of *C. impunctatus*; it has never been reared, but from its mode of occurrence it seems most probable that it will be found to breed in water-logged soil, especially soil of a peaty nature.

REFERENCES

- BACOT, A. W., and TALBOT, G. 1919. The comparative effectiveness of certain culicifuges under laboratory conditions. *Parasitology*, **11**, 221-236.
 BUCKLEY, J. J. C. 1933. A note on the Development of *Filaria ozzardi* in *Culicoides furens* Poey. *J. Helminth.*, **11**, 257-258.
 BUCKLEY, J. J. C. 1934. On the Development in *Culicoides furens* Poey, of *Filaria* (= *Mansonella*) *ozzardi* Manson, 1897. *J. Helminth.*, **12**, 99-118.
 CARTER, H. F., INGRAM, A., and MACFIE, J. W. S. 1920. Observations on Ceratopogonine Midges of the Gold Coast, with descriptions of New Species. Parts I-II. *Ann. Trop. Med.*, **14**, 187-272.
 DOVE, W. E., HALL, D. G., and HULL, J. B. 1932. The salt marsh Sand Fly Problem. *Ann. Ent. Soc. Amer.*, **25**, 505-522.

- EDWARDS, F. W. 1926. On the British Biting Midges. Trans. Ent. Soc. London, 1926, 389-426.
- EDWARDS, F. W. 1931. *Culicoides riethi* Kieffer, a new British biting midge. Entomologist, 64, 1.
- GOETGHEBUER, M. 1919. Métamorphoses et mœurs du *Culicoides pulicaris* Linn. Ann. Soc. Ent. Belg., 59, 25-30.
- GOETGHEBUER, M. and LENZ, F. 1933-4. Heleidae (Ceratopogonidae). In Lindner's "Die Fliegen." Stuttgart.
- JOBLING, B. 1928. The Structure of the Head and Mouth parts in *Culicoides pulicaris* L. Bull. Ent. Res., 18, 211-236.
- JOBLING, B. 1929. Trans. R. Soc. Trop. Med. Hyg., 22, 304.
- MAYER, K. 1934. Die Metamorphose der Ceratopogonidae. Arch. Naturg. N. F., 3, 205-288.
- RIETH, J. T. 1915. Die Metamorphose der Culicoidinen. Arch. Hydrobiol., Supp., 2, 377-442.
- SHARP, N. A. D. 1928. *Filaria perstans*; its Development in *Culicoides austeni*. Trans. R. Soc. Trop. Med. Hyg., 12, 371-396.
- STEWART, J. S. 1933. *Onchocerca cervicalis* (Railliet and Henry 1910) and its Development in *Culicoides nubeculosus* Mg. Univ. Camb. Inst. Anim. Path., 3, 272-284.
- STEWART, J. S. 1935. Fistulous Withers and Poll-evil. Equine and Bovine onchocerciasis compared, with an account of the life-histories of parasites concerned. Vet. Rec. (N.S.), 15, 1563-1573.
- THIENEMANN, AUG. 1928. Chironomiden-Metamorphosen. I. Arch. Hydrobiol., 19, 585-623.

Family

SIMULIIDAE

(BLACK-FLIES)

THE small flies of this family are of world-wide distribution; about five hundred species are now known, of which we have eighteen or nineteen in Britain. Though classified into rather numerous genera by some writers, it is more usual and more convenient to include them all in the single genus *Simulium*.

Simuliidae may easily be recognised by their plump bodies, rather short legs, and hump-backed shape, which would cause a non-specialist to classify them as "flies" rather than as "gnats," though their structural features place them in the suborder Nematocera not far from the midges. In length of body they vary from about one-sixteenth to about one-quarter of an inch, and are thus on the average larger than the midges but smaller than the mosquitoes. The wings are unusually broad and have a distinctive venation; the antennae, which are alike in the two sexes, are short and bare, with eleven segments. The males, which do not bite, differ from the females in having their eyes greatly enlarged and meeting on the top of the head, the facets of the upper part of the eye being much larger than those of the lower part.

Almost without exception the early stages of Simuliidae are passed in running water. The one exception which proves the rule is the case of *S. adersi* Pom., the larvae of which have been found on rocks on the wave-beaten shores of small islands in Lake Victoria (Uganda). The larvae require a high degree of aeration in the water, and are always to be found in the swiftest parts of whatever stream they are living in; they can only colonise rivers of slow current where plenty of green plants are present to increase the oxygen supply, and on such plants they are found in those parts which are continually waving about in the flow of the stream. When transferred to still water the larvae soon die of asphyxia, though they may live for some days on wet moss. They

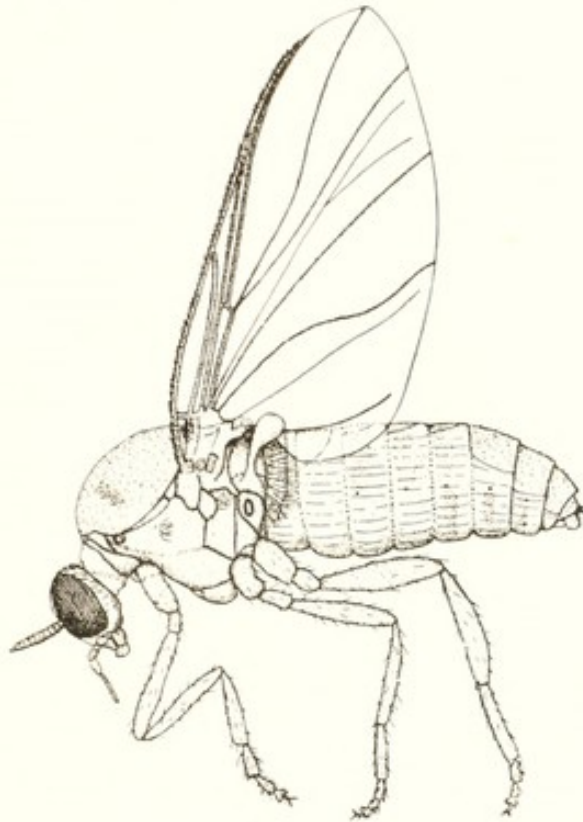


FIG. 20.—A black-fly (*Simulium ornatum* Mg.). Side view of ♀.

are usually found near the surface of the water and rarely at a greater depth than a foot.

The larvae are of highly characteristic form. The large head is provided with a conspicuous pair of "mouth-fans," which serve to catch the food (any organic particles) as it floats by, and the plump body is swollen on the posterior half. Immediately behind the head is a single proleg, and at the posterior end of the body is a circlet of minute hooks, sometimes miscalled a "sucker." The larvae progress with a looping motion like a geometrid caterpillar, and fix themselves by the posterior circlet to plants or stones, using a sticky secretion applied from the mouth; when dislodged they retain hold of a silken thread with their anterior proleg, and can resume their position by climbing along the thread by means of the mouth and proleg.

The larva moults six times, changing to a pupa with the final moult. Before

pupation the larva spins a silken cocoon to shelter the pupa, which, being unprovided (as a rule) with special organs of fixation, requires protection from the current. The form of the cocoon varies greatly according to the species; in the British species it is usually slipper-shaped and always pointed and closed behind, broad and open in front, with the open end facing down-stream. From the front end of the pupa project the respiratory organs (which again vary greatly in form according to the species) with the aid of which the pupa extracts air from the water.* When the adult fly is fully formed, air is collected within the pupal skin; eventually this skin splits, the fly escapes and floats to the surface in its bubble of air without being wetted; the wings are instantly unfolded and the insect flies to a nearby resting-place.

The egg-laying habits are still not well known, and certainly vary a great deal. Probably in most species the eggs are deposited in jelly-like masses at the edge of the water on any objects which are partly immersed; in some cases the females enter the water to lay, walking in along some support to a depth of several inches, and in others it is believed that they scatter their eggs on the surface while in flight, dipping the tail into the water each time an egg is deposited. The eggs laid by one female number several hundreds, as many as 350 having been counted.

Unlike midges and most mosquitoes, many Simuliidae have a considerable range of flight. In Britain they have often been found in numbers at distances up to two miles from their nearest breeding-place, even in calm weather. Abroad much greater ranges than this have been noted, the greatest being in the Anglo-Egyptian Sudan, where *S. griseicollis* has been found numerous in places as much as 200 miles distant from its home in the river Nile. Such flights as these are doubtless largely aided by wind, but it is known to be a habit of *Simulium* to migrate from the breeding grounds in search of food, and for the females to return later to lay their eggs.

The mouth-parts of Simuliidae, though comprising the same elements as those of mosquitoes, are very much shorter, and their mode of action as well as their detailed structure is quite different. The strong mandibles are formed like a pair of scissors, the left mandible having a knob on its under surface near the middle of the blade which fits into a socket in the right mandible, thus forming a fulcrum, while the "handles" of the scissors are attached to the muscles which move them. In the act of biting an initial snip in the skin of the victim is made by the mandibles; the maxillae, which are provided with strong recurved teeth, are then pushed into the puncture and enlarge the opening until it is sufficiently large and deep for the other mouthparts to be inserted and to form a food-canal through which blood may be sucked.

The blood-sucking habit is probably common to all Simuliidae; it has been found that a blood-meal is essential for the reproduction of some species, and perhaps this is true of all. Rubzov (1936) thus summarises his studies on this point:

* There has been some dispute as to whether the respiratory filaments extract dissolved air from the water or collect passing bubbles. Probably both processes take place, perhaps to a differing degree in different species. Smart has found that *S. ornatum* can be bred in a film of water in which no bubbles are present.

" A special search showed that for the complete development of the eggs of *S. venustum* Say., *S. morsitans* Edw., *S. latipes* Meig. and *S. decimatum* Dur. and Rubtz., blood-sucking and an additional nutrition with juices and water before and after fertilisation is necessary. The fertilisation itself stimulates ovogenesis which has been stopped at some first stages and has called forth the necessity of blood-sucking. The quantity of consumed blood must be large enough, as all ovarioles develop simultaneously and the lack of food material stops their development."

Bequaert (1938) also remarks that " as yet there is no reliable evidence that any of the Simuliidae are normally addicted in nature to anything but a diet of vertebrate blood, or that females fed in captivity on a blood-free diet could deposit viable eggs." He says that no black flies have been observed attacking reptiles or amphibians, and classifies them according to their habits into (1) those attacking chiefly or perhaps exclusively birds ; (2) those attacking mammals but not man ; and (3) those attacking man as well as other mammals.

The remarks of Rubzov (1936) on the effect of weather conditions on the biting of *Simulium* in East Siberia are worth quoting, as they describe almost equally well the conditions in this country :

" The black-flies show a considerable activity at a temperature of 14° – 22° C., with an optimum of about 19° – 20° C. The humidity of the air also has a great significance, and the greatest activity is observed under the relative humidity of about 70–95 per cent. The wind velocity has sometimes a decisive role. Even a small wind diminishes the activity of black-flies, and a wind of about 4–5 metres per second completely interrupts it. All other conditions being identical, the activity increases in cloudy weather and decreases in clear sunny weather [this is doubtfully true in Britain]. After sunset the attacks of the black-flies discontinue for the whole night. A slight rain does not prevent attacks, a strong rain stops them. Barometrical pressure has a particularly great influence. Its lowering extraordinarily increases the activity of the bloodsuckers. It is not the low pressure itself that is so important, but the change in the direction of its fall. The blood-sucking activity of the black-flies reaches its climax in the sultry, murky, cloudy hours preceding a thunderstorm."

Perhaps the most notorious of all the Simuliidae is the Golubatz fly (*Simulium columbaschense* Schönbauer), so called from the old castle of Golubatz, on the banks of the Danube in the department of Pojarevatz, Yugoslavia. This fly breeds in the river Danube, being almost confined to the region of the Iron Gate, where conditions are particularly suitable for its development. In dry years, when the level of the river falls, it is able to colonise larger areas of the river bed, and consequently to increase enormously in numbers. When this happens (as in 1923 and again in 1934) vast swarms of flies spread from the breeding area over the surrounding country to a distance of 50 miles or more, partly through their own flight but largely through being carried passively by wind. The flies attack domestic animals in such numbers as frequently to cause their deaths, partly from loss of blood and partly from the poisonous effect of their bites. A census made in 1923 showed that in that year in

Rumania, Bulgaria and Jugoslavia nearly 20,000 domestic animals were killed, including horses, cattle, sheep, goats and pigs, besides wild animals, such as deer, hares and foxes, all in the latter half of April. In 1934 the number was even larger, partly owing to the fact that the flies spread to districts where the peasants were unfamiliar with the pest and with the procedure necessary to protect their beasts.

Another black-fly which has caused enormous losses of live-stock is the "southern buffalo-gnat" (*S. pecuarum* Riley), which in some seasons develops

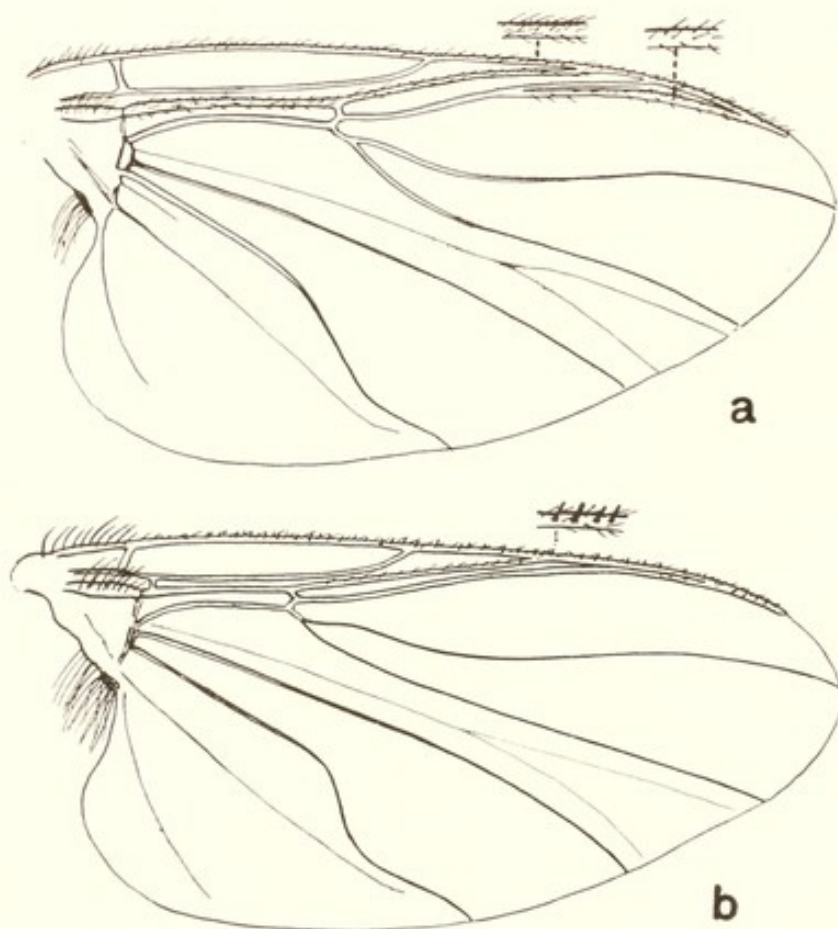


FIG. 21.—Wings of *Simulium*: a, *S. hirtipes* Fries; b, a species resembling *S. ornatum* Mg.

in vast numbers in parts of the Mississippi valley. Mules appear to be particularly susceptible to its attacks; over a thousand of them were killed by the flies in the year 1931, and over 500 in April 1934. It is said that neglect of dykes during and after the civil war was one of the main causes of black-fly plagues during that period, through the multiplication in times of flood of small streams suitable for breeding *S. pecuarum*.

The attacks of black-flies on man are fortunately less serious, and fatal cases have been but rarely placed on record. Nevertheless these flies may be so numerous and venomous (as, for example, in parts of northern Canada) as to render large tracts of country more or less uninhabitable during the summer

They are also a scourge in several islands of the Marquesas group, in Northern India and Burma, and in many parts of tropical Africa. Some species appear to be unable to pierce the human skin, but without actually biting can make themselves very offensive by their pestering attentions, and by getting into the eyes, ears or nostrils.

The bite is apt to be more painful than that of a mosquito, and often results in the development of a hard lump or swelling which may persist for days or even weeks.

In recent years many discoveries have been made regarding the transmission of parasitic worms of the genus *Onchocerca* by species of *Simulium*

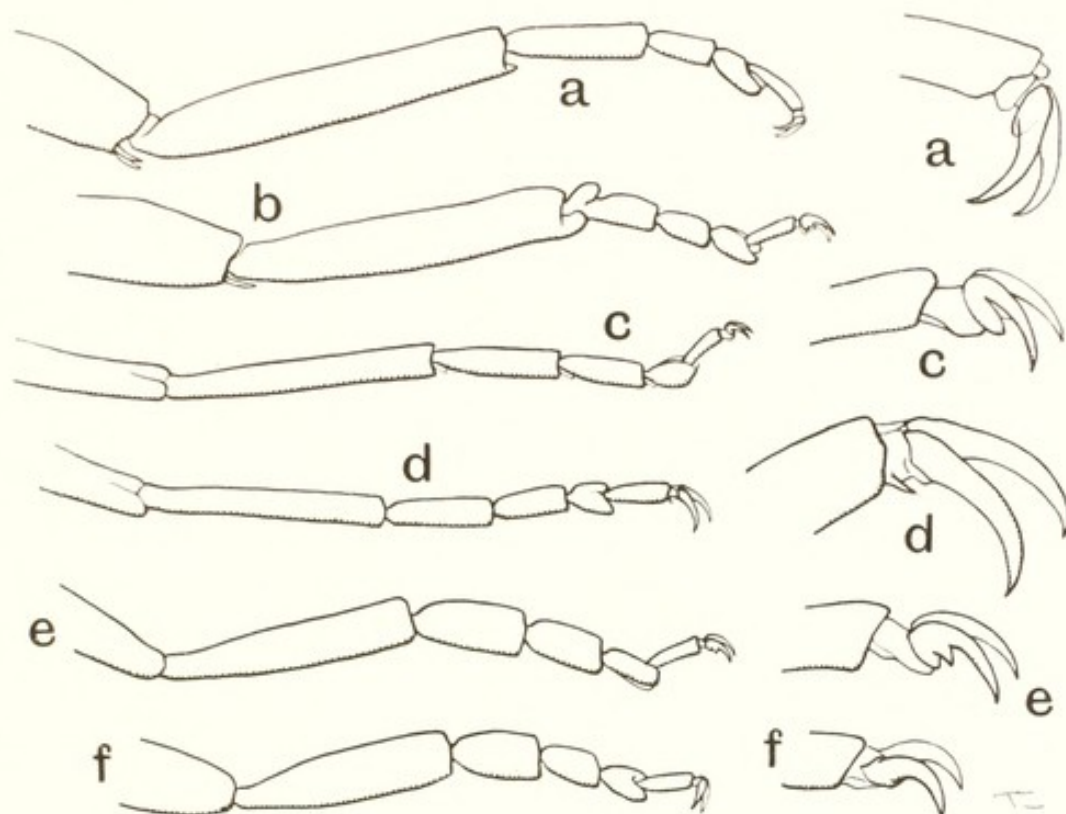


Fig. 22.—Tarsi of *Simulium*, with claws more enlarged (but all to same scale). a. *S. hirtipes*, hind tarsus ; b. *S. ornatum*, hind tarsus ; c. *S. latipes*, front tarsus ; d. *S. equinum*, front tarsus ; e. *S. ornatum*, front tarsus ; f. *S. morsitans*, front tarsus.

Following up a suggestion made by F. W. Dry in 1922, Blacklock (1926) demonstrated that the worm *Onchocerca volvulus*, which in the young stage is a common human parasite over a large part of Tropical Africa, undergoes development and is transmitted by *Simulium damnosum* Theobald, and subsequent workers have shown that *S. neavei* Theobald is also a carrier of this parasite. The worms give rise to small subcutaneous nodules or tumours and skin eruptions, and in some districts are also a frequent cause of blindness. A similar parasitic worm (*Onchocerca caecutiens*), causing similar troubles of the skin and eyes, is common in the coffee-growing districts of Guatemala and Mexico, and has been found by Strong and others to be carried by three species of *Simulium*, *S. metallicum* Bellardi, *S. ochraceum* Walker, and *S. callidum*.

Another case of transmission of *Onchocerca* by *Simulium* has been brought to light by J. S. Steward (1934, 1937), who showed that *O. gutturosa*, a parasite found in the brisket of cattle, is carried by *S. ornatum* Mg. in England; in this case, however, the parasite causes no serious injury.

Apparently only one case is established of a protozoal disease being carried by *Simulium*, O'Roke (1934) having stated that *S. venustum* Say, carries a malaria-like disease of ducks (caused by *Leucocytozoon anatis*) in Michigan.

As repellants against the bite of *Simulium* on cattle or horses various mixtures have been recommended, of which the following are examples:

(a) Marlatt (1934) advises a 5 per cent. emulsion of pine tar oil. This is said to be effective, but when the insects are abundant and in hot weather, from two to five applications per day may be needed.

(b) Baranoff (1934) advises a mixture of three parts of rectified kerosene with ten parts of yellow vaseline. One ounce of this ointment per horse or cow applied in the morning is said to remain effective all through the day.

For use on the human skin the repellants recommended against midges (p. 30) will probably be found equally effective against the attacks of *Simulium*.

The British species of *Simulium* were reviewed by Edwards (1915 and 1920), seventeen species being then recognised, a total which was subsequently (1927) increased by two. No further additions have been made, and the following keys and notes are mainly compiled from the papers cited. For further information, especially regarding the males, larvae and pupae, reference may be made to these papers and to the more detailed description of the early stages by Puri (1925).

KEY FOR IDENTIFICATION OF THE BRITISH SIMULIIDAE.

(Females only)

1. Wings (fig. 21, *a*) with an extra vein (R_2+3) present and with fine hairs only on costal margin; second hind tarsal segment simple; body and legs dark *hirtipes* Fries
Wings (fig. 21, *b*) with vein R_2+3 absent, and with minute spinules mixed with the hairs on costal margin 2
2. Front tarsi (fig. 22, *c, d*) slender and cylindrical; front tibiae dark, or not obviously silvery; abdomen dull at tip; base of radial vein hairy 3
Front tarsi (fig. 22, *e, f*) more or less flattened (compressed); front tibiae silvery on outer surface; abdomen with tip shining; base of radial vein bare 11
3. Hind tarsi (fig. 22, *a*) with second segment simple, without trace of excavation at base; hair of thorax erect; body and legs dark *tredecimatum* Edw.
Hind tarsi (cf. fig. 22, *b*) with second segment more or less deeply excavated above near base; hair of thorax decumbent 4
4. Claws (fig. 22, *c*) of normal size, each with a thumb-like projection at the base; integument of thorax dark, without stripes; pleurae bare 5
Claws (fig. 22, *d*) much larger than usual and without projection at base; integument of thorax more greyish, with three narrow dark lines; first segment of hind tarsus largely yellow; pleural membrane with a patch of hairs 10
5. Legs entirely blackish; pubescence of abdomen dull whitish 6
Legs partly yellowish; pubescence of both thorax and abdomen bright golden and dense. . . 9
6. Pubescence of thorax whitish, or partly brownish; second segment of hind tarsus only slightly excavated at base above; eyes closer together than usual. 7
Pubescence of thorax golden; second segment of hind tarsus very distinctly excavated at base above; eyes wider apart 8

7. Pubescence of thorax all pale *subexcisum* Edw.
 Pubescence of thorax with three dark stripes *yerburyi* Edw.
8. Larger species (wing 4-4.5 mm.); pubescence of abdomen dense *costatum* Fried.
 Smaller species (wing barely 3.5 mm.); pubescence of abdomen very scanty; abdomen
 pink in life *latipes* Mg.
9. Femora and tibiae clear yellow, with black tips *aureum* Fries
 Femora and tibiae darker, the latter with a dark ring close to the base. *angustitarsis* Lundst.
10. Larger (wing 3-4 mm.); thorax and legs darker *equinum* L.
 Smaller (wing 2-2.5 mm.); thorax and legs paler *salopiense* Edw.
11. Frons (above antennae) and face (below antennae) grey, dull; shoulders with white mark-
 ings (fig. 24) 12
 Frons blackish, shining (face usually grey) 14
12. Front and middle femora mainly yellow *variegatum* Mg.
 Femora mainly dark 13
13. Pleural membrane with soft hairs; claws with a small sharp tooth near middle. *ornatum* Mg.
 Pleural membrane bare; claws not toothed *nölleri* Fried.
14. Shoulders marked as in *S. ornatum*; claws toothed 15
 Markings on shoulder different, or absent; claws simple 16
15. Pleural membrane with soft hairs *ornatum* var. *nitidifrons* Edw.
 Pleural membrane bare *monticola* Fried.
16. Face black, shining, like the frons; legs mainly black *tuberosum* Lundst.
 Face grey; legs more extensively pale 17
17. Thorax almost dull, with coarser pubescence 18
 Thorax somewhat shining, with much finer pubescence 20
18. Basal two-thirds of hind tibia clear yellow (hind femora almost all black, contrasting with
 the yellow base of tibia) *reptans* L.
 Basal half of hind tibia yellow, but less sharply distinguished from the black apical
 portion 19
19. Rather less than basal half of middle tibia yellowish *venustum* Say.
 Rather more than half of middle tibiae yellowish *morsitans* Edw.
20. Thorax rather brightly shining; front coxae reddish *erythrocephalum* Deg.
 Thorax less shining, with traces of two greyish longitudinal stripes; front coxae blackish
erythrocephalum form *sericatum* Mg.

***Simulium hirtipes* Fries**

One of the largest of the British Simuliidae, and the only representative in this country of the subgenus *Prosimulium*, sometimes regarded as a genus distinct from *Simulium*, owing to the peculiarities of structure mentioned in the key. The body and legs are uniformly dull blackish and clothed with dull yellowish pubescence.

S. hirtipes is chiefly a mountain species, being widely spread in the Scottish Highlands from Perth to Sutherland. It is doubtful if the species occurs in England; an isolated record from Crowborough, Sussex, requires confirmation as it may have been due to an error in labelling. The occurrence of the species in North America has now been definitely established (Twinn, 1936), and it has also been found in Eastern Siberia (Rubzov).

According to the late J. W. Yerbury this is "the earliest of the biting pests of Scotland," the adults appearing in May; though common in some localities, it is not known to be abundant enough anywhere in Britain to be a serious pest. It is recorded by Dorogostaisky, Rubzov and Vlasenko as a severe blood-sucker in Eastern Siberia, attacking man, cattle, and other animals.

The early stages are found in rapid hill streams ; the larvae do not congregate in large masses, but are scattered over large stones or on the rocky bottom. There is probably only one generation in the year.

***Simulium tredecimatum* Edwards ***

A blackish species in many respects resembling *S. hirtipes*, but with marked structural differences as indicated in the key.

The occurrence of this species in Britain requires confirmation. The only record at present is the original one of larvae taken "from stomach of trout, England," the locality and collector being unknown.

S. tredecimatum has been found in Norway by Olstad.

***Simulium subexcisum* Edwards**

Another blackish species with pale pubescence, superficially resembling the last two, but differing in structural details.

S. subexcisum, though nowhere common, is widely distributed in Britain, having been recorded from Hants, Sussex, Devon, Hereford, Middlesex, Herts., Arran, Inverness, Nairn, Sutherland. It has also been found in Canada (*Twinn*).

There are no records of the feeding habits of this species. Adults appear in April and May. Larvae occur in small temporary rills ; owing to the nature of the breeding places there can only be a single annual generation.

***Simulium yerburyi* Edwards**

This is very similar to *S. subexcisum*, of which it may be no more than a variety.

The few known specimens were taken in Herts. (Knebworth), Inverness (Nethy Bridge) and Nairn.

Life history similar to that of *S. subexcisum*.

***Simulium costatum* Friederichs**

Except for the more brassy tint of the pubescence of the thorax, this large *Simulium* might easily pass on a superficial examination for *S. hirtipes*, though its structural features are quite different.

At present *S. costatum* has been found in only three places in Britain : Barton, near Torquay ; Barton, north-east of Luton ; and Ditchley, Oxon. It has also been found in Germany and Denmark, in Central and Eastern Siberia, and (surprisingly) in the Patagonian Andes (Edwards, 1931) ; presumably it will eventually be found to occur across the width of Europe and Asia and throughout the length of America.

The species is at present so little known that there are no records of its feeding habits in Britain, but the larvae have been found on stones and leaves

* This species may perhaps be synonymous with *S. pallipes* Fries, as suggested by Dorogostaisky, Rubzov and Vlasenko (1935).

in small and fairly rapid streams. In Eastern Siberia it is recorded by Dorogostaisky, Rubzov and Vlasenko as "very widely distributed common species. In streams and rivers of moderate swiftness. Frequently in great numbers. Severe bloodsucker."

***Simulium latipes* Meigen**

Though resembling the five species just considered in its dark thorax and legs, the female of *S. latipes* is readily distinguishable in life by the pinkish colour of the abdomen, which even in perfect specimens is only very scantily clothed with fine pale hair; the fine pubescence of the thorax is brassy instead of whitish.

S. latipes is a common species throughout England and Scotland, and is also recorded from Ireland, as well as from Canada; the adults are found chiefly in April and May.

In spite of its abundance, the records of biting by *S. latipes* are so few that it cannot be regarded as a pest. It is possible that it bites chiefly birds, as do some nearly related species.

The normal breeding places of *S. latipes* are small streams and rills with gravelly bottoms which are liable to dry up during the summer; only exceptionally are the larvae found in larger streams. There is usually only one brood, though a second brood may be hatched in August if the streams are still running. Ussing records that in Denmark the eggs are laid under stones in the bed of the stream; they can withstand drying, though even when the stream fails in summer there is usually some dampness under the stones.

***Simulium aureum* Fries**

Females of this species in perfect condition are resplendent objects, the back of the thorax and the whole of the abdomen being densely clothed with bright golden scaly pubescence; when seen in flight they appear like little golden balls. The legs are conspicuously parti-coloured, black and yellow.

S. aureum occurs throughout Britain and is not at all uncommon though easily overlooked; it is also widespread in North America where it has been known as *S. bracteatum* Coq.

There are no records of bloodsucking by this species in Britain, but Bequaert (1938) states that in North America it bites goslings; in Africa a very similar species has been found clustering on the rumps of fowls.

The life-history of *S. aureum* is similar to that of *S. latipes*, the larvae occurring chiefly in small streams and rills, especially those with a stony or gravelly bottom. There may be two generations in the year.

***Simulium angustitarsis* Lundström**

The resemblance between this and *S. aureum* is rather close, and the females of the two have been confused; the most obvious difference is the presence in this species, and the absence in *S. aureum*, of a dark ring near the base of each tibia.

S. angustitarsis is less common in Britain than the allied *S. latipes* and *S. aureum*, and has so far been found only in the southern, south-eastern and midland counties of England and Wales.

The larvae occur in weedy rivers with only a moderate current, in company with other species such as *S. ornatum*, *S. erythrocephalum* and *S. equinum*, but in smaller numbers; they are rarely found in small streams.

There are no records of the feeding habits of this species.

Simulium equinum Linnaeus

The unusually large simple claws, and the presence of three narrow dark lines forming a trident or somewhat lyre-shaped mark on the thorax, are two features peculiar to this species and the nearly related *S. salopiense*; in newly hatched specimens, however, the dark lines tend to be obscured by the golden pubescence which covers the thorax as well as the abdomen, and moreover the lines may not be very distinct in dark specimens. The legs in *S. equinum* are mainly blackish, only a little yellowish about the knees. The pleural membrane is rather densely clothed with whitish pubescence, another feature which this species shares with *S. salopiense* and in which it differs from all other British *Simulium* except *S. ornatum*.

S. equinum is an abundant species in many parts of England (especially, perhaps, in the eastern counties) and has also been recorded from Wales (Llandrindod Wells), Scotland (East Lothian) and Ireland (County Clare and County Wexford), but so far as known at present it does not occur in the highlands of Scotland.

The activities of this fly are only too well-known to agriculturists and horse-keepers owing to its habit of sucking blood from the ears of horses, and to a less extent of cattle; in the neighbourhood of its breeding places the ears of horses when not protected by ear-caps may sometimes be seen to have their inner surfaces covered with a close-packed "pile" of *S. equinum*, and these attacks may give rise to severe ulceration. *S. equinum* seems to be the only species of the genus (and indeed the only blood-sucking fly) in Britain which has this habit, and it attacks the ears almost exclusively. Only occasionally does it bite man.

The larvae of *S. equinum* are found in rivers with a slow or moderate current, and almost always on water-plants such as *Ranunculus*, *Scirpus*, or *Potamogeton*, usually in company with *S. erythrocephalum* or sometimes *S. ornatum* or *S. reptans*. The females have been observed to crawl under water to a depth of several inches to lay their eggs on submerged vegetation or sticks. There are two or three generations during the year, the adults being most numerous in April, July and September; the adults of the spring generation are larger.

Petersen (1924) records *S. equinum* as attacking the ears of cattle and sheep as well as horses, and states that the flies actually mate in the ears of the host.

Simulium salopiense Edwards

(Fig. 23)

The female of this species, not hitherto described in detail, is so similar to that of the related *S. equinum* that differentiation between them is not easy. Since the original description was published more ample material has become available, from which it appears that the female of *S. salopiense*, apart from being smaller than that of *S. equinum*, differs in having the ground-colour of the thorax lighter greyish, with the markings more distinct and the front ends of the three narrow dark lines more distinctly enlarged into spots, and the tibiae much more extensively pale towards the base.

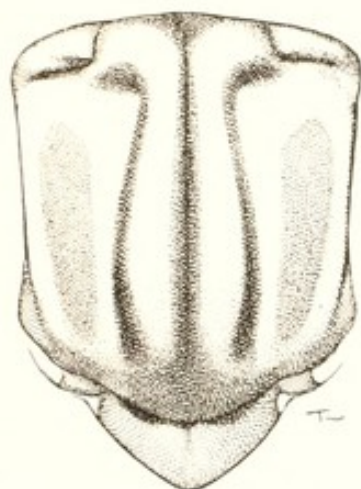


FIG. 23.—*Simulium salopiense* Edw.
Thorax of ♀ from above.

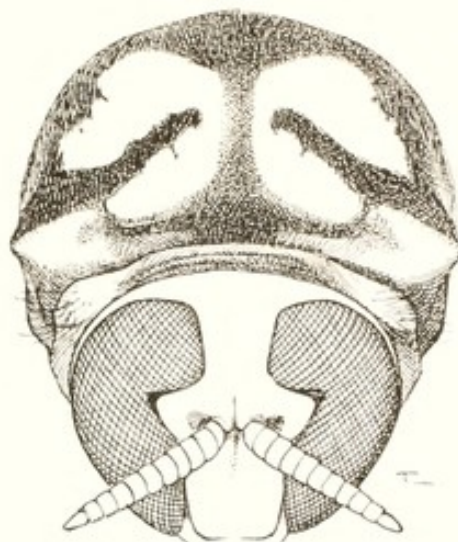


FIG. 24.—*Simulium ornatum* Mg.
Thorax of ♀ from in front.

The following records for the occurrence of this species in Britain are now available: HANTS: River Test*; Minstead, Ringwood. SALOP: River Severn near Shrewsbury. HEREFORD: River Wye near Hereford (*J. S. Steward*). WILTS.: River Avon near Chippenham (*F. T. K. Pentelow*).

There are no records of blood-sucking by this species, but its habits are probably similar to those of *S. equinum*.

As in the case of *S. equinum* the larvae are found on submerged water plants in rivers of moderate current

Simulium ornatum Meigen

(Figs. 20, 24, and Plate 15)

This belongs to a small group of species which are characterised (in the female sex) by having large silvery-grey patches on the shoulders, the rest of the thorax being dull greenish-black; the silvery-grey patches each include a transverse dull black mark which when viewed from behind becomes silvery,

* In describing this species from adults only, I suggested the possibility that a pupa found by Mosely in the River Test and figured by me (*Bull. Ent. Res.* 11, 236) as a variety of *S. equinum* might be that of *S. salopiense*. This has now been established as correct by Steward and Pentelow, who have reared *S. salopiense* in numbers from pupae.

while the silvery areas become black; the abdomen is nearly bare, with the tip shining black; the legs are banded with black and yellow. From the other species of this group *S. ornatum* is easily distinguished under a strong lens by the presence of a patch of soft hairs on the pleural membrane (*i.e.* the area of the side of the thorax a little in front of and below the root of the wing). In the typical form of the species the frons is dull grey. It is one of the largest species.

S. ornatum is one of the commonest species of the genus in England and Wales, though apparently becoming less common towards the north; in Scotland it has been found as far north as Perthshire and Elgin, and is abundant in many streams around Edinburgh.

S. ornatum commonly attacks cattle, and to a less extent horses, biting chiefly the belly and the inner sides of the thighs, also the neighbourhood of the eyes and nostrils, but not the ears. It also bites man on occasion, though it is not recorded as a troublesome pest. It has been shown by Steward to act as the intermediate host of the worm *Onchocerca gutturosa* in cattle. The chief breeding places of *S. ornatum* are large streams or small rivers with moderate current and plenty of aquatic vegetation; it is also found in small stony streams, but not in rapid mountain streams. There are two or three generations in the year; as with some other species, the adults of the spring brood seem to be larger than those of subsequent broods.

***Simulium ornatum* variety *nitidifrons* Edwards**

This differs from the typical form of the species almost solely (so far as the adult female is concerned) in having the frons distinctly shining, blackish. It is abundant in the New Forest and has been recorded from Devonshire, Shropshire, Wigtownshire and Barra Is. but does not seem to occur in the eastern and midland counties. There are no records regarding its feeding habits.

***Simulium nöllei* Friederichs**

(*S. subornatum* Edwards)

This is a rather large species much resembling *S. ornatum*, from which it differs essentially in having the pleural membrane bare and the claws simple, without the small tooth characteristic of the female of all the other members of the group of *S. ornatum*; in this latter feature it resembles *S. reptans* and related species.

S. nöllei is a much more local species in Britain than *S. ornatum*, but records are available from the following counties: Sussex, Hants, Brecknock, Salop, Herts., Cambs., Notts., Oxon. Nothing is known of its feeding habits.

***Simulium monticola* Friederichs**

This very much resembles the variety *nitidifrons* of *S. ornatum*, with which it agrees in thoracic markings and in the somewhat shining frons, differing in the bare pleural membrane and also in having the abdomen entirely black instead of more or less banded with pale grey.

S. monticola largely replaces *S. ornatum* in the west and north of England and in Scotland, its larvae being very common on rocks and stones in rapid hill streams. There are two broods in the year, the first emerging in May, the second in August.

Simulium variegatum Meigen

Though in most respects similar to *S. ornatum*, this species is very readily distinguished by the much more extensively yellow legs, the front and middle femora being almost entirely yellow; in addition the front tarsi are rather more slender and the pleural membrane is bare.

S. variegatum is common in the west and north of England and in Wales and Scotland; its distribution is thus similar to that of *S. monticola*; like that species *S. variegatum* breeds in swift stony streams, though the two species have not often been found together, perhaps because *S. variegatum* has a preference for the larger streams.

S. variegatum has been recorded as attacking horses about the nose and eyes, and on the belly.

Simulium reptans Linnaeus.

There is some doubt as to which species Linnaeus intended to designate under the name *Culex reptans* (if indeed he did intend one particular species), but the name has been applied in this country and by most continental writers to an insect which is in the female sex somewhat like the common *S. ornatum*, but is about two-thirds the size, with the grey markings on the shoulders less conspicuous and not including a dull black area, the front tarsi broader, and the claws simple; the frons is shining black (more conspicuously so than *S. ornatum nitidifrons* or *S. monticola*) though the face is grey; the femora are black, the tibiae yellow with the tips broadly black.

S. reptans is a common species in the west of England and in Wales, and still more so in the Lake District of England and in Scotland. It is recorded as a pest of man, dogs and cattle.

The larvae are found in swift shady rivers in hilly regions, on the flat upper surfaces of large stones or sometimes on water-plants such as *Ceratophyllum*. So far as known there is only one brood.

Simulium venustum Say

(*S. austeni* Edwards)

The female of this species is very much like that of *S. reptans*, the only obvious difference being that the black and the yellow parts of the tibiae are less noticeably contrasted and the yellow less in extent.

The distribution of *S. venustum* in Britain is quite different from that of *S. reptans*, as it is almost confined to the south and south-east of England, where the larvae occur in weedy rivers of moderate current; the first brood appears at the end of April and there is probably a second brood later in the year.

There are no definite records of blood-sucking by this species in Britain, though in north America (where it is widespread and abundant) it is said to attack the ears of horses, and also to bite ducks, amongst which it spreads a malaria-like disease. It is also recorded as a pest in Eastern Siberia.

***Simulium morsitans* Edwards**

The female of this species hardly differs from that of *S. venustum* (though the male and pupae are readily separable).

S. morsitans is a common and troublesome biting pest in the New Forest and adjoining parts of Hampshire; it has not been noted as common elsewhere in this country, though specimens have been found in Oxfordshire, Cambridgeshire, and Inverness.

The larvae occur in weedy rivers and streams and there appear to be two broods in the year, the adults appearing in May and July.

***Simulium tuberosum* Lundström**

This is one of the smallest species of the genus in Britain. Though structurally similar to *S. reptans* and related species it is very distinct in appearance, the thorax lacking the whitish shoulder-patches and the legs being almost entirely black; also, the face is polished black like the frons, instead of being greyish.

S. tuberosum is an abundant species in the north of England and in Scotland, and has also been recorded from Devonshire. It is reported as a pest to man, dogs and cattle, and it was stated by two observers in 1913 to have increased greatly in numbers during the few years prior to that date; since then, however, no further complaints have been received at the Museum.

The larvae occur in company with those of *S. reptans* in rapid rivers, usually on large stones; they are not found in the smaller streams.

***Simulium erythrocephalum* De Geer**

(*S. argyreatum* (Mg.) Lundst.)

This species is rather well distinguished from *S. reptans* and other related species by the distinctly shining greenish-black thorax, which is clothed only rather scantily with inconspicuous hair and has no very definite whitish patches on the shoulders; as in *S. reptans* the frons is shining black and the face grey, but the legs are more extensively black than in *S. reptans*. A peculiarity of this species is that the adults of the spring brood differ from those of the summer brood not only in size but also in colour and to some extent in markings; the distinctions in the female sex between the spring brood (form *sericatum*) and the summer broods are noted in the key.

S. erythrocephalum is an abundant species in the midlands and eastern counties of England, and has also been recorded from the lowlands of Scotland, but is apparently absent from the highlands.

All records go to show that this is the most annoying species of the genus to man in the areas where it is common. The spring brood is on the wing in

April, the main summer brood in June, and subsequent broods during the remainder of the summer.

The early stages are found in weedy rivers with slight or moderate current, usually in association with *S. equinum*.

Axel Peterson (1924) finds *S. erythrocephalum* (*argyreatum*) to be the species most troublesome to cattle in Denmark, and to have caused a series of fatalities among domestic animals in that country.

REFERENCES

- BARANOV, N. 1934. Golubačka mušica u godini 1934. Vet. Archiv, Zagreb, **4**, Pts. 8-9. [Review in Rev. Appl. Ent., B, **22**, 203.]
- BEQUAERT, J. 1938. The black-flies, or Simuliidae, of the Belgian Congo. Amer. Journ. Trop. Med., **18**, Suppl., 116-136.
- BLACKLOCK, D. B. 1926. The Development of *Onchocerca volvulus* in *Simulium damnosum*. Ann. Trop. Med., **20**, 1-48, 203-218.
- BRADLEY, G. H. 1935. Notes on the Southern Buffalo-gnat, *Eusimulium pecuarium* (Riley). Proc. Ent. Soc. Washington, **37**, 60-64.
- BRYANT, J. 1935. Endemic retino-choroiditis in the Anglo-Egyptian Sudan and its possible Relationship to *Onchocerca volvulus*. Trans. R. Soc. Trop. Med. Hyg., **28**, 523-532.
- CIUREA, J. and DINULESCU, G. 1924. Ravages causés par la mouche de Goloubatz en Roumanie ; ses attaques contre les animaux et contre l'homme. Ann. Trop. Med., **18**, 323-337.
- DRY, F. W. 1922. A Human Disease possibly carried by *Simulium* in Kenya Colony. Bull. Ent. Res., **12**, 233.
- DOROGOSTAISKY, V., RUBZOV, I. and VLASENKO, N. 1935. [Notes on taxonomy, biology, and geographical distribution of black flies in East Siberia.] Mag. Parasit. Inst. Zool. Acad. Sci. U.R.S.S., **5**, 107-204.
- EDWARDS, F. W. 1915. On the British species of *Simulium*.—I. The Adults. Bull. Ent. Res., **6**, 23-42.
- EDWARDS, F. W. 1920. On the British species of *Simulium*.—II. The early stages ; with corrections and additions to Part I. Bull. Ent. Res., **11**, 211-246.
- EDWARDS, F. W. 1927. Notes on British *Simulium*. Ent. Mo. Mag., **63**, 255-257.
- EDWARDS, F. W. 1931. Simuliidae. Dipt. Patagonia and S. Chile, **2**, 121-154.
- GIBBINS, E. G. 1933. Cutaneous Onchocerciasis in a *Simulium damnosum*-infected region of Uganda. Ann. Trop. Med., **27**, 489-496.
- GIBBINS, E. G. 1938. The Mouth-Parts of the Female in *Simulium damnosum* Theobald, with special reference to the transmission of *Onchocerca volvulus* Leuckart. Ann. Trop. Med., **32**, 9-20.
- MARLATT, C. L. 1933. Report of the Chief of the Bureau of Entomology. Washington, D.C. U. S. Dept. Agric.
- O'ROKE, E. C. 1934. A malaria-like disease of ducks caused by *Leucocytozoon anatis* Wickware. Bull. Sch. For. Univ. Mich., **4**.
- PENTELOW, F. T. K. 1935. Notes on the Distribution of the Larvae and Pupae of *Simulium* spp. in the River Tees and its Tributaries. Parasitology, **27**, 543-546.
- PETERSON, AXEL. 1924. Bidrag til de Danske Simuliers naturhistorie. D. Kgl. Danske Vid. Selsk. Skr., Nat. Math. Afd., **8**, 237-341.
- PURI, I. M. 1925. On the Life-History and Structure of the Early Stages of Simuliidae. Parasitology, **17**, 295-369.

- RUBZOV, I. A. 1936. Notes on the Biology and Ecology of Black Flies. Mag. Parasit. Inst. Zool. Acad. Sci. U.R.S.S., **6**, 169-200.
- SMART, J. 1934. On the biology of the Black Fly, *Simulium ornatum*, Mg. Proc. R. Phys. Soc., **22**, 217-238.
- SMART, J. 1935. The Internal Anatomy of the Black Fly, *Simulium ornatum* Mg. Ann. Trop. Med., **29**, 161-170.
- SMART, J. 1936. Notes on the Simuliidae occurring at Fortingal, Perthshire. Scott. Nat., **1936**, 22-26.
- STEWART, J. S. 1937. The Occurrence of *Onchocerca gutturosa* Neumann in Cattle in England, with an account of its Life-History and Development in *Simulium ornatum* Mg. Parasitology, **29**, 212-219.
- STRONG, R. P. and others. 1938. Onchocerciasis in Africa and Central America. Amer. J. Trop. Med., **18**, Suppl. 1.
- TWINN, C. R. 1936. The Black Flies of Eastern Canada. Canad. J. Research, D, **14**, 97-150.
- USSING, HJ. 1925. Faunistiske og biologiske Bidrag til danske Simulier's Naturhistorie. Vid. Medd. Dansk. Naturh. Foren., **80**, 517-542.
- WU, YI FANG. 1931. A Contribution to the Biology of *Simulium* (Diptera). Mich. Acad. Sci. Arts and Lett., **13**, 543-599.

BRACHYCERA

By H. Oldroyd, M.A.

Family

RHAGIONIDAE

(LEPTIDAE)

THE blood-sucking habit has been observed in certain members of the family Rhagionidae ("snipe-flies"), though never in this country. Verrall (1909, p. 234) refused to accept the only European records of biting by species of *Rhagio* (*Leptis*), but there are a number of independent authorities who claim to have observed attacks made on human beings by members of the genera *Symphoromyia* and possibly *Atherix* in North America, *Dasyomma* in S. America, and *Spaniopsis* and possibly *Austroleptis* in Australasia. Species of the first two genera mentioned occur in Britain, but no records exist of their sucking blood. Lindner (1931, p. 140) remarks that in the Alps he has often found females of *Symphoromyia crassicornis* Panz. settling on his head and sucking up the sweat, but however long they have been allowed to continue doing so they have never pierced the skin. This, as he remarks, throws doubt upon, though it does not necessarily invalidate, most of the published records of blood-sucking by this particular fly.

The North American authorities are included in the very full bibliography given by Leonard (1930).

Family

TABANIDAE

HORSE-FLIES, BREEZE-FLIES, DUN-FLIES, CLEGS or STOUTS.—In Kent the species of *Haematopota* (pl. 20, 21) were formerly known locally as *Brimps* (Theobald, 1904, p. 15), and Lady Fenn (1797, p. 69) says: "They have been called *burrel-* or *whame-flies* by some English authors." Moufet (1634, p. 61) wrote: "Anglis *burrel-flye*, *stowt* and *breesse* dicitur: atque etiam ab adhaerendo *Clegg* & *Clinge*z," but his later remark "Hanc Angli a *Whame* and a *Burrel-flye* propriè vocant" appears to apply to an Oestrid. According to a recent informant *Chrysops caecutiens* (pl. 16) is known locally in Hereford as the "thunder fly."

Owing to the large size of many of the species Horse-flies, in the British Isles as elsewhere, are the most formidable of all blood-sucking Diptera. Indeed, a large female of *Tabanus sudeticus* Zeller (pl. 30), measuring up to 1 inch in length, with a wing expanse of nearly 2 inches, is exceeded in size by very few exotic species of this family, and frequently excites the surprise of

those who are not entomologists when they learn that it is really a British insect. The Horse-flies, which are world-wide in their distribution, are also a large family, the total number of species described up to the year 1938 inclusive amounting to some 3,000. In 1925, according to Lindner (1925, p. 138), over 400 species were known to exist in the Palaearctic Region, and 28 are found in the British Isles. They belong to the genera *Chrysops*, *Haematopota* and *Tabanus*; the genus *Pangonius*, remarkable for its elongate proboscis, does not occur in this country, though a number of species are found in southern Europe.

APPEARANCE

In appearance the Tabanidae are stoutly built flies with a large head, which in the males is almost wholly composed of the eyes. In all the British species the eyes of the males meet together in the middle line, but those of the females are distinctly, and often widely separated by the *frons*, upon which may be seen one or more bare, shining *frontal calli*, which are of great importance in the determination of species. The males often have an area in the upper portion of the eyes composed of larger facets than those below, the extent and sharpness of demarcation of this area varying in different species.

In life the eyes of Tabanidae usually exhibit golden-green or purple markings, which are of value for the identification of the species. They are especially brilliant in the females of *Chrysops* and *Haematopota*, which, as pointed out by Girschner (1887, p. 156), possess probably the finest eyes of all insects; this author, in an interesting discussion of the practical significance of eye-colours in Diptera, suggests that they may be correlated with a poorly developed sense of sight. After death the colour of the eyes rapidly changes to a dull brown, until scarcely a trace of the markings remains. In the plates to this work the eyes are shown as in dried specimens, from which perforce the original drawings had to be prepared, but in many cases notes on the natural colour and pattern are given in the account of the species concerned.

The eye-colours can be revived to some extent by placing the dried specimen in a relaxing tin on damp sand covered with blotting-paper, but the markings of the body are likely to receive permanent injury by this treatment. Goffe (1932a, p. 16) recommends immersion in a solution made up as follows: *Acetic acid (glacial)*, 1 part; *glycerine*, 1 part; *soln. of perchloride of mercury (Brit. Pharm. strength)*, 1 part; *rectified spirit*, 48 parts. This can be used to restore the eye-markings in dried specimens, which, if then enclosed in a glass-stoppered glass tube, will retain their colours indefinitely.

In front of the eyes project conspicuously the antennae which are composed of three segments, while below the head in all the British species is normally visible the fleshy proboscis or lower lip which encloses the piercing mouthparts. The palpi, which lie one on each side of the proboscis, are swollen and fleshy, and differ in shape in the two sexes. The body is clothed with short hair, which unfortunately is readily rubbed off in captured specimens, so that they are often sadly altered in appearance, and bear little resemblance to the same species

when freshly emerged.* The large bristles known as macrochaetae, which are a conspicuous feature in certain other families such as the Asilidae (Robber-flies) are entirely wanting in all Horse-flies. In coloration as in the shape of the body, Horse-flies throughout the world show relatively little variation, and our British species are very similar in appearance to many of those belonging to the same genera found in Africa, India and elsewhere.

OCCURRENCE AND HABITS

Horse-flies may be met with throughout the summer in fields, open spaces in woods, or by the roadside in the country, where, given a good season and favourable weather conditions the bloodthirsty females are often a scourge to man and beast. Thus Dr. C. Walton (1918) writing of blood-sucking flies as observed by him in the Aberystwith area of Cardiganshire during the period 1913-16, mentions counting between thirty and forty *Haematopota pluvialis* (pl. 20) on a man's back on June 28th, 1914, and states that on June 21st, 1915, he "killed 200 upon four working horses in a few minutes." On a subsequent page, referring to the summer of 1916, he speaks of working farm horses being "driven frantic and difficult to control" by the attacks of *Tabanus sudeticus* (pl. 30). Of the latter species, Dr. Walton remarks: "their abundance may be judged when I say that I could easily fill a killing bottle in half-an-hour from a pair of horses during the hay harvest (at Crosswood), and a waggoner killed between twenty and thirty on one horse during a morning's horse-hoeing." Most people at one time or another have noticed a herd of cattle careering about a pasture-field with tails in the air, or, as farmers say, "gadding." Such behaviour of the animals is doubtless due to sympathetic action evoked by some form of fly-attack, but the actual species of fly concerned in any given case, whether Warble-fly (*Hypoderma*), biting Muscid (see p. 115, and pls. 37, 38) or Tabanid is usually very difficult to determine. For a discussion of the species of fly concerned in producing "gadding," see Appendix B.

The edges of woods are favourite haunts of certain species of Horse-flies, and while resting in such a place on a hot day, even when insects are not numerous, one may frequently notice a *Haematopota* or two, or a specimen of one of the smaller species of *Tabanus* crawling with much deliberation over one's coat and making preliminary investigations with its proboscis. *The females alone suck blood*: the males may be met with on flowers, or sometimes hovering in the air like the Syrphidae (Hover-flies), but are best taken during hot weather, when they descend to drink from pools and streams (see Jones, 1922, and Goffe, 1935).

Tabanidae sometimes take other food than blood. Writing of the North American species *Tabanus sulcifrons* Macq., Hine (1906, p. 25), says: "I am thoroughly convinced that the females take much other food than blood, and do not believe it would be overstating the facts to say that specimens of this

* Tabanidae for determination should therefore be in the best possible condition, neither crushed nor rubbed, and the colouration of the eyes, with the pattern of the markings, if any, should always be noted before the specimen is killed.

sex may pass the period of adult life without taking blood at all." Hine had often seen both sexes on foliage, and observed the insects sipping up dew on the leaves. He had also noticed, in a number of species of *Chrysops* and *Tabanus*, both sexes feeding upon the honeydew produced by Aphididae.

The species of *Haematopota* and the smaller species of *Tabanus* are remarkable for the quietness with which they alight on their victims, the sharp prick of the bite being often the first intimation of their presence. On the other hand, the larger species of *Tabanus* betray their approach by their deep hum. When once the operation of sucking blood has begun, Horse-flies, like any other blood-sucking Diptera, may easily be killed or captured. Owing to the size of the Tabanidae the wound inflicted by the mouthparts of many of the species is especially severe. Anyone who has seen *Tabanus verralli* (pl. 29), or *T. sudeticus* (pl. 30) attacking horses must have noticed the large drops of blood which exude and trickle from the spots bitten by the flies. Among domestic animals, however, horses are not the only victims; pigs and sheep are often attacked, and in other countries mules, camels and elephants suffer severely. Wild animals are similarly tormented. In the course of an article on red deer in the Scottish Highlands, published in *The Times* of September 11th, 1926, the anonymous author remarks: "Perhaps because of the absence of rain, the large cleg fly [probably *Tabanus distinguendus* Verrall, pl. 26] has not been seen so much this year as usual. This biting fly is at its worst in the early days of July, and stags and hinds have to move up to the high tops to escape it." This statement brings to mind a much earlier one relating to the Sudan. Sir Samuel Baker (1867, p. 210), writing of the country between the Settite and Atbara Rivers, mentions herds of game retreating from the south before the attacks of the "Seroot," under which name several species of *Tabanus* and *Pangonius* are known to Europeans on the Blue and White Niles.

Cameron (1926, p. 5) estimates that an animal grazing in an area heavily infested with the Canadian Horse-fly *Tabanus septentrionalis* Loew (a species very similar in size and general appearance to the British *T. bromius* L., pl. 33), might lose as much as 100 c.c. ($\frac{1}{6}$ pint) of blood during the course of a hot summer's day. The effect of such a continued drain on the vitality of stock, coupled with the restlessness induced by the persistent attacks, can well be imagined.

Abundant though certain species such as the commoner forms of *Haematopota* sometimes are in the British Isles, we have to turn to Continental records in order to realise how serious a pest these flies may become, owing to their extraordinary bloodthirstiness. Thus in some parts of Russia (see Portschinsky, 1900, p. 807) Horse-flies in summer were so excessively numerous and bloodthirsty that agricultural operations had to be carried out at night, while in parts of Siberia such as the shores of the River Orm, settlers were compelled to abandon the zone infested with these pests. In this connection some observations by Major A. D. Fraser (1920), made in North Russia during the summer of 1919, while serving with the Vologda Force, are of such interest as to be worth quoting in full. The observations in question were made "in

the vicinity of Obozerskaya, a small village on the Archangel-Vologda railway, roughly 80 miles due south of Archangel."

After describing the nature of the country, and stating that the entire district is "one continuous forest of pines, firs, etc." containing but little undergrowth, but swampy and "waterlogged even in July, when the heat was quite trying," Major Fraser continues: "Before I arrived in the country mosquitoes were numerous and troublesome, and the troops had been provided with mosquito-nets and veils. Midges were also annoying, but no other biting-flies were in evidence until June 20th, a warm sunny day following a couple of days of rain, when numbers of Tabanidae appeared. A day or two later they had increased to such an extent that they were present everywhere in swarms, and although at their worst in the forest, they were a pest in the villages, houses, trains, etc. Near the edge of the forest many more than a hundred Tabanidae could be counted on one person at the same time, while hundreds of others would be flying around. In the forest itself they were present in almost incredible numbers. There were many officers and men in the Force who had lived and travelled in all parts of the world, but all those I met agreed that never before had they encountered these flies in such swarms.

"Soon after the middle of July the flies diminished very considerably in numbers, and during the early part of August only an occasional fly or two would be seen on a particularly fine day.

"The flies seemed quite as eager to attack human beings as animals, and at their worst were a far worse pest than ever I have found tse-tse flies. The majority settled on one's legs, and in the forest they attacked in such numbers that work in it was rendered almost impossible. . . . The local inhabitants performed most of their outdoor work during the night, and kept their cattle and other animals in their sheds during the heat of the day. When a journey had to be made in the daytime the drivers of the horses as far as possible selected a time when they expected a wind would rise and cause the flies to become less troublesome. Before setting out they would rub their ponies with paraffin, a supply of which they would take with them. They would then proceed in convoys and make the journey as quickly as possible, using branches of trees to beat away the flies. The leading horse in a convoy seems to be attacked more severely than the others, and the animal's head appears to be the favourite place of attack; but if blood has been made to ooze from any part of the animal, this point always attracts a swarm of flies. As for human beings, I have heard it stated by British officers that they have been bitten through Bedford-cord riding breeches . . . some individuals suffered from bites which developed into nasty septic sores requiring medical attention.

"It was noticed that a small, dark-coloured fly (probably a non-biting Muscid) constantly accompanied the Tabanidae, and sucked up any blood which flowed from the wounds caused by them."

Goffe (1931, p. 46) notes that when attacking human beings, Horse-flies differ in the parts of the body they select. "Species of *Tabanus* and *Atylotus* [*Ochrops*] seem to prefer the legs, either just above or just below the

knees *; species of *Therioplectes* [*Sziladynus*] make for the crutch of the legs; species of *Chrysozona* [*Haematopota*] prefer one's wrists; whilst *Chrysops* species attack the back of one's neck." Jones (1920, p. 7) found that *Chrysops* species caused him great inconvenience by biting on the forehead just above the eyes.

Having observed that Horse-flies frequently seek pools in order to drink, Portschinsky hit upon the expedient of covering with a thin layer of petroleum the surface of water in certain lakes and pools in districts infested with the fly. The experiment was a brilliant success, and the insects were destroyed in enormous numbers, the majority in attempting to drink adhering to the oil, while others, although they managed to fly away, were subsequently poisoned or choked by the oil. In a pool little larger than one square yard in area, there are reputed to have thus been destroyed over two thousand Horse-flies in five days. In this way, certain localities such as the Park of Pawlowsk near Leningrad were completely cleared of Tabanidae.

It is interesting to note that no specimens of *Haematopota* came to drink at the pools, an experience corroborated by Goffe (1935, p. 102). The late Mr. Hugh Jones, however, was more fortunate in the New Forest in July 1921, an extremely dry year; he took males of *Haematopota pluvialis* (pl. 20, p. 84) in company with those of a number of species of *Tabanus* and *Chrysops*, in the act of drinking at a pool in the bed of a partially dried-up stream (see Jones, 1922, p. 40). A layer of petroleum on the surface of the water is fatal to aquatic Horse-fly larvae, just as it is to those of mosquitoes.

LIFE-HISTORY

A valuable illustrated account, with bibliography, of the life-histories of all the species of Tabanidae of which accounts have been published, from 1760 to 1916 inclusive, is given by Marchand (1920). The majority of species of Tabanidae deposit their spindle-shaped whitish eggs, which gradually become brown or black after laying, closely packed in rounded or flattened masses, attached to the leaves and stems of rushes, or to other smooth surfaces over water or wet ground. According to Surcouf (1924, p. 46): "certain species oviposit in damp earth, in vegetable mould, in dry glades, rotten wood, and even sand on the sea-shore." Each egg-mass may contain from 250 to as many as 500 eggs, neatly deposited in a regular pattern.

After a lapse of a few days, the larvae from an egg-mass deposited over water hatch simultaneously and fall into the water, where, according to statements by P. V. Isaac (1924) and other observers in India, they shed their skins for the first time within half-an-hour. In three Indian species of *Tabanus* studied by Isaac the skin was cast seven times during the course of larval life, while the larva of a fourth species of the same genus was found to moult eight times, the change to the pupa taking place at the last moult.

Schwardt (1936) describes the life-history of a N. American species,

* Mr. Goffe writes: "The preference of *T. maculicornis* for the ankles is also very noticeable, and a Tabanid there is almost always this species."

Goniops chrysocoma O.S., in which the eggs are laid on the under-surface of a leaf. The female clings to the leaf in a position covering the eggs and broods them until they hatch, after which the female dies. Intermittently the wings are rapidly vibrated, but it is not yet established whether this plays any part in controlling the temperature. This peculiar habit may perhaps be compared with the clusters of ovipositing females of the Rhagionid fly *Atherix ibis* Fabr., which are sometimes found in this country (see Verrall, 1909, p. 288).

Horse-fly larvae, which are soft-bodied, whitish grubs with a longitudinally striated integument sometimes exhibiting dark bands or other markings, are found in water, earth, sand, or decaying wood. In shape they are cylindrical, tapering at each end, with a small retractile head, and a body composed of twelve segments. The head is armed with a pair of powerful recurved mouth-hooks (mandibles) which are used in seizing prey, and are even capable of inflicting a sharp prick upon the skin of a human hand. Each of the first seven abdominal segments is encircled near its anterior margin with a ring of fleshy retractile protuberances (parapodia), of which when fully developed there are two transverse dorsal, one lateral on each side, and four rounded ventral ones (Hart, 1895, p. 222; Cameron, 1934, pp. 227 *et seq.*).

Tabanid larvae, except apparently those of the genus *Chrysops* (see Stammer's observations on the behaviour and food of larvae of *C. caecutiens* L. in captivity, *infra*, p. 79), are carnivorous, preying upon small Crustacea, beetle and other larvae and pupae, snails (*cf.* Hart, 1895, p. 221) and worms; in captivity, if a number are kept together they usually display marked cannibalistic tendencies. It is therefore advisable, if a number of Tabanid larvae are to be bred at once, to keep each larva in a separate vessel. For accounts of the technique of rearing Horse-fly larvae see Surcouf (1924), Isaac (1924), Marchand (1920), Cameron (1926, 1934 and 1935), and Schwardt (1936); see also the notes on *Haematopota pluvialis* below (p. 85).

The winter is passed in the larval stage, which in some cases is even prolonged into the third year, Surcouf (1924, p. 59), writes: "The duration of the larval stage varies according to the species, and it also depends upon the conditions, whether favourable or otherwise to development. Thus in a former work ('*Tabanides d'Afrique*,' 1909, p. 9) we mentioned the rearing of a larva found by E. Roubaud at Meudon on October 3rd, 1905, and presented to us. This larva pupated on May 16th, 1907, but the pupa died as the result of an accident. On the other hand, a batch of larvae found by us in the Ursine pool, near Chaville in the spring of 1914, was left to its fate in a large trough at the end of July 1914, and in the spring of 1915 produced a number of adults of *Tabanus bisignatus* Jaenn., *T. bromius* Linn., and *Chrysops caecutiens* Linn. . . .

"Still more recently in the Laboratoire Colonial of the Paris Museum we have had a batch of a hundred larvae collected in Verrières Wood (Mare à Chalot) on April 22nd, 1920. The eggs from which these larvae were hatched must therefore have been laid during the summer, or at least during the autumn of 1919. Some of them changed into pupae in July 1920, but the majority,

i.e. the smallest specimens, hibernated twice, and produced adults in June 1921.

"It may be concluded from what has been said that the larval stage lasts for about a year, but that in the aquatic species it frequently extends to two years. Under exceptional conditions Tabanidae have been bred from larvae living in dry places, and here, as a general rule development appears to have been rapid."

Horse-fly pupae, which resemble those of Lepidoptera, remain stationary in mud, damp rubbish at the edge of water, or just below the surface of the soil. Though at first generally pale yellowish or greenish, they become darker (yellowish or reddish brown) with age. Each of the first six abdominal segments bears in front of its hind margin a circlet of stiff, bristle-like hairs, which in the genus *Tabanus* are interspersed with short pointed tubercles. The tip of the abdomen is armed with a cluster of six large, tooth-like spines.

The pupal stage lasts but a short time (ten to twenty-three days in Surcouf's experience), and the perfect insect makes its escape through a split in the median dorsal line of the head of the pupa-case. "The hatching of the adult," writes Surcouf (1924, p. 61), "would appear to take place at different times of the day according to the season and the species. On July 22nd, 1908, we saw a *T. nigrifacies* Gobert hatch from sea-sand at 7.30 a.m., while emergences of *T. bromius*, *Haematopota pluvialis*, and *Chrysops caecutiens* occurred both in the evening and at daybreak." Of the duration of adult life the same author remarks (1924, pp. 61-62): "Under natural conditions Horse-flies disappear very quickly; we have often found that Tabanids persisted for scarcely more than a week at a given spot, and that others then hatched out in their place."

Mr. Goffe (in correspondence) makes the interesting suggestion that some of the "forms" which he has been able to recognise in many British species of Tabanidae may be biological races correlated with differences in the media chosen for oviposition. "A quite small form which appears structurally to be only *bromius*, but looks quite different, occurs constantly at several localities where it appears that the larvae have had to feed in loose soil in woods, away from moisture in any other form."

NATURAL ENEMIES

Tabanidae are subject to the attacks of insect enemies in both the egg and the adult stage. In Illinois, U.S.A., a tiny parasitic Hymenopteron (*Phanurus tabanivorus* Ashmead) has been bred from the egg-masses of *Tabanus atratus* Fabr, one of the largest and commonest of North American Horse-flies, and in Austria an allied species (*Phanurus (Telenomus) tabani* Mayr.) was reared by Brauer from the eggs of an undetermined species of *Tabanus*. Other examples of attacks upon Horse-fly eggs by minute parasitic Hymenoptera have been recorded.

The adults are sometimes carried off by Robber-flies (*Asilidae*). Thus at Brockenhurst in the New Forest on July 14th, 1894, Colonel Yerbury took a female of *Machimus atricapillus* Fall. feeding upon a male of *Chrysops caecutiens*

Linn., and Hobby (1931, 1933) in addition to this example, lists captures of *Haematopota pluvialis* Linn. by two species of Asilidae, *Asilus crabroniformis* Linn. and *Machimus atricapillus* Fall. and a capture of *Tabanus bromius* Linn. by *Neoitamus cyanurus* Loew. The same author records a capture of *Chrysops sepulchralis* Fabr. by the Yellow Dung-fly, *Scatophaga stercoraria* Linn., observed at Hengistbury Head, Hants by E. R. Goffe.

Spooner (1934, p. 51) found one *Tabanus montanus* Meig. and several *Haematopota pluvialis* Linn. among the prey rejected by a wasp *Metacrabro quadricinctus* Fabr. during the reconstruction of its burrow, at Plympton, Dartmoor in July 1934. Isolated records of Tabanidae as prey of fossorial wasps are given by Hamm and Richards (1930, pp. 99, 117), and by Hobby (1932, p. 79). In the United States of America and elsewhere, as reported by Hine and other observers, wasps, both fossorial species of the family Bembecidae and also members of the genus *Vespa*, often play a useful part by pouncing upon and flying away with Horse-flies which are molesting cattle, horses or human beings. Hobby (1936, p. 102) quotes a record supplied by Dr. O. W. Richards of the Dragonfly *Cordulegaster boltonii* Don. preying upon *Tabanus bromius* L. at Slioch, Ross-shire, a very unusual locality for this species (see below, p. 109), but Dr. Hobby tells me that this record has subsequently been found to refer to *T. montanus*.

In July 1938, at Laugharne, Carmarthenshire, Mr. J. F. Thomas took five males and one female of *H. pluvialis* among the food of nestling swallows. Mr. Thomas has kindly supplied notes on his previous records. Single specimens of *H. pluvialis* were taken also in 1935 and 1937, and of *H. italica* in (?) 1933 and 1934. These isolated records suggest that the capture of Tabanidae by swallows is purely fortuitous.

TABANIDAE AS CARRIERS OF DISEASE

Although the bite of a Horse-fly always involves some risk of accidental infection of the wound, and may set up considerable irritation in susceptible persons, no Tabanid in this country has ever been shown to transmit disease, either in man or in animals. There are, however, a number of exotic species, especially in the tropics, which are habitual carriers of pathogenic organisms. The few affecting man all belong to the genus *Chrysops*: in West Africa *C. dimidiata* Wulp and *C. silacea* Austen are responsible for conveying from man to man the parasitic worm *Loa loa* Guyot, which is the cause of Calabar Swelling, and in North America another species, *C. discalis* Will. is a mechanical transmitter from jack rabbits to man of the bacterium producing the disease known as Tularemia.

Throughout the Old-World tropics occurs a disease of domestic animals known in India as "surra," and in Egypt as "El-Debab." This is due to the presence of a flagellate, *Trypanosoma evansi* Steel, which is believed to be carried by a number of different species of Tabanidae. There is no evidence of the development of the parasite within the fly, such as occurs in the trypanosomes of sleeping-sickness and "Nagana," which are carried by the Tse-tse fly,

Glossina, but transmission is said to be entirely mechanical, through contamination of the proboscis of the fly during feeding. A short account of this disease, particularly in Egypt, is given by Efflatoun (1930, p. 19). Other diseases which horse-flies are known or suspected to carry, in other parts of the world, include anthrax, "swamp fever", and anaplasmosis of cattle (see Philip, 1931, pp. 10-12; Cameron, 1926, 1935; and Schwardt, 1936).

PREVENTIVE AND PROTECTIVE MEASURES

In this country Horse-flies are rarely so numerous as to make control measures worth while, but in a badly infested area some reduction may be achieved by drainage of ponds and swampy areas which provide oviposition sites for the flies (see under *Chrysops*, below, p. 78), or by oiling the surface of standing water (see above, p. 72). Grazing animals derive relief from the provision of a shed, or other shelter, preferably with a curtain of canvas over the doorway; the flies, being lovers of sunlight, rarely penetrate into the darkened interior, and the canvas curtain helps to dislodge those flies clinging to the animal as it enters.

Repellants are very limited in their effectiveness, being difficult to apply sufficiently thoroughly, and soon dissipated from an animal working in the open air. Moreover, unless made up and applied with extreme care, they entail considerable risk of damage to the animal's skin. Various formulae have been tried in the United States, and the whole subject of stock-protection is admirably summarised by Philip (1931, pp. 70-73).

No preparation seems yet to have been devised which is powerful enough to repel Horse-flies and yet suitable for application to the human skin.

THE GENERA OF BRITISH TABANIDAE

In recent years the names of several of the genera of British Tabanidae have been changed, or changes of name have been proposed. Owing to splitting up of the old genera *Therioplectes* Zeller and *Atylotus* Osten-Sacken, the British species formerly included in them have been transferred to *Sziladyneus* Enderlein and *Ochrops* Szilády respectively; in this volume the two latter are regarded as subgenera only, and are included under *Tabanus* Linnaeus. There has been much dispute about the proposed revival of the names published by Meigen in 1800, and the matter has been referred to the International Commission on Zoological Nomenclature. If these names were revived the name *Haematopota* would have to be replaced by *Chrysozona*—a change which has already been adopted by Goffe in his monograph of 1931, and by many Continental workers—but pending a decision on this point the better-known name *Haematopota* is used in this work.

The keys in the section of this work dealing with Tabanidae are intended to apply to female specimens of British species only.

- A. Wings with a conspicuous cross-band of dark brown or black *Chrysops* Meigen
- B. Wings mottled grey and white *Haematopota* Meigen
- C. Wings clear; sometimes with a brownish tinge towards the foreborder, but never with any definite markings *Tabanus* Linnaeus

Subfamily PANGONIINAE

Genus CHRYSOPS Meigen

Of the sixty valid species of this genus which down to the year 1926 had been recognised as occurring in the Palaearctic Region only four have so far been met with in the British Isles. Verrall's suggestion (1909, p. 439) that *Chrysops rufipes* Meig. and *C. parallelogramma* Zeller are likely to occur in Britain has not yet been justified. Although more than one species of *Chrysops* is often locally abundant and troublesome in the south of England the genus does not seem to be very plentiful in Scotland. The genus *Chrysops* is the only representative in this country of the sub-family *Pangoniinae*, characterised by having spurs at the tip of the hind tibiae.

In *Chrysops caecutiens*, *C. quadrata* and to a lesser degree in *C. relictus* there is a striking difference between the sexes in the colouration and pattern of the abdomen (*cf.* pl. 16). The dark transverse band on the wings, though present in both sexes, is usually more sharply defined in the female than in the male. In the resting position the wings are flat and half open, *i.e.* somewhat wider apart at the tips than in *Tabanus*.

In life the eyes of all species of *Chrysops* are extremely beautiful, even when compared with those of other Tabanidae which as a family are noted for the beauty of their eyes. The ground colour is golden- or reddish-green, and is marked with purple spots and lines.

The females of the various species of *Chrysops*, which attack human beings as well as domestic animals, are often extremely bloodthirsty and are capable of inflicting a severe bite. Males of this genus are frequently to be met with upon flowers, especially Umbelliferae and, according to Jones (1922, p. 41), *Senecio* and *Mentha arvensis*.

The various species of *Chrysops* deposit their eggs upright, usually in a single layer forming variously shaped batches upon the leaves and stems of reeds or other plants overhanging flowing or stagnant water. The following account by Professor J. S. Hine of oviposition of *Chrysops moerens* Walker as observed by him at Sandusky, Ohio, is worth quoting.

"The female," writes Professor Hine, "alights on a leaf with her head downward and begins the process by pushing the tip of her abdomen forward toward the under part of the thorax and placing the protruding end of an egg against the leaf. The end sticks fast by means of a glue-like substance which accompanies it, and she moves the tip of her abdomen back to its normal position, thus freeing the egg. By similar movements one or two eggs are placed by the side of the first, and two or three more to the other side of it. The unfinished end soon becomes V-shaped; she moves slowly forward, lifts the tip of her abdomen to one arm of the V and places eggs along it until the apex is reached; then changes to the other arm of the V and places eggs along it down to the apex again. It was noted in specimens of this species that sometimes a female would place as many as three rows of eggs on one side before changing to the opposite side. It is only necessary to study a mass of these eggs in order to see the precision in reference

to one another, with which the different eggs are laid." (See Hine, 1906, p. 37).

In places where these flies are abundant the elongate eggs, which are white when newly laid, and subsequently become opalescent brownish (dark brown, or even shining black in some exotic species), are deposited in countless myriads, closely packed in sheets. The larvae live in water, mud, or the matted and sodden remains of aquatic vegetation, and both larvae and pupae are of the usual Tabanid type.

The larva may be distinguished from those of *Tabanus* by the last segment of the antenna being considerably longer than the preceding one, instead of being the same length or much shorter. Pupation apparently takes place as a rule in the mud, in moist earth or in damp sand, close to the water's edge. According to Stammer (1924, p. 126), the larvae of *Chrysops* are not predaceous and show no tendency towards cannibalism when kept together in captivity. The same writer states (1924, p. 127) that the development cycle in *Chrysops* lasts only one year.

Although British species are not concerned, it may be of interest to remark that the only members of the family Tabanidae hitherto proved to play a part in the transmission of human disease belong to the genus *Chrysops* (see above, p. 75).

Schwardt (1936, p. 59) states that where *Chrysops* is breeding in the mud round the margins of a pond in such numbers as to be troublesome, some measure of control can be achieved by clearing the shores of the pond so that within 10 or 12 feet of the water's edge there are no stones or sticks to provide oviposition sites, and no plants or *débris* projecting above the surface of the water. Sudden changes in level of the water, as, for example, when heavy rains follow a prolonged drought, also help by drowning the pupae, or driving them out of the mud to be destroyed by predators.

KEY TO THE FEMALES OF THE BRITISH SPECIES OF *Chrysops*

1. Ground-colour of body entirely shining bronze-black. Hind margins of segments with tawny pubescence (Plate 19) *sepulcralis* Fabr.
Ground colour of base of abdomen predominantly yellow.....2
2. Upper surface of second visible segment with a black mark like an inverted V in centre, usually sharply defined, but sometimes indistinct. Middle tibiae black, paler at base (Plate 16) *caecutiens* Linn.
Second abdominal segment otherwise marked. Middle tibiae yellowish brown, blackish at apex3
3. Second abdominal segment orange yellow with a single black spot which varies from almost nothing to a large rectangular or quadrate blotch (Plate 17) *quadrata* Meigen
Second abdominal segment yellow, bearing two black lobes inclined downwards and outwards, usually united at their bases (Plate 18) *relicta* Meigen

***Chrysops caecutiens* Linnaeus**

(Plate 16)

The figures in the plate afford a fairly accurate picture of the striking sexual differences shown by *C. caecutiens* in the colouration and markings of the thorax, abdomen and wings. Although similar contrasts are seen also in

Chrysops relictus (p. 81) and to a lesser extent in *C. quadrata* (p. 80), they are so pronounced in *caecutiens* as to suggest that the sexes belong to different species. It should be noted, however, that on the ventral surface of the basal half of the abdomen of the male *C. caecutiens* there is a light patch on each side, which frequently extends on to the dorsal surface and then forms a more or less conspicuous fleck on each side of the second segment.

Verrall (1909, pp. 425, 427, figs. 241, 243) gives black and white illustrations of the eye-markings of both sexes of *caecutiens*. In the males the eyes touch for less than one-third of the distance between the occiput and the antennae; the facets on the upper part are dilated and purplish brown in death, on the lower part small and blackish. In the females the eye-facets are all equal.

The length of British specimens of *C. caecutiens* as represented by the specimens in the British Museum varies from 8 to 10.5 mm. in both sexes.

C. caecutiens is widely distributed in the south of England and in the midlands, and has been taken all over Great Britain up to the north of Scotland. Verrall (1909, p. 428) considered that it was rather less common than *relictus*, but later records show *caecutiens* to be the commonest species of the genus, at least in the south. It was taken as early as May 24th, in S. Devon by Col. Yerbury, and is on the wing till the middle of September. Jones (1920, p. 7) found this species extremely abundant in the New Forest, and writes: "For several days in July I was forced to give up collecting owing to the sight of both eyes almost disappearing, chiefly the work of *Chrysops caecutiens*, who delighted to bite on the forehead, just above the eye." Mr. F. C. Morgan, curator of the Hereford Museum, in a recent inquiry about this species, states that it is locally known as the "thunder fly," and that it is troublesome in biting dogs.

Surcouf (1924, p. 47) has described the oviposition of this species on the leaf of a reed as witnessed by him in July, 1914, at Saint-Gobert (Aisne), in France. The eggs hatched on the following day, and the young larvae, which were barely 1 mm. in length, at once slid down into the water at the foot of the reed.

The larval and pupal stages of *C. caecutiens* are passed in mud on the margins of streams. In mud piled up beside a rapid stream in a meadow, Beling (1888, p. 2) found, on July 8th, 1887, a larva, five pupae and several pupa cases; the pupae were collected and produced two males and three females between July 11th and 15th. Elsewhere in north Germany larvae of *caecutiens* were found in abundance by Stammer (1924, p. 123) in the mud bordering a small, sluggish stream, the margins of which were fringed with tall beech and ash.

According to the same author (pp. 126, 127) the larva of this species feeds on decaying organic matter, and in all probability is not predaceous. He kept five larvae together for four weeks in a small vessel without supplying them with animal food. They did not attack one another, and the contents of their intestines appeared to consist only of the fine mud in which they were living. It is indeed asserted by Stammer that no one has observed a predaceous mode of life in a *Chrysops* larva. The larva may attain a length of 17 mm., and is

spindle-shaped, moderately deeply striated, and has only six retractile pseudopods instead of the usual eight on the front margin of each segment from the fourth to the tenth. The ground colour is greenish, the body wall transparent, and the internal organs readily visible.

C. caecutiens is found in all parts of Europe from Sweden to Corsica.

***Chrysops quadrata* Meigen**

(Plate 17)

The basal half of the upper surface of the abdomen in the male of *C. quadrata* shows a considerable amount of paler coloration at the sides, although the median quadrate black spot on the second segment, a continuation of the black area of the first, is very much larger than in the female, and nearly reaches the hind margin. As in the female the hinder portion of the third segment and sometimes that of the fourth as well is conspicuously yellow. The median black spot on the second abdominal segment of the female is variable in shape as well as in size, being sometimes nearly square, sometimes more or less distinctly cordate. Frequently, especially when more or less quadrate, it is connected with the blotch on the first segment, but in very many cases it is separate.

So far as it is possible to judge from the not very extensive series of British representatives of this species at present contained in the Museum, *C. quadrata* varies from 7.5 mm. to 9 mm. (males) or 10.5 mm. (females).

This species is not often met with, especially in the north, though according to Verrall (1909, p. 431) it is "widely spread over the southern and midland counties." Goffe (1931, p. 55) says: "It is very common in the New Forest, particularly in the district surrounding Matley Passage and Denny Lodge." Verrall also states that *C. quadrata* was taken at Aviemore, Inverness-shire, in July 1899 by Lt.-Col. Yerbury. There is no other Scottish record, and none from Ireland.

Dates of capture of the Museum specimens range from June 24th to September 1st, the earliest date mentioned by Verrall being June 7th.

Males of *C. quadrata*, with others of *caecutiens* and *relicta* were among the male Tabanidae taken by Jones (1922, pp. 40-41) drinking on the wing from a muddy pool in Rhinefield Enclosure, Lyndhurst, New Forest. Goffe (1935, p. 102) also found large numbers of males of this species between June 15th and August 2nd, in the Lyndhurst-Beaulieu district of the New Forest. "They were observed to fly in rapid evolutions very close to the water for a few seconds, touching the water at intervals of a second or so; the movements rather reminded one of the small whirligig beetles of the genus *Gyrinus* Linn. They were also found resting on grass, etc., overhanging the water." Unlike Mr. Jones, Mr. Goffe did not see a single *caecutiens*.

The pupal stage, according to Lundbeck (1907, p. 96), is passed in moist sand near water.

Chrysops quadrata occurs all over Europe, Lundbeck gives it as "not uncommon" in Denmark.

***Chrysops relictus* Meigen**

(Plate 18)

In the male of this species the basal half of the upper surface of the abdomen is conspicuously yellow on each side, the second visible segment exhibits a large, black, median blotch which is bifurcate posteriorly, and the middle and hind tibiae are reddish-yellow. In the female illustrated in the plate the wings are in a resting position, and the spots on the second segment of the abdomen are somewhat obscured, the pale lateral extremities of the first two segments being scarcely distinguishable. In reality, when the wings are clear of the body the pale areas are very conspicuous. The markings of the male abdomen are similar to those of the female, but the sides of the basal portion are deeper in tone, and the pale triangles much less distinct.

The plate fails to show the markings of the upper surface of the thorax as clearly as could be wished. In the female there are a pair of fairly broad, olive-grey, longitudinal stripes, one on each side of a dark median line, and fused together at their anterior ends, where they appear bluish-grey; a broad, dark olive-grey or iron-grey longitudinal stripe outside these to the right and left; and a greyish-olive or deep olive-grey lateral border on each side, clothed with shining yellow hair.

Full details of the coloration and markings of the eyes in this species, with a figure of the eye in the male, are given by Verrall (1909, p. 432, 434, fig. 247).

British examples of *Chrysops relictus* in the Museum measure from 8 to 11 mm. in the male, and from 9 to 11 mm. in the female.

In the British Isles *C. relictus* is generally distributed and sometimes locally common, from South Devon to the north of England, besides being found in Wales and Ireland. Goffe (1931, p. 57) says that it seems to be most common round watery places on old heathlands, and that it is stated to be more common in Scotland than *C. caecutiens*.

The dates of capture of the specimens in the Museum range from May 24th to August 31st, but at Reading the late Mr. B. D. Burtt took both sexes as late as September 18th. The last-mentioned were taken on water mint, where the male was feeding on the flowers, and on August 24th, at Bulmersh Park, Reading, Mr. Burtt found males of *relictus* swarming everywhere on the lake margin, resting on the flowers of the water mint, on rush leaves, and on every water-lily leaf. On June 29th and July 2nd, 1922, in Rheidol Valley, Aberystwyth, males were taken by the same collector on water dropwort (*Oenanthe* sp.).

Lundbeck (1907, p. 97) states that the pupa of this species is some 13 mm. in length, and in Denmark has been found in sand at Fures Lake. Beling met with three pupae of *C. relictus* in sand at the edge of a small brook in a meadow in the Harz district in North Germany. He describes the pupa as dirty brownish-yellow in colour, 12 mm. in length and 3 mm. in breadth.

Chrysops relictus occurs over the whole of Europe, and in Germany, according to Kröber (1920, p. 125), it is probably the commonest species of its genus.

Chrysops sepulcralis Fabricius

(Plate 19)

In *Chrysops sepulcralis* the upper surface of the body is deep black in the male and bronze-black in the female; the absence of pale hairs along the posterior borders of the segments of the abdomen in the male give it a much blacker appearance. In other respects, apart from the approximated eyes in the male, the two sexes are closely similar and do not show the striking colour-differences of *caecutiens* and *relicta*. A small but useful further mark of identity is a prominent angle on the outer margin of the transverse band on the wing, on the anterior side of the third longitudinal vein and just before its fork (see pl. 19).

Verrall (1909, p. 435) describes the eyes in the male of this species.

British specimens of this species range in size from 6.5 to 9 mm. in the male sex, and from 7 to 9 mm. in the female. Verrall (1909, p. 436) speaks of *C. sepulcralis* as the smallest British species of the genus, but occasionally females of *quadrata* are smaller than the average *sepulcralis*.

The present species is decidedly the rarest of the British *Chrysops*, although in certain localities in the south of England it is common enough at the proper season. Nothing is known of the occurrence of *C. sepulcralis* in Ireland, and with the exception of a record from Perthshire the British localities are confined to Hants and Dorset. Verrall, however (1909, p. 439) wrote: "It is very probable that the so-called 'black variety' of *C. caecutiens* mentioned by Duncan in 1837 [p. 455] as having occurred in Sutherlandshire and in the south of Scotland may refer to this species."

On June 30th, 1905, six females of the present species were taken, with many other Tabanidae, in a meadow near Aberfoyle, Perthshire by Mr. W. Evans (1907, p. 54), and were examined by Verrall, who noted them (1909, p. 438) as being in some ways different from the typical females of this species. The collector stated that they were "not uncommon."

The first specimens of *C. sepulcralis* to be recorded as British were two males, taken at Studland Heath, Dorset, on August 3rd, 1895, by Capt. Savile Reid, and in more recent years the species has been captured in large numbers on Wareham Heath and Morden Heath by Miss E. K. and Mr. N. D. F. Pearce. The latter authors (1917, p. 257), wrote: "... The male sits on grass stems round the edge of the swamps, and rises for short flights when approached." The males in this locality were said to be "solitary or sparse," but the late Mr. B. D. Burtt found them much more numerous in north-east Dorset, near the Hampshire border. In a field-note Mr. Burtt says he "saw any number of male *C. sepulcralis* flying low, about 12 to 9 inches above the marsh, or settled half-way up rush and grass stems, where they clung like black triangles, with eyes glowing. In some the eyes appeared copper-coloured, in others half green to almost pure jade green. . . ."

The preliminary stages of *C. sepulcralis* do not appear to have been observed.

According to Kröber (1925, p. 20) the distribution of this species is "north

and central Europe," and in 1920 (p. 100) the same author gave its occurrence as Germany, Denmark, Lapland, Sweden, Finland and Russia. It appears to be absent from the French fauna, which is rather surprising since in England the principal locality is on the Channel coast. Goffe (1931, p. 59) points out that the British specimens do not entirely agree with Kröber's description of the species, and Surcouf (1924, pp. 218, 219), while making a similar comment upon specimens named by Lundbeck, lists the closely related *C. maurus* Siebke as British.

Subfamily TABANINAE

Genus HAEMATOPOTA Meigen

DUN-FLIES or CLEGS

The practically universal occurrence of the common Cleg, *Haematopota pluvialis* Linn. throughout the British Isles, coupled with the aggressiveness of the females, renders this species one of the most familiar of British Horse-flies. Three other species of the genus occur in this country. The range of *H. crassicornis* in the British Isles, if less extensive than that of *H. pluvialis*, is still wide, but the other two species, *H. bigoti* and *H. italica* are of more local occurrence.

The characteristic shape and colouration of *Haematopota* can be studied when one of these insects has quietly alighted for the purpose of sucking blood. The body, in all cases, is narrow and elongate, and the wings in the resting position meet together at the base and then diverge slightly, sloping somewhat like the roof of a house. The British species of the genus are sombrely coloured flies, with dusky bodies only partially relieved by more or less distinct greyish markings. The wings are suffused with drab-grey (brown in *crassicornis*) and in all cases bear the distinctive markings characteristic of the genus. These consist of pale "rosettes" which always occupy the same relative positions. The eyes in the living insect are shining coppery-green, bluish green, or brassy-green, with the upper and lower margins and three horizontal and partly zig-zag lines dark brown.

The early stages of *H. pluvialis* have been studied by Cameron (1934), and notes of some of his conclusions will be found under that species (p. 85).

Although extremely bloodthirsty and pertinacious in their attacks and when numerous making their presence felt by both human beings and domestic animals, the females of most species of *Haematopota* are somewhat sluggish flies, and when actually sucking blood may easily be caught with the fingers or in a glass tube. Males sometimes hover in the air after the manner of Syrphidae (Hover-flies), as was observed by the late Major E. E. Austen in Palestine, near Jaffa on April 29th, 1918. Six males of the species later described by him as *Haematopota sewelli* were taken at 9.0 a.m. while hovering poised in the air in front of a tent on the outside of which two females of the same species were resting.

Colonel Yerbury, on the other hand, described this motion as "dancing," and Verrall (1909, p. 329) writes: "the males sometimes dance in hot sunshine

between eleven and twelve o'clock, in groups of from six to nine individuals above pine stumps (as seen by Colonel Yerbury at Nairn on July 9th, 1904); they alternately rise and fall between 5 and 12 feet from the ground, and when the sun is obscured, rest on the pines; I have never seen this habit, but have commonly found them resting on posts or rails, or towards evening on flowers."

Major Austen (manuscript notes) wrote: "It may be of interest to remark that Africa is peculiarly rich in species belonging to *Haematopota* and evidently represents the head-quarters of the genus. Thus at the present time (1925) the number of known Palaearctic species amounts to some twenty-seven, while the Oriental species similarly number forty-nine. From the Ethiopian Region, however, the Museum possesses representatives of no fewer than one hundred and twenty species, a few of which have yet to be described, and it is safe to say that the figure mentioned will be considerably exceeded when all the African species of *Haematopota* are known."

KEY TO THE FEMALES OF THE BRITISH SPECIES OF *Haematopota*.

1. Antennae conspicuously longer than the head, more than one and a half times length of head from back to front; first antennal segment cylindrical, not swollen, approximately equal in length to third segment; wing markings rather pale *italica* Meigen
Antennae not conspicuously longer than head, not more than one and a half times length of head from back to front; first antennal segment not cylindrical, but more or less ovoid, shorter than third segment.....2
2. Third antennal segment black throughout, rarely very slightly reddish at base; first antennal segment short, very distinctly swollen, and shining black (Plate 21)..... *crassicornis* Wahlb.
Third antennal segment more or less reddish on basal half; first antennal segment not so conspicuously swollen, usually constricted near tip, and only apical part shining3
3. Middle and hind femora more or less yellow or reddish; upper surface of abdomen with a pair of sharply defined pale spots on each segment except possibly the last... *bigoti* Gobert
Femora entirely blackish; paired abdominal spots poorly defined, and absent from first, or first and second segments (Plate 20) *pluvialis* Linn.

***Haematopota pluvialis* Linnaeus**

The common Dun-fly or Cleg. (Plate 20)

Of British blood-sucking flies other than midges, mosquitoes and black-flies, this species is one of the commonest, most aggressive and most generally distributed, occurring throughout the British Isles. Verrall recorded it from May 28th to September 16th (1909, p. 336), and Goffe (1931, p. 63) adds: "occasionally even to October." The specimens in the British Museum vary in length from 8 to 11 mm. in the male and 7 to 11 mm. in the female. Kröber (1925, p. 51) gives the distribution of this species as Europe, Siberia and North Africa.

So long ago as 1834 Curtis wrote of this species: "... the females, which attack both men and horses, sometimes appear in myriads without one male." Although the males of *H. pluvialis*, as of most Tabanidae, are not easily met with (compare, however, *H. crassicornis*, below), there are occasionally striking exceptions to this rule. Thus Kröber (1922, p. 157) writing of *H. pluvialis*, states: "On one occasion at Curslak near Hamburg, in the

early morning of June 12th, on some railings closing a cow-pasture," he "met with a good 200 males, all freshly emerged, and not a single female among them." Jones (1922, p. 40) took males of this species, among others, over muddy pools in the bed of a partially dried-up stream in the New Forest, and records that, like *Chrysops* they are great "mud-sitters."

Cragg (1912) has described the method of feeding of *pluvialis*.

"After a short preliminary investigation in which the labium appears to be used as a tactile organ, the piercing styles are inserted by a series of short sharp forward thrusts of the thorax, the labium being retracted and the labella everted behind the rest of the proboscis, and the maxillary palps extended in front. As the wound is deepened the fly elevates itself on its hind legs, till the abdomen is tilted up at an angle of 45° or so, the forelegs being meanwhile extended in front of the proboscis, with their tibiae held parallel to the surface. While in this position the abdomen gradually distends and slight peristaltic movements can be seen in it. [These are attributed by Cameron (1934, p. 214) not to peristalsis, but to rhythmic respiratory movements.] In a short time a clear fluid begins to exude at the anus, and this goes on as long as the insect feeds, the fluid becoming tinged with blood towards the end of the meal, and even in some cases appearing to consist of unfiltered blood. Several times during the process the mouth parts are withdrawn a little and again thrust in; finally they are withdrawn by a few sharp jerks and the fly, after resting a moment to clean its proboscis with its forelegs, flies away. A small drop of blood usually oozes from the puncture, and a faint ring of hyperaemia, with usually some slight irritation, mark the site for a day or two. The pain caused by the bite is usually trifling, less than that of a mosquito bite. Some individuals, however, appear to be remarkably sensitive, and may suffer for days, even a week or longer, from local irritation or inflammation [*cf.* Verrall (1909, p. 329)]. The fly takes about three minutes to obtain a full meal, and while feeding it is not readily disturbed; and the process can be watched on one's hand through a pocket lens."

Cameron (1934, p. 214) found that unfertilised females in captivity would not feed, a conclusion which was supported by the behaviour of specimens caught in the field. A second meal was not usually taken until after oviposition, which might be delayed from six to twelve days. This author also notes that although engorgement usually takes three to six minutes (*cf.* Cragg's observations, above), feeding might continue for as long as thirty minutes. He suggests the tapping of a lymphatic instead of a blood-vessel as one cause of protracted feeding.

For a very full account of the biology of *Haematopota pluvialis* Meigen, see Cameron, 1934.

***Haematopota crassicornis* Wahlberg.**

(Plate 21)

In both sexes *H. crassicornis* is a much blacker-looking species than *H. pluvialis*, and the characters specified in the key on page 84 for the separation

of the females can really be applied to either sex. The dilated first antennal segment implied by the name "*crassicornis*" is not entirely reliable, for, as Verrall (1909, p. 336) points out, the males of *pluvialis* may have a stouter first antennal segment than the females of *crassicornis*; but *crassicornis* may always be recognised by the entirely shining first segment, and the entirely black third segment of the antennae.

According to the specimens in the Museum collection, the size of this species varies from 8.5 to 10.6 mm. in the male, and 8 to 11.5 mm. in the female.

While *H. crassicornis* is widely distributed in the British Isles, as also in Continental Europe, it is, generally speaking, less common than *H. pluvialis*. Verrall (1909, p. 331) and Goffe (1931, p. 64) both regard *H. crassicornis* as commoner in Scotland than in England, and consider it likely to exceed in numbers *H. pluvialis*, at least locally. Mr. Goffe (in correspondence) writes: "I have often been pestered by *crassicornis* in Scotland. On 24th June, 1933, in Glenmore Forest they were very abundant. It goes to higher altitudes than *pluvialis*." Cameron, on the other hand (1934, p. 213) found *crassicornis* comparatively rare in Scotland.

The dates of capture of the Museum specimens range from May 24th to July 27th, while Verrall's records extended to August 14th.

It is remarkable that in the series of this species in the Museum the males should outnumber the females—eighteen males to eleven females—especially since the specimens were taken on a number of different occasions. This is not an instance of the temporary and local occurrence of males only, such as was noted above under *pluvialis*, and it may perhaps indicate that the females of *crassicornis* are less prone to attack man than are those of the other species. Local swarms of males do occur in *crassicornis*, as shown by a note by Miss Ricardo (1906, p. 98): "The four males collected by me form part of a series of two dozen or so caught in one week, resting on the highest and sunniest spots of a stone wall round an unoccupied farmyard. No females were to be seen. I was not successful in discovering their breeding-place."

According to Kröber (1922, p. 155) the area of distribution of *H. crassicornis* includes Europe and Morocco.

***Haematopota italica* Meigen**

So long ago as 1834 a very fair coloured figure of the female of this fly was published by Curtis in his "British Entomology," but in spite of this the species is only slightly better known in Britain than *H. bigoti*. Hitherto the species does not seem to have been met with in Wales, Scotland or Ireland, and most of the specimens so far collected, like those of Curtis, have been obtained in Essex. Verrall and Yerbury found it not uncommon in the salt marshes of the Essex and Suffolk coasts in 1907.

In the female sex *H. italica* is readily distinguishable from any other British species of *Haematopota* by the length of its antennae (see key, p. 84). *The antennae of the male, however, are not unusually elongate*, and in this sex care is necessary to avoid confusing *italica* with *pluvialis*. The male of *italica*

presents the following differences when compared with the male of *pluvialis*. The hair on the eye is much longer; the fringe of erect hair on the hind margin of the vertex is shorter, and yellowish or buff-yellow instead of black; the first segment of the antenna is clothed mainly with yellowish instead of black hair (at least above); the pale markings on the dorsum of the body, including the thoracic stripes and abdominal spots are much more distinct, and the wings are paler.

This species is on the wing throughout August. There are specimens in the Museum taken on 23rd July and 4th September, and Verrall (1909, p. 345) says: "one female occurred at Aldeburgh as late as September 19th."

The size of specimens in the British Museum varies from 9 mm. to 10.5 mm. in the male, and 10.4 mm. to 12.6 mm. in the female.

In this country *italica* is apparently coastal in distribution. Goffe (1932*b*, p. 42) suggests that the single record for Matley Bog, New Forest, may be accounted for by specimens carried by wind from the Calshot area, where he found the species, though sparingly, in 1931 and 1932. In Denmark, according to Lundbeck (1907, p. 106) *H. italica* is as common as *pluvialis*, or nearly so, and it often occurs together with this species.

Haematopota bigoti Gobert

This species, described in 1883, from material obtained in the Landes district of south-western France, and apparently from the female only, is little known in the British Isles, and is at present represented in the Museum collection by fewer than a dozen specimens. All these are females, and are chiefly from the south-eastern counties of England. The male has apparently not yet been taken in this country.

The female rather resembles that of *pluvialis*, but the wing-markings in fresh specimens (according to Goffe) are noticeably paler, while the middle and hind femora are more or less yellowish. Usually they are grey or black only at the tip, but sometimes the base, particularly of the middle femora is also dark. When the wings are spread out the species is easily recognised by the conspicuous pale spots on the *first* abdominal segment (female). The head is also distinctly broader, when compared with a female of *H. pluvialis*.

Verrall (1909, p. 770) figures the eye-markings in this species, and states that the bands appear to be different from those of the other British species of *Haematopota*.

H. bigoti has so far been taken in this country only in July and August.

The eight females of this species in the Museum, from localities in Suffolk, Essex and Kent, and from Studland, Dorset, bear out Goffe's conclusion that, in this country at least, this species frequents coastal marshes. It has also been taken in Somerset (Tickenham) by Mr. H. L. F. Audcent, in Norfolk (Burnham Overy) by Mr. P. Freeman, in Hants by Mr. Goffe (1932*b*, p. 42), and in the Isle of Wight (St. Helens Oyster Beds) by Mr. A. H. Hamm.

The Museum does not at present contain any Continental specimens of this species, but from records given by Kröber (1922, p. 161) it occurs in Italy, Hungary, Algeria and Morocco, as well as in the north and south of France.

Genus *TABANUS* Linnaeus(Including the sub-genera *Sziladynus* Enderlein and *Ochrops* Szilády.)

From all parts of the world nearly two thousand species of this genus are known, of which twenty occur in this country and are discussed in the following pages. Since the first publication of "British Blood-sucking Flies" in 1906, changes have been made in the names and in the definitions of several species, largely through the work of Goffe and Collin.

Most of the specimens then listed as *Tabanus bovinus* Linn. are now regarded as belonging to the form *perplexus* Verrall (*verralli*, nom. nov., see p. 113), which was described as a variety of *T. sudeticus* Zeller (see Verrall, 1909, p. 399), but which Collin (1932, p. 38) is "convinced must rank as a species." Similarly *T. bisignatus* Jaennicke is now regarded not as a variety of *T. tropicus* Meigen, but as a separate and quite distinct species. Nearly all the lighter specimens which used to be called "*T. tropicus*" are now regarded as light specimens of *bisignatus*, while the true *tropicus*, like *bovinus*, is very much less common than was formerly supposed; it is, indeed, almost indistinguishable from *T. solstitialis* Meigen.

Austen (1906, p. 36) added *T. borealis* Meigen to the British List from one male (Glen Avon, Banffshire, *W.R.O. Grant*). Verrall (1909, p. 366) gave his opinion that this specimen was merely a male of *T. montanus* Meigen, a view with which Major Austen (manuscript notes) finally concurred. Meanwhile Goffe (1931, p. 37) recorded as *borealis* a single female in the Hope Museum, Oxford, but Collin (1932, p. 37) declared that this specimen was a normal *bisignatus* Jaenn. With Professor Carpenter's permission I have been able to borrow this specimen from the Hope Museum, and it appears to be indistinguishable from the series of *T. bisignatus* in the British Museum collection. *Tabanus borealis* Meigen has therefore been omitted from this volume.

A discussion of the various generic and sub-generic names in use in this group, particularly those proposed by Enderlein (1923) has been given by Goffe (1931), and is outside the scope of this volume.

KEY TO THE FEMALES OF THE BRITISH SPECIES OF *Tabanus*.

1. Eyes (under ordinary hand-lens) distinctly hairy (sub-genus *Sziladynus*) 2
 Eyes under ordinary hand-lens not obviously hairy 8
 NOTE.—The eyes of females of the sub-genus *Ochrops* may appear hairy when seen from certain angles, but they are not *obviously* so.
2. Legs entirely black (Plate 22) *micans* Meigen (p. 90)
 Legs not entirely black, tibiae at least being pale at base 3
3. Frontal triangle (*i.e.* space immediately above antennae) bare and shining (text-fig. 26 and Plate 25) *luridus* Fallén (p. 91)
 Frontal triangle pollinose and dull 4
4. Upper surface of abdomen black, with whitish patches, and without or with not more than a little dull reddish colouring at sides of segments near base (Plates 23, 24) 5
 Each side of first three or four abdominal segments obviously orange to over one-third of width (Plate 26) 6
5. Vertex with tuft of black hairs behind ocelligerous tubercle. Abdomen sometimes with pale lateral areas near base *bisignatus* Jaenn. (p. 91)
 Vertex without tuft of black hairs *montanus* Meig. (p. 93)

6. Reddish abdominal colouring extending more or less distinctly to segment four, which has short yellow pubescence at sides (Plate 26) *distinguendus* Verr. (p. 94)
 Reddish abdominal colouring not extending beyond segment three. Segment four with black pubescence at sides 7
7. Hair-fringes on hind tibiae pure white for basal half. 2nd sternite entirely orange, without black central stripe. A rather larger, inland species *solstitialis* Meig. (p. 95)
 Hair-fringes on hind tibiae with some black hairs on whole length. 2nd sternite with pronounced black central stripe. A rather smaller, coastal species. *tropicus* Linn. (p. 96)
8. Large forked vein near wing tip usually with small branch at base (Plate 27) (compare also *T. luridus*, *T. glaucopis*). Frontal calli rudimentary or almost wanting (sub-genus *Ochrops*) 9
 Forked vein usually without small branch (cf. *T. plebeius*). Frontal calli well developed (sub-genus *Tabanus*) 12
9. A small species (11 mm. or less), mouse-grey in colour with only a trace of reddish coloration near base of abdomen. Thorax and abdomen with long greyish pubescence. Forked vein sometimes without appendix *plebeius* Fallén (p. 97)
 Larger species (13 mm. or more) with more or less yellowish appearance. Pubescence short, grey or partly golden-yellow. Forked vein rarely without appendix 10
10. Ochreous species clothed with short silky golden hairs. Abdomen brownish-golden, with conspicuous yellow side margins to first three segments *fulvus* Meig. (p. 98)
 Yellowish-grey species, abdomen with two dark bands separated by broad ashy stripe 11
11. Greyish species. Femora yellow at tips only; frontal callus narrow and parallel-sided *rusticus* Linn. (p. 99)
 Yellowish-grey species, abdomen distinctly yellow at sides of base; femora yellow on apical half; frontal callus not parallel-sided (plate 28) *nigrifacies* Gobert (p. 99)
12. Very large species (18 mm. or more); abdominal segments with pale margins, and one row of pale triangular spots in the middle; eyes in life unbanded 13
 Smaller species (10 mm.–18 mm.) with three rows of pale abdominal spots; eyes often banded in life 15
13. Ground-colour of abdomen black or dark blackish brown on all segments; median triangles short, equilateral, not reaching front margin of segments; ground colour of underside of abdomen blackish or grey *sudeticus* Zeller (p. 100)
 Base of abdomen more or less reddish-yellow in ground-colour, with black central stripe and row of pale triangles; underside of abdomen with some pinkish colouration towards base 14
14. Abdomen extensively reddish yellow at sides on four or more segments; median triangles long, concave-sided, first three practically reaching fore-border of their segment; abdomen extensively pink basally below; frontal callus as in text-fig. 37 *bovinus* Linn. (p. 102)
 Abdomen somewhat reddish at sides, but nearly all segments blackish on front half; triangles variable, usually like *sudeticus*, sometimes like *bovinus*; underside of abdomen a little pinkish or yellowish at extreme base; frontal callus as in text-fig. 38 *verralli* Oldr. (*perplexus* Verrall) (p. 103)
15. Upper frontal callus heart-shaped and isolated from lower one 16
 Upper frontal callus elongate and united with lower 17
16. Frontal triangle bare and shining (text-fig. 39); eyes in life with three purple bands *glaucopis* Meig. (p. 104)
 Frontal triangle pollinose, not shining (text-fig. 40); eyes in life unbanded *cordiger* Meig. (p. 105)
17. Large species (16–18 mm.); abdomen very dark, with three very prominent rows of pale triangles *autumnalis* Linn. (p. 106)
 Small species (13–16 mm.); abdomen grey, with three rows of triangles 18

18. Small grey species, with black and white pubescence; postocular rim rather broader than usual; cheeks with black hairs at upper end, near bases of antennae; eyes in life with one band *maculicornis* Zett. (p. 107)
 Larger brownish-grey species, with pubescence distinctly yellowish; postocular rim normal.....19
19. No black hairs on upper end of cheeks; abdomen sometimes a little reddish near base; eyes in life with a single band *bromius* Linn. (p. 108)
 A few black hairs on upper end of cheeks; abdomen usually reddish about sides of first three segments; eyes in life unbanded *miki* Brauer (p. 110)

***Tabanus micans* Meigen**

(Fig. 25 and Plate 22)

This shining black species is distinguishable from *T. bisignatus* Jaenn., with which alone it is likely to be confused, by its having the legs entirely black. The male has a bunch of long, erect, coarse black hairs at the tip of the first segment of the front tarsi, and on the three following segments. Brauer (1880, p. 137) describes the eyes of the living male thus: "on the lower half with three purple bands on a bright green ground, and purple-coloured lower margin; or bluish-violet, underneath with three green bands bordered with red." The eyes of the female are green, with either three or four purple bands.

Specimens in the British Museum range in size from 13.5 in the males and smaller females to 15.5 in the largest females.

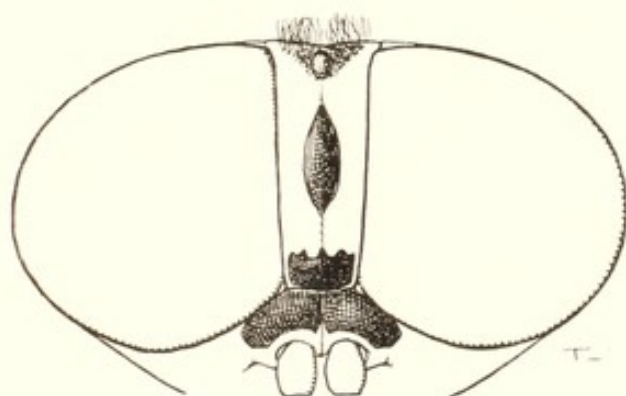


FIG. 25.—*T. micans* Mg. ♀. Head.

In the British Isles *T. micans* is undoubtedly one of the rarest of the representatives of its genus, and at the present time the Museum possesses only eleven British examples. The species has been recorded in isolated localities from Hampshire to Inverness, and Verrall could only record it between June 11th and June 23rd (1909, p. 355). It has since been taken in the second half of May, and Continental

records extend into August, but British captures seem to be restricted to May and June (Carter's record from Loch Voil, Perthshire in 1919 is *June* 26th, not July as printed by Goffe, 1931, p. 91). Goffe attributes the apparent rarity of this species, in part at least, to its appearance early in the season when there are fewer hot sunny days on which it might be conspicuously active. He also states that "Dr. F. H. Haines has taken it in numbers in the S. Dorset marshes." Hamm (1933, p. 67), records having taken males of *T. micans*, near Oxford "sucking up moisture from a bare patch on the path."

This species appears to have been taken all over Europe except in Denmark and Scandinavia; it does not appear in Lundbeck's Danish list. Kröber (1924, p. 71) states that it occurs in the morning on Umbelliferae, especially *Heracleum*.

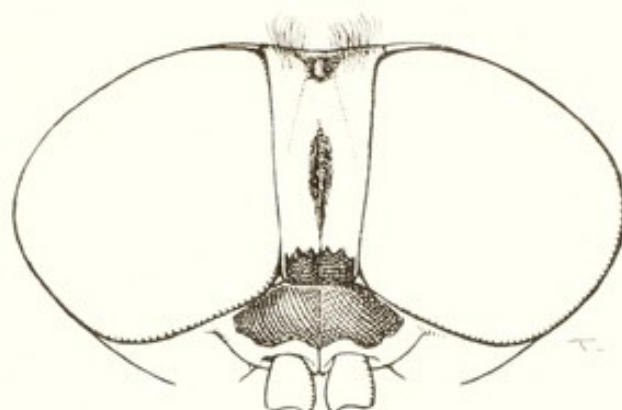
Tabanus luridus Fallén

(Fig. 26 and Plate 25)

The shining frontal triangle or subcallus (the space between the lower inner angles of the eyes and the bases of the antennae) distinguishes the female of this species from *montanus* and from the pale form of *bisignatus*, which it somewhat resembles. In the male the frontal triangle is whitish-grey pollinose. In both sexes the body as a whole is shining. Brauer (1880, p. 44) describes the eyes of the male as "green, with three purple bands and red margin next the face," and those of the female as "green, with three purple bands." The eye of the male is without a conspicuous area of enlarged facets. It will be observed that the specimen illustrated in Plate 25 has a small appendix to the upper branch of the forked vein, and in the females, at any rate, of this species such an appendix is not infrequently present.

Although France and Bohemia are said to be included in its area of distribution (*cf.* Séguy, 1926, p. 151), *T. luridus* would nevertheless appear to be characteristically a northern species, which has only been taken in one British locality outside Scotland; at Whixall Moss, Salop, Mr. C. H. W. Pugh took a male in June, 1934, and Mr. T. Hignett took females in June and July, 1936 (see Goffe, 1937, p. 189). In a letter to Major Austen, Colonel Yerbury wrote: "In Scotland this is the earliest of the Tabanidae. In May 1905, it was met with in numbers near Nairn, where both sexes were found sitting on a sandy road. . . . Probably all the Tabanidae seen by me in Scotland at this time of the year belonged to this species." Mr. Goffe (in correspondence) tells me that in the Scottish Highlands *luridus* is almost or quite over when *montanus* appears.

Kröber (1925, p. 66) gives its distribution as north and central Europe and Siberia. Lundbeck, speaking of Denmark (1907, p. 117) says *luridus* is usually "only taken in single specimens."

FIG. 26.—*T. luridus* Fallén. ♀. Head.**Tabanus bisignatus** Jaennicke(? = *T. paganus* Fabricius)

(Fig. 27 and Plate 23)

This dark species often strongly resembles *T. micans*, but may at once be distinguished by its having the tibiae red basally, contrasting with the all-black legs of *T. micans*. The plate fairly represents an "average" female specimen, but the extent of the lighter markings on the first two abdominal segments varies from practically nothing to conspicuous lateral patches on the first two segments. The males are very similar in appearance, except that

they apparently always have the lateral light patches very distinct, and covering three segments.

The female *bisignatus*, particularly the darker form with the side-margins practically absent, is one of the commonest of the species of *Tabanus* in this country, though, except locally, it seems to be much less common on the Continent. It is a woodland species, and is widespread in the south and midlands from May to August.

It is apparently to the males of this species that the remarks of Jones (1922, p. 41) apply. He speaks of having, in the New Forest "on several occasions in 1921, found the males of *Tabanus tropicus* sitting on damp mud by the margins of partially dried-up puddles," but adds that most specimens captured in this position proved to be females (see also under *T. solstitialis*, p. 95). Goffe (1935, p. 106) has taken the males in large numbers in June-July over water in the New Forest.

At Chantilly, not far from Paris, in 1914, Surcouf (1921, p. 18), found

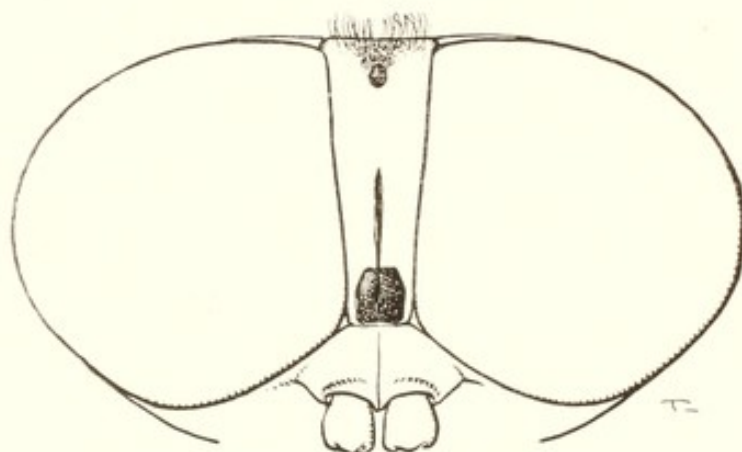


FIG. 27.—*T. bisignatus* Jaenn. ♀. Head.

seventy-six larvae of this species among a layer of fallen oak-leaves carpeting the bottom of a shallow pond not more than a few centimetres deep. In captivity some of these larvae, which like those of other Tabanidae are carnivorous and extremely voracious, devoured several Chironomid larvae ("blood-worms"), and seemed to prefer them to Copepods, which are able to escape more easily. In June, 1930, Mr. H. St.-J. K. Donisthorpe found several Tabanid pupae in a swan's nest at Windsor, and both sexes of *T. bisignatus* were bred out.

Until recently the light form of this species was held to be the *T. tropicus* of Linnaeus, the commoner dark form being known as "*T. tropicus bisignatus* Jaenn.", under which name it still appears in Continental works (e.g. Kröber, 1925, pp. 57, 72, and Séguy, 1926, p. 153). Collin (1932, p. 39), and later Goffe (1935, p. 106), have put forward the view that the true *T. tropicus* Linn. is a different, quite distinct species (see below, p. 96). The form previously known as "*T. tropicus*" is thus left without a name, and Goffe has revived a suggestion of Verrall's (1909, p. 403) that it may be the *Tabanus paganus* of Fabricius, who described the species from "Henly," England.

Should this view be generally accepted the older name *paganus* will, of course, take precedence. The typical *paganus* would be the form with light side-margins, the "*T. tropicus*" of Verrall, while the common dark form would become *T. paganus* Fabr. var. *bisignatus* Jaenn.*

***Tabanus montanus* Meigen**

(Fig. 28 and Plate 24)

In the male of this species the sides of the abdomen are always more or less tawny; in the female such tawny markings may be absent. The absence of a small tuft of black hair on the crown of the head, behind the ocellar tubercle is a useful distinguishing mark in the male. This sex shows an area of enlarged facets in the upper part of the eye, but the size of the larger facets varies somewhat in different specimens, and the line of demarcation between large and small facets is not always very conspicuous.

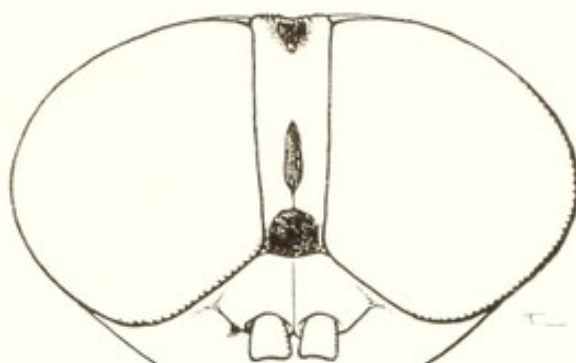


FIG. 28.—*T. montanus* Mg. ♀. Head.

Brauer (1880, p. 144) describes the eye of the male in life as "green, with three purple bands and red lower margin bordering the face," while of the female he writes: "Eyes emerald green, with three linear carmine-red bands, the middle one of which often does not reach the hinder margin of the eye; upper and lower margin emerald green." According to Colonel Yerbury, in notes on specimens in the British Museum, the bands may be either one or three in different individuals, and may be yellow, dark orange, chocolate or brown.

The specimens of this species in the Museum range in size from 12 to 14.5 mm. in the male, and from 12 to 15 mm. in the female.

In 1906, when the first "Illustrations of British Bloodsucking Flies" appeared, Austen (1906, p. 39), wrote: "So far as regards the British fauna, *Th. montanus* would appear to be essentially a Scotch and Irish species, since the Museum collection includes no specimens from England or Wales." In 1935, however, Audcent (1935, p. 90) was able to state that this species had been recorded from Cheshire, Derbyshire, Glamorgan, Hampshire, and Devonshire, and from Scottish and Irish localities, and to remark on its probable occurrence in Northern England. This at once elicited a reply from Fordham (1935, p. 114), who gave several localities in Yorkshire and Lancashire, so that the species is now shown to be widespread, if local, all over the British Isles, except perhaps in the south-eastern counties.

As its name implies, this species is usually met with in mountainous or hilly districts, where it appears to be common, at least locally, but it seems not to be confined to such localities. Haines (1932, p. 40) took a number of specimens

* I have been unable to trace the type of *T. paganus* Fabr. Dr. Schröder tells me that it was probably in the Kiel Museum, but if so, it has been destroyed by pests.

at Hurn, Hants, between the end of June and the first week in August, on a low-lying sandy heath, and commented on the unusualness of this locality. The localities quoted by Fordham (1935, p. 114), however, include Holker Moss, Lancashire—which although on the edge of the Lake District, is itself at an altitude of less than 100 feet—and Askham Bog, which is well out on the Plain of York. It is clear, therefore, that this species may be met with in other than mountainous districts.

According to Kröber (1925, p. 67), *montanus* Meig. occurs all over Europe, and in Siberia and Japan.

Major Austen in his manuscript notes wrote: "In 'Illustrations of British Blood-sucking Flies,' p. 38, 1906, *Tabanus (Therioplectes) borealis* Meigen was recorded as British owing to an error of determination. Further scrutiny of the solitary male (the specimen from Glen Avon . . .) upon which the record was based, shows that the late Mr. Verrall (1909, p. 366) was undoubtedly correct in referring this individual to the present species."

Spooner (1934, p. 51) records a specimen of *T. montanus* among the prey of the wasp *Metacrabro quadricinctus* Fabr. at Plympton, Dartmoor, and the record of a Tabanid as prey of the Dragonfly *Cordulegaster boltonii* Don. given by Hobby (1936, p. 102) is said to refer to this species.

***Tabanus distinguendus* Verrall.**

(Fig. 29 and Plate 26)

Closely similar to *T. solstitialis* Meigen, this species is distinguished by having the orange sidemargins extending back at least to the fourth abdominal segment in the female. The amount of orange coloration on the fourth segment is very variable, and although the yellow pubescence of this segment is

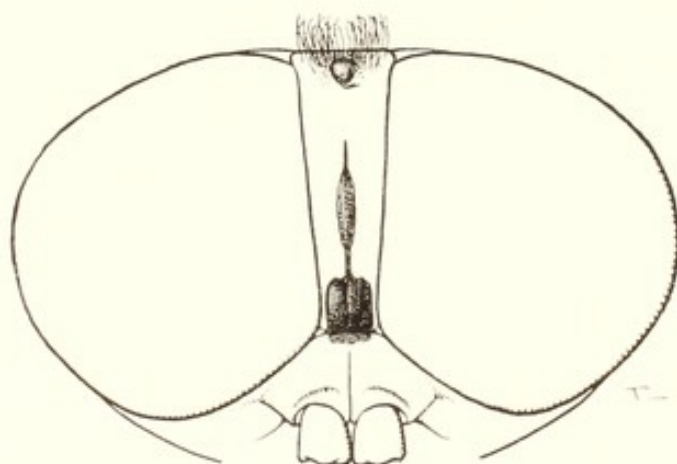


FIG. 29.—*T. distinguendus* Verrall. ♀. Head.

usually sufficiently obvious for recognition, specimens are found which are very difficult to place either in *distinguendus* or *solstitialis*. In fact the late Major Austen in his manuscript notes stated emphatically that he believed the two species to be inseparable, and Goffe (1931, pp. 98-99) records two varieties which he is unable to locate with certainty, though he provisionally lists them

as forms of *distinguendus*. The two species are here listed separately to facilitate the naming of the common typical form of *distinguendus*, and following the practice of Kröber (1925, pp. 58, 64).

Typical *distinguendus* is one of the commonest British representatives of its genus. Goffe (1935, p. 108) found the males "exceedingly numerous" at pools in the New Forest, and took one hundred and thirteen specimens. Like *bisignatus* they darted several times over the surface of the water before rising rapidly away. The specimens in the British Museum were taken from early June to the end of July, and Goffe (1931, p. 98) says "even September."

A female of *distinguendus* in the British Museum was reared in August, 1922, by Mr. H. St.-J. K. Donisthorpe from a pupa found by him near Norwich, in a rotten and moist pine stump. The length of the puparium of this specimen is 19 mm., and the female which emerged is sub-normal in size (13.5 mm.).

The males in the Museum range in length from 14.5 to 16 mm., and the females from 15 to 17 mm.

***Tabanus solstitialis* Meigen**

(Fig. 30 and Plate 26)

A species closely resembling *T. tropicus* Linn., though as far as can be seen from the two specimens in the British Museum, *solstitialis* can be recognised by having the line of pubescence on the dorsal (extensor) surface of the hind tibiae entirely white on the basal half, not with black hairs over the whole length as in *tropicus*. Mr. Goffe tells me that he finds *solstitialis* readily distinguished by the more sharply defined red and black areas on the abdomen. Female with orange markings on only three segments (cf. *distinguendus*, p. 94), and with some black hairs at sides of segments two and three.

In life the eyes of male *solstitialis*, according to Brauer (1880, p. 150) are "dark green with a strong purple sheen above, with two purple bands on the lower third and with rudiments of a similar band on the edge of the larger facets," while those of the female are described as "bright green, with a coppery sheen, or bluish-green with three narrow purple bands which often have a yellow edging."

Jones (1922, p. 41) writes of this species: "... *solstitialis* (next to *T. bromius* the commonest present) was much more casual in its mode of flight, and not infrequently 'rested' for a short space on some convenient leaf overhanging the stream. The 'rest' was presumably for the purpose of imbibing the water collected on the fore legs during the 'dip' . . . for, so far as I could make out . . . this was the method used in drinking, although possibly a certain amount of moisture is gathered in the beak-like proboscis as well . . .

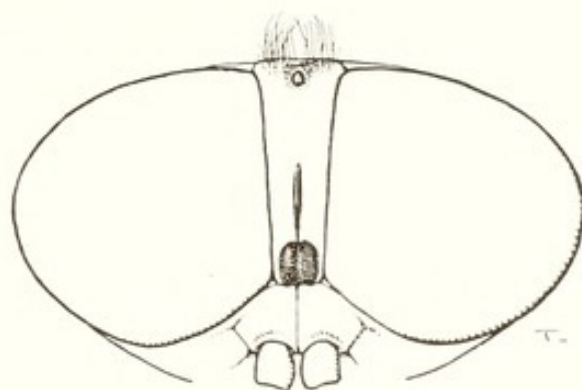


FIG. 30.—*T. solstitialis* Mg. ♀. Head.

the rest was never a preliminary to a dip. . . ." Goffe, however (1935, p. 107), comes "to the conclusion that the very few males which have hitherto been referred to *solstitialis* Meig. belonged either to *Sz. tropicus* Linn., *sensu* Collin, or to some other allied species, and that we have not previously recognised the male of *solstitialis* Meig." This author records the capture of ten males which he believes to represent the true *solstitialis* Meigen, of which "eight were drinking and had a habit quite similar to that of *Sz. paganus* [= *T. bisignatus* Jaenn.]." These males closely resemble the males of *bisignatus*, and Goffe gives a table of differences between them.

Lundbeck (1907, pp. 120-121), writing of *solstitialis* in Denmark, states that the pupa measures from 18 to 20 mm. in length, and that a larva found by him on May 22nd, pupated on June 1st, the imago making its appearance fifteen days later. Another larva found in July spent eleven days in the pupal state. "The larvae were very voracious, one devoured twelve larvae of *Hoplodonta viridula* [Stratiomyidae] in a few days. Brauer states that the pupa is found in water. I do not think this is correct, my larvae would not transform in the water, but when I put the full grown larvae in earth they soon transformed. A larva which I kept in captivity for some time, but without feeding it, transformed at last to pupa, but this was small and the imago only measured 12.5 mm."

The species is found over most of Europe, Siberia and Asia Minor. "There is no sure record of it from Scandinavia" (Lundbeck).

***Tabanus tropicus* Linnaeus**

(Fig. 31)

Goffe (1931, p. 94) and Collin (1932, p. 39) have suggested that the females of this species should have lateral orange patches on three segments of the abdomen, while in the male these markings should extend to the fourth segment. This definition excludes most of the specimens hitherto recorded by

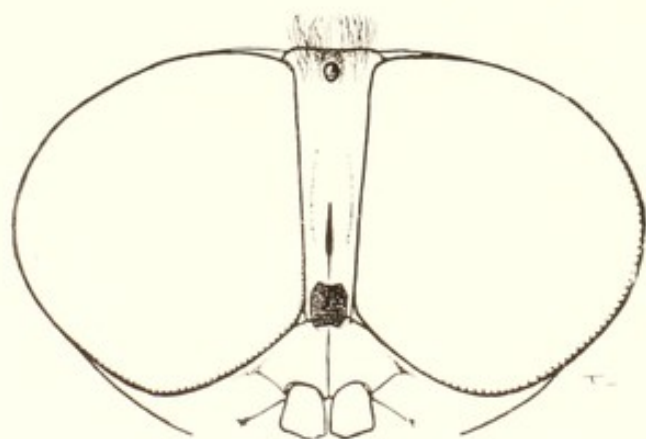


FIG. 31.—*T. tropicus* Linn. ♀. Head.

various authors as *T. tropicus*, which are now regarded as being merely lighter specimens of *T. bisignatus* Jaenn. (see p. 92). An exception is the record of Duncan (1840, p. 328), who, figuring a male, distinctly states that the first four segments are widely fulvous at the sides. He adds: "This species is not one of the most common, but it occurs now and then throughout the country . . . eyes green, with three transverse rays of purple."

As thus restricted the species includes only one of the specimens listed by Verrall (1909, p. 360), the female from Worcester, July 3rd, 1869, which Verrall (previous page) mentions as having been accepted as *tropicus* by the

Continental worker, Brauer. In the addenda (p. 771) Verrall mentions thirty-eight females taken by Colonel Verbury at Crymlyn Bog, Glamorgan on July 24th, 1908, which Collin (1932, p. 39) accepts as conspecific with the Worcester specimen. Collin also states that he has found this species early in August in the Norfolk Broads. The British Museum possesses eleven of the Crymlyn Bog specimens and two females of this species taken in the Norfolk Broads by Professor P. A. Buxton. There are also two females from Kenmare, County Kerry, and Glengariff, County Cork.

T. tropicus Linn. as thus limited is very difficult to separate from *T. solstitialis* Meigen (see key). There are apparently few reliable records of males of this species from Britain, all the published records, including that of Jones (1922, p. 41) referring to the light form of *bisignatus* Jaenn, but Mr. Goffe informs me that Mr. Collin found the males as numerous as the females at Horning in July, 1934.

According to the specimens available in the Museum collection this species has been taken between June 13th (Cork) and August 10th (Norfolk), and always from a locality on or near the coast. Kröber (1935, p. 72) gives its occurrence as May to August, and its distribution as Europe, Siberia, Japan and Formosa.

Stammer, who has collected and studied Tabanid larvae in the vicinity of Greifswald in north Germany writes (1924, p. 123): "Of the species of *Tabanus* the larva of *Tabanus tropicus* . . . was the most common, I found it almost always in the damp moss of marshy meadows, in the mossy margins of forest pools, or in fields. On a few occasions I also met with it in the mud, much mixed with leaves, of a nearly dried-up pool in Wampen Forest." On a subsequent page (p. 132) Stammer gives a description of the larva, which he says may attain a length of 30 mm.; the pseudopods and striation are strongly developed; the ground colour is brownish, and there are two longitudinal rows of darker spots on the outer side of the dorsal pseudopods on the first to eleventh segments. Unfortunately it is not clear whether the species referred to is *T. tropicus* in the present sense, or the light form of *T. bisignatus* (*T. paganus* Fabr. according to Goffe.)

***Tabanus plebeius* Fallén**

(Fig. 32)

Although the forecast of Verrall (1909, p. 381) that this species "will probably occur in Britain, as it has been found in France and Denmark" was justified two and a half years later, the three specimens in the Museum are the only British specimens known to me.

T. plebeius is the smallest British *Tabanus*, measuring only 10.5 to 11 mm. in length. It is a dusky mouse-grey species, clothed with short greyish or yellowish-grey hair, and, in the female sex at least, with a double longitudinal series of triangular black marks in the centre of the dorsal surface of the abdomen. From *T. rusticus*, with which alone it is likely to be confused, *plebeius* may be distinguished by its smaller size, and by the greater length, particularly in the male, of the fringe of erect hair on the upper portion

of the head behind the eyes. This is black, curved, and very long in the male, pale and shorter in the female. The eyes in both sexes have a clothing of rather

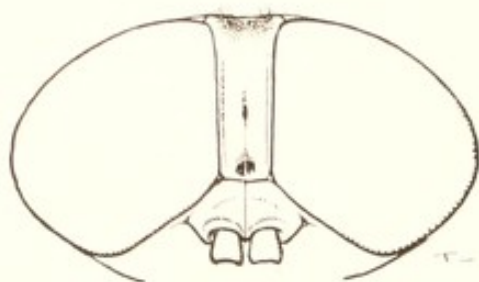


FIG. 32.—*T. plebeius* Fallén. ♀. Head.

dense, but very fine and inconspicuous hair, and in the female, a narrow, dark transverse line. The small frontal calli in the female are often scarcely distinguishable.

The three females in the British Museum were all taken in Cheshire in July 1911, by Mr. H. Womersley, at Abbot's Moss and Delamere Forest. One of the females from Delamere Forest was in the collection of the late Colonel T. Jermyn, recently presented to the Museum by Mrs. Jermyn.

Kröber (1925, p. 82) gives the occurrence of *plebeius* as north and central Europe, in July and August.

***Tabanus fulvus* Meigen**

(Fig. 33 and Plate 27)

T. fulvus and the three closely related species *plebeius*, *rusticus* and *nigri-facies* belong to the sub-genus *Ochrops*, of which perhaps the most distinctive character is the presence in the female sex of two small, usually rounded frontal calli, which are widely distant from the eye-margins (cf. *cordiger* and *glaucopis*). It may be noted that in *fulvus* these calli are not always distinguishable, one or both being sometimes apparently wanting.

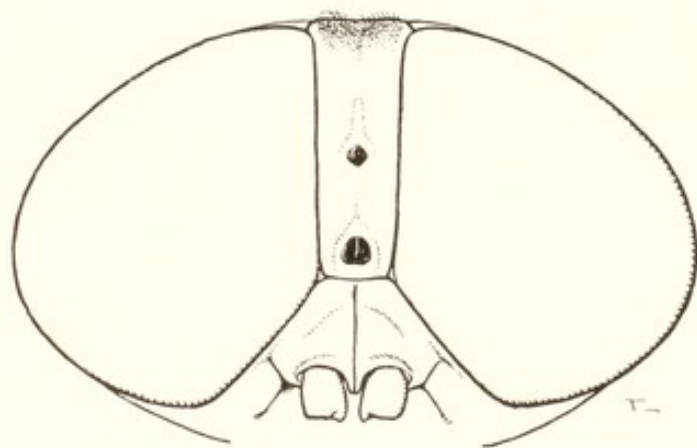


FIG. 33.—*T. fulvus*. Mg. ♀. Head.

The beautiful golden coloration will serve for the recognition of the present species—which is one of the rarer of our British Horse-flies—though rubbed specimens look very different owing to the disappearance of the golden pile. The eyes of the male are densely clothed with fine pale hair, and are usually without bands, though they have an upper area of larger

facets. Brauer (1880, p. 170) describes the eyes of the female as "pale olive-green, with an oblique fine dark line and several almost black round spots."

The specimens in the Museum are 14 mm. long in the male and 13 to 16 mm. in the female, and were taken in June and July. Verrall (1909, p. 384) took it up to August 17th.

Goffe (1931, p. 104), says *fulvus* ". . . has been recorded from most of the southern and midland counties where there are extensive old bogs . . . the males are usually taken by sweeping herbage on the margins of bogs, or are

found on flowers." Jones (1922, p. 41) noted that *fulvus* did not appear at his pool in the New Forest, "preferring more open, heathy woods, or those adjoining heaths." It has been recorded from Scotland and from Ireland, but outside the New Forest it is decidedly uncommon.

T. fulvus is generally distributed in central and southern Europe, and is also found in Scandinavia, Russia and Asia Minor. Shiraki (1918, p. 173) records it as occurring in Japan, where, in the opinion of Japanese veterinary surgeons, it possibly transmits a form of equine infectious anaemia.

***Tabanus rusticus* Linnaeus**

(Fig. 34)

In the British Isles this species is uncommon, and decidedly rarer than *T. fulvus*. According to Brauer (1880, pp. 168, 169) the eyes of the male in certain specimens have a purplish transverse line at the junction of the large and small facets; similarly those of the female are either unbanded or in some cases have a single narrow band. In size this species is much the same as *T. fulvus*, though sometimes distinctly smaller, the two females in the Museum being barely 12.5 mm.

Verrall (1909, p. 387) states that all his examples of this species had been taken in Sussex, near Lewes and Eastbourne, in July and September; two of these specimens are now in the Museum, where they are the only British representatives of this species. Verrall had one record from Huntingdonshire (Monks Wood), and *rusticus* has also been recorded from the New Forest and the Hants-Dorset border.* Goffe (1931, p. 106) writes: "Duncan (1837) [1836, p. 368] recorded it as scarce in Scotland, but common in Cambridgeshire, but I am unable to refer to captures in either place."

On the Continent the species is recorded as occurring in central Europe, the Mediterranean and the Caucasus. A solitary female taken in Japan has been recorded by Shiraki (1918, p. 179) as belonging to a form of this species.

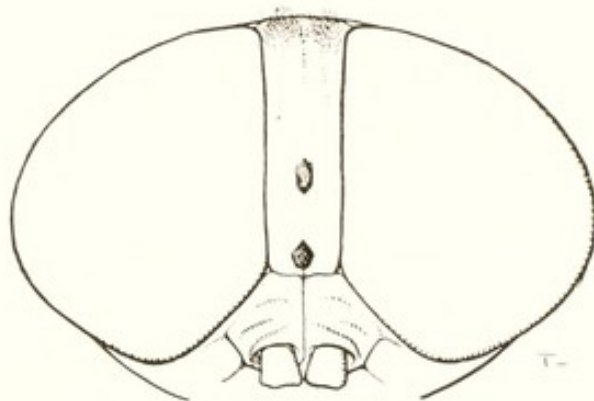


FIG. 34.—*T. rusticus* Linn. ♀. Head.

***Tabanus nigrifacies* Gobert**

(Fig. 35 and Plate 28)

This is the species named by Verrall (1909, pp. 381, 388), and Goffe (1931, p. 106) *Tabanus (Atylotus) latistriatus* Brauer. According to Szilády (1915, p. 95), who saw some of Verrall's specimens in the British Museum, Verrall's *T. latistriatus* is really *T. nigrifacies* Gob., while the true *latistriatus* Brauer is a south and east European and Transcaspian variety of *T. rusticus* Linn. Szilády states that the two occur together only in Corfu.

* Mr. Goffe (in correspondence) tells me that these records are erroneous, and refer to a form of *T. fulvus*.

The Museum specimens of this species vary in length from 13 to nearly 16 mm. It is a well-marked species, easily separated from *T. fulvus* by the lack of conspicuous yellow pile, and from *T. rusticus* by the presence on the outer (extensor) surface of the hind tibiae of a more or less conspicuous and regular fringe of black hairs. The eyes are densely hairy in the male, only moderately so in the female. Verrall (1909, p. 390) describes the eyes of the female as "opalescent green with peculiar shifting spots according to the point of view, and these spots are rather few in number and are not arranged in rows, but there is also a slight crossband."

In the British Isles up to the present time *T. nigrifacies* seems to have been met with only in Essex, Kent and Dorset; writing of Colonel Yerbury's captures of this species at Walton-on-Naze in 1907, Verrall (1909, p. 391) states that the insect "occurred on the salt marshes near the town from August 8th to 22nd, and upon one occasion Colonel Yerbury saw them in some numbers amongst sheep; the males were obtained by sweeping the herbage." The species apparently occurs only in August in this country.

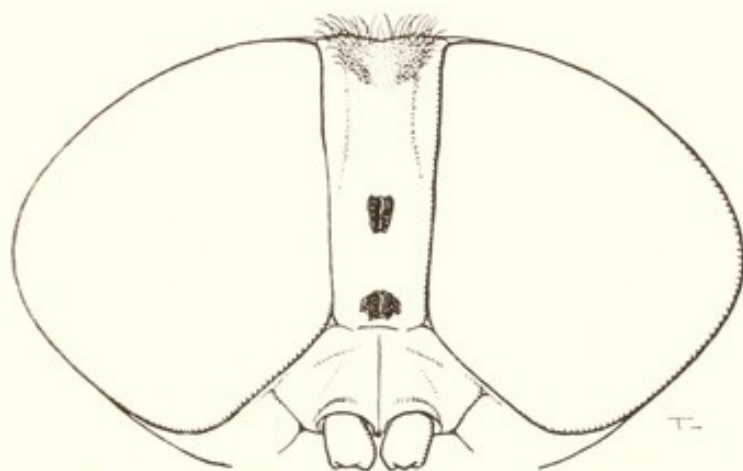


FIG. 35.—*T. nigrifacies* Gobert. ♀. Head.

In Brittany, Surcouf (1924, p. 52) found larvae of this species in seaweed on the sea-shore, and also took a male in the act of emerging from its pupa-case, which was sticking out of the sand. It is possible that *T. nigrifacies* and certain other species of the same subgenus (*Ochrops*) prefer to breed in mud or sand which is periodically flooded by the tide. In North Africa, on the shore of Jerba Island, Tunis, Professor Seurat of the University of Algiers, found larvae of *T. (Ochrops) seurati* Surcouf in large numbers in damp sand beneath masses of *Posidonia* (a marine flowering plant) cast up by the sea (see Surcouf, 1924, p. 52). Surcouf also mentions the finding of adult females of the same species on seaweed on the coast of Algeria. The above-mentioned larvae were feeding on sand-hoppers (*Talitrus locusta* Pall.), and other larvae of *T. seurati* were found by Professor Seurat on November 14th, 1923, living under the same conditions on the shore of the bay of Algiers.

***Tabanus sudeticus* Zeller**

(Fig. 36 and Plate 30)

Those who have had practical experience of this and of the two following species (*bovinus* Linn. and *verralli* Oldr.) in life will readily confirm Colonel Yerbury's observation that they "make a deep hum when flying round one quite unlike the note produced by the smaller Tabanidae." The sound

emitted by these magnificent flies is, in fact, in proportion to their size, since these three are the bulkiest of all British Diptera. As a rule, *sudeticus* is the largest; a large female of *T. verralli* may measure just over 23 mm. ($1\frac{1}{2}$ inch) in length, while the length of the largest *sudeticus* in the Museum is exactly 1 inch. Flies such as these are exceeded in size by very few representatives of their genus in any part of the world.

The eyes in all three species are bare, and in life devoid of bands, and according to Brauer (1880, pp. 184, 185), while the eyes of the male of *bovinus* are entirely green, those of the male *sudeticus* are "blackish with a coppery sheen, the larger facets greyish, the smaller ones more reddish." The males of *sudeticus* and *verralli* have the facets in the upper part of the eye much larger than the lower facets and sharply divided from them, but in *bovinus* the eye-facets in both sexes are uniform. The eye-colour of the female is given by

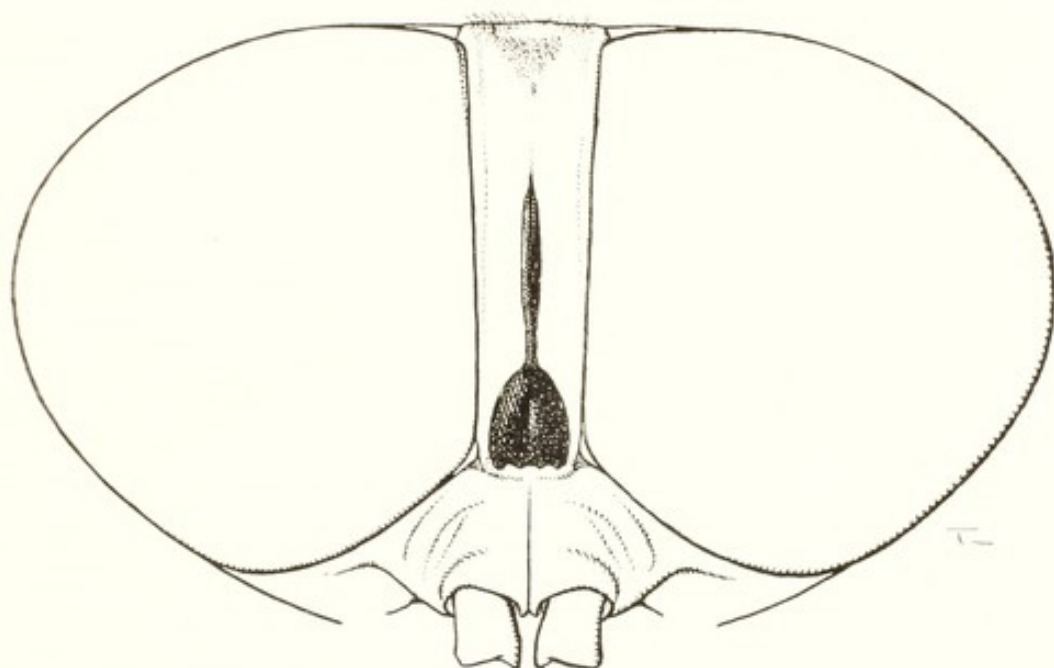


FIG. 36.—*T. sudeticus* Zeller. ♀. Head.

Brauer as emerald green in *bovinus* and "always blackish-brown with a coppery sheen" in *sudeticus*.

The female *sudeticus* is readily separated from the other two species by the very dark colour of the abdomen, even at the base and on the underside.

In the British Isles the typical form of this species, despite its name, appears to have a northern distribution, the Museum specimens being all from Scottish localities, except one male from Ambleside, Westmorland. A form of this species, named *sudeticus meridionalis* by Goffe (1931, p. 74) occurs in Surrey and other southern counties along with *verralli*. In Britain this species is usually on the wing only in July and August, though Continental authors include June in its season. *T. sudeticus* is generally distributed on the Continent.

In a field-note attached to one of the specimens taken by him at Crosswood,

Cardiganshire in July, 1916, Mr. C. L. Walton states that "all kinds of farm stock, including sheep are severely attacked" by this fly. Zeller (1842, p. 815) wrote of this species that it "mingles with *T. bovinus* on the wing, but is somewhat less common . . ." and added: "Probably it is the males of this species that on hot forenoons are seen poised for a long time in the air over the tops of pine saplings and fully grown trees, and then, after suddenly darting forward like arrows, once more hover apparently motionless for a similar period in another spot." In Austria, according to Brauer (1880, p. 185): "Before sunrise the males hover and swarm in the air above the highest mountain tops, *e.g.* the Dobratsch (on the authority of Buchmüller) and Hohen Zinken (as stated by Frauenfeld); they also sit on fences in the sun during the morning after emerging from the pupa; the females are found on the leaves of shrubs and on cattle."

***Tabanus bovinus* Linnaeus**

(Fig. 37)

This, the type species of the genus *Tabanus*, has been the subject of much confusion, and if the conclusions of Collin (1932, p. 38) are to be accepted, very few of the records, even of Verrall, are trustworthy. In view of this one doubts the value of Goffe's suggestion (1931, p. 72) that "collectors who take the species would greatly assist our knowledge of its distribution if they would publish their captures," especially as no reliable method of separating the females of

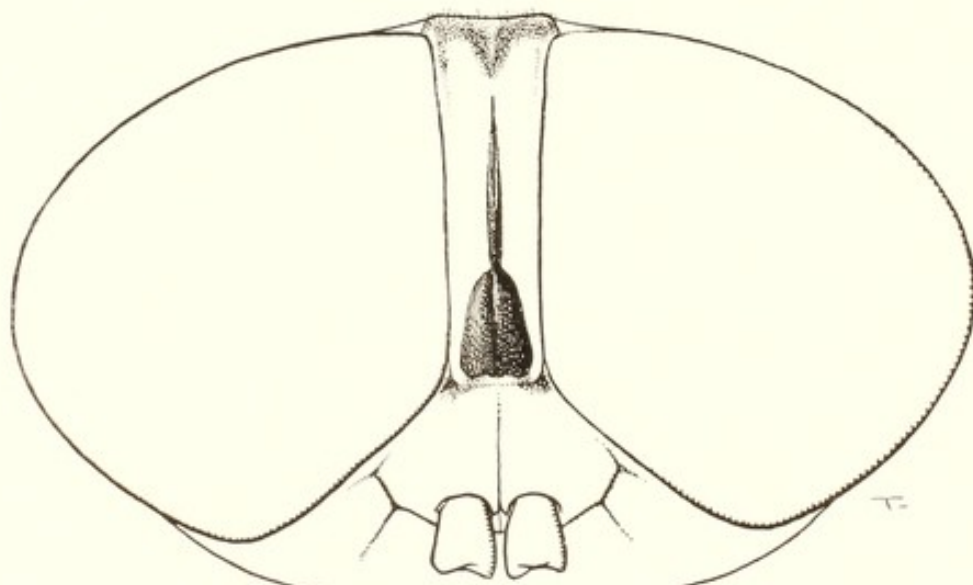


FIG. 37.—*T. bovinus* Linn. ♀. Head.

bovinus and *verralli* has yet been given, except the examination of long series of both, or possibly by dissection.*

The male, of course, should be readily recognisable by the uniform faceting of the eyes. As already noted, the prevailing eye-colour in *bovinus* is some

* Goffe (1935, p. 102) gives the following differences: "Compared with *T. perplexus* Verrall the specimen [*T. bovinus*] has the sides of the first two abdominal segments a uniform and paler brown, paler legs, paler squamae, palpi almost devoid of black hairs, and the third antennal segment black except at the extreme base, whilst when viewed obliquely from behind the lower margins of the abdominal segments do not 'stand out' as they do in *T. perplexus*."

shade of green, and one may repeat Collin's remark (1932, p. 38) that "one should on no account fail to catch and pin any of these larger New Forest Tabanids having green, or coppery-green, instead of coppery-brown eyes."

Four of the five specimens in the Museum are unfortunately without dates of capture, the fifth reading merely "New Forest, 6/68." Kröber (1925, p. 108) gives June and July for the occurrence of this species.

Brauer (1880, p. 187) writes of *T. bovinus* in Austria: "The females swarm round horses, cattle, and deer. The males hover in the air in clearings in woods, and above somewhat elevated places in meadows, but not over mountain-tops, especially on sultry, thundery days in the sun after downpours of rain, or early in the morning."

***Tabanus verralli*, nom. nov**

(*T. sudeticus* var. *perplexus* Verrall.)*

(Fig. 38 and Plate 29)

Described by Verrall himself, and regarded by Goffe (1931, p. 75) and Continental authors as a variety of *sudeticus* Zeller, *T. verralli* is in appearance closely similar to *bovinus* Linn., and in the opinion of Goffe and Collin has often appeared in records as *bovinus*. In fact the late Major Austen (manuscript notes) decided that "careful examination of specimens of Verrall's 'var. ? *perplexus*' determined by the late Mr. Verrall himself shows that this

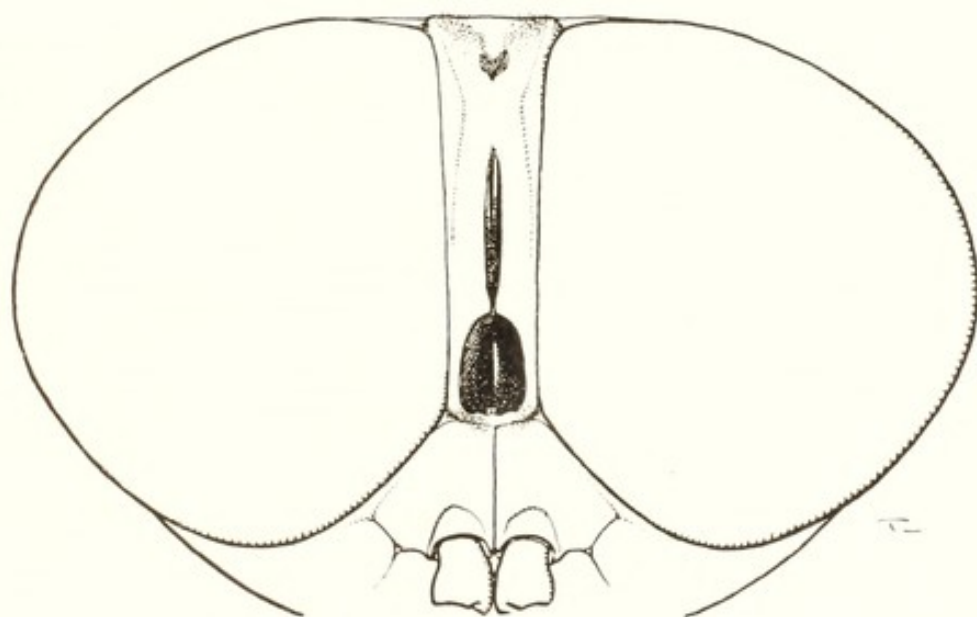


FIG. 38.—*T. verralli* Oldr. ♀. Head.

supposed variety of *T. sudeticus* really belongs to *T. bovinus* L., and does not even differ from the normal form of that species sufficiently to warrant the retention of the varietal name."

The females of *verralli* and *bovinus* are only to be separated with difficulty (see footnote to *T. bovinus*) since the differences in shape of the frontal callus are frequently obscured by abrasion of the surrounding pile. The male of

* See note, p. 113.

verralli, on the other hand, is readily recognised by its having the upper eye-facets enlarged, as in *sudeticus*, whereas the eye-facets of *bovinus* are practically uniform in size.

T. verralli is the commonest of the three largest Tabanids to occur in the New Forest, and Goffe (1931, p. 76) has found it "to be generally distributed on the open bogs and boggy heaths in the south of the New Forest." It has been recorded from the West of England, from Wales, and from S.W. Ireland. Goffe suggests that "some at least of the six males of '*T. bovinus*' taken by Mr. H. P. Jones in the New Forest in 1921" [Jones, 1922, p. 41] belonged to *verralli*.

British records of this species, like those of *sudeticus* Zeller, range from the end of June to August

***Tabanus glaucopsis* Meigen**

(Fig. 39 and Plate 36)

Until recently *T. glaucopsis* shared with *T. plebeius* the distinction of being the rarest British *Tabanus*, and very few collectors have hitherto been fortunate enough to meet with it. While the female closely resembles that of *bromius* in size and general appearance, it may be at once recognised by the two separate frontal calli, and the shining upper part of the frontal triangle. The eye-facets of the male are larger on the upper part, and according to Brauer (1880, p. 199) the colour is "grey, dark on the margin, green below with a purple shimmer ;

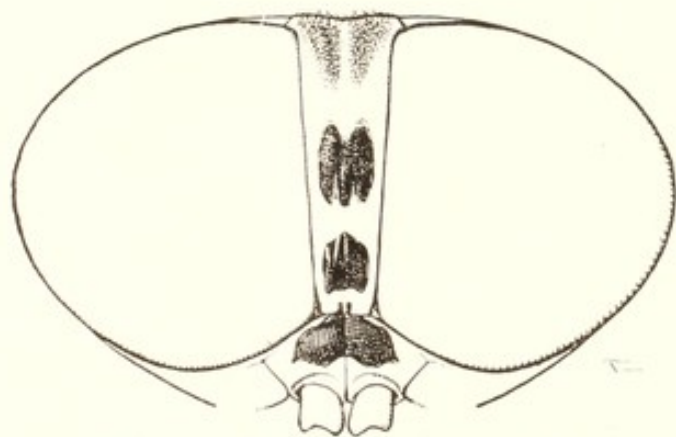


FIG. 39.—*T. glaucopsis* Mg. ♀. Head.

in the lower fourth with three purple bands, the uppermost of which is divided towards its inner extremity." The eyes of the female he describes as "... bare, green, red above near the vertex and below on the margins, in the centre with three curved yellow bands, margined with purple," though under a lens minute hairs can be detected in the eyes of the female. Often in the female the forked vein of the wing bears an appendix at its base.

The few specimens of this species in the Museum range in size from 14.5 to 18 mm., but Continental specimens as small as 13.4 mm. are in the collection.

Verrall (1909, p. 420) wrote : "*T. glaucopsis* is very little known as a British species," and only single specimens had been taken until July 21st, 1923, when the late Mr. B. D. Burtt found the species at Streatley, Berks., and in that and subsequent years took a number of specimens. In July 1925 Mr. Burtt took thirty females in twenty minutes, and wrote that "the flies were very common, and a great number could have been taken." In 1929, and again in 1930,

Goffe (1931, p. 85) found this species in abundance on the chalk Downs between Salisbury and Winchester, and noted that it seems to disappear below an altitude of two or three hundred feet. Andrews (1934, p. 125) recording *glaucopis* from Eynesford, Kent and Box-Hill, Surrey, remarks that its habitat "appears to be confined to woods on the chalk."

In recording his captures Burt (1924, p. 18) expressed the opinion that breeding took place in dew-ponds on the Downs, though on August 4th he noted the occurrence of freshly emerged females at a time when the dew-ponds were entirely dried up. Goffe dissents from this view, and suggests "the moist earth in the wooded slopes of the hillsides" as a more probable breeding-place.

T. glaucopis is distributed throughout Central and Southern Europe between July and September.

***Tabanus cordiger* Meigen**

(Fig. 40 and Plate 35)

The name *cordiger* refers to the upper frontal callus of the female of this species, which, when fully visible and not deformed by rubbing, is roughly heart-shaped. The two sexes are very closely similar, and in both the base of each antenna is connected with the corresponding eye by a dark brown horizontal band (not shown in figure). Brauer (1880, p. 201) describes the eyes of the male as "grey above, green in the lower fourth, with a dark, but rarely purple transverse band between the large and small facets," and those of the female as "naked, without bands."

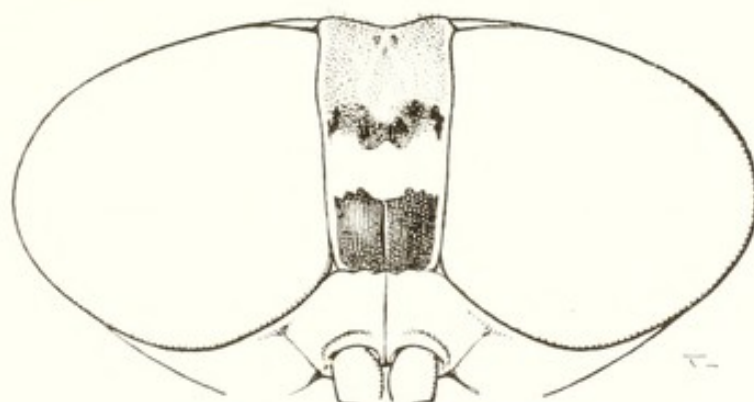


FIG. 40.—*T. cordiger* Mg. ♀. Head.

T. cordiger varies in length from 13 to 15 mm. in the male and from 13 to 16 mm. in the female.

According to Colonel Yerbury, this species is "usually a rare insect, but occurs plentifully in the Abernethy Forest, Inverness, in July and August," while the late Mr. B. D. Burt found it extremely abundant in woodland dells in Cardiganshire, S. Wales, where he found it particularly annoying as "unlike many of the larger horse-flies it is neither shy nor easily scared away." It has been recorded from isolated localities in several southern and midland

counties, and Goffe (1931, p. 84) suggests that "it is probably overlooked in south and middle England through its superficial resemblance to the common *T. bromius* and *T. maculicornis*."

T. cordiger occurs throughout Europe, though it is not included in Lundbeck's Danish list (1907). It has been recorded from Asia Minor, but Major Austen believed that these records, and probably some of those from southern Europe applied to a closely allied species, *T. leleani* Austen.

Surcouf (1921, p. 18) states that a larva of this species was found on March 4th, 1913, near Montpellier, S. France, in the stump of a poplar which had just been felled. The wood, though soft and damp, was not yet rotten. The larva was placed in a glass jar with some of the wood, but nothing else, and left to its fate, and the adult insect appeared on June 10th.

***Tabanus autumnalis* Linnaeus**

(Fig. 41 and Plates 31 and 32)

Ranking fourth among British Tabanidae in point of size, *T. autumnalis* is considerably smaller than the *bovinus* group, and at the same time distinctly larger than any other British species. This fact, together with the very clear-cut pattern of three rows of pale triangles on the upper surface of the abdomen makes this species unmistakable.

The eyes of the male which exhibit above and in front a sharply circumscribed area of large facets, are sparsely clothed, at least above, with minute

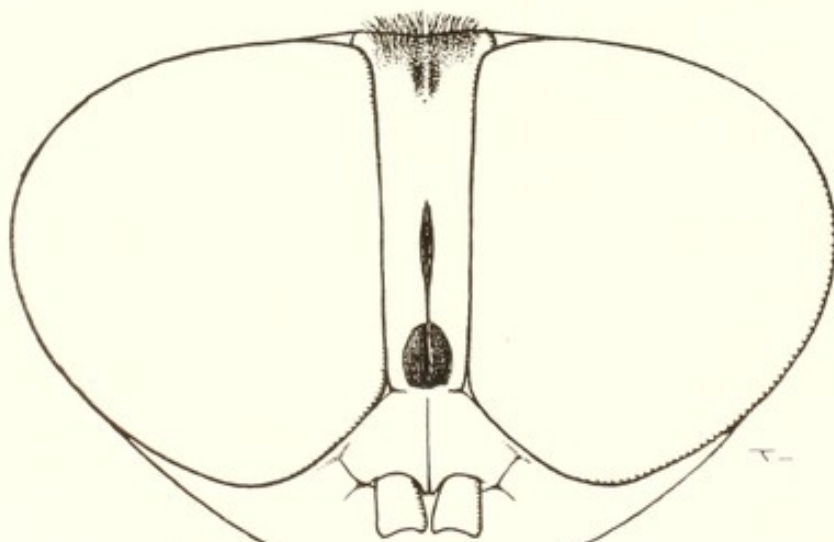


FIG. 41.—*T. autumnalis* Linn. ♀. Head.

and very short pale hairs, distinguishable with difficulty under an ordinary lens; the eyes of the female are bare. In both sexes the eyes are devoid of bands, and Brauer (1880, p. 192) describes those of the male as "black, iridescent, the large facets grey."

Owing to the strong development of ferruginous ground-colour in the abdomen of the male there is usually a well-marked sexual difference (*cf.* pls. 31 and 32). Occasionally, however, even in England, females of *T. autumnalis*

are met with in which the abdomen has a conspicuous ferruginous tinge on each side of its proximal half, and in Algeria and also in Cyprus females in which the ground-colour of the abdomen is predominantly ferruginous are of normal occurrence. In *T. autumnalis* found in Palestine there is no difference in coloration between the sexes, the females having practically no trace of black except at the tip, and a species described by Szilády as *Tabanus brunescens* was regarded by Major Austen as merely the Mediterranean form of *autumnalis*.

The specimens in the British Museum vary in length from 16·5 to 20 mm in the male, and 16·5 to 19 mm. in the female; the wing expanse of a large female may reach 37 mm., or nearly 1½ inches.

T. autumnalis is predominantly a southern species, and practically all the records are from the southern counties. Wingate, however (1906, p. 100), records it from Durham (Bishop Auckland (♂, ♀), and Harperley). It does not appear to occur in Scotland or Ireland. Outside the British Isles the species is found throughout Europe from Sweden to Corsica and Corfu, and also occurs in Asia Minor, and north Africa.

A female in the Museum collections, taken at Gravesend on July 29th, 1906, by Colonel Yerbury bears the field-note: "apparently ovipositing in wet mud at the side of ditch," and in Austria Kollar (1854, p. 533) found larvae and pupae of this species in the banks and shallow places of the river Wien. Lundbeck (1907, p. 130) states that pupae have been found in moist loam, and that he has records of the adult from May 4th (which he considers exceptionally early) to August 3rd.

***Tabanus maculicornis* Zetterstedt.**

(Fig. 42 and Plate 34)

Along with *T. cordiger* and *T. plebeius* this species is one of the smallest representatives of the genus.

In the male the lateral extremities of the second and sometimes also of the third abdominal segment are tinged with russet brown, and the spots are smaller and less strongly developed, otherwise the abdominal markings resemble those of the female. The head of the male, which is relatively much larger than that of the female, is deeply hollowed out posteriorly. The eyes in the male, though usually described as bare are really sparsely clothed with very minute, erect, pale hairs just distinguishable under a hand lens, while the upper part of each eye has a sharply defined area of larger facets. In life, according to Brauer (1880, p. 197), the eyes of the male are "green, with a broad purple band at the junction of the differently sized facets," while those of the female are "Green, often with a coppery sheen, with a sometimes narrower, sometimes broader purple band, which becomes less distinct towards the inner and outer margins."

The specimens in the Museum vary in length from 10·5 to 13 mm. in the male and from 11·5 to 13·5 mm. in the female.

As stated by Verrall (1909, p. 412) the male of *maculicornis* may be distinguished from that of any other British species of *Tabanus*, except *cordiger* and *glaucopis*, by the fringe of long hairs at the back of the head above. From

the male of *cordiger* the present species is distinguished by having the antennae cinnamon-coloured, instead of black at the base, and from the male of *glaucopis* by its dull frontal triangle. Verrall also states that "the black hairs on the upper part of the side-cheeks near the base of the antennae distinguish *T. maculicornis* in both sexes from all its allies."

This species is on the wing in June and July, and is very common in the south of England, though Goffe (1931, p. 86) regards it as "not nearly so abundant, nor so widely spread as *T. bromius*." Verrall (1909, p. 413) recorded it from Perthshire (Rannoch), apparently the only record beyond the Midlands, and Goffe (1931, p. 86) mentioned that *maculicornis* had not yet appeared in the faunal lists of either Cornwall or the Isle of Wight; Thornley (1933, p. 62),

however, points out that it is recorded in the Victoria County History of Cornwall (1906) from Middle Lynter, 1. vi. 1900.

On the Continent *maculicornis* occurs in north and central Europe ("from Scandinavia to the Tyrol" according to Verrall).

Males of this species were taken by Jones (1922, p. 40) and Goffe (1935, p. 105) notes that the habits are similar to those of *T. bromius*.

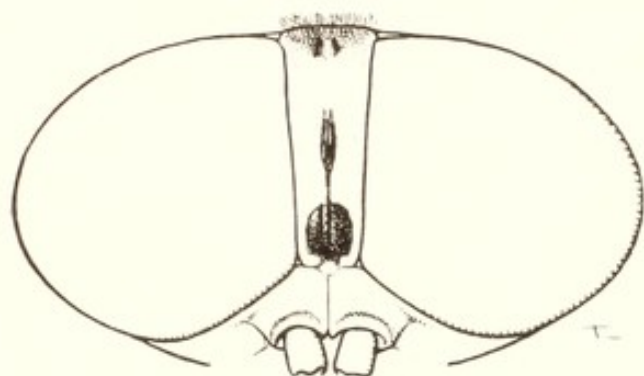


FIG. 42.—*T. maculicornis* Zett. ♀. Head.

Lundbeck (1907, p. 132) found a larva of this species "in boggy soil," and its pupation period was nineteen days, while Stammer (1924, p. 123), during September and October found larvae "in rotting vegetation removed from the River Ryck and piled in heaps on its banks." The latter author does not believe that the heaps represent the original habitat of the larvae. "Owing to the character of the stream," he writes, "which resembles a canal with steep banks and deep water, it is scarcely to be supposed that the larvae came from the Ryck itself; and that they did so is also rendered unlikely by the fact that I did not find any of the larvae in heaps situated upon a dry and somewhat more elevated spot. On the other hand, I succeeded in obtaining several additional specimens from the moss covering the wet low-lying meadows. I am therefore inclined to assume that the larvae were originally living in this moss, and that they then migrated into the heaps of vegetable matter and flourished there in consequence of the very abundant fauna. Larvae of Anthomyiidae, Chironomidae, Psychodidae, Ephydriidae, Stratiomyiidae, Cecidomyiidae, and beetles, besides mites and other creatures developed therein."

Tabanus bromius Linnaeus

(Fig. 43 and Plate 33)

This species, at least in the south of England, is the commonest British *Tabanus*. The large, conspicuous, and sharply defined yellowish spots on the abdomen give it quite a distinctive appearance, which can be confused only with *glaucopis*, a species at once recognised by its isolated upper callus and

shining frontal triangle. Except for a more noticeable amount of pale coloration at the sides of the base of the abdomen in the male, the two sexes are closely similar. While the form of *T. bromius* shown in pl. 33 would seem to be not uncommon in this country, and to be the form normally met with on the Continent, in England it is more usual to find the reddish abdominal side coloration more distinct.

The eyes in the male have an upper area of conspicuously enlarged facets, and in both sexes have a single purple band. Brauer (1880, p. 188) describes the eyes of the female as "sometimes lighter, sometimes darker green, shimmering red . . . with one purple band." Goffe (1932 *a*, p. 16) records the capture of two females of this species with the eye-band scarcely visible.

In the Museum collection the males vary in length from 13.5 to 15.5 mm. and the females from 13 to 16 mm.

In England *T. bromius* is on the wing from June to August, and Goffe (1931, p. 81) says it "seems to occur in every suitable situation in almost every southern county." Like *autumnalis*, *T. bromius* is a southern species, and is rare beyond the Midlands, and unknown in Scotland. It is found throughout Europe, and eastward to Afghanistan.

Goffe (1935, p. 103) notes that the males of *bromius* are "undoubtedly the most difficult to capture" when visiting water, and corroborates the experience of Jones (1922, p. 40) of the swiftness of their descent and return.

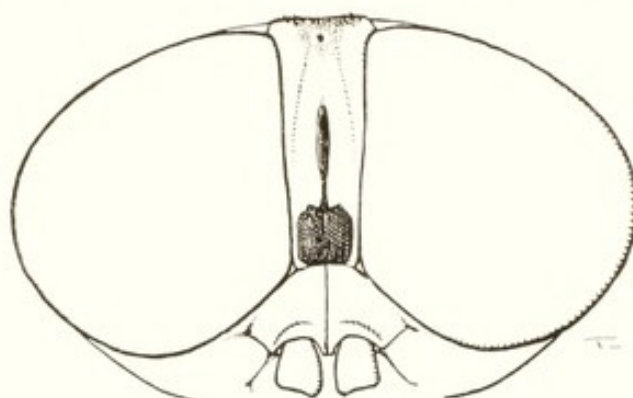


FIG. 43.—*T. bromius* Linn. ♀. Head.

Lundbeck (1907, p. 128) mentions the finding of a larva of this species in a lake—a somewhat curious experience in view of the statements by various other authors mentioned below—while the late Mr. Holland of the Oxford University Museum, found a pupa in sand at St. Helens, Isle of Wight, on July 7th, 1899 (Verrall, 1909, p. 410).

Beling (1875) writes: "The larvae live by choice in the turf-clad soil of meadows, grass-plots, the green strips round the edges of fields, and similar places. They are frequently turned up and brought to light by the activities of moles, and during the spring and summer of 1874 I often found them, and later the pupae also, in fresh mole-hills, especially in meadows. As a rule the duration of the pupal stage is between a fortnight and three weeks, and the perfect insects make their appearance from the second half of the month of June onwards. The larvae feed by sucking out earthworms, the larvae and pupae of other insects, and their own kind if all else be lacking, but in case of need they can apparently subsist on nothing but earth, in which I have kept them for months at a time until they pupated." Mr. Goffe (in correspondence) writes: "I think the main reason for *T. bromius* being so widely spread is that the larvae can feed in almost anything from earth to water."

Stammer (1924, pp. 124, 133) mentions finding the larvae of this species, on one occasion, in the mud beside a small stream near Greifswald in Pomerania, and states that it has also been met with in damp moss on tree-stumps quite away from water. Surcouf and Fischer (1925) found larvae and pupae in a heap of dry chalky soil at Rumigby (Ardenne); the larvae were placed in dry earth and fed and the adults emerged after a pupal stage which lasted on the average for three weeks. According to these authors the larva of *T. bromius* is perfectly capable of piercing the human skin with its mandibles, producing a smarting pain which lasts for several minutes before growing less, while the mark of the bite is visible for a fortnight. In captivity the larvae were found to prey upon brandlings [*Eisenia (Allolobophora) foetida* Sav. the red manure-heap worm; "les vers rouges des fumiers"] in preference to ordinary earthworms, but they fastened greedily upon frogs. The French observers, who describe the larval mouth-parts and their mode of use, deny that the mouth-hooks are used in locomotion.

***Tabanus miki* Brauer**

(Fig. 44)

This is a little known species, which has only been clearly recognised in this country in recent years. It was first recorded as British by Goffe (1931, p. 82), who took a number of females in the New Forest, and on subsequent search was able to find a number of specimens in various collections under other names. He states that in the opinion of Mr. Collin the two females

recorded by Verrall (1909, p. 404) as *T. glaucus* Meig. also belong to this species.

The female is usually distinguished from that of *bromius* by the unbanded eyes, though Goffe's record (1932 a, p. 16) of specimens of *bromius* without eye-bands destroys much of the value of this character. The male is said to have "eyes bare, green, with one purple band on the lower border of the

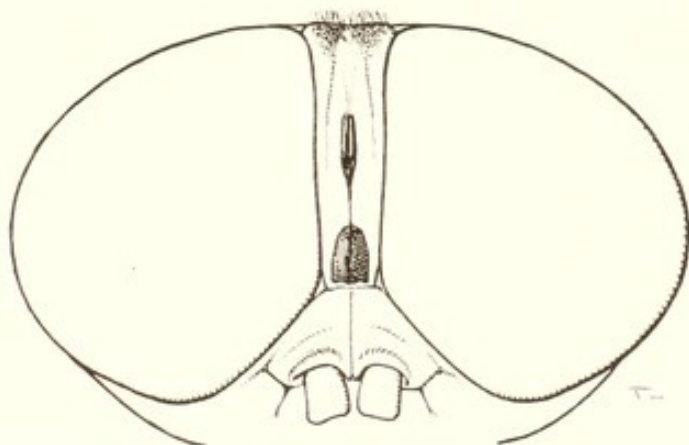


FIG. 44.—*T. miki* Brauer. ♀. Head.

enlarged facets, lower margin green" (Brauer, 1880, p. 195), and to be distinguished from that of *bromius* by the long black postocular hair-fringe (Goffe, 1931, p. 82).

The three specimens in the British Museum all measure about 15 mm. All the specimens recorded by Goffe were taken in the New Forest, except one female from Oakers Wood, Moreton, Dorset (F. H. Haines), and two from Bubbenhall, Warwickshire (J. W. Saunt). Dates of capture ranged from June 24th to the end of August.

The species is mainly Central European in distribution, though Surcouf

(1924, p. 179) states that a variety of it exists in Spain, and according to Lundbeck (1907, p. 131), it occurs very rarely in Denmark. It is not in the French list of Séguy (1926).

REFERENCES

- ANDREWS, H. W. 1934. Three "Diptera" Records. Ent. Record, **46**, 125-6.
- AUDCENT, H. 1935. *Sziladynus montanus* Meig. in Cheshire. J. Soc. Brit. Ent., **1** (3), 90.
- AUSTEN, E. E. 1906. Illustrations of British Blood-sucking Flies. London (B.M.).
- BAKER, SIR SAMUEL. 1867. The Nile Tributaries of Abyssinia. London (Macmillan & Co.).
- BELING, TH. 1875. Beitrag zur Metamorphose zweiflügeliger Insecten. Archiv. f. Naturg., **41**, (1), 35-37.
- BELING, TH. 1882. *idem* Archiv. f. Naturg., **48** (1), 187-240.
- BELING, TH. 1888. *idem* Verh. zool.-bot. Ges. Wien **38**, Abh., 1-4.
- BRAUER, F. 1880. Die Zweiflügler des Kaiserlichen Museums zu Wien, Denskr. k. Akad. Wiss. Math.-Nat. Wien, **42**, 105-216. (Separate paging 1-112.)
- BURTT, B. D. 1924. The Distribution of *Tabanus glaucopsis* Meig. on the Streatley Downs. . . . Ent. Mon. Mag., **60**, 17-18.
- CAMERON, A. E. 1926. Bionomics of the Tabanidae of the Canadian Prairie. Bull. Ent. Res. **17**, 1-42.
- CAMERON, A. E. 1934. The Life History and Structure of *Haematopota pluvialis* L., Trans. Roy. Soc. Edinb., **58** (1), 211-250.
- CAMERON, A. E. 1935. Insect Pests of 1934. Trans. Highland and Agric. Soc. Scotland (5) **47**, 94-118. (Separate paging, 1-25).
- CLARK, BRACY. 1815. An Essay on the Bots of Horses and other Animals. London.
- COLLIN, J. E. 1932. A Review of Mr. E. Rivenhall Goffe's paper on Tabanidae, Trans. Ent. Soc. S. England, 1930. Ent. Record **44**, 37-39.
- CRAGG, F. W. 1912. The Structure of *Haematopota pluvialis* Meig. Sci. Mem. Med. and Sanit. Depts. India, N.S., **55**, 1-36.
- CURTIS, J., 1834. British Entomology **8** (Diptera).
- DUNCAN, J. 1836. Characters and descriptions of the Dipterous Insects indigenous to Britain. Magaz. Zool. Bot. **1**, 145-167, 359-368.
- DUNCAN, J. 1837. *idem* t.c. 453-459.
- DUNCAN, J. 1845. In Jardine, Naturalist's Library **28**, Insects **1** (29, original issue 1840), pp. 1-331.
- EFFLATOUN, H. C. 1930. A Monograph of Egyptian Diptera III, Tabanidae, Mém. Soc. Roy. Ent. Egypte **4** (1), pp. 1-114.
- ENDERLEIN, G. 1923. Studien an blutsaugenden Insekten: 1. Grundlagen eines neuen Systems der Tabaniden. Mitt. Zool. Mus. Berlin **11** (2), 255-409.
- EVANS, W. 1907. *Chrysops sepulchralis* F., *Therioptectes montanus* Meig., and other Tabanidae at Aberfoyle (Forth). Ann. Scottish Nat. Hist. **61**, 54.
- FENN, LADY. 1797. A Short History of Insects. Leverian Museum, Norwich.
- FORDHAM, W. J. 1935. *Sziladynus montanus* in the north of England. J. Soc. Brit. Ent. **1** (4), 114.
- FRASER, MAJOR A. D. 1920. Notes on Blood-sucking Flies in North Russia during the Summer of 1919. Bull. Ent. Res. **11** (3), 195-197.
- GIRSCHNER, E. 1887. Einiges über die Färbung der Dipterenaugen. Berl. Entom. Zeitschr. **31** (2), 155-162.

- GOFFE, E. R. 1931. British Tabanidae. Trans. Ent. Soc. S. England **6**, 43-114.
- GOFFE, E. R. 1932A. On a method of preserving and/or restoring the colour bands on the Eyes of Tabanidae after Death. J. Ent. Soc. S. England, **1** (1), 15-16.
- GOFFE, E. R. 1932B. *Chrysozona* (= *Haematopota*) *italica* Meig. and *C. bigoti* Gob. in Hampshire. J. Ent. Soc. S. England, **1** (2), 42.
- GOFFE, E. R. 1935. Male Tabanidae in the New Forest, Hants, 1933-34. J. Soc. Brit. Ent. **1** (4), 100-109.
- GOFFE, E. R. 1937. *Sziladynus luridus* Fall. (Dipt. Tabanidae) taken in England, and a further English locality for *Sz. montanus* Meig. J. Soc. Brit. Ent., **1** (7), 189.
- HAINES, F. H. 1933. *Theriopectes* (= *Sziladynus*) *montanus* Meig. taken in Hampshire. J. Ent. Soc. S. England **1** (2), 39.
- HAMM, A. H. 1933. *Theriopectes micans* Mg., and other Tabanidae in and near Oxford. J. Ent. Soc. S. England, **1** (3), 66-67.
- HAMM, A. H., and RICHARDS, O. W. 1930. Biology of the British Fossorial Wasps of the families Mellinidae, . . . Trans. Ent. Soc. London, **78**, 95-131.
- HART, C. A. 1895. On the Entomology of the Illinois River and Adjacent Waters. Bull. Illinois State Lab. Nat. Hist., **4**, 149-284.
- HINE, J. S. 1906. Habits and Life-Histories of some Flies of the family Tabanidae. Tech. Ser. U.S. Dept. Agric. Bur. Ent. **12** (2), 19-38.
- HOBBY, B. M. 1931. The British species of Asilidae and their Prey. Trans. Ent. Soc. S. England **6**, 1-42.
- HOBBY, B. M. 1932. Observations on the Habits and Prey of the Fossorial Wasp, *Mellinus arvensis* L. Trans. Ent. Soc. S. England, **7** (1931), 68-80.
- HOBBY, B. M. 1933. Supplementary List of the Prey of Asilidae: Prey of Scatophaga. J. Ent. Soc. S. England, **1** (3), 69-77.
- HOBBY, B. M. 1936. Dragonflies and their Prey. Proc. Roy. Ent. Soc. London (A), **11**, 101-103.
- ISAAC, P. V. 1924. A Practical and Simple Method of Rearing Tabanid Larvae. Mem. Dept. Agric. India, Ent. Ser. VIII, No. 5, 53-59.
- JONES, H. P. 1920. 1919 in the New Forest. Entomologist, **53**, 5-10.
- JONES, H. P. 1922. Notes on the Habits of Male Tabanidae. Entomologist, **55**, 40-42.
- KOLLAR, V. 1854. Beiträge zum Haushalte der sehr lästigen Viehbrensen (Tabanidae). Sitzgsber. math. naturw. Cl. K. Akad. Wiss. Wien, **13**, 531-535.
- KRÖBER, O. 1920. Die Chrysops-Arten der Palaearktischen Region, Zool. Jahrb. **43**, Abt. f. Syst., 41-160.
- KRÖBER, O. 1922. Beiträge zur Kenntnis Palaearktischer Tabaniden Teil I. Archiv. f. Naturg. **88** Abt. A, 8, 114-164.
- KRÖBER, O. 1924. *idem* Teil II. Archiv. f. Naturg. **89**, Abt. A, 12, 55-118.
- KRÖBER, O. 1925. Tabanidae in Lindner, "Die Fliegen der Palaearktischen Region," 4 (1) **19**, 1-146.
- LEONARD, M. D. 1930. A Review of the Dipterous Family Rhagionidae (Leptidae) in the U.S. and Canada. Mem. Amer. Ent. Soc. **7**, 1-181.
- LEONARD, M. D. 1931. Some Notes on My Revision of the Rhagionidae (Diptera). Trans. Amer. Ent. Soc., **57**, 321-323.
- LINDNER, E. 1925-. Die Fliegen der Palaearktischen Region **1** (Handbuch), 1-.
- LUNDBECK, W. 1907. Diptera Danica **1**.
- MARCHAND, W. 1920. The Early Stages of Tabanidae (Horse-flies). Monog. Rockefeller Inst. Med. Res. No. 13, pp. 1-203.

- MOUFET, T. 1634. Insectorum sive minimorum animalium theatrum. Londini.
- PEARCE, E. K. 1921-28. Typical Flies: a Photographic Atlas of Diptera. Series 1-3. Camb. Univ. Press.
- PEARCE, N. D. F. and PEARCE, E. K. 1917. Diptera on Wareham Heath. Entomologist 50, 257.
- PHILIP, C. B. 1931. The Tabanidae (Horse-flies) of Minnesota with special reference to their biologies . . . Tech. Bull. Univ. Minnesota Agric. Exp. Stat. 80, 1-128.
- PORTSCHINSKY, J. 1899. Die Bremsen (Tabanidae) und die einfachste Methode dieselbe auszurotten. Min. Agric. and State Domains. [In Russian, summary in German, by N. von Adelung in Zool. Central-blatt, 7, 807-808, 1900.]
- RICARDO, G. 1906. Notes on the Genus *Haematopota* . . . in the British Museum Collection. Ann. Mag. Nat. Hist. (7) 18, 94-127.
- SCHWARDT, H. H. 1936. Horse-flies of Arkansas. Bull. Arkansas Agric. Exp. Station, 332, 1-65.
- SÉGUY, E. 1926. Faune de France 13, Diptères Brachycères, Tabanidae, 119-157.
- SHIRAKI, T. 1918. Bloodsucking Insects of Formosa: Pt. I. Tabanidae, 1-442.
- SPOONER, G. M. 1934. Ejected Dipterous Prey of *Metacrabro quadricinctus* F. Hym.; Crabronidae, J. Soc. Brit. Ent., 1 (2), 48-53.
- STAMMER, H. J. 1924. Die Larven der Tabaniden, Zeitschr. f. Morph. u. Ökol. der Tiere, 1 (1), 121-170.
- SURCOUF, J. 1921. Genera Insectorum, 175, Tabanidae, 1-205.
- SURCOUF, J. 1924. Les Tabanides de France, Encycl. Ent. 5, 1-246.
- SURCOUF, J., and FISCHER, Ed. 1925. Notes sur la vie larvaire et nymphale du *Tabanus bromius* Linn. Bull. Soc. Ent. France, 1924, No. 20, 232-237.
- SZILÁDY, Z. 1915. Subgenus *Ochrops*, eine neue Untergattung der Gattung *Tabanus* Linn. Ent. Mitt. 4, 93-107.
- THEOBALD, F. V. 1904. Second Report on Economic Zoology, Brit. Mus. (Nat. Hist.).
- THORNLEY, A. 1933. Diptera Tabanidae from Cornwall. J. Ent. Soc. S. England 1 (3), 60-62.
- VERRALL, G. H. 1909. British Flies, 5, 320-439.
- WALTON, C. L. 1918. Some Results of a Survey of the Agricultural Zoology of the Aberystwyth Area. Parasitology, 10, 205-266.
- WINGATE, W. J. 1906. A Preliminary List of the Durham Diptera with analytical tables. Trans. Nat. Hist. Soc. Northumb. (N.S.) 2, 1-416.
- ZELLER, P. C. 1842. Dipterologische Beyträge (2). Isis von Oken, 26, 815.

NOTE.—While this work was in the press I discovered that the name *Tabanus perplexus* had been used by Walker (1860, Insecta Saundersiana, Diptera 1, p. 32) for a species from Colombia. I therefore propose that *T. perplexus* Verrall (1909) be renamed *T. verralli*.

CYCLORRHAPHA

By John Smart, Ph.D.

Family MUSCIDAE

THE vast majority of the flies in this family are, like the common house fly (*Musca domestica* L.), not blood sucking in their feeding habits, and have soft mouth-parts adapted to lapping up exposed fluids. In one sub-family (Stomoxydinae), however, the soft proboscis usual in the family has been modified into a horny stylet which can penetrate the mammalian skin and through which, after penetration has been accomplished, blood can be sucked up. Certain members of this sub-family, such as the Tse-tse flies (*Glossina* spp.) of Africa, have been incriminated with the transmission of organisms patho-

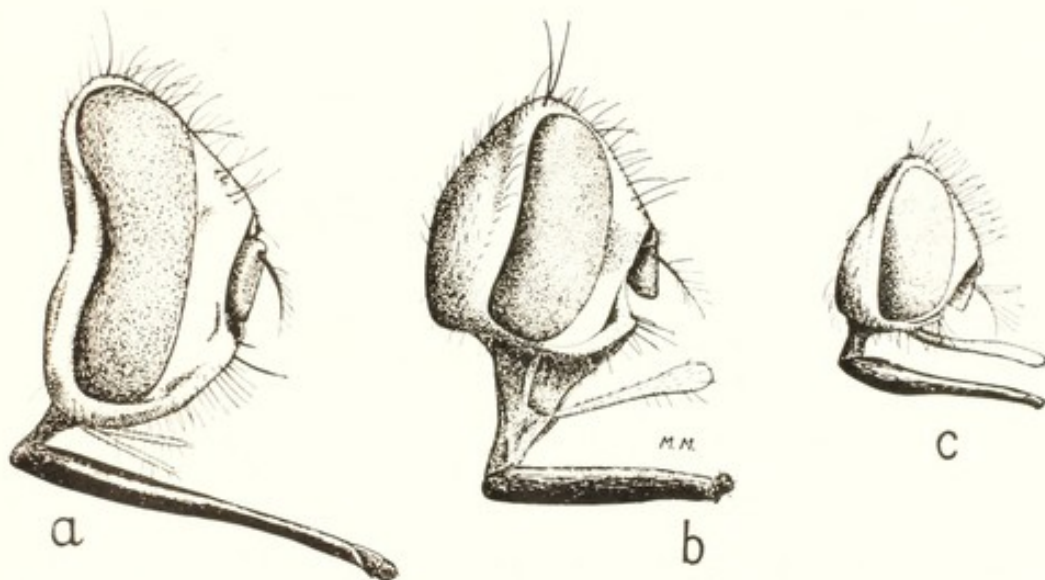


FIG. 45.—Lateral views of heads of British blood-sucking Muscidae, to same scale ($\times 12$).
a. *Stomoxys calcitrans* L. b. *Haematobia stimulans* Mg. c. *Lyperosia irritans* L.

genic to man and animals. This does not, however, so far as is known, occur in any of the three species noted below as being found in the British Isles.

These flies bite and suck blood throughout their flight period, which is roughly from late spring to early autumn. They are most noticeable towards the end of the period (August) when they are more abundant than in the early months. Unlike other dipterous bloodsuckers they, even if undisturbed, often withdraw the proboscis and reinsert it during the course of a meal in another part of the skin of the host or even fly to another host and recommence feeding on it. On some occasions they seem to obtain a full meal of blood in as short a period as five minutes, while on others they may feed for as long as thirty

minutes before being satisfied. The time probably depends on the amount of blood flowing in the particular part of the skin that they have bitten. They are vicious and persistent biters, and their appetite is such that they may sometimes continue to feed after they are completely gorged and with the surplus undigested blood oozing from the anus.

The young stages of these flies are usually passed in decaying organic matter; details of their life-histories are noted below where these are available.

The three British species may be distinguished by the use of the following key:—

1. Proboscis long, palpi short and thread-like, bites man and animals (fig. 45, *a*)
Stomoxys calcitrans L.
- Proboscis short, palpi normal, ensheathing the proboscis.....2
2. Palpi pale tawny, clavate and shorter than the proboscis, bites both man and animals (fig. 45, *b*)*Haematobia stimulans* Mg.
- Palpi darkish grey, not clavate, as long as the proboscis, does not bite man (fig. 45, *c*)*Lyperosia irritans* L.

The males of all three species can be distinguished from the females by the closer approximation of the compound eyes in the former sex. Both sexes bite and suck blood.

Genus STOMOXYS Geoffroy

***Stomoxys calcitrans* L.**

(The Biting House Fly, or Stable Fly) (Plate 37)

This fly is very similar in general appearance to the common house fly (*Musca domestica* L.), hence one of its common appellations. It can, however, easily be distinguished from it by the presence of the horny proboscis, which, even when the fly is alive and at rest, can be seen projecting horizontally in front of the head.

Of very wide distribution in various parts of the world, *Stomoxys calcitrans* L. is the only European representative of the genus. It seems to be distributed throughout the British Isles. It is to be found on the wing from May to October in southern districts and for a relatively shorter period in the more northern parts.

The adult attacks both man and his domestic animals and when present in numbers it can be a veritable plague. When the bites are particularly numerous a swelling of the tissues may occur, followed by severe inflammation.

The eggs are usually laid on decaying vegetable matter that has been contaminated with animal excreta, *e.g.* chopped straw, hay and chaff on the ground around a cattle-feeding trough. In exceptional cases oviposition may take place on decaying hay or straw that is uncontaminated, and also on horse manure, but never on the "colder" dungs of cattle and pigs. The egg measures about 1 mm. in length, and is of an elongate ovoid shape and a creamy white colour. A large number are laid at a time and after a period which varies according to the temperature, but which on the average consists of three days,

the larvae hatch from the eggs and descend into the material upon which they were laid. The young larvae are typical muscoid maggots, whitish in colour and attaining ultimately to a length of about 20 mm. They feed and grow amongst the debris and reach maturity after a period of two to three weeks in the summer time. When full-fed the larvae migrate to the drier parts of their feeding ground and pupate there, either near the edge of it or in the soil beneath. The puparium is red-brown in colour and about 7 mm. in length. The pupal stage may last from six days to three or more weeks, depending on the temperature. After emergence the adult fly may live as long as ten weeks (in the laboratory).

The flies are capable of strong flight, but on isolated farms their numbers can be considerably reduced by careful elimination of their breeding grounds. Care must be taken that manure is stacked properly and that the fluids from it do not get dispersed. Feeding stuffs should be handled in such a way as to prevent waste material accumulating and heaps of old straw and hay must not be permitted since when decomposition reaches a certain stage the flies, as pointed out above, can breed in such situations.

Genus HAEMATOBIA Robineau-Desvoidy

Haematobia stimulans Mg.

(Plate 38, fig. 1)

This fly is slightly smaller than *Stomoxys calcitrans* and larger than the other biting British Muscid, *Lyperosia irritans* (see below), both of which it resembles in general appearance. It may, however, be distinguished from the other two by the relative length of the proboscis and the palpi.

The fly appears to be generally distributed in the British Isles and in the south is to be taken on the wing from May to September and for a shorter period in the North. Abroad its range does not seem to extend beyond Europe.

It attacks both man and his domestic animals and its bite produces results similar to that of *Stomoxys calcitrans*. The life-history of this fly is not known in detail, but it is probably similar to that of *Stomoxys calcitrans* in most respects. The eggs are laid on cattle droppings in the field.

Genus LYPEROSIA Rondani

Lyperosia irritans L.

(The Horn Fly) (Plate 38, fig. 2)

This is the smallest of the three British Blood-sucking Muscidae. It resembles the others superficially, but is fairly easily distinguished by its smaller size, a distinction that may be confirmed by the characters noted in the key given for the separation of the three species.

In the British Isles it appears to be an uncommon insect and to be confined to the south, where it is on the wing from May to August. It attacks cattle and horses, but not man, and receives its common name of Horn fly from its

habit, when present in numbers, of clustering around the bases of the horns of cattle. Outside the British Isles its range includes Europe and North America, where it is known under the name of *Haematobia serrata* R.-D.

The life-history is very similar to that of *Stomoxys calcitrans* except that the eggs are laid on fresh cattle droppings. The larvae develop in the "cow-pat" and when mature pass into the soil beneath and pupate there.

Family HIPPOBOSCIDAE

The flies composing this Family are parasitic upon mammals and birds, and are probably descended from ancestors belonging to the Muscidae, which underwent modification in structure as a consequence of a parasitic mode of life. The body in all cases is flattened and leathery; the feet are provided with well-developed claws to enable the insect to cling to the hair or feathers of the host; and while some of the species are fully winged, others show a progressive reduction in this respect reaching the completely wingless state in the Sheep Ked. But even in the fully winged forms, since the flies are true parasites, the wings, as a rule, are made use of merely in order to reach the host, or, in the case of the males, in order to find an individual of the opposite sex, and thereafter it is only in exceptional circumstances, such as the death of the host, or too active pursuit by the human hand, or when taking a short flight from one host to another, that these flies are ever seen upon the wing. The proboscis in the Hippoboscidae is curved, extremely slender, and protrusible, but it is composed of the same parts as that of the Muscidae mentioned above. It is very doubtful if any authentic records of these insects actually biting man exist. Their presence on a human being is probably in all cases accidental.

The Hippoboscidae are viviparous. The egg hatches within the body of the female and the larva is retained within her body and nourished there till it is fully grown. Only one larva is carried at a time and when it is eventually extruded it pupates at once. The puparium is a rounded body usually of a brown or reddish colour and very smooth, superficially resembling a berry or seed rather than an insect pupa. Little is known of the life-histories of these insects with the exception of the Sheep Ked (*Melophagus ovinus* L.) which, as an insect of economic importance, has been the subject of investigations.

Where their life-history is known it appears that the adults are fairly long lived (four months in the case of *Melophagus ovinus*). The insects probably survive the winter almost entirely in the pupal stage, lying in the disused nests and lairs of their hosts. *Melophagus ovinus*, the Sheep Ked, is an exception to this in that it breeds throughout the year on the infested sheep.

The British species may be separated by the use of the following key:—

1. Wings functional and normally developed2
- Wings reduced, non-functional, broken off or absent5
2. Wings with only three well developed longitudinal veins; common on deer (Plate 44)
Lipoptena cervi L.
- Wings with 7 or 8 well developed longitudinal veins3

3. Anal cell closed by a cross vein; ocelli present; usually on birds (Plates 40, 41) (*Ornithomyia*)8
 Anal cell not closed by a cross vein; no ocelli.....4
4. Wing membrane wrinkled, claws bidentate, head not obviously "fitting" the thorax.
 On horses, cattle, etc (Plate 39)*Hippobosca equina* L.
 Wing membrane not wrinkled, claws tridentate, head definitely "fitting" the thorax; on
 the heron and its allies*Ornithoponus ardeae* Macq.
5. Halteres present, wings reduced or broken off.....6
 Halteres absent, wings completely aborted; on sheep (Plate 45, fig. 2) *Melophagus ovinus* L.
6. Wings absent, *i.e.* broken off, claws single; common on deer (Plate 45, fig. 1)
 *Lipoptena cervi* L.
 Wings merely reduced in size and non-functional, claws tridentate; on swifts, swallows and
 martins7
7. Ocelli present, wings strap-like, seven times as long as broad and almost as long as the legs;
 usually on martins (Plate 42)*Stenopteryx hirundinis* L.
 Ocelli absent, wings twice as long as broad and only about half the length of the legs;
 usually on swifts (Plate 43)*Crataerhina pallida* Latr.
8. Palpi uncoloured, medio-cubital cross vein (m.-cu.) 4 times the length of the radio-median
 cross vein (r.-m.), last (anal) vein shorter (see fig. 46) (Plate 40)..... *O. avicularia* L.
 Palpi dark brown, medio-cubital cross vein twice the length of the radio-median cross vein,
 last (anal) vein longer (see Figs. 47 & 48)9
9. Underside of the head and thorax with dark markings; usually on grouse and moorland
 birds (Plate 41).....*O. lagopodis* Sharp
 Head and thorax without such markings*O. fringillina* Curtis

In addition to the characters given in the key it will be found that the species of *Ornithomyia* show distinctive hair patterns on the wings. The nature of these may be appreciated by reference to figs. 46, 47 and 48.

Genus LIPOPTENA Nitzsch

Lipoptena cervi L.

(The Deer Fly; the Deer Ked) (Plates 44 and 45, fig. 1)

This species is parasitic on several species of deer including the roe, red and fallow deer in the British Isles. On emerging from the pupa both sexes possess wings, which, in the case of the female at any rate, as soon as the insects reach the host, appear to break off close to the base, leaving stumps only where the wings had been before. Specimens of both sexes found upon a deer are usually in this wingless condition, in which case they resemble the sheep ked (*Melophagus ovinus*) closely, but from which they may be distinguished by the presence of actual wing stumps and halteres. In the autumn months, however, winged males are sometimes met with in woods inhabited by deer; these differ considerably in appearance from the wingless males found in company with the females amongst the hair of the host, being paler in colour and more slender in the abdomen, while the males that have lost their wings are more like the females, and are darker in colour with a broader and stouter abdomen. Both sexes have been taken in flight around a dead deer, but the females shed their wings on being killed.

Lipoptena cervi is found throughout Europe, and appears to be generally

distributed in this country wherever its hosts are to be found. A dark (melanic) form has been taken on roe-deer in Strathconan Forest, Ross and Cromarty.

Genus ORNITHOMYIA Latreille

The three British species of this genus,* *avicularia* L., *lagopodis* Sharp, and *fringillina* Curtis, are all bird parasites, and not easily distinguished from each other except by the characters given in the key on p. 119. In passing, it may be noted, however, that in freshly caught examples of these flies both *avicularia* and *fringillina* have a greenish tinge in their body coloration that is never found in *lagopodis*.

These flies are seldom found otherwise than on their bird hosts or in their nests. Occasionally they will fly around and alight on some one carrying a newly shot bird on which as likely as not they were living before disturbed by the shooting. Males, presumably searching for females, are sometimes taken in flight apart from any host.

They occur on a large variety of birds, but it would appear that sea-birds, ducks, geese and other truly aquatic birds are free from them. (See also p. 127.)

Ornithomyia avicularia L.

(Fig. 46 and Plate 40)

This species is larger than either *lagopodis* or *fringillina*, the wing span measuring about 15 mm.

O. avicularia appears to be commonest in the southern parts of the British

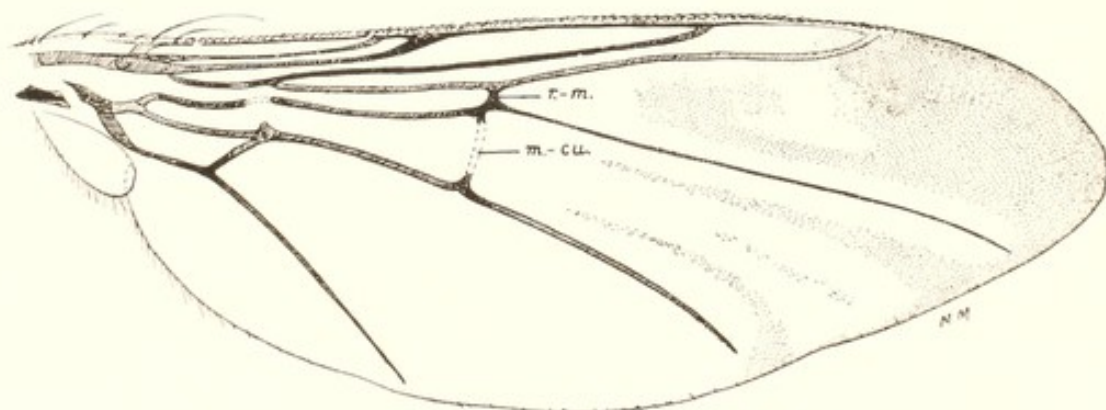


FIG. 46.—Wing of *Ornithomyia avicularia* L. $\times 12$.

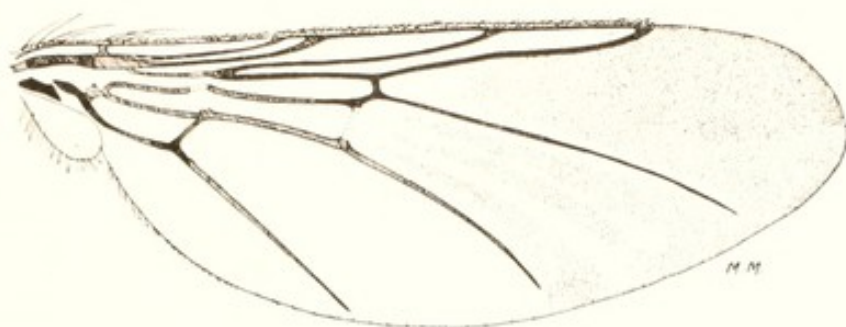
Isles. Birds upon which it has been taken include sparrow hawk (young), kestrel, long-eared owl, barn owl, little owl, red-backed shrike, starling, wood pigeon, pheasant, partridge, blackbird, chaffinch.

* A fourth species has been found on swallows in France and may perhaps occur in this country.

Ornithomyia lagopodis Sharp

(Fig. 47 and Plate 41)

O. lagopodis is slightly smaller than *avicularia*, having a wing span of about 12 mm. Its main habitat appears to be Scotland and the north of England. The host it is most frequently taken on is the red-grouse from which it derives its scientific name. Other birds from which it has been taken are blackcock,

FIG. 47. Wing of *Ornithomyia lagopodis* Sharp. $\times 12$.

owl, snipe, golden plover, peewit, oyster catcher, curlew, wheatear, rock pipit, meadow pipit. (See also p. 127.)

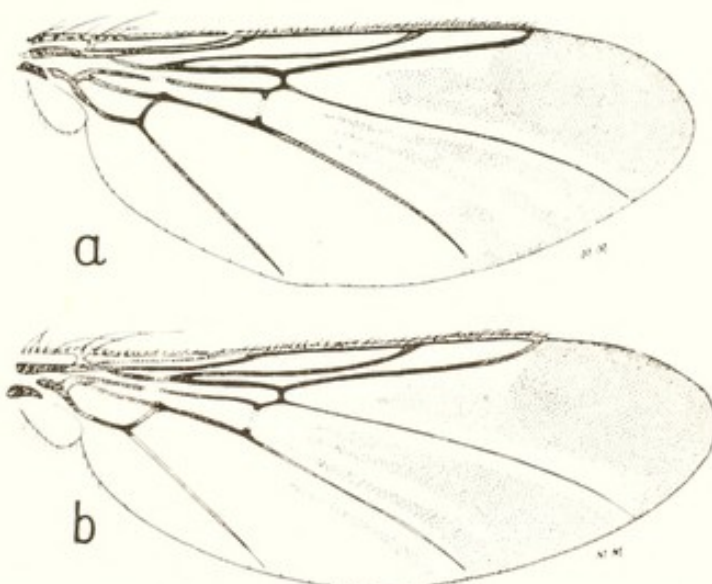
This species is easily distinguished from *avicularia* by its generally darker colour, particularly by the dark palpi, and by the more extensively pubescent wings.

Ornithomyia fringillina Curtis

(Fig. 48)

Though common on the Continent this species appears to be rare in the British Isles. It has been taken on an immature robin (Somerset), and on a swallow (Kent), and on robin and hedge-sparrow (Hants).

It is slightly smaller wing span (10 mm.) than *lagopodis*, from which, however, it can be easily distinguished by its pale coloration. In this respect it resembles *avicularia*, but the palpi, as in *lagopodis*, are dark and the wing venation is also similar to that species. On the Continent it occurs on a variety of birds.

FIG. 48.—Wings of two forms of *Ornithomyia fringillina* Curtis. $\times 12$. a. ♂ from young robin at Bath, Somerset. b. ♂ from robin at Sway, Hants.

The wings are less pubescent than those of *O. lagopodis*, but exhibit

some variation in this respect. Some specimens examined have the anal area of the wing bare (fig. 48 *a*), but a few (all from Sway, Hants), taken on robin and hedge-sparrow, have a narrow stripe of fine hairs in this area (fig. 48 *b*).

Genus HIPPOBOSCA Linnaeus

Hippobosca equina L.

(The Forest Fly) (Plate 39)

As indicated by the English name, the principal home of this species in the British Isles is in the New Forest, in Hampshire, where it may often be seen in bee-like clusters, sometimes numbering many hundreds, on the ponies and cattle which run wild there. The flies chiefly congregate on parts where the skin is thinnest, beneath the tail, on the perinaeum, and on the inner surfaces of the thighs. The bite does not seem to cause pain, and the animals bred in the forest take no notice of the fly, but strange horses and especially donkeys are sometimes driven almost frantic by the irritation caused by a single Forest Fly crawling over them. The toothed claws enable the fly to cling so tightly to the hair that it is impossible for an animal to dislodge it by a brush from its tail, and the quick and somewhat crablike movements of the insect, which when disturbed usually moves sideways, tickle the host and are exceedingly irritating to sensitive animals.

The Forest Fly is on the wing from May till October, and while it appears to be commonest in the south of England it has been taken as far north as Aberdeen. It occurs in Europe and many other parts of the world to some of which it was no doubt carried on horses taken thither by man.

Genus ORNITHOPONUS Aldrich

Ornithoponus ardeae Macq.

This insect, which is found in Europe on the heron and its allies, has only been taken once in the British Isles. The unique specimen was taken on a dead purple heron, an occasional visitor to the British Isles, in Pembrokeshire in 1932.

It is of the same general appearance as *Hippobosca equina*, from which, however, it may easily be distinguished by the absence of the wrinkles on the wings and other characters alluded to in the key, apart from the difference of host.

Genus STENEPTERYX Leach

Stenepteryx hirundinis L.

(Plate 42)

In the British Isles this insect is usually found on martins and more rarely on swallows and swifts. It is incapable of flight, its wings being reduced in size and non-functional.

It is found throughout Europe and its range is probably co-extensive with that of its host, though it probably cannot maintain itself outside the nesting area of the host bird.

Captured martins, especially fledglings, may have a very large number of these parasites crawling about on them. There do not appear to be any records of the adult insect being taken at times of the year when the martins are away, but dormant pupae, in which form the insect survives the winter, have been taken in old nests.

Genus CRATAERHINA v. Olfers

Crataerhina pallida Latr.

(Plate 43)

While this insect is sometimes found on swallows, martins and some other birds, the swift is undoubtedly its true host.

As is the case with *Stenepteryx hirundinis* very little is known of its life-history and habits. The adult insect is to be taken on swifts, particularly newly flown fledglings, during June and July in the British Isles. It is fairly active and like *Stenepteryx hirundinis* it may occasionally be found in houses, having crawled thither from the nest of its host. The possibility of its ever attacking a human being is remote. The species survives the winter as a dormant pupa in the hosts' disused nests.

Genus MELOPHAGUS

Melophagus ovinus L.

(The Sheep Ked, "Sheep Tick", "Sheep Louse") (Plate 45, Fig. 2)

A higher degree of adaptation to a parasitic existence is exhibited by this species than by any of the foregoing members of the Hippoboscidae, since the wings are entirely wanting in both sexes and the halteres are absent. This peculiarity, coupled with the general strangeness of its appearance, which presents little resemblance to an ordinary fly, and the fact that it passes its whole life-cycle in the wool of the sheep, has gained for the insect two of the popular names mentioned above. When seen in the fleece of the sheep these insects give the impression of spiders crawling amongst the wool. It is doubtful if their presence causes any direct harm to the sheep, but the irritation set up by them if present in large numbers may cause the sheep to rub itself and resultant abrasions may become infected by the maggot fly (*Lucilia sericata* Mg.).

The adults are long-lived, as are probably most of the Hippoboscidae, and it has been estimated that the female may live for as long as four months during which time she may produce 10 to 12 larvae. The larvae pupate immediately and remain amongst the wool. The puparia are frequently washed out of the fleece in large numbers when sheep are dipped, but the best method of control is to store the wool from shorn sheep well away from them and from other sheep.

Keds in the shorn wool die in the course of a few days, and they cannot travel far in search of a new host.

The Ked occurs throughout the British Isles and in most other parts of the world where sheep have been taken.

Family
NYCTERIBIIDAE

Genus *NYCTERIBIA* Latreille

All the members of this family are parasitic on bats. They are small rather spider-like wingless creatures of a tawny colouration. The two species that occur in this country are about $\frac{1}{8}$ inch long and do not appear to show any marked host specificity amongst the British bats. The adults leave their hosts when about to give birth to their young which, like those of the Hippoboscidae,

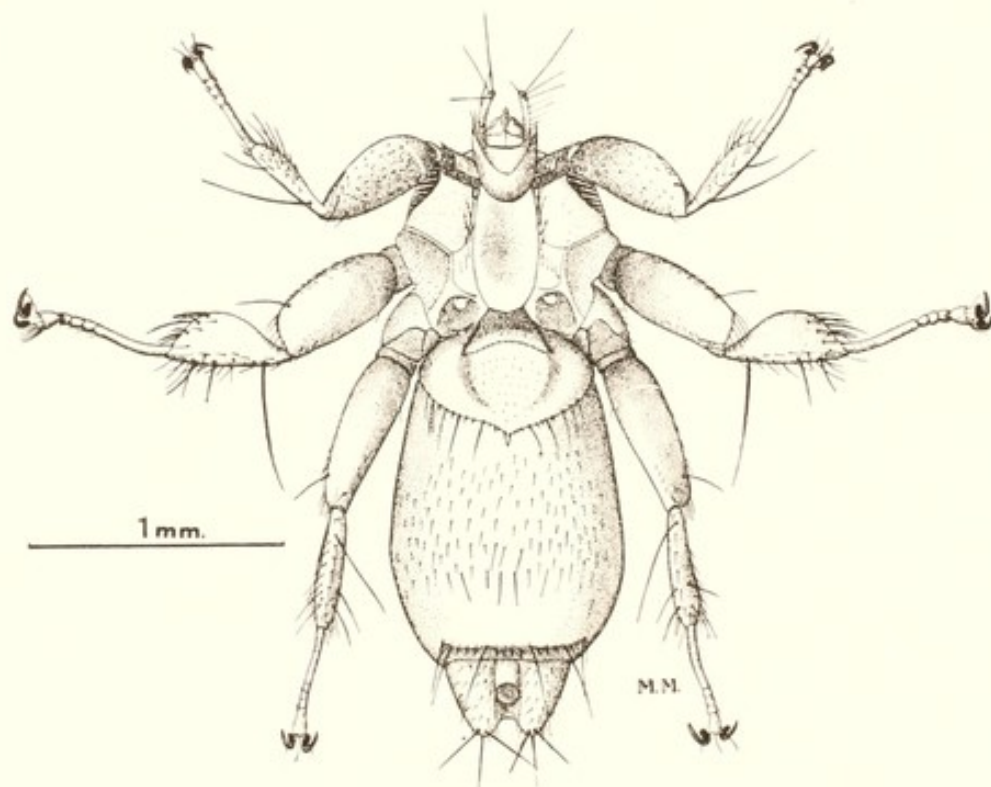


FIG. 49.—*Nycteribia (Listropodia) pedicularia* Latreille.

♀ from Daubenton's Bat at Henley-on-Thames. Dorsal view of whole insect. (NOTE.—In life the head may be folded back along the groove in the middle of the thorax; the drawing shows it tilted upwards).

are mature larvae; they are attached by the parent to the beams or walls of the bat roost and immediately pupate there. The adults pierce the skin and suck the blood of the host. Little more is known of the habits of the British species, but Hase (1931) has published extensive notes on the habits of a Venezuelan species.

The two British species may be separated by the use of the following key.

Femora and tibiae ovoid, the insect having a somewhat "flea-like" appearance, legs shortish *N. pedicularia* Latreille
 Femora and tibiae elongate, legs long, having a very "spider-like" appearance *N. biarticulata* Hermann

There has been some discussion recently in print as to the correct application of certain names in relation to the British species. The names

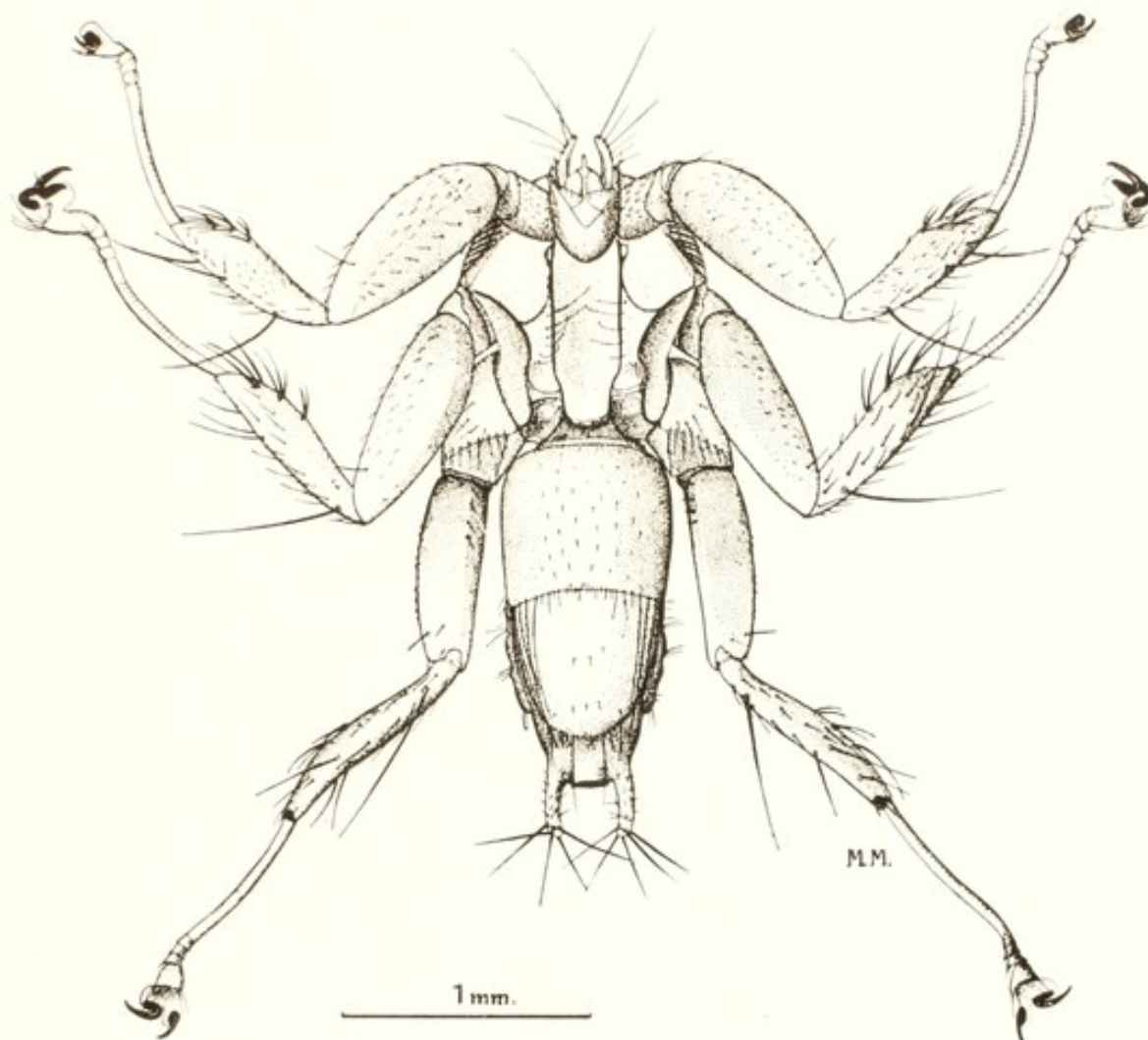


FIG. 50.—*Nycteribia* (*Stylidia*) *biarticulata* Hermann.

♀ from Greater Horseshoe Bat at Braunton, North Devon. Dorsal view of whole insect; head as in Fig. 49.

given here are those used by Scott (1934). Notes on this matter have been published by Thompson (1936).

***Nycteribia* (*Listropoda*) *pedicularia* Latreille**

(Fig. 49; fig. 51, a)

This is the smaller of the two British *Nycteribia*, and it appears to be the rarer. Scott (1934) has described the puparium of this species in detail with notes on the biology of the species. All the records are from Daubenton's Bat (*Myotis daubentoni* (Kuhl)).

Nycteribia (Stylidia) biarticulata Hermann

(Fig. 50; fig. 51, b)

This, the larger species, has been taken on a variety of bats. Thompson (1937) has published notes on the various records of its capture and on the literature relevant to both the British species.

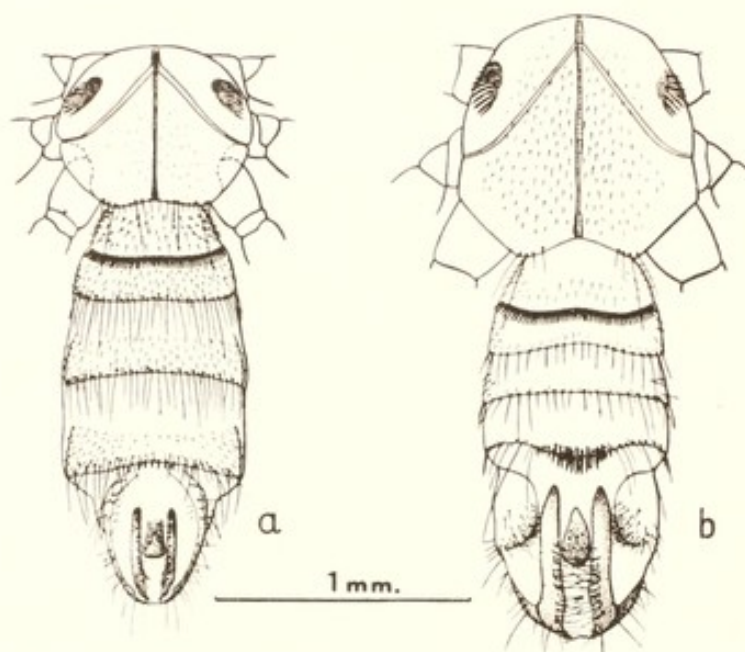


FIG. 51.—British Nycteribiidae, under side of body of ♂.

- a. *N. (L.) pedicularia* Latreille. From Daubenton's Bat at Henley-on-Thames.
 b. *N. (S.) biarticulata* Hermann. From Greater Horseshoe Bat at Braunton, N. Devon.

It has been recorded from the Greater Horseshoe Bat (*Rhinolophus ferrum-equinum insulanus* (Barrett-Hamilton)), the Lesser Horseshoe Bat (*Rhinolophus hipposideros minutus* (Montagu)) and the Common Pipistrelle (*Pipistrellus pipistrellus* (Schreber)).

REFERENCES

There is an extensive literature on the Muscidae due to their potential and actual importance as carriers of disease. The Hippoboscidae and Nycteribiidae have a much smaller literature. Reference may be made to the following text-books, volumes and papers from serial publications.

- GRÜNBERG, K. 1907. Die Blutsaugenden Dipteren. Fischer, Jena.
 FALCOZ, L. 1926. Diptères Pupipares, Faune de France, **14**. Lechevalier, Paris.
 HASE, A. 1931. Über die Lebensgewohn einer Fledermausfliege in Venezuela; *Basilia bellardii* Rondani (Fam. Nycteribiidae—Diptera pupipara). Beiträge zur experimentellen Parasitologie 5. Zeits. f. Parasitenkunde **3**, 220–257.
 HERMS, W. B. 1923. Medical and Veterinary Entomology. Macmillan, New York.
 MATHESON, R. 1932. Medical Entomology. Thomas, Springfield, Ill. U.S.A.
 MITZMAIN, M. B. 1913. The Bionomics of *Stomoxys calcitrans* Linnaeus; a preliminary account. Phil. J. Sci., Sect. B, **8**, 29–48.
 PATTON, W. S. and CRAGG, F. W. 1913. Textbook of Medical Entomology. Christ. Lit. Soc. India, London.

- RILEY, W. A. and JOHANNSEN, O. A. 1938. Medical Entomology. McGraw-Hill, New York, N.Y., U.S.A.
- SCOTT, H. 1934. The puparium of *Nycteribia (Listropoda) pedicularia* Latr. with general remarks on this stage in Nycteribiidae. Ent. Mo. Mag. **70**, 255-259.
- SÉGUY, E. 1923. Diptères Anthomyides, Faune de France, **6**. Lechevalier, Paris.
- SWINGLE, L. D. 1913. The Life-History of the Sheep Tick, *Melophagus ovinus*. Univ. Wyoming Agr. Exp. Sta. Bull. **99**.
- THOMPSON, G. B. 1936. A check list of the Hippoboscidae and Nycteribiidae parasitic on British Birds and Mammals. Ent. Mo. Mag. **72**, 91-94.
- THOMPSON, G. B. 1937. The Parasites of British Birds and Mammals XVII. A bibliography of the previous records of Nycteribiidae, together with additional records and notes. Ent. Mo. Mag. **73**, 274-278.
- THOMSEN, M. 1938. Stuefluen og Stikfluen. 176de Beretning fra Forsogslaboratoriet. Kobenhavn.
- WILHELMI, J. 1917. Die gemeine Stechfliege (Wadenstechter); Untersuchungen über die Biologie der *Stomoxys calcitrans* L. Paul Parey, Berlin. Mon. Zeit. angew. Ent. No. 2.

ADDENDUM

Since the present volume went to press the writer has had submitted to him for identification a small collection of Hippoboscidae, taken from birds shot by Colonel R. Meinertzhagen in the Orkneys in August 1938. All the specimens taken proved to be *Ornithomyia lagopodis* Sharp. They were taken on green plover, red grouse, rock pipit, meadow pipit, rook, starling, blackbird, merlin and arctic skua.

Consequently the names of the following birds should be added to the list of hosts of *O. lagopodis* Sharp on p. 121—green plover, rook, starling, blackbird, merlin and arctic skua. The last mentioned is of particular interest in that, so far as is known to the writer (see p. 120), there are no previous records of any of the British species of *Ornithomyia* occurring on aquatic birds other than waders.

APPENDIX A

THE GENITALIA OF THE BRITISH *CULICOIDES* WITH NOTES ON SYNONYMY

By F. W. Edwards, Sc.D., F.R.S.

No detailed comparative study of the male hypopygium of the European *Culicoides* having hitherto been made, the opportunity has been taken of filling this gap in our knowledge in so far as concerns the British species. It was already known from the researches of Carter, Ingram and Macfie (1920) on the African species, and of Root and Hoffman (1937) on the American species, that, as in most other groups of Diptera, the male genitalia provide characters of the highest importance for classification.

The scattered descriptions and figures hitherto published of the hypopygia of the European species are mostly totally inadequate, as they omit any reference to the organs which are of greatest importance for classification, the aedeagus and parameres. Indeed, the only full description of the hypopygium of any European *Culicoides* which I have been able to find in print is that by Pomerantzev (1932) of *C. nubeculosus* Mg.; this author gives a complete account of the skeletal and anatomical structures. In addition, Root (1937) has given good figures of two European species (*C. chiopterus* Mg. and *C. obsoletus* Mg.) which also occur in North America, and Vimmer (1932) has adequately figured one species (*C. trivittatus* Vimmer) which is evidently very different from any of those occurring in Britain or North America.

In the present contribution, figures and brief descriptions are given of all the species, now twenty-nine in number, which have so far been recognised as occurring in Britain. The material of European *Culicoides* in the British Museum is extremely scanty, and very few species, additional to those found in Britain, are represented by male specimens; figures of these species are added.

The figures here given all show the appearances in ventral view of specimens mounted without pressure in canada balsam, after clearing in potash and staining with carbol fuchsin. It was found desirable to illustrate two or more specimens of some species in order to demonstrate the amount of individual variation to be expected as well as specific differences.

Reference to fig. 53 *a*, in which the parts are shown diagrammatically, will make clear the terminology employed, but a few further words of explanation are desirable.

The hypopygium of *Culicoides* is of rather simple structure. To a chitinous ring formed by a large dorsal plate (*ninth tergite*) and a smaller ventral plate (*ninth sternite*), are articulated the large forceps (consisting of two segments, the *coxite* and *style*), and protected by the tergite and coxites are the true genital parts (*aedeagus* and *parameres*). Beneath the distal part of the ninth

tergite are two pubescent flaps (*cerci*), which are the only hard parts of the tenth or anal segment; these are of no value in classification and are omitted from most of the figures. The aedeagus (so-called) is a movable piece which may appear very different in shape in different mounts, according to whether its apex is directed backwards or downwards, an important point to remember in making comparisons. The coxites have each two internal processes at their base, a *ventral root* passing immediately beneath the aedeagus and a *dorsal root* articulating with the base of the parameres; as first pointed out by Root and Hoffman the ventral root is a structure of considerable taxonomic importance. The membranous area connecting the sternite with the aedeagus is in some species entirely bare, in others more or less densely covered with microscopic spicules, the condition of this membrane being apparently constant for any one species.

The most surprising result of this examination has been the discovery that on hypopygial characters *C. stigma* Mg. and *C. parroti* Kieff. fall in the same group with *C. nubeculosus* Mg. and *C. riethi* Kieff., a relationship which would not have been suspected from their external appearance, though it is also indicated externally by one or two other features such as the presence of 8 to 10 long bristly hairs on the margin of the scutellum instead of the usual 3 to 6, the presence of a pair of small tubercles on the front, and the shape of the fourth tarsal segment, which tends to be rather shorter than usual and is sometimes more or less cordiform. Another result, less unexpected, has been that certain species, notably *C. vexans* and *C. fascipennis* (as hitherto understood in this country) prove to be composite. The following appears to be a natural grouping of the British species according to hypopygial characters:

A. Parameres fused at base; aedeagus usually bifid at tip.

C. stigma, parroti, nubeculosus, riethi.

B. Parameres quite separate, aedeagus never bifid.

1. Tergite with apico-lateral processes well-developed; usually with median notch; parameres various but without tuft of fine hairs at tip.

a. Ventral root of coxite foot-shaped.

C. vexans, albicans, brunnicans, truncorum.

b. Ventral root of coxite simple (long or short).

C. fascipennis group, *C. pictipennis* group, *C. cunctans, heliophilus, pumilus.*

2. Tergite with apico-lateral processes reduced or absent; without median notch.

a. Parameres with fine hairs at tips.

C. pulicaris, halophilus, impunctatus, arcuatus.

a. Parameres simple.

C. obsoletus, chiopterus.

As is so frequently the case among insects, the female genitalia offer very much less tangible characters for classification than do those of the male; nevertheless, certain species are well distinguished by the form of their spermathecae. The relationship of the four species *C. stigma, parroti, nubeculosus*

and *riethi* is confirmed by the fact that they all possess a single spermatheca which is either of irregular shape or with an oblique opening into a wide duct. Two more species (*C. salinarius* and *circumscriptus*) also possess a single spermatheca, but in these it is of regular oval shape with a short neck opening into a narrow duct. All the remaining British species (including those with unspotted wings) have two functional spermathecae which are broadly oval or slightly pear-shaped, and a third rudimentary one. It is interesting to note that according to Root and Hoffman the same three types of spermathecae are

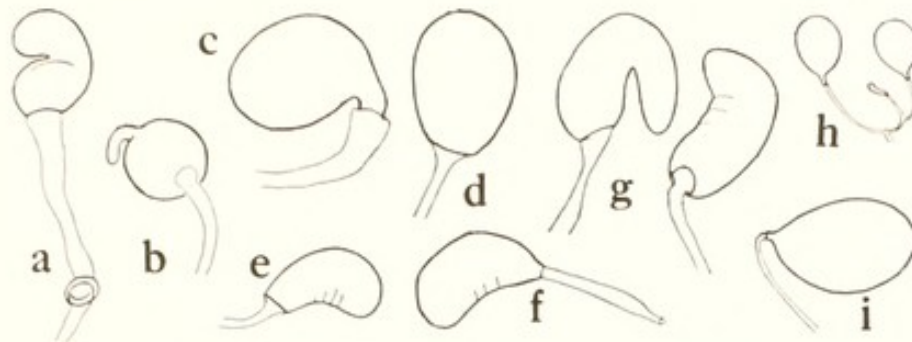


FIG. 52.—Spermathecae of *Culicoides*: a, *parroti*; b, *stigma*; c, *nubeculosus*; d, *riethi*; e–g, *puncticollis* (e, Dardanelles; f, Baghdad; g, Madeira, two specimens); h, *pumilus*; i, *circumscriptus*.

found among the North American species, and, as in Europe, the large majority of the species belong to the third group. The principal types are illustrated in fig. 52.

The synonymy here suggested is mainly that which appears to me to be probable from a study of the published descriptions; much of it needs checking from a re-examination of the types, where these exist (many are probably lost). In a few cases I have come to conclusions different from those of Goetghebuer regarding the significance of Kieffer's names.

C. stigma Mg.

(Fig. 53, b; fig. 52, b)

Ceratopogon stigma Meigen, 1818, Syst. Besch. 1, 73.

Culicoides kiefferi Goetghebuer, 1912, Ann. Biol. lacustre, 5, 3 (sep.).

Culicoides unimaculatus Goetghebuer, 1920, Mem. Mus. Belg., 8, 57.

Culicoides cordiformatarsis Carter, 1916, Ann. Trop. Med. 10, 134.

Tergite of unique form, its distal margin divided into four lobes of which the outer pair (the usual apico-lateral processes) are narrower and the inner pair broader and more rounded, but all of about equal length. Sternite deeply emarginate. Coxite of unusual shape, being widened on its inner face sub-apically as well as basally; ventral root short and blunt. Style with only about the basal third swollen and hairy, tip rounded. Aedeagus with two long sharp points.

Spermatheca single, of very peculiar form, globular with a thumb-like appendix; ring on duct not evident.

C. parroti Kieff.(Fig. 53, *c*; fig. 52, *a*)

Culicoides parroti Kieffer, 1922, Arch. Inst. Past. Afr. Nord., 2, 502; Kieffer, 1925, Faune de France, Ceratopogoninae, 79.

Tergite more normal in shape than in *C. stigma*; processes long and slightly divergent, no accessory lobes between them, but margin of tergite slightly indented in middle. Sternite with rather shallow emargination. Coxite scarcely enlarged basally and not at all apically. Style curved, with

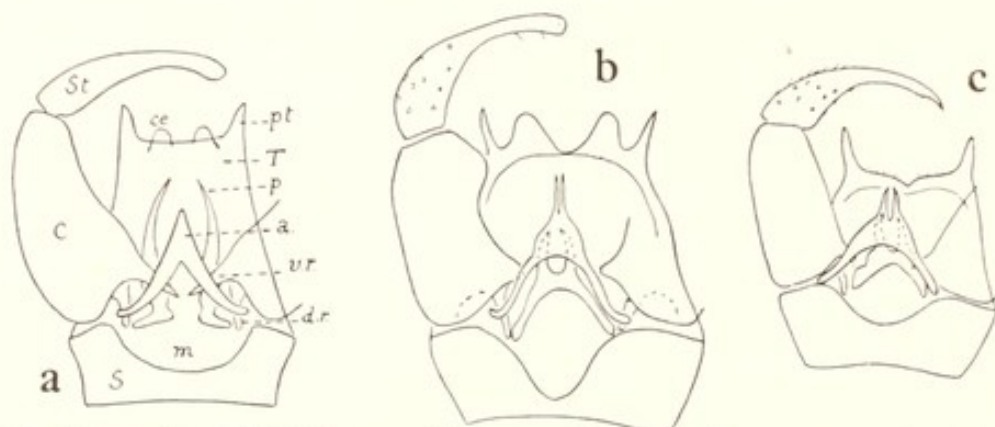


FIG. 53.—Hypopygia of *Culicoides*, ventral view: a, diagram to illustrate nomenclature of parts; b, *stigma*; c, *parroti*.

a, aedeagus. C, coxite. ce, cercus. d.r, dorsal root of coxite. m, membrane. p, parameres. p.t, apico-lateral process of tergite. S, sternite. St, style. T, tergite. v.r, ventral root of coxite.

sharp-pointed tip. Aedeagus deeply bifid at tip. Fused parameres similar in shape to aedeagus.

The above description is from a male from Angora, Turkey (*M. Sureia Bey*), which agrees with British females in all details of colouring. (I have seen no British males).

C. nubeculosus Mg.(Fig. 54, *a*; fig. 52, *c*)

Ceratopogon nubeculosus Meigen, 1830, Syst. Besch., 6, 263.

Culicoides puncticollis Goetghebuer, 1912, Ann. Biol. lacustre, 5, 2 (sep.).

Culicoides punctaticollis Goetghebuer, 1920, Mem. Mus. Belg., 8, 56.

Tergite with very long, finger-like processes, which are only slightly divergent. Sternite only slightly emarginate, membrane bare. Coxite much widened at base, its inner face with the fine pubescence denser than in related species, ventral root very thick. Style not obviously bent, thick and provided with long hairs on more than the basal half, the shorter, bare terminal portion pointed. Aedeagus broad, somewhat square-ended, not bifid. Parameres very extensively fused, with the tips almost threadlike.

The Japanese form described by Tokunaga (1937) as *C. nubeculosus* is evidently not this species, but an unnamed one of the same group.

C. riethi Kieffer(Fig. 54, *b*; Fig. 52, *d*)*Culicoides riethi* Kieffer, 1914, Arch. Hydrobiol. Supp. 2, 237.*C. pullatus* Kieffer, 1915, Arch. Hydrobiol. Supp. 2, 474.*C. crassiforceps* Kieffer, 1924, Bull. Soc. Moselle, 29, 15.? *C. cordatus* Kieffer, 1921, Arch. Inst. Past. Afr. Nord., 1, 114.

Tergite with processes much shorter than in *C. nubeculosus* and rather widely divergent, portion of tergite between them forming a shallow V. Coxite not much widened at base, ventral root not very thick. Style distinctly bent, the bare terminal portion long. Aedeagus with two long points, its sides more or less membranous. Parameres less extensively fused than in *C. nubeculosus*, tips not threadlike.

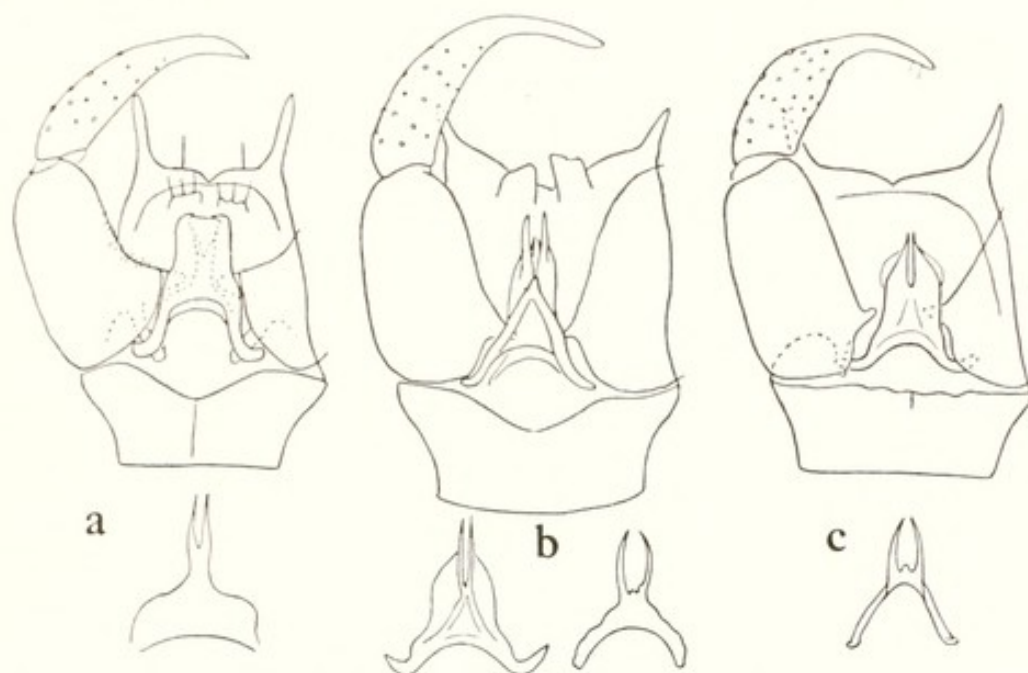


FIG. 54.—Hypopygia of *Culicoides*, ventral view: a, *nubeculosus*; b, *riethi*; c, *puncticollis*. Parameres shown separately, also aedeagus of *riethi*.

C. puncticollis Becker(Fig. 54, *c*; fig. 52, *e-g*)*C. pulicaris* var. *algecirensis* Strobl., 1900, Wien. Ent. Zeit. 19, 170.*C. puncticollis* Becker, 1902, Mith. Zool. Mus. Berlin, 2, 2, 75.*C. impressus* Kieffer, 1918, Ann. Mus. Nat. Hung., 16, 47.*C. algecirensis*, Kieffer 1919, Ann. Mus. Nat. Hung., 17, 39.*C. donatieni* Kieffer, Arch. Inst. Past. Afr. Nord., 2, 504.*C. sciniphes* Kieffer, 1924, Bull. Soc. Ent. Egypte, 8, 261.? *C. flavitarsis* Vimmer, 1932, Sbornik, 8, 144.? *C. vavrai* Vimmer, 1932, Sbornik, 8, 144.? *C. bipunctatus* Vimmer, 1932, Sbornik, 8, 144.? *C. nubeculosus* (Meigen) Medwedewa, 1928.

Tergite intermediate in shape between that of *C. nubeculosus* and *C. riethi*. Other characters much as in *C. riethi*; the small differences shown in the figures may not be constant.

This species is represented in the British Museum by a series of specimens from Madeira (*Wollaston*), Macedonia (*C. M. Wenyon*), the Dardanelles (*A. D. Fraser*), and Baghdad (*P. J. Barraud*, *J. E. M. Boyd*). All are females with the exception of one male from Baghdad (here figured), but all are so similar that they must almost certainly belong to the same species. All were hitherto determined as *C. nubeculosus* Mg., but as shown by the hypopygium this determination was certainly incorrect; I believe the species is correctly named as above.

The small projections on the front (one above the base of each antenna) noticed by Kieffer when describing *C. donatieni* are normally to be seen in all three species of this group.

The few specimens mounted for examination of the spermatheca show that variation exists in the form of this organ, even among specimens from the same locality; one of two Madeiran specimens mounted has a peculiar bent spermatheca such as Root and Hoffman have figured as the normal form in the American *C. varipennis* Coq., a fact which is of interest in view of the fact that these authors record an abnormal spermatheca of *C. varipennis* resembling that of *C. riethi*. *C. varipennis* is evidently closely related to *C. puncticollis*; a male from Illinois in the British Museum has a hypopygium almost identical with that of the European species (the parameres lacking the hair-like tips shown in Root's figure), but the two seem to be rather well distinguished by wing-markings.

***C. salinarius* Kieffer**

(Fig. 55, *d, e*)

Culicoides salinarius Kieffer, 1914, Arch. Hydrobiol., Supp. 2, 236.

C. halobius Kieffer, 1914, Arch. Hydrobiol., Supp. 2, 237.

? *C. meinerti* Kieffer, 1915, Ent. Medd. 10, 284.

C. punctatidorsum Kieffer, 1924, Bull. Soc. Hist. Nat. Moselle, 30, 17.

Culicoides crassiforceps Goetghebuer (*nec* Kieffer), 1935, Encycl. Ent. Dipt., 8, 4.

Tergite with apico-lateral processes long and slightly divergent, median notch deep (but rather variable). Sternite with wide and deep emargination, membrane covered with spicules. Coxite with ventral root very short. Style nearly straight, slightly enlarged at tip. Parameres rather slender at base, swollen for some distance beyond the bend, then gradually narrowed, nearly the distal half slender, tip bent but not hair-like.

I am indebted to Professor Thienemann for material from the original series of *C. salinarius* and *C. punctatidorsum*, and find the two to be identical; in describing *C. salinarius* (and also *C. halobius*) Kieffer overlooked the punctuation of the thorax. The wing-markings are quite as in the British specimen here illustrated, and not as shown by Goetghebuer in Lindner's "Die Fliegen"; Dr. Goetghebuer informs me that his figures were prepared from specimens which were badly faded, the markings being difficult to make out; this will explain the discrepancies.

C. meinerti was described by Kieffer from specimens which had been completely bleached through long immersion in preserving fluid, so that no

comparison can be made with other species in regard to markings. A cotype female which I have examined through the kindness of Mr. S. L. Tuxen has a single spermatheca shaped as in *C. salinarius*, and I therefore include *C. meinerti* as a probable synonym. The fourth tarsal segment though somewhat shorter than the fifth is not obviously cordiform.

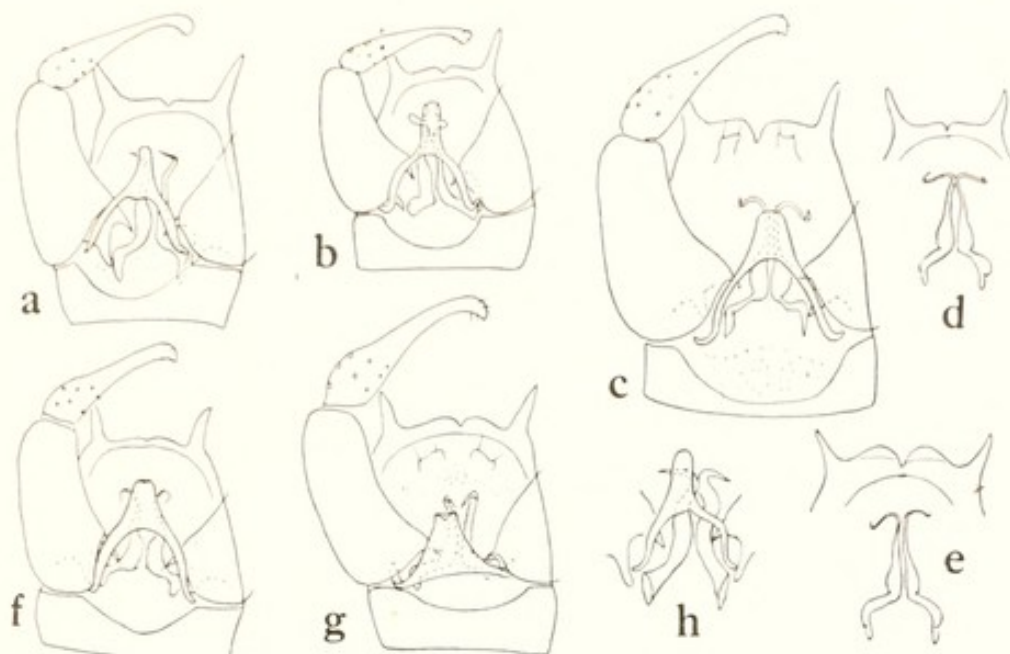


FIG. 55.—Hypopygia of *Culicoides*, ventral view: a, *maritimus* (Portsmouth); b, *simulator* (Knebworth); c, *circumscriptus* (Hayling I.); d, e, *salinarius* (d, Dingwall; e, Sassendorf, Germany, paratype); f, *odibilis* (Letchworth); g, h, *pictipennis* (Wood Walton, two positions of parameres and aedeagus).

C. circumscriptus Kieff.

(Fig. 55, c; fig. 52, i)

Culicoides circumscriptus Kieffer, 1918, Ann. Mus. Nat. Hung., 16, 49.

C. nadayanus Kieffer, 1918, Ann. Mus. Nat. Hung., 16, 95.

? *C. algarum* Kieffer, 1924, Bull. Soc. Hist. Nat. Moselle, 30, 18.

? *C. salicola* Kieffer, 1924, Arch. Inst. Part. Alg., 2, 405.

C. salicola var. *pictidorsum* Kieffer, 1924, Arch. Inst. Part. Alg., 2, 406.

C. edwardsi Goetghebuer, 1921, Mem. Mus. Belg., 8, 177.

? *C. polymaculatus* Vimmer, 1932, Sbornik, 8, 144.

? *C. albonotatus* Vimmer, 1932, Sbornik, 8, 144.

C. pulcher (*pulscher*) Géza Zilahy, 1934, Bull. Soc. Ent. Bulg., 8, 155.

The two males of this species which have been studied show no obvious difference in the structure of the hypopygium from *C. salinarius*, except that the parameres are more abruptly narrowed near the middle.* This distinction may not be constant, and I have been unable to find any characters other than wing-markings on which the two may be separated. The breeding-places also being similar, it may be that *C. circumscriptus* is a mere variety of *C. salinarius*; it is retained as distinct at present because the difference in markings seems

* The figures given by Tokunaga (1937), of Japanese *C. circumscriptus* show the parameres as in *C. salinarius*, but the wing-pattern as in our *C. circumscriptus*.

fairly sharply defined and because the pattern in *C. circumscriptus* shows little variation as between specimens from Britain and from Palestine.

Goetghebuer's figure of *C. algarum* suggests that this is merely a form of *C. circumscriptus* in which the pale markings are more extensive than usual, so that the wing appears pale with irregular dark bands.

***C. odibilis* Austen**

(Fig. 55, *f*)

Culicoides odibilis Austen, 1921, Bull. Ent. Res., **12**, 114.

C. winnertzi Edwards, 1926, Trans Ent. Soc. London, 1926, 406.

Ceratopogon pictipennis Winnertz (*nec* Staeger), 1852, Linn. Ent., **6**.

Tergite with processes long but very little divergent, median notch shallow. Sternite with moderately large excavation, membrane bare. Coxite scarcely widened at base, ventral root longer than in the other species of this group. Style nearly straight, very little enlarged at tip. Aedeagus with distinct antero-ventral margin. Parameres bent near base, widened for some distance beyond the bend, then slender, with almost hair-like recurved tip.

Austen's type male of *C. odibilis* from Palestine agrees with British examples in wings and hypopygium; the slight difference in thoracic markings is probably within the range of individual variation.

***C. pictipennis* Staeger**

(Fig. 55, *g, h*)

Ceratopogon pictipennis Staeger, 1839, Nat. Tidsskr., **2**, 593.

Ceratopogon arcuatus Winnertz, 1852, Linn. Ent., **6**, 39.

Culicoides guttularis Kieffer, 1918, Ann. Mus. Nat. Hung., **17**, 45.

The hypopygium of this species shows only slight differences from that of *C. odibilis*, the chief being in the shape of the parameres, which are not obviously widened beyond the bend and taper more evenly, the tips not being hair-like. The ventral roots of the coxites are shorter.

***C. maritimus* Kieff.**

(Fig. 55, *a*)

Culicoides maritimus Kieffer, 1924, Bull. Soc. Hist. Nat. Moselle, **30**, 16.

The hypopygium of the single specimen mounted differs from those of *C. pictipennis* and *odibilis* chiefly in having the membrane between sternite and aedeagus clothed with spicules; in this and most other respects it resembles *C. salinarius* and *circumscriptus*, but the slender tips of the parameres are less drawn out. Tergite with processes long, tapering, divergent.

***C. simulator* sp. n. (p. 40)**

(Fig. 55, *b*)

Tergite with the processes long and slender (more so than in *C. odibilis* or *C. cubitalis*). Sternite with membrane bare. Coxite with ventral root short. Style nearly straight, distinctly enlarged at tip. Aedeagus with the distal part long and parallel-sided but not narrow. Parameres long, with curled hair-like tips.

The hypopygium of the specimen figured is very much like that of *C. odibilis*, *C. cubitalis* and the American *C. simulans* Root and Hoffman, but there are small differences which, taken in conjunction with the obvious distinction in wing-markings, induce me to regard it as representing a distinct species. The name *simulans* is in any case preoccupied by *C. simulans* Vimmer, 1932.

***C. fascipennis* Staeg.**

(Fig. 56, *e, f*)

Ceratopogon fascipennis Staeger, 1839, Nat. Tidsskr., 2, 594.

? *Culicoides albonotatus* Kieffer, 1918, Ann. Mus. Nat. Hung., 16, 94.

Tergite with processes finger-like, separated by a broadly V-shaped notch. Sternite with deep emargination, membrane rather densely covered with spicules. Coxite with ventral root very short. Style slightly curved, with about the basal half thickened, tip scarcely enlarged. Aedeagus broad, with well-marked anterior margin. Parameres stout, tips bent almost at right angles and tapering to a point.

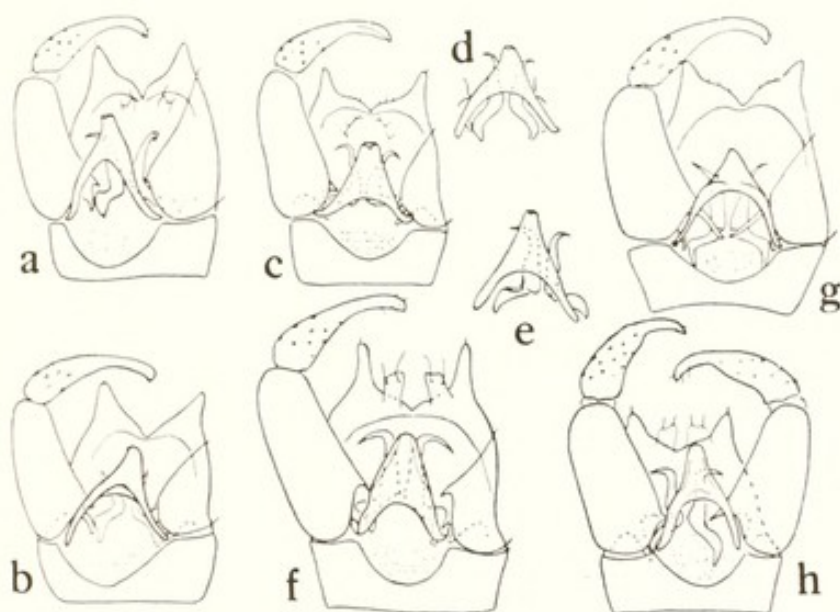


FIG 56.—Hypopygia of *Culicoides, fascipennis* group, ventral view: a–d, *pallidicornis* (a, Windermere; b, Budapest, cotype; c, Arran; d, S. Devon); e, *fascipennis* (e, Dingwall; f, Germany det. Winnertz); g, *tentorius*; h, *odiatu?* (Dartmouth).

The above diagnosis is drawn up from a German specimen in the British Museum determined by Winnertz; males from Dingwall differ slightly in the form of the aedeagus and parameres (fig. 56, *e*) and have the processes of the tergite shorter but still finger-like. Staeger's type is unfortunately lost, but the Dingwall females agree better with the original description than do those of the allied species *C. pallidicornis*; I therefore use the name *fascipennis* for this species, which is well distinguished in the female sex by the hairy basal cell.

C. pallidicornis Kieffer(Fig. 56, *a-d*)*Culicoides pallidicornis* Kieffer, 1919, Ann. Mus. Nat. Hung., **17**, 46.*C. distinctus* Kieffer, 1916, Arch. Hydrobiol. Supp., **2**, 492.*C. dileucus* Kieffer, 1921, Bull. Soc. Hist. Nat. Moselle, **29**, 55.*C. subfascipennis* Goetghebuer, in part (*nec* Kieffer).

Tergite with the processes broader than in *C. fascipennis*, more or less triangular instead of finger-like, so that the whole distal margin of the tergite tends to appear bifid. Remaining parts much as in *C. fascipennis*, but parameres somewhat narrower, especially towards the tips.

The specimens examined exhibit some variation in hypopygial structure, though all are quite similar externally. In a cotype of *C. pallidicornis* in the British Museum (fig. 56, *b*) the parameres are definitely shorter than in six British males (from different localities) of which mounts were made; some of the latter agree with the cotype in the shape of the tergite (fig. 56, *a*), but one or two show an approach to the form of *C. fascipennis* (fig. 56, *c*). If the British form is distinct from *C. pallidicornis* it may be *C. dileucus* Kieff. A specimen received from Dr. Goetghebuer as *C. subfascipennis* Kieff. was identical with British examples; I do not think this determination can be correct as Kieffer described *C. subfascipennis* from a female with striped thorax.

C. odiatus Austen(Fig. 56, *h*)*Culicoides odiatus* Austen, 1921, Bull. Ent. Res., **12**, 112.? *C. pallidicornis* Kieffer var. *brunco-scutellatus* Géza Zilahy, 1934, Bull. Soc. Ent. Bulg. **8**, 155.

This was described from two females from Palestine, and no male has since been obtained in that country. A single British male which I refer doubtfully to this species has a hypopygium very much as in *C. pallidicornis*, but with some differences which may be significant, the most notable of which is that the style is swollen and hairy on much more than the basal half.

C. tentorius Austen(Fig. 56, *g*)*Culicoides tentorius* Austen, 1921, Bull. Ent. Res., **12**, 110.

Hypopygium very like that of *C. pallidicornis*, but differing definitely in the long, slender ventral root of the coxite, and in having the parameres more abruptly narrowed at the tips. The structure is almost exactly like that figured by Root and Hoffman for *C. biguttatus* Coq., except that the American species is shown as having the sternal membrane much more densely spicular.

C. tentorius has been recorded only from Palestine. Externally the male is very similar to *C. pallidicornis*, having scantily haired wings as in that species, with no hairs in the cubital fork. The female seems rather well distinguished from *C. pallidicornis* by the more distinct white spots on the wing, and by the paler (uniformly light reddish-brown) thorax.

C. cubitalis sp. n. (p. 40)

(Fig. 57, c, d)

Culicoides subfasciipennis var. *analis*, Kieffer, 1925, Faune de France, Ceratopogoninae, 81.

Tergite with the processes rather thick but rather long and divergent, margin of tergite between them nearly straight, with small median notch. Sternite with the usual wide emargination, membrane bare. Coxite with ventral root rather long, simple. Style nearly straight, slightly enlarged at tip. Aedeagus broad, antero-ventral margin well defined. Parameres long, with foot-shaped bases and hair-like curled tips.

In the form of the tergite and parameres and the bare sternal membrane the hypopygium of this species differs widely from those of the *C. fasciipennis*



FIG. 57.—Hypopygia of *Culicoides*, ventral view: a, b, *truncorum* (a, Snailwell; b, Brockenhurst); c, d, *cubitalis* (c, Letchworth; d, Arran); e, *neglectus*? (Belgium).

group, but it shows rather a close resemblance to *C. odibilis*, a species to which it bears little resemblance in coloration. The American *C. simulans* Root and Hoffman is also similar in hypopygial structure, and intermediate in wing-markings between *C. cubitalis* and *C. odibilis*.

Kieffer's description of *analis* agrees, so far as it goes, with our material, but I do not think *analis* can be a variety of *subfasciipennis*, the original description of which indicates a very different insect with striped thorax. The name *analis* is preoccupied in *Culicoides* by *C. analis* Santos Abreu, 1921.

C. truncorum sp. n. (p. 41)

(Fig. 57, a, b)

Tergite broadly truncate apically, processes short and almost parallel, median notch slight. Sternite with moderate emargination, membrane bare. Coxite rather long and narrow; ventral root foot-shaped, but the "heel" not very prominent. Style somewhat curved at tip, which is not swollen. Aedeagus with very slender arch and narrow apex, ventral surface not sclerotised. Parameres long and slender, without sharp bend near base, the bent tips long and slender and provided with several fine barbs.

The hypopygium of this species bears some resemblance to that of *C. albicans*, but is quite different from any species of the *C. fasciipennis* group.

C. vexans Staeger

(Fig. 58, c-f)

Ceratopogon vexans Staeger, 1839, Nat. Tidsskr., 2, 593.*Palpomyia pungens* Kieffer, 1901, Bull. Soc. Nat. Hist. Metz, 21, 163.*Culicoides perpungens* Kieffer, 1925, Faune de France, 11, 77.

Tergite rather variable in shape; processes usually short, sometimes moderately long; distal margin of tergite rather deeply notched in middle, sometimes with a pair of broadly rounded lobes developed between the apico-lateral processes. Sternite with shallow emargination, membrane bare. Coxite somewhat narrowed distally; ventral root foot-shaped, with long "toe," but the "heel" not very prominent. Aedeagus without definite antero-ventral

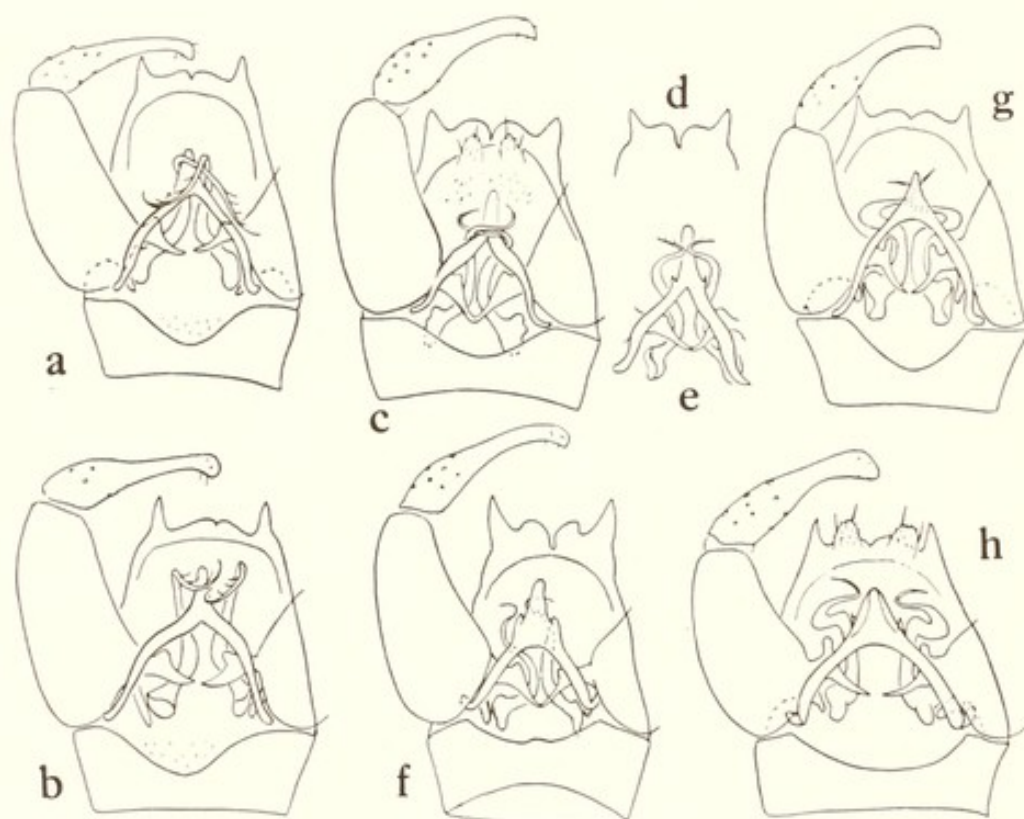


FIG. 58.—Hypopygia of *Culicoides*, ventral view: a, b, *albicans* (a, Germany, det. Winnertz; b, Manchester); c-f, *vexans* (c, e, New Forest; d, Oxford; f, Wood Walton Fen); g, h, *brunnicans* (g, Snailbeach; h, Northwood).

border, distal part narrow and often pale, a small projection on each side, not always obvious. Parameres slender, sinuous, tips very thin, normally bare but occasionally with one or two fine barbs.

I am indebted to Drs. S. Andersen and S. L. Tuxen for reporting upon the hypopygium of Staeger's type ♂ of *C. vexans*; they inform me that it agrees completely with the figures here given, notably in regard to the form of the parameres and ventral roots of coxites.

C. albicans Winn.(Fig. 58, *a, b*)*Ceratopogon albicans* Winnertz, 1852, Linn. Ent., 6, 41.

Tergite with rather short apico-lateral processes; middle of posterior margin less deeply notched than in *C. vexans* and not distinctly bilobed. Sternite with moderate emargination, membrane in the emargination bearing a few spicules. Coxite much as in *C. vexans*, aedeagus also rather similar. Parameres slender, bent almost at right angles beyond middle, the distal part with 3 to 5 barb-like branches.

The identity of this species is established by a male in the British Museum named by Winnertz himself.

Lundström and Goetghebuer have both attempted to distinguish *C. vexans* and *C. albicans* by the presence or absence of hairs in the lumen of the second radial cell, but I do not find this feature diagnostic.

C. brunnicans sp. n. (p. 43)(Fig. 58, *g, h*)

Tergite much as in *C. albicans*, but rather broader. Sternite with moderate emargination, membrane bare. Coxite shorter and broader than in *C. vexans* or *albicans*, ventral root foot-shaped as in the other two species, but the "heel" very much more prominent. Style somewhat stouter. Parameres stout nearly to the tips, which are conspicuously S-shaped.

C. neglectus Winn. (?)(Fig. 57, *e*)(?) *Ceratopogon neglectus* Winnertz, 1852, Linn. Ent., 6, 46.*Culicoides neglectus* var. *albohalteratus* Goetghebuer, 1935, Bull. Soc. Ent. Belg., 75, 414.

Tergite with long, finger-like processes. Sternite with membrane bare. Coxite with short, simple ventral root. Style nearly straight, tip slightly curved and not enlarged. Parameres angled near base, tips very slender and strongly curved.

The above diagnosis and accompanying figure (fig. 57, *e*) have been prepared from a male from Melle, Belgium, recorded by Goetghebuer in the above reference and kindly lent me by him for examination. The hypopygium is extremely similar to that of *C. odibilis*, which is surprising considering the dissimilarity of the insects in external appearance.

C. cunctans Winn.(Fig. 59, *b, c*)*Ceratopogon cunctans*, Winnertz 1852, Linn. Ent., 6, 42.

Tergite with the processes long, finger-like, parallel or nearly so, margin of tergite between them straight and bearing a row of short hairs. Sternite apparently variable in shape, one or two of the four specimens mounted showing a pair of pubescent lobes in the middle, these lobes not visible in the others

(possibly folded inwards). Coxite rather broad; ventral root short or moderately long, simple, not foot-shaped. Style straight, tip not enlarged. Aedeagus small, somewhat truncate. Parameres stout, tips curled but not much thinner than the stem.

C. heliophilus Edw.

(Fig. 59, *d*)

Culicoides heliophilus Edwards, 1921, Scot. Nat., 1921, 124.

? *C. albihalter* Kieffer, 1919, Ann. Mus. Nat. Hung., 17, 37.

? *C. vitreipennis* Austen, 1921, Bull. Ent. Res., 12, 108.

Tergite with processes rather long, somewhat divergent, median notch conspicuous. Sternite with shallow excavation, membrane bare. Coxite not very stout, ventral root moderately long and slender, not foot-shaped. Aedeagus truncate at tip. Parameres stout for two-thirds of their length, tips slender and curved.

Specimens from Scotland and Epping Forest are quite alike.

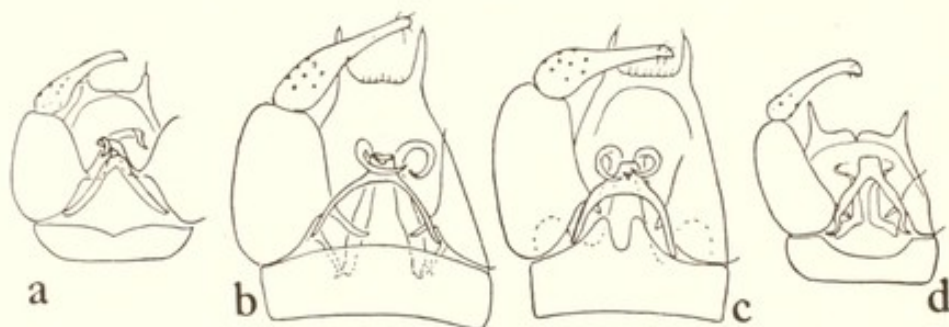


FIG. 59.—Hypopygia of *Culicoides*, ventral view: a, *pumilus*; b, c, *cunctans* (b, Letchworth; c, Dingwall); d, *heliophilus* (Epping).

Goetghebuer (in correspondence) thinks that *C. albihalter* Kieff. may be an earlier name for *C. heliophilus*, but this cannot be established until males have been obtained from Central and Southern Europe; meanwhile, the name *heliophilus* is retained because it expresses the peculiar habits of this species. In Austen's type of *C. vitreipennis* (which may well be the same as *C. albihalter*) the hairs on the radial cells are pale like those on the rest of the wing; this may prove to be a specific difference from *C. heliophilus*.

C. pumilus Winn.

(Fig. 59, *a*)

Ceratopogon pumilus Winnertz, 1852, Linn. Ent., 6, 46.

C. minutissimus Zetterstedt, 1855, Dipt. Scand., 12, 4860.

Culicoides nanulus Kieffer, 1919, Ann. Mus. Nat. Hung., 17, 38.

Tergite with processes rather short, nearly parallel; margin of tergite between them with slight median notch. Sternite only slightly emarginate, membrane bare. Coxite short and broad, ventral root short. Style almost straight, tip not enlarged. Aedeagus consisting of the arch only. Parameres stout almost to the tips.

C. nanulus Kieff. is included as a synonym of *C. pumilus* on the strength of a female paratype in the British Museum.

C. chiopterus Mg.(Fig. 60, *b*)*Ceratopogon chiopterus* Meigen, 1830, Syst. Besch., 6, 263.*Ceratopogon amoenus* Winnertz, 1852, Linn. Ent., 6, 35.*Culicoides chiopterus* Root and Hoffman, 1937, Amer. J. Hyg., 25, 156.

Tergite roughly rectangular, with the posterior margin concave, the corners somewhat prominent but not forming well-marked processes. Sternite with a wide and deep central concavity, membrane bare. Coxite rather long and narrow, without specially dense pubescence on inner side, ventral root long and slender. Style rather short, enlarged and rounded at tip, but less so than in *C. obsoletus*. Aedeagus with distinct antero-ventral margin, pointed tip and dorsal peg. Parameres with long, slender, recurved tips.

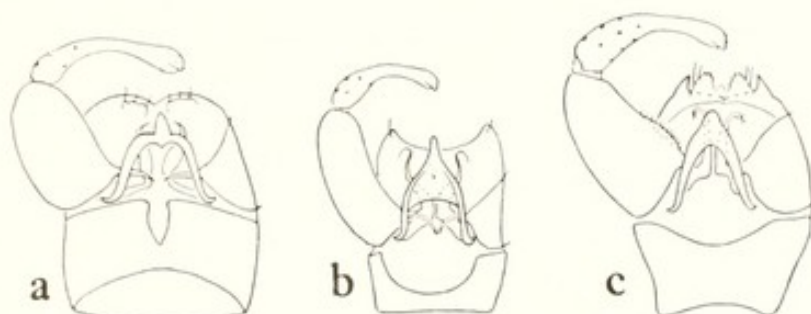


FIG. 60.—Hypopygia of *Culicoides*, ventral view: a, *obsoletus*; b, *chiopterus*; c, *impunctatus*.

C. obsoletus Mg.(Fig. 60, *a*)*Ceratopogon obsoletus* Meigen, 1818, Syst. Besch., 1, 76.*Ceratopogon varius* Winnertz, 1852, Linn. Ent., 6, 35.*Ceratopogon sanguisugus* Coquillett, 1901, Proc. U.S. Nat. Mus., 23, 604.*Ceratopogon yezoensis* Matsumura, 1915 (*teste* Tokunaga, 1937).*Culicoides sanguisugus* Malloch, 1915, Bull. Illinois Lab., 10, 301.*Culicoides lacteinervis* Kieffer, 1919, Ann. Mus. Nat. Hung., 17, 47.*Culicoides clavatus* Kieffer, 1924, Bull. Soc. Hist. Nat. Moselle, 29, 56.*Culicoides rivicola* Kieffer, 1924, Bull. Soc. Hist. Nat. Moselle, 29, 56.*Culicoides heterocerus* Kieffer, 1921, Bull. Soc. Hist. Nat. Moselle, 29, 57.*Culicoides pegobius* Kieffer, 1922, Ann. Soc. Sci. Brux., 41, 235.*Culicoides concitus* Kieffer, 1923, Ann. Soc. Sci. Brux., 42, 71.*Culicoides obsoletus* Root and Hoffman, 1937, Amer. J. Hyg., 25, 155.

Hypopygium very distinctive, differing from all other British species of the genus in having no trace of apico-lateral processes on the tergite; in the narrow, slit-like median emargination of the sternite; in the shape of the style, which is as much enlarged at the tip as at the base; and in the peculiar shape of the aedeagus. Coxite short and broad, its ventral root long and narrow. Parameres rather broad, the short pointed tips turned inwards.

C. pulicaris L.

(Fig. 61, a)

Culex pulicaris Linnaeus, Syst. Nat. Ed. 10, 603.*Ceratopogon punctatus* Meigen, 1804, Klass., 1, 29.*Culicoides cinerellus* Kieffer, 1919, Ann. Mus. Nat. Hung., 17, 40.*Culicoides flavipluma* Kieffer, Bull. Soc. Hist. Nat. Moselle, 30, 19.*C. pulicaris* var. *ocellaris* Kieffer, Ann. Soc. Sci. Brux., 40, 276.

Tergite with the processes short, almost triangular, and slightly convergent, distal margin straight or slightly concave. Sternite only slightly emarginate, membrane bare. Coxite with a conspicuous hump on inner side near base, this hump bearing dense, short, stiff pubescence, ventral roots short. Style curved, slightly enlarged at the rounded tip. Aedeagus without a definite antero-ventral margin, sclerotisation being confined mainly to the arch. Parameres long, angled near base, with a small tuft of fine hairs at tip.

There appears to be no difference in structure of hypopygium between "typical" *C. pulicaris* and the variety *punctatus* (*ocellaris*).

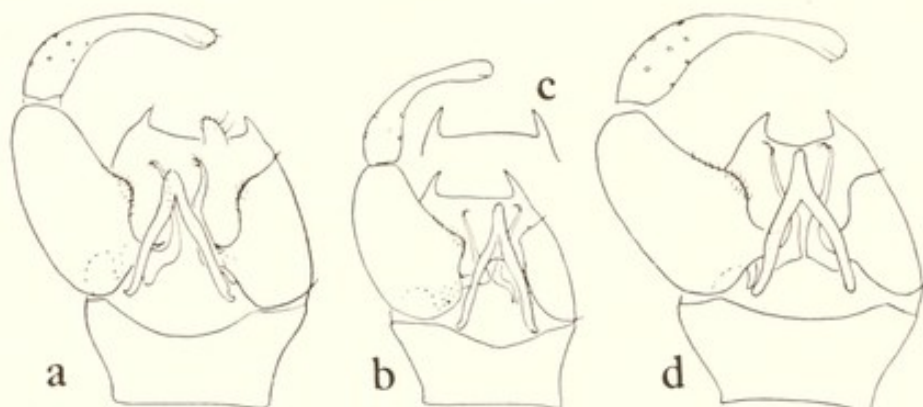


FIG. 61.—Hypopygia of *Culicoides*, ventral view: a, *pulicaris*; b, c, *halophilus* (b, Carnarvonshire; c, Arran); d, *delta*.

C. halophilus Kieffer

(Fig. 61, b, c)

Culicoides halophilus Kieffer, 1924, Arch. Inst. Past., 2, 404.*Culicoides biclavatus* Kieffer, 1924, Bull. Soc. Hist. Nat. Moselle, 30, 14.*Culicoides pulicaris* var. *C.*, Edwards, 1926, Trans. Ent. Soc. London, 1926, 406.*Culicoides pulicaris* var. *edwardsi* Goetghebuer, 1933, in Lindner's "Die Fliegen," Heleidae, 46.*Culicoides pulicaris* var. *edwardsianus* Goetghebuer, 1933, Bull. Soc. Ent. Belg., 73, 367.

Two specimens from different localities (Arran and Carnarvonshire) agree in showing slight differences in hypopygial structure from specimens of *C. pulicaris* examined: the processes of the tergite are longer, and the point of the aedeagus is also longer. These small differences may be significant when considered in conjunction with the differences in wing-markings and in breeding habits, the present form being apparently confined to saline or brackish-water areas.

So far as may be judged from the descriptions Kieffer's names *halophilus* and *biclavatus* both apply to this form; as regards *halophilus* Dr. Goetghebuer has reached the same conclusion as I have done. Whether *halophilus* was

published before or after *biclavatus* it is at present impossible to say, both appearing late in the year 1924; the former name is adopted as being more appropriate.

A species very closely related to *C. halophilus* is *C. newsteadi* Austen, 1921, of Palestine. This differs chiefly from *C. halophilus* in the more sharply-defined wing-markings, much as *C. puncticollis* differs from *C. riethi*; in both cases the two may be northern and southern forms of the same species.

Culicoides delta sp. n. (p. 48).

(Fig. 61, *d*)

C. pulicaris var. *D*, Edwards, 1926, Trans. Ent. Soc. London, 1926, 407.

The hypopygium of this species or variety is rather closely similar to that of *C. pulicaris*. In two of three specimens mounted there is one rather obvious difference in that the processes of the tergite are much closer together, but in a third specimen they are almost as wide apart as in the specimens of *C. pulicaris* examined. The tip of the aedeagus is longer and narrower. However, in spite of the lack of obvious differences in the hypopygia, I am inclined now to regard this as a distinct species both from *C. pulicaris* and from *C. impunctatus*, the difference in wing-markings being supported by a slight difference in density of macrotrichia on the wings.

I suggested in 1926 that this form might be Goetghebuer's *C. impunctatus*, but specimens of the latter from Hockai, Belgian Ardennes (the type locality) sent me by Dr. Goetghebuer, prove that his species is the one I had erroneously determined as *C. arcuatus* Winnertz (see below).

C. impunctatus Goet.

(Fig. 60, *c*)

Culicoides impunctatus Goetghebuer, 1920, Mem. Mus. Belg. 8, 55.

Ceratopogon arcuatus Edwards (*nec* Winnertz), 1926, Trans. Ent. Soc. London, 406.

Hypopygium very similar to that of *C. pulicaris*, notably in the shape of the processes of the tergite, the presence of dense short pubescence on much of the inner sides of the coxites, and the fine hairs at the tips of the parameres; differs from *C. pulicaris* in having the hump on the inner side of the coxite less pronounced, and also in the broader aedeagus, and shorter parameres; the differences are indefinite and are not always so pronounced as shown in the figures, but in spite of this I have no doubt of the distinctness of the species.

Since 1919 this species has been determined in the British Museum collection as *C. arcuatus* Winn., but as shown fairly clearly by Winnertz's description and figure and confirmed by a paratype kindly lent from Bonn by Dr. Reichensperger, Winnertz's *arcuatus* is the same as Staeger's *pictipennis*, the type of which I examined in Copenhagen in 1923. Belgian specimens sent by Dr. Goetghebuer as *arcuatus* agree with Winnertz's and Staeger's types.

This book was almost ready for publication when specimens were received from Mr. J. E. Collin of an apparently undescribed species of *Culicoides*. In the attempt to determine this species it was found that the names *arcuatus* Winnertz and *impunctatus* Goetghebuer had been misapplied in the British Museum collection, and further that two distinct species, both undescribed, had been confused in the wrongly named Museum series of "*impunctatus*." The requisite corrections in nomenclature have been made in the preceding text, and one of the new species has been described as *C. delta*, sp. n.; the other two are described and figured below.

***Culicoides grisescens* sp. n.**

A rather large species of the *C. pulicaris* group, agreeing with other members of this group in having the wing-markings dark (though faint) on a pale ground, and the second radial cell largely included in a pale area, but with the eyes of the female narrowly separated. Thorax more or less unmarked, greyish. Wings without a separate dark spot in cubital fork. Wing-length about 2 mm.

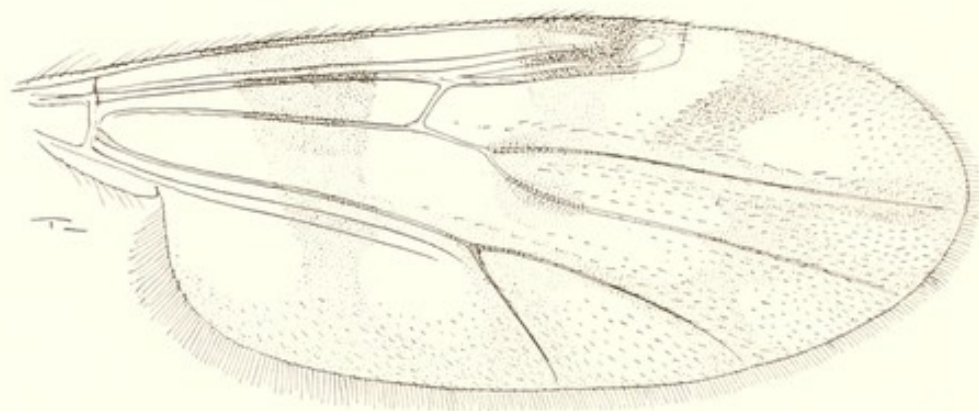


FIG. 62.—*Culicoides grisescens* sp. n. Wing of ♀.

Thorax dark grey, in most specimens uniformly so, but in a few examples a wedge-shaped brown mark is present behind each humeral pit, the point of the wedge directed forwards. Hair pale but not conspicuously so. Legs dark; tibiae and tarsi may be lighter than femora, but the hind tibia has no pale ring at the base, in this respect resembling that of *C. delta*. Wings, when seen by reflected light, with very little yellow tinge on the pale areas, a blackish mark in middle of front margin, other dark markings greyish and usually diffuse and ill-defined, in some specimens rather more restricted and definite; except that the markings are fainter the wing shows no very obvious difference from that of *C. delta*.

MALE HYPOPYGIUM: Tergite of distinctive form; processes of moderate length and each bearing a terminal hair, distal margin between processes strongly convex and without median emargination (thus differing from all the other British species). Sternite with shallow excavation, membrane bare,

Coxite longer than in *pulicaris* and without trace of enlargement on inner face, short hairs less dense than in *pulicaris*. Style not enlarged at tip. Aedeagus broad, antero-ventral margin distinct. Parameres as in *pulicaris* with a few fine hairs at tip.

PERTH: Rannoch, vii. 17, 2♂ 1♀, including type ♂ (*J. J. F. X. King*). INVERNESS: Nethy Bridge, 1♀, viii. 13 (*King*). Tulloch, Glen Spean, vii. 17, 8♂ (*K. J. Morton*). CROMARTY: Dingwall, viii. 09, 7♀ (*King*). ARRAN: Brodick, v. 19, 1♀ (*F. W. Edwards*). CHESHIRE: Delamere, vii. 28, 2♀ (*H. Britten*).

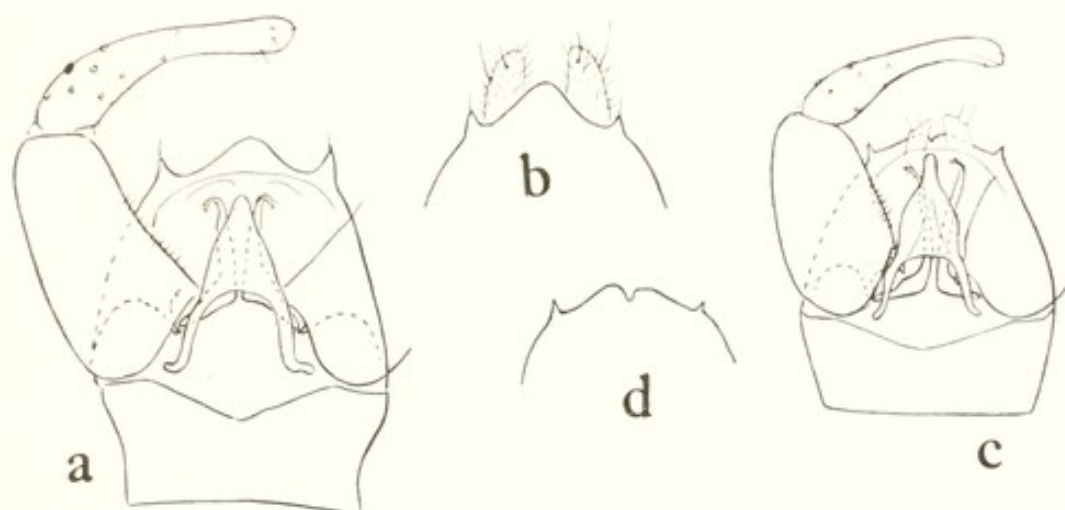


FIG. 63.—Hypopygia of *Culicoides*, ventral view: a,b, *grisescens* (a, Rannoch; b, Tulloch, tip of tergite and cerci); c,d, *fagineus*, two specimens.

This species is very similar to, and possibly only a form of, *C. sordidellus* Zett. of Greenland, but the male of Zetterstedt's species being unknown it is unsafe at present to assume the specific identity of the British and Greenland forms. Some females of *C. sordidellus* in the British Museum from West Greenland (*Vevers*) are somewhat larger than Scottish specimens and have the pale areas of the wing reduced in size so that the wing appears greyish with pale spots rather than the reverse. On the other hand three females from Obozerskaya, south of Archangel (*A. D. Fraser*) are in all respects similar to those described above, so that the species probably has a wide distribution in northern countries.

Culicoides fagineus sp. n.

A rather small species of the *C. pulicaris* group, agreeing with other members of this group in having the eyes of the female in contact, the wings with dark markings on a pale ground, and the second radial cell largely enclosed in a pale area. Wings without a separate dark spot in cubital fork, as in *C. impunctatus* and similar species. Wing-length about 1.5 mm.

Thorax rather light brown or buff-coloured (perhaps darker in older specimens; most of those examined were rather freshly emerged). Hair all pale.

Front of mesonotum with darker brown markings resembling in form those of *C. pulicaris* and *C. delta*, but smaller; a median triangle with its apex pointing backwards occupies the area between the humeral pits but does not extend nearly so far back as in the other two species; joined to this triangle on each side is a dark brown stripe which extends from the humeral pit to about the middle of the mesonotum. Legs mainly brownish, but knees and tarsi paler; on the hind legs the extreme tip of femur and base and tip of tibia yellow. Wings yellow by reflected light, especially in female; markings uniformly dark and sharply defined (much more so than in *C. impunctatus*), alike in the two sexes and showing little variation from the arrangement depicted in Fig. 64; a

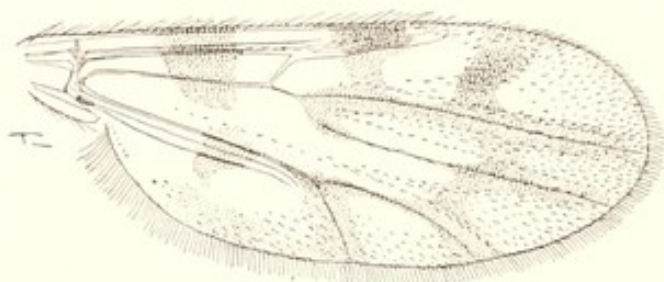


FIG. 64.—*Culicoides fagineus* sp. n. Wing of ♀. (Markings shown rather too faint.)

noteworthy feature is that the lower branch of the median fork is free from darkening on its basal half (except for the spot at the base), whereas in *C. impunctatus* it is continuously darkened. Hairs of membrane in female spread over most of distal half of wing and on lower half of anal area, in male almost confined to distal third, the cubital fork being almost or quite bare.

MALE HYPOPYGIUM: Tergite of distinctive form; processes very short, distal margin between processes convex but with a small rounded excavation in middle (thus differing from *pulicaris* and similar species). Sternite with shallow excavation, membrane bare. Coxite with short hairs on inner face as in *pulicaris*, but with little or no trace of hump; ventral root short. Style not much enlarged at tip. Aedeagus broad, with tip narrowed, antero-ventral margin well defined. Parameres as in *pulicaris* with a few fine hairs at tip.

HANTS: Bank, near Lyndhurst; about 50♂ and 30♀ reared from very moist and decaying debris taken from a large hollow in a beech-tree attacked by fungus, vi. 1939 (*J. E. Collin*). From the same pabulum were reared numerous specimens of *C. obsoletus* and of a variety (?) of *C. pulicaris*, and a few *C. truncorum*, as well as large numbers of four or five other species of Ceratopogonidae of the genera *Forcipomyia* and *Dasyhelea*, besides other Diptera.

REFERENCES

- CARTER, H. F., INGRAM, A., and MACFIE, J. W. S. 1920. *Ann. Trop. Med. and Parasit.*, **14**, 187-274.
 POMERANTZEV, B. I. 1932. *Mag. Paras. Inst. Zool. Acad. Sci. U.R.S.S.*, **3**, 183.
 ROOT, F. M. and HOFFMAN, W. A. 1937. *Amer. J. Hyg.*, **26**, 150-176.
 TOKUNAGA, M. 1937. *Tenthredo*, **1**, 233-337.
 VIMMER, A. 1932. *Sbornik*, **8**, 144.

APPENDIX B

"GAD-FLIES"

By the late Major E. E. Austen, D.S.O

Although at the present day the words *Oestrus*, *Tabanus*, and *Asilus*, used as generic distinctions, are applied to three very distinct groups of flies, belonging to as many families, and differing widely in structure as well as in habits, in classic times they appear to have been synonyms. That is to say the οἰστρος of Homer, *tabanus* of Varro, and *asilus* of Vergil was an insect, the attacks of which terrified cattle and caused them to run wildly about, or as English farmers say, to "gad." According to Bradley (Murray's "New English Dictionary," Vol. IV, 1901) the original sense of the substantive *gad*, which is derived from the Old Norse *gadd-r*, is probably that of 'spike,' the meaning being similar to that of *goad* (from the Old English *gád*),—"a rod or stick, pointed at one end or fitted with a sharp spike and employed for driving cattle, especially oxen used in ploughing"; then, figuratively, "something that pricks or wounds like a goad." The application of the term *gad-fly* to species of the family Tabanidae, insects with a sharp piercing proboscis, and well-known pests of cattle, was therefore perfectly natural, and it was equally natural to assume that these flies were responsible for the *gadding* of cattle, a phenomenon which has been known from the time of Homer—τὰς μὲν τ' αἰόλος οἰστρος ἐφορμηθεὶς ἐδόννησεν, ὥρη ἐν εἰαρινῇ: "[the cattle] that the nimble gad-fly, rushing upon them, drives about in spring-time" (Odyssey 22, 300). Bradley gives the following quotations from the English poets: "You shall see them toss their tails and gad, As if the breeze had stung them" (Dryden and Lee, 1678: *Oedipus*, I); "Like oxen maddened by the breeze's sting" (Pope, 1725: *Odyssey*, XXII, 335).*

Nevertheless it is believed by certain authors that a confusion of ideas has taken place here, that the old writers were mistaken in ascribing the gadding of cattle to the bites of Tabanidae and the dread of their attacks entertained by the animals, and that the real "gad-flies" in this sense are the *warble-flies* of the genus *Hypoderma* Latr., which belongs to the family Oestridae and was formerly included in the Linnean genus *Oestrus*. Thus Bracy Clark (1815, p. 46), writing of "The *Oestrus bovis*, or Gad-Fly" which from his coloured figures appears to be the true *Hypoderma bovis* Degeer, says: "This act [oviposition] appears to be attended with severe suffering or apprehension at least, which makes the cattle run wild and furious and gad or stray from the pastures; and hence the ancient epithet of Gad-fly. When yoked to the plough, the attack of this fly is attended with real danger, since they become perfectly uncontrollable, and will often run directly forwards through the hedges, or whatever obstructs their way. There is provided on this account, to many ploughs, a contrivance immediately to set them at liberty. When the cattle

* Lady Fenn (1797, p. 68) writes of *Tabanus bovinus*—"the Great Horse-fly"—"These flies are seen in summer to harass cattle, which are sometimes so molested by their stings that they go mad, agitate themselves, run down precipices, tear themselves against the stumps of trees."—H.O.

are attacked by this fly it is easily known by the extreme terror and agitation of the whole herd; the unfortunate object of the attack runs bellowing from among them to some distant part of the heath or the nearest water; the tail from the severity of the pain is held with a tremulous motion straight from the body, and the head and neck stretched out to the utmost; the rest from fear usually follow to the water, or disperse to different parts of the field. And such is the dread and apprehension in the cattle of this fly that I have seen one of them meet the herd when almost driven home and turn them back, regardless of the stones, sticks and noise of their drivers; nor could they be stopped till they reached their accustomed retreat in the water."

Metaxa (1816) writing of "*Oestrus bovis* L. : *Asilus* of the Romans : *Asillo*", makes the erroneous assertion that the females bore a hole with their ovipositor into the skin of their victims. It is also stated that the flies "in the warmest hours of the day dart upon the backs of the oxen, making a whistling noise the while. . . . The puncture made by this *Oestrus* is most painful, and the oxen on simply hearing it at a distance take to flight." For a reference to, and translation from Metaxa's work, the present writer is indebted to his friend, Mr. William North, M.A., of Sidney Sussex College, Cambridge.*

It is true that the warble-flies (the larvae of two species of which, *Hypoderma lineatum* Vill. and *H. bovis* Degeer are found in "warbles" or sacs beneath the skin of the backs of cattle, while those of a third British species, *H. diana* Brau. similarly infest red deer) are incapable of biting, and that the ovipositor is unable to pierce the skin, the eggs being merely attached to the skin of the victims. Yet, although absolute proof is wanting, and must under the circumstances of the case be extremely difficult to obtain, it is thought that the approach of a *Hypoderma* is terrifying to cattle, while modern observation shows that these animals, like horses, are indifferent to the attacks of *Tabanidae*. Thus the author was informed by the late Lt.-Col. Yerbury that cart-bullocks in Ceylon are in no way terrified by the attacks of horse-flies, and this statement is corroborated by Lt.-Col. Bingham for cart-bullocks in Burma. In Germany the author has seen horses in harness contentedly feeding from a nose-bag though attacked by several large *T. bovinus*, the bites of which, when the flies were disturbed, caused great drops of blood to roll down the horses' skins. Beyond a kick with the hind foot or a swish with the tail the horses appeared to take no notice of the flies, either when actually sucking blood or when flying round preparatory to settling. According to Col. Bingham elephants in Burma, though sorely pestered by horse-flies, which make them bleed in a moment, are equally unconcerned. Only when a bite is inflicted on a particularly sensitive spot will the elephant lift a hind foot, or give a swish with its tail.

* Compare also Moufet (1634, p. 62), referring to the Bot-fly under the name "*Asilus*": "It does not cling, nor suck blood, but merely pierces by means of the sting in its tail, and in order to attack horses flies in pursuit of them for a very long distance. By instinct horses fear this fly and shudder at its very touch, often striving with tail, feet and lips to drive away the bloodthirsty assailant. There are those who hold that this fly does not pierce by means of a sting, but affixes dung to the hairs of the horse by means of its tail, from which troublesome nits are generated." But he cautiously adds that it is better to reserve judgement on a matter so improbable.—H.O.

The following letter, received by the author many years ago from his friend Mr. Albert Piffard of Felden, Boxmoor, an excellent entomologist and an accurate observer, may appropriately be printed at this point.

"My reasons for supposing that Oestridae terrify cattle, and that Tabanidae do not, are founded upon the following easily observed facts. *Haematopota* quite commonly settles on horses in harness and sucks their blood, but even a nervous horse seldom becomes at all restive unless the fly attacks the belly or some very sensitive part, and even then I have never known of one becoming panic struck. I have repeatedly noticed *Tabanus bromius* on cows and killed it full of blood, but never saw a cow display alarm or irritation from its presence. Now Tabanidae fly quite noiselessly*; but *Hypoderma bovis*, as I was told by Dr. Capron, and *Gastrophilus equi*, as I know from hearing it, make an alarming sound a little like but much louder than that produced by *Sirex gigas* (The Great Tailed Wasp) when on the wing. I have many times seen cattle maddened by the gad-fly, and on one occasion I made a capture of an allied species under somewhat similar circumstances. I had noticed an old screw in a pasture plunging and capering like a colt, and on approaching perceived a fly circling round him with a terrible buzzing: I took it and it proved to be *Gastrophilus equi*.

"Many years ago a French peasant girl, then nursemaid to my children, used to amuse them and mystify the cowman by standing at the gate of the meadow and causing the cows to rush about with their tails cocked. On my inquiring how the little miracle was worked, she showed me that by making a hissing sound scarcely audible to me a few paces off, she alarmed the cattle at, I think, quite one hundred yards distance. This, at least, shows that the sound is sufficient to cause the panic, and I have never seen the effect produced by the bite of a *Tabanus*.

"I should imagine that the trick of hissing for the fly must be a very ancient one, and that the passage in Isaiah, Chapter VII, verses 18, 19—'And it shall come to pass, in that day, that the Lord shall hiss for the fly that is in the uttermost part of the rivers of Egypt, and for the bee that is in the land of Assyria'—refers to this. Possibly the 'fly' and 'bee' alluded to may be *Hypoderma bovis* and *Gastrophilus equi* respectively; the latter, as you know, is not very unlike a bee."†

Theobald (1904, pp. 127, 130), writing of *H. lineatum* Vill., and *H. bovis* De G., says: "The flies, by frightening stock when on the wing, and on the lookout for a host on which to deposit their eggs, frequently cause loss among 'in-calf' cows by making them stampede about the fields. . . . They produce a low audible hum, which causes the animals to stampede and seek shelter."

Colonel Yerbury, who devoted himself for many years to the collection and

* This is an error as regards the larger species such as *Tabanus sudeticus* and *T. bovinus*, which make a deep hum when on the wing.—E. E. A.

† Mr. Piffard's statements are confirmed by a Cheshire farmer, Mr. C. Alcock of Castle Hill, Ringway. Mr. Alcock stated in conversation (July 1939) that cattle are not affected by the presence of horse-flies, but that the noise of the warble-fly causes them to "gad"; he further stated that he had sometimes amused himself by imitating the buzz of the warble-fly and thereby causing "gadding".—F. W. Edwards.

study of Diptera, was inclined to believe that no particular fly is responsible for the gadding of the cattle, but that the animals, when worried by *Simulium* and *Culicoides*, get into a nervous state, and are readily driven into a panic by a sound such as the hum of a wasp. It must be pointed out that if cattle are really so alarmed by the circling round of a *Hypoderma* that they run wildly round in this way, their behaviour can only be due to one of two reasons: either the hum of the *Hypoderma* must in itself be particularly terrifying to cattle, or they must recognise the fly and instinctively associate it with the pain and discomfort subsequently caused by the warbles on their backs. The latter hypothesis, however, is scarcely tenable, since cause and effect are not directly consecutive. In any case, further observations are desirable for the purpose of clearing up this interesting question, and communications from readers of this work who are able to throw any light upon the subject are cordially invited. Possibly, in the end, it will be found that the gadding of cattle is not due to flies at all, but is the result of an innate impulse of the cattle themselves, and that the phenomenon is akin to the mad antics indulged in when approached, or towards sundown, by the uncouth-looking South African antelopes known as gnus (*Connochoetes*).

REFERENCES

- CLARK, BRACY. 1815. An Essay on the Bots of Horses and other Animals. London.
FENN, LADY. 1797. A Short History of Insects. Leverian Museum, Norwich.
METAXA, LUIGI. 1816. Delle Malattie Contagiose ed Epizootiche degle Animali Domestici 2, 134 *et seq.* Roma, Stamperia De Romani.
MOUFET, T. 1634. Insectorum sive minimorum animalium theatrum. Londini.
THEOBALD, F. V. 1904. Second Report on Economic Zoology. London, British Museum (Nat. Hist.).

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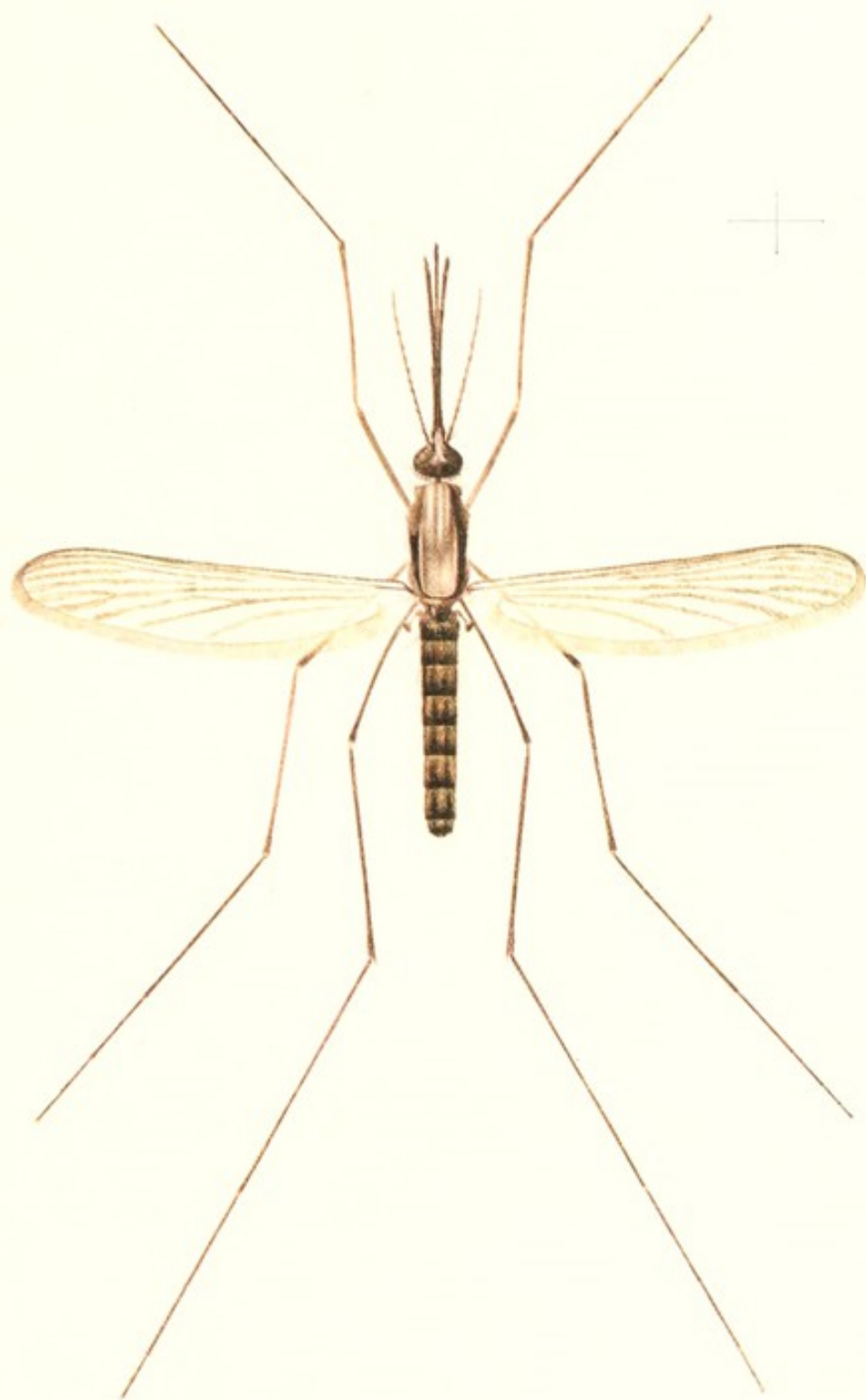
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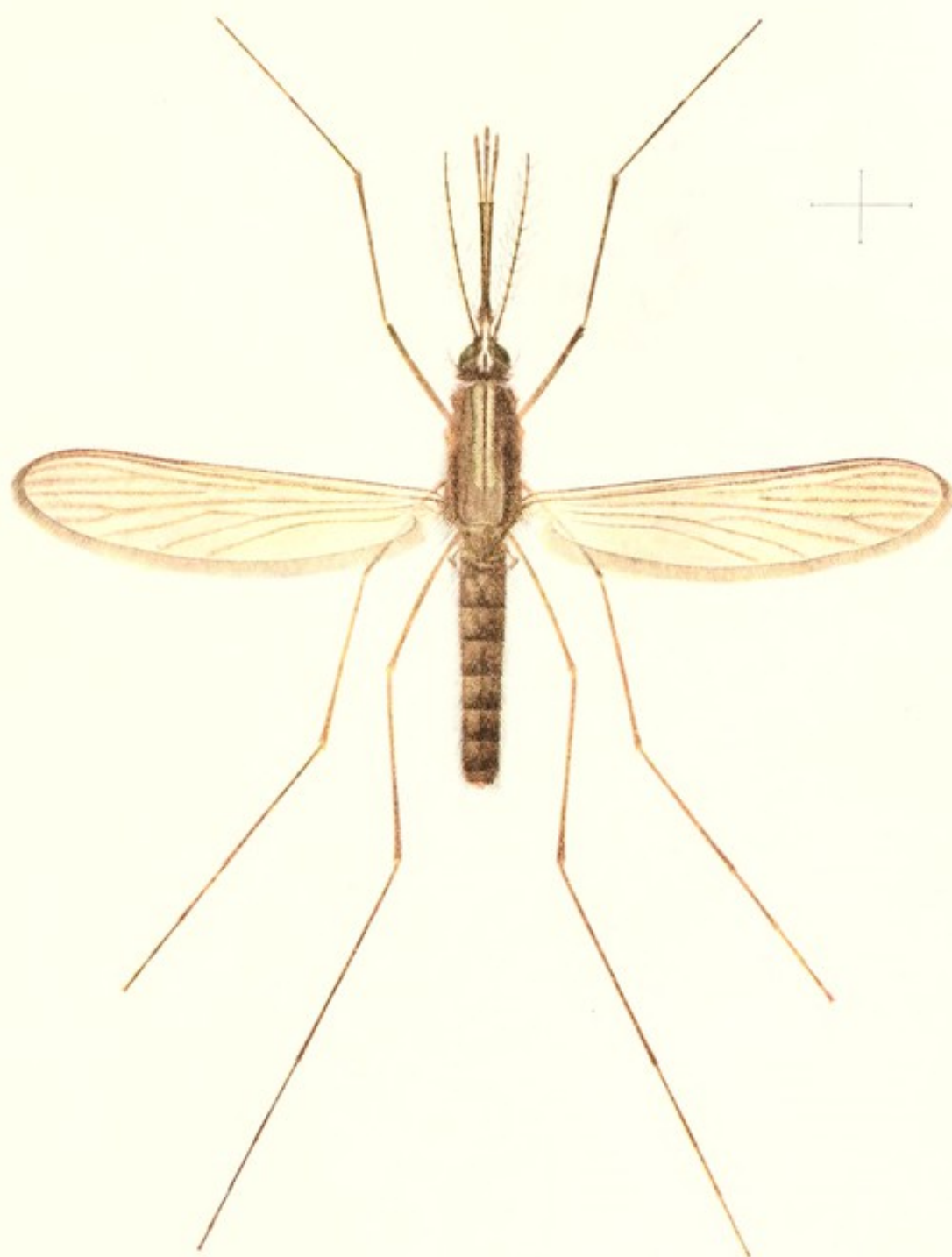
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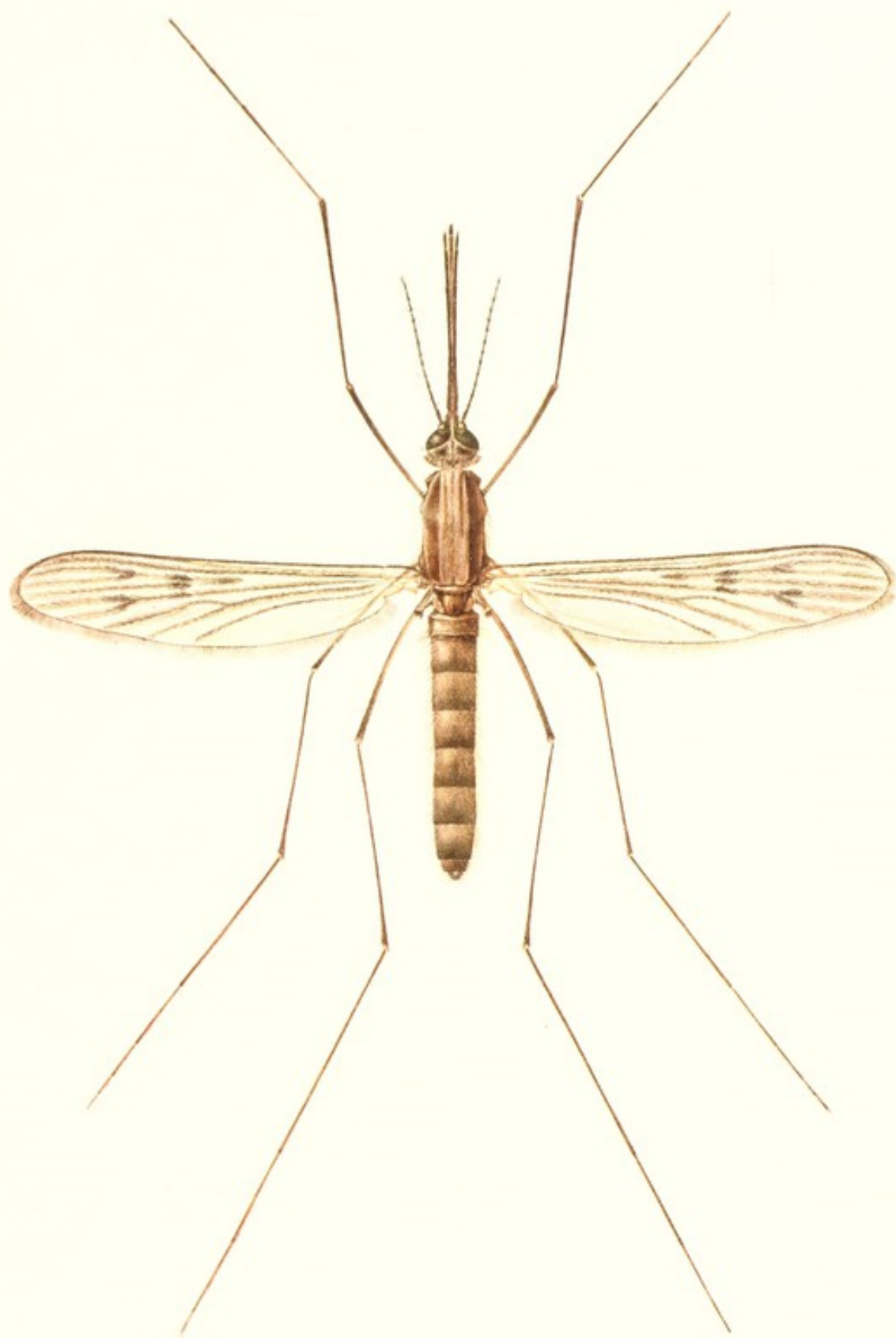




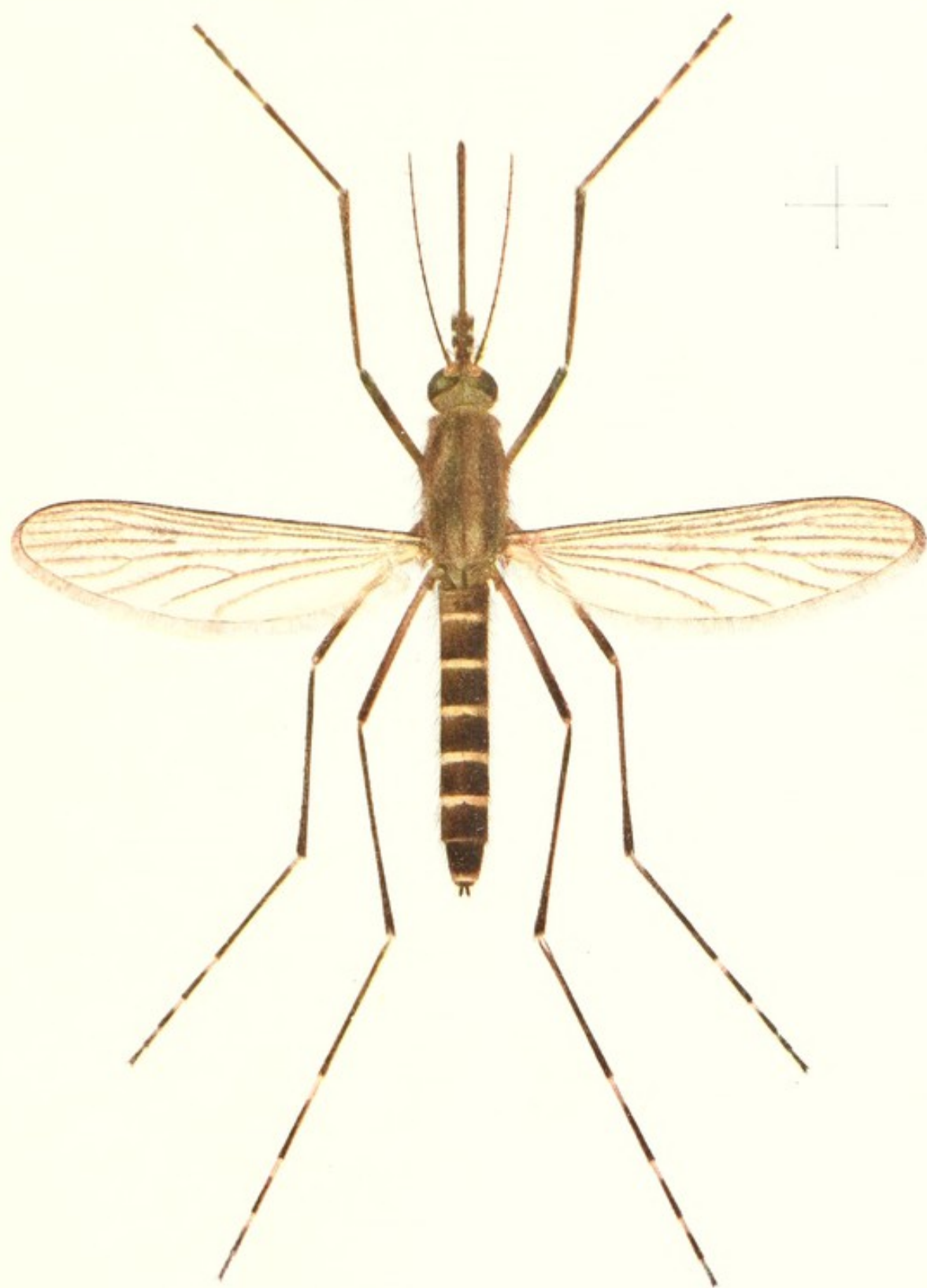
Anopheles plumbeus (Female)



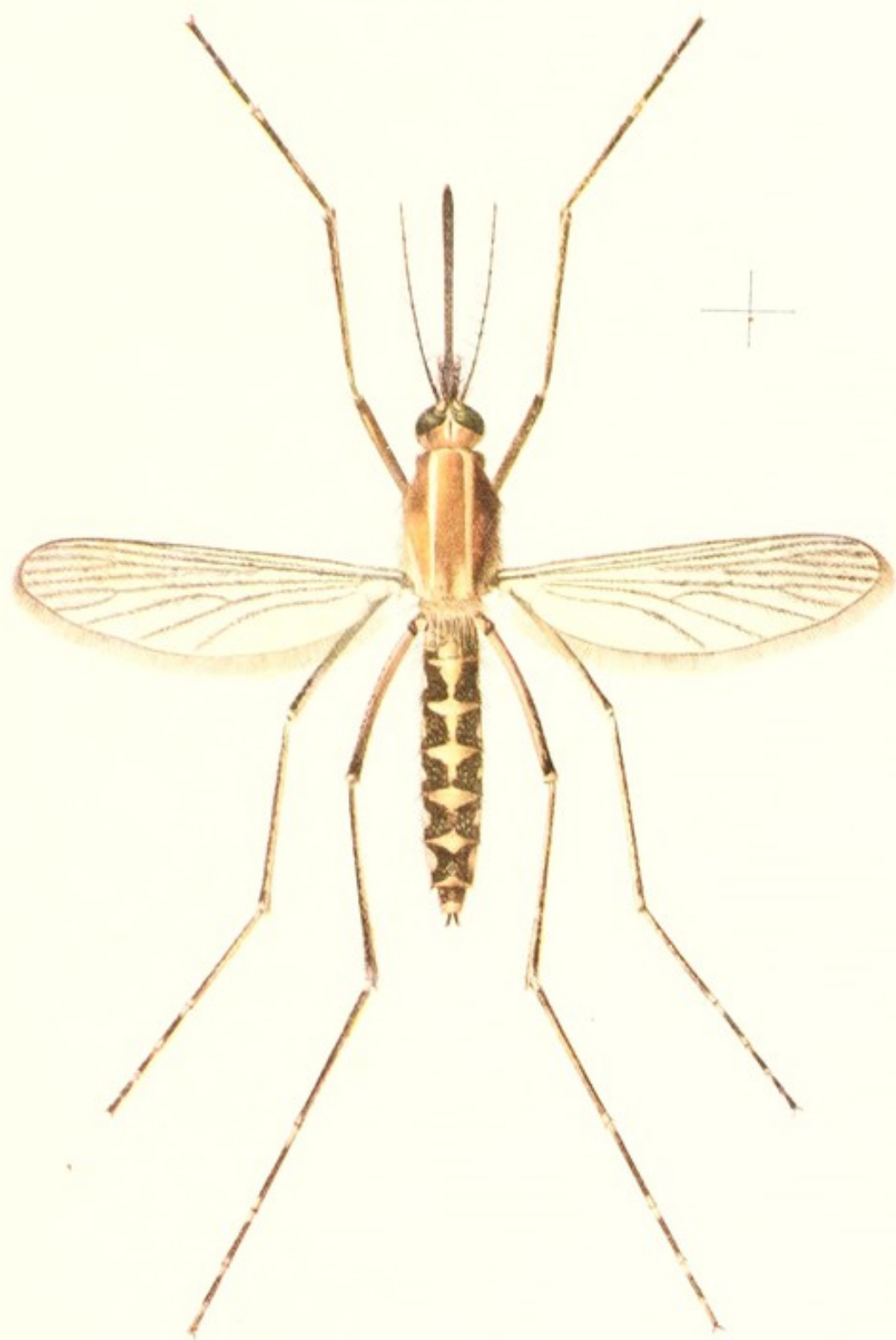
Anopheles claviger (Female)



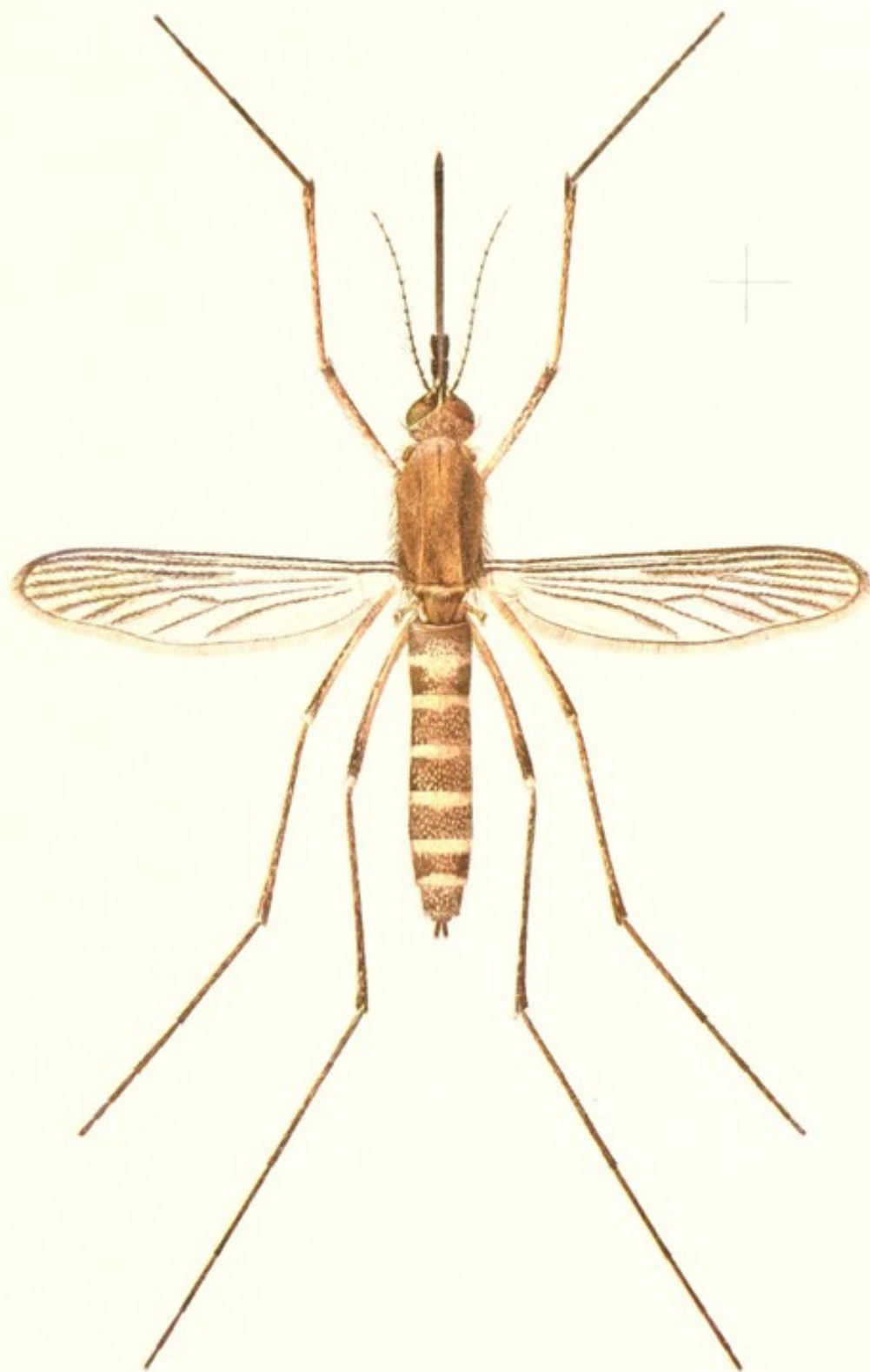
Anopheles maculipennis (Female)



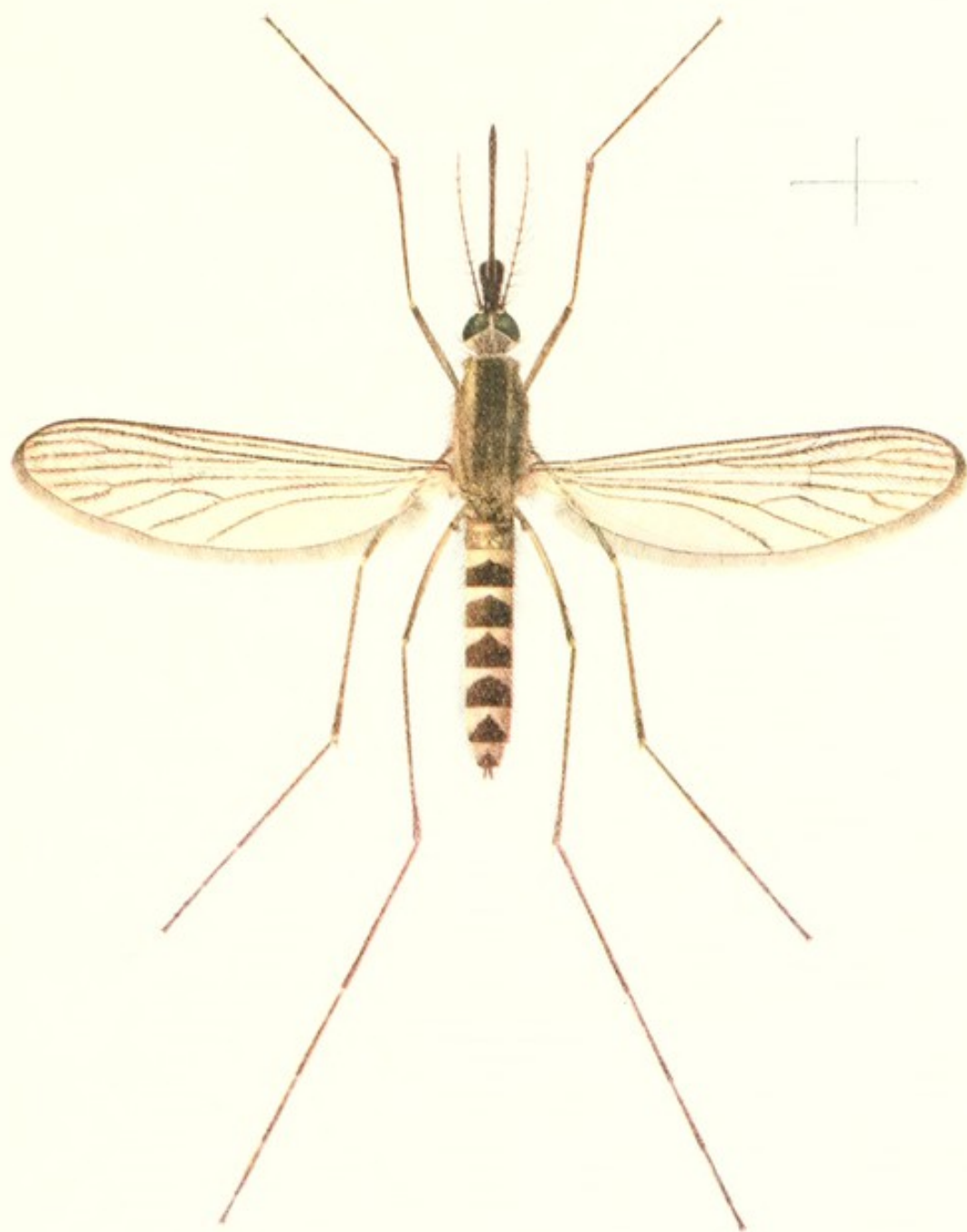
Aedes cantans (Female)



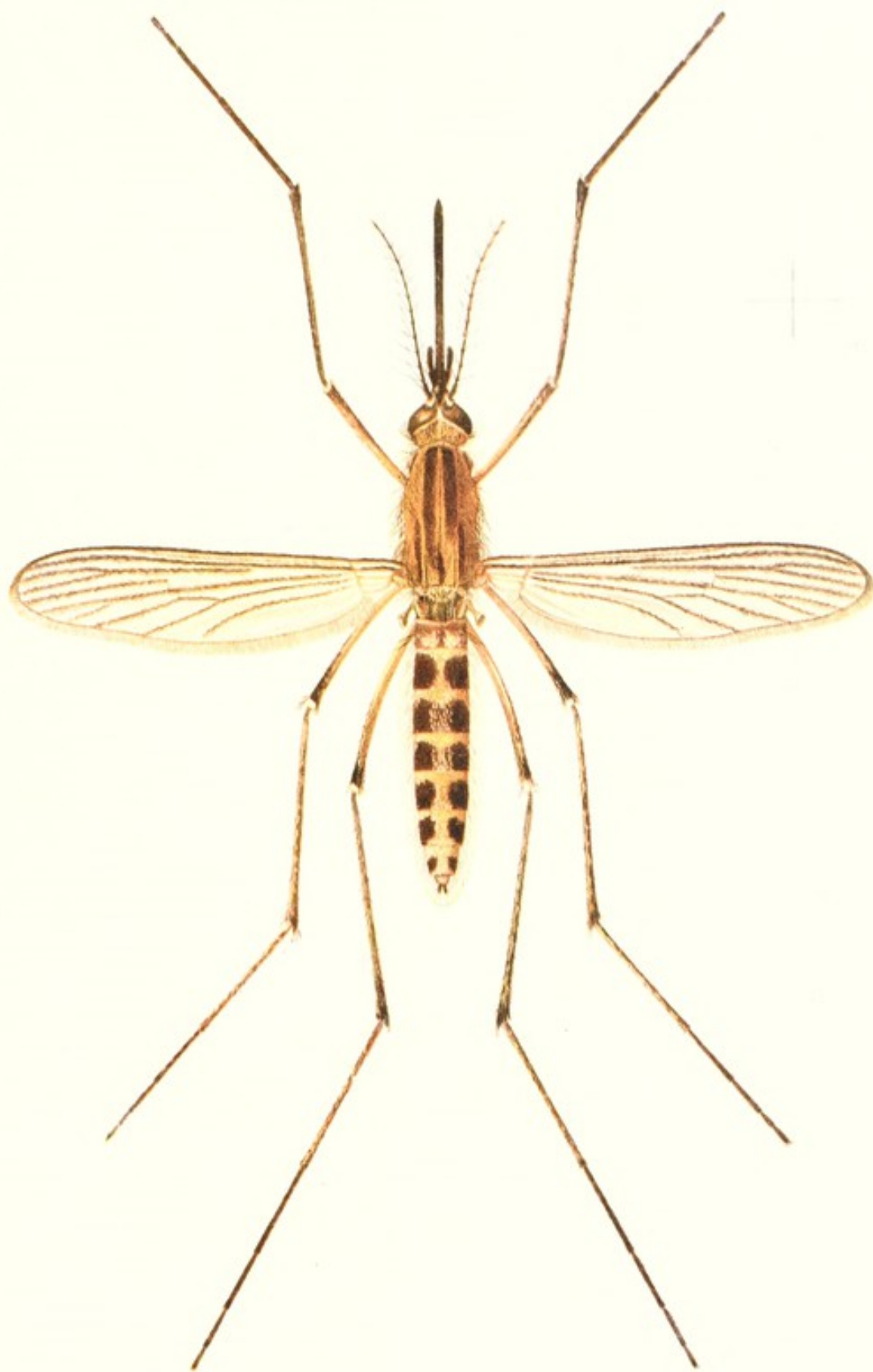
Aedes caspius (Female)



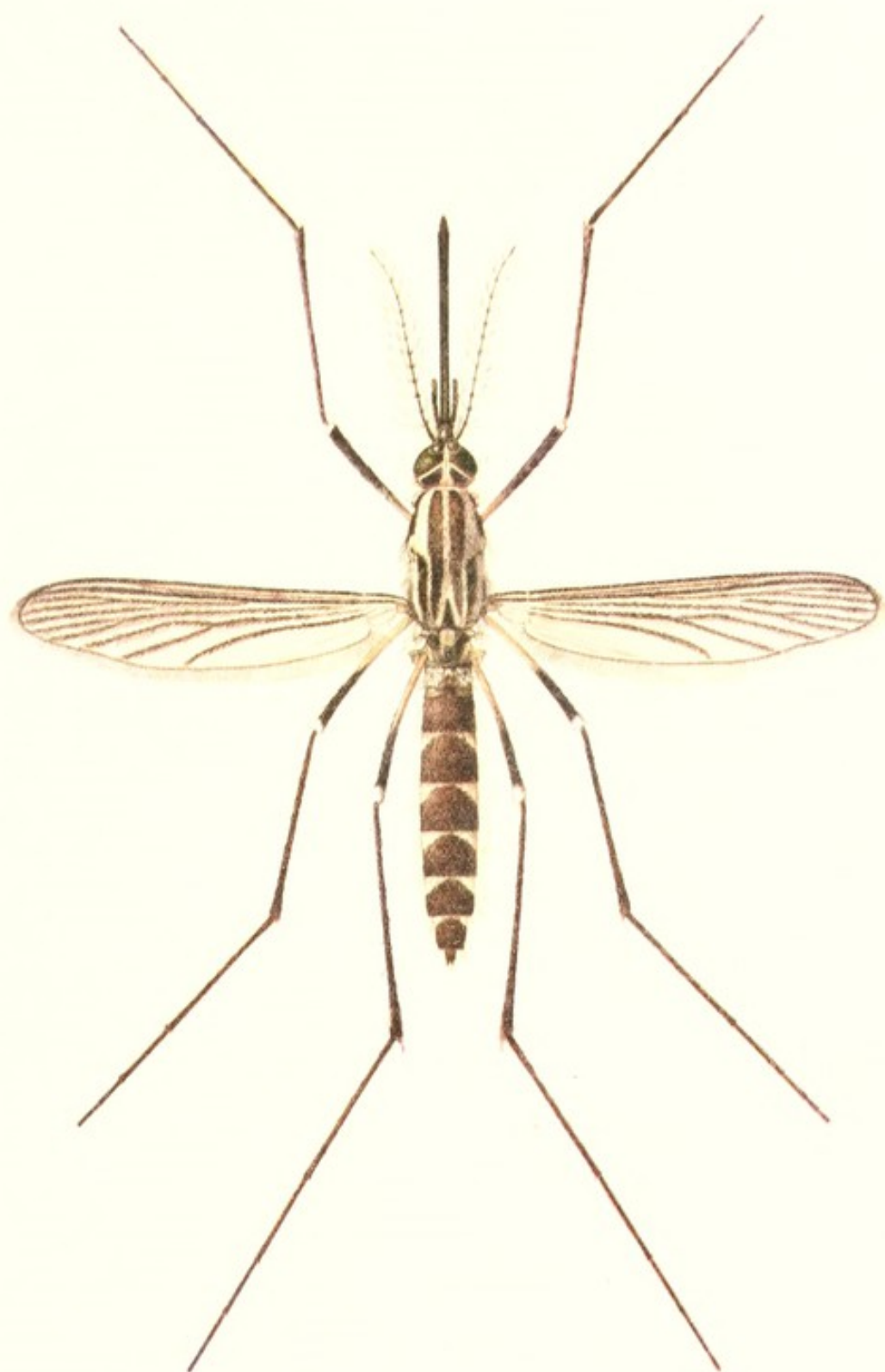
Aedes detritus (Female)



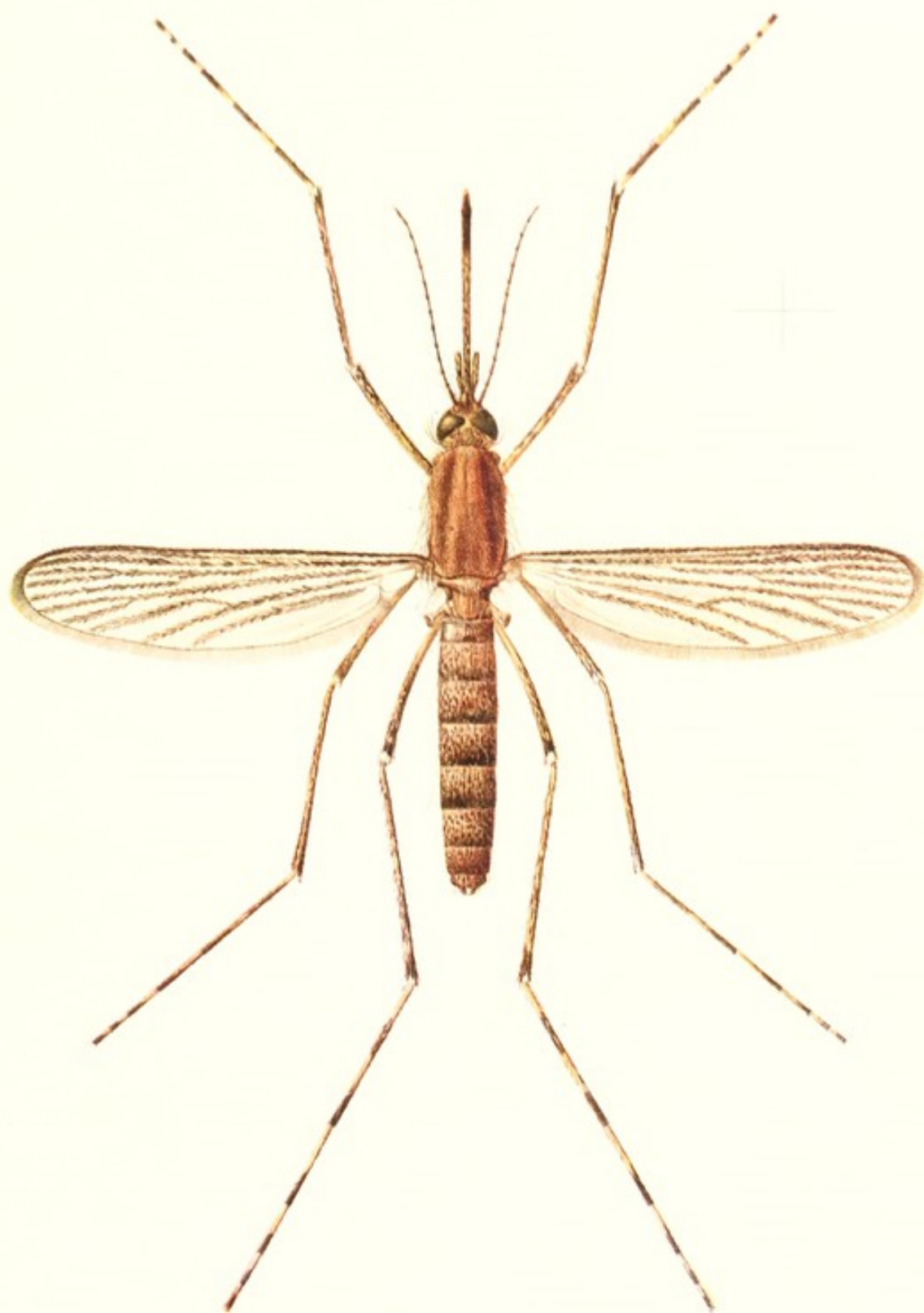
Aedes punctor (Female)



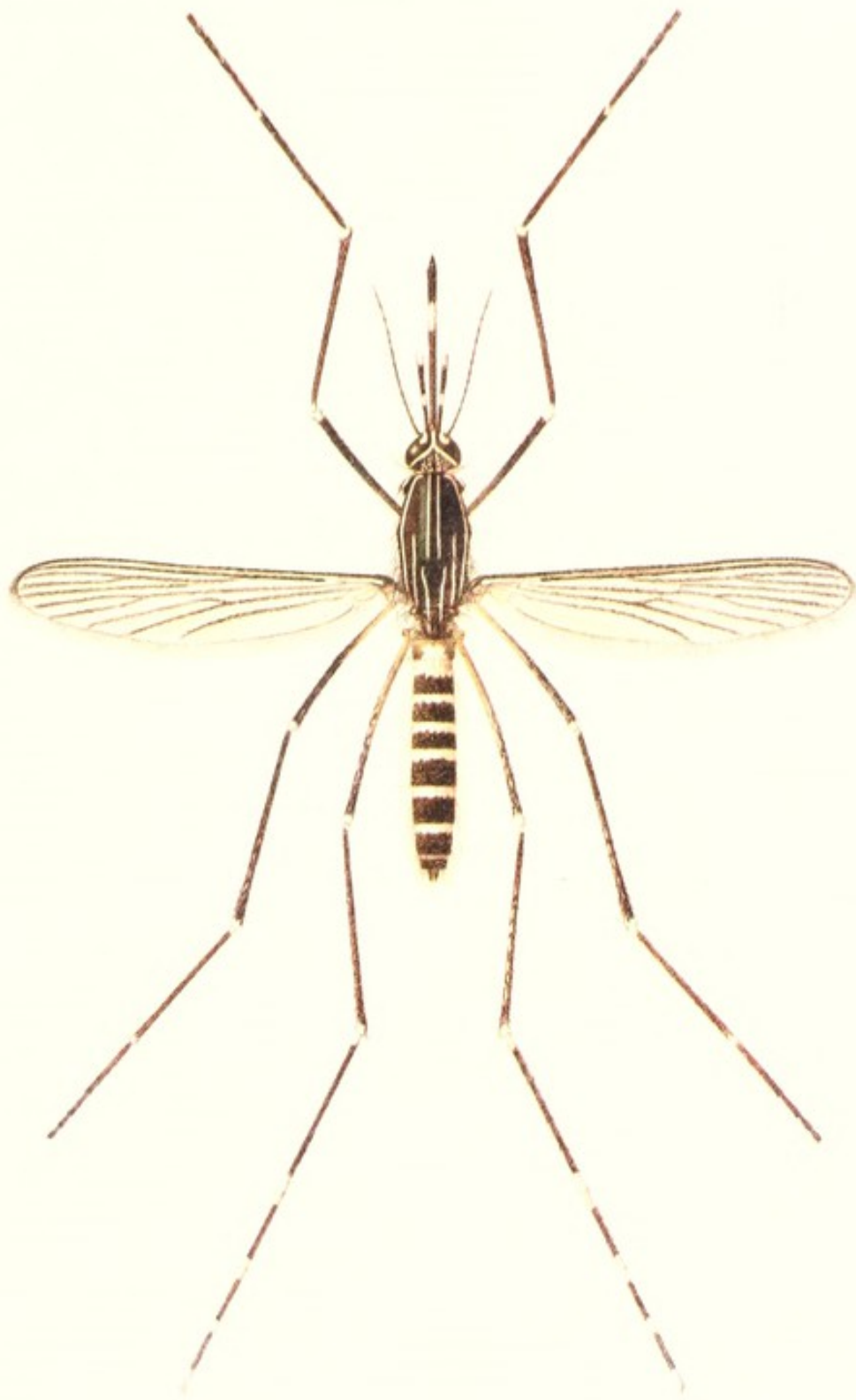
Aedes rusticus (Female)



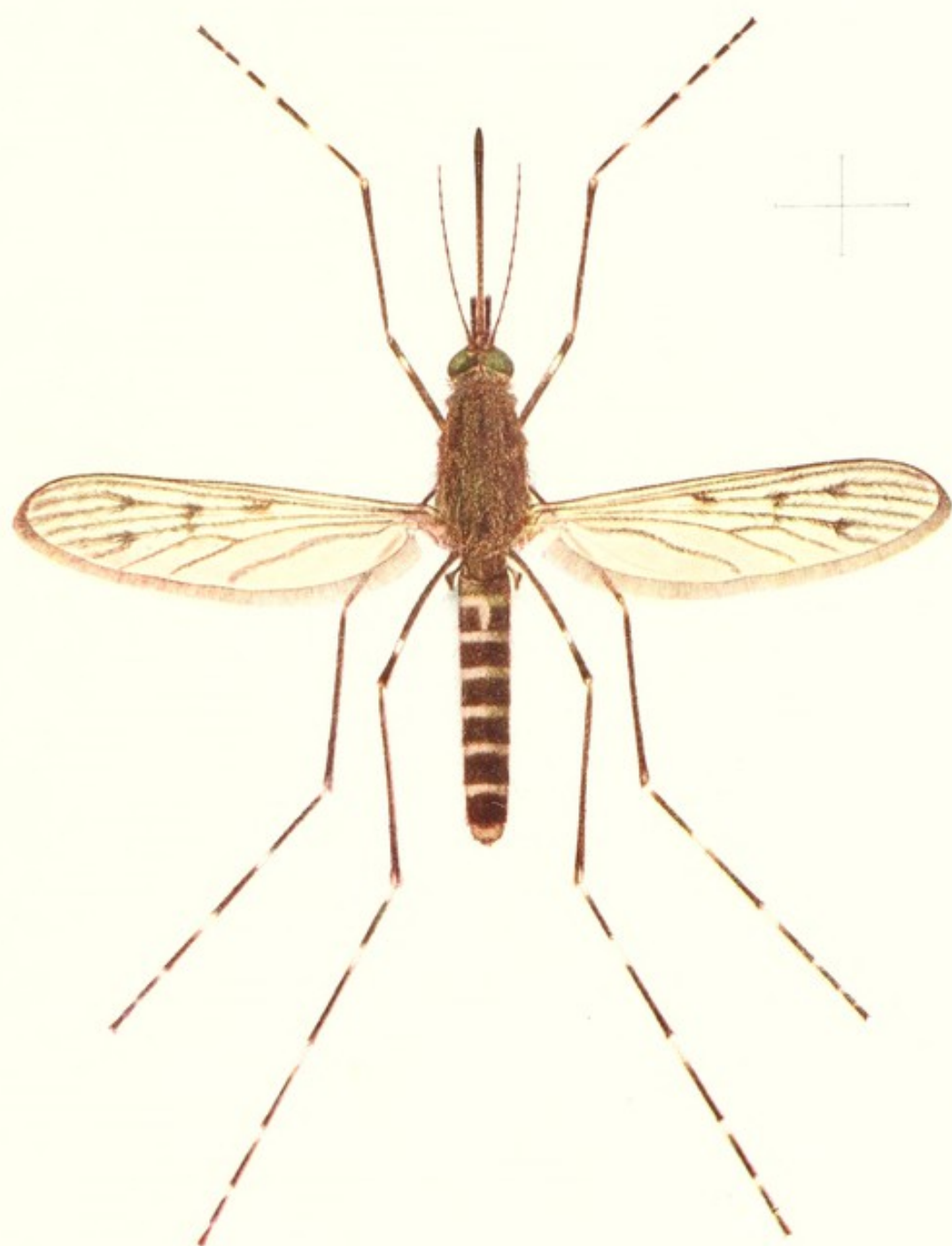
Aedes geniculatus (Female)



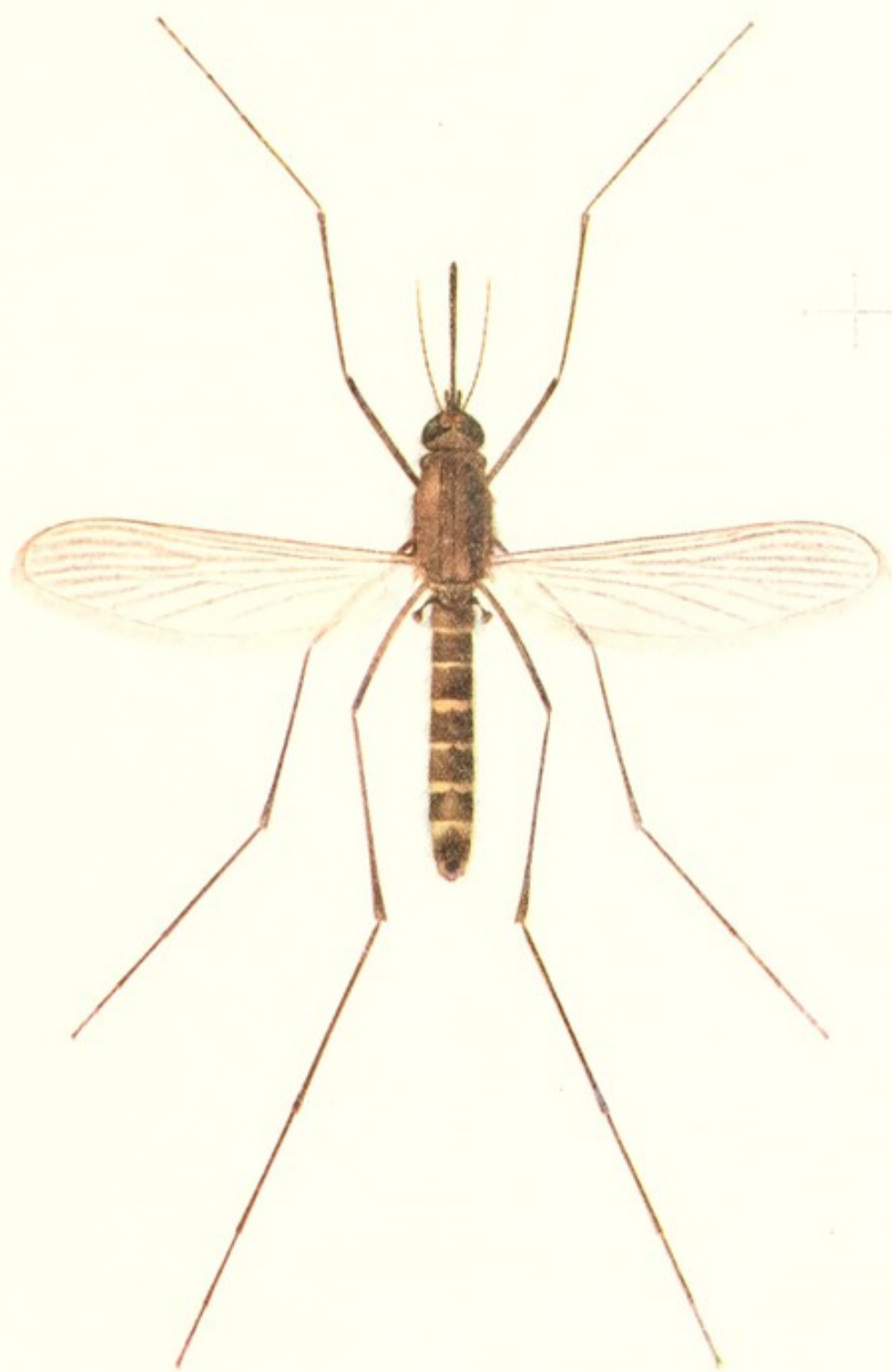
Taeniorhynchus richiardii (Female)



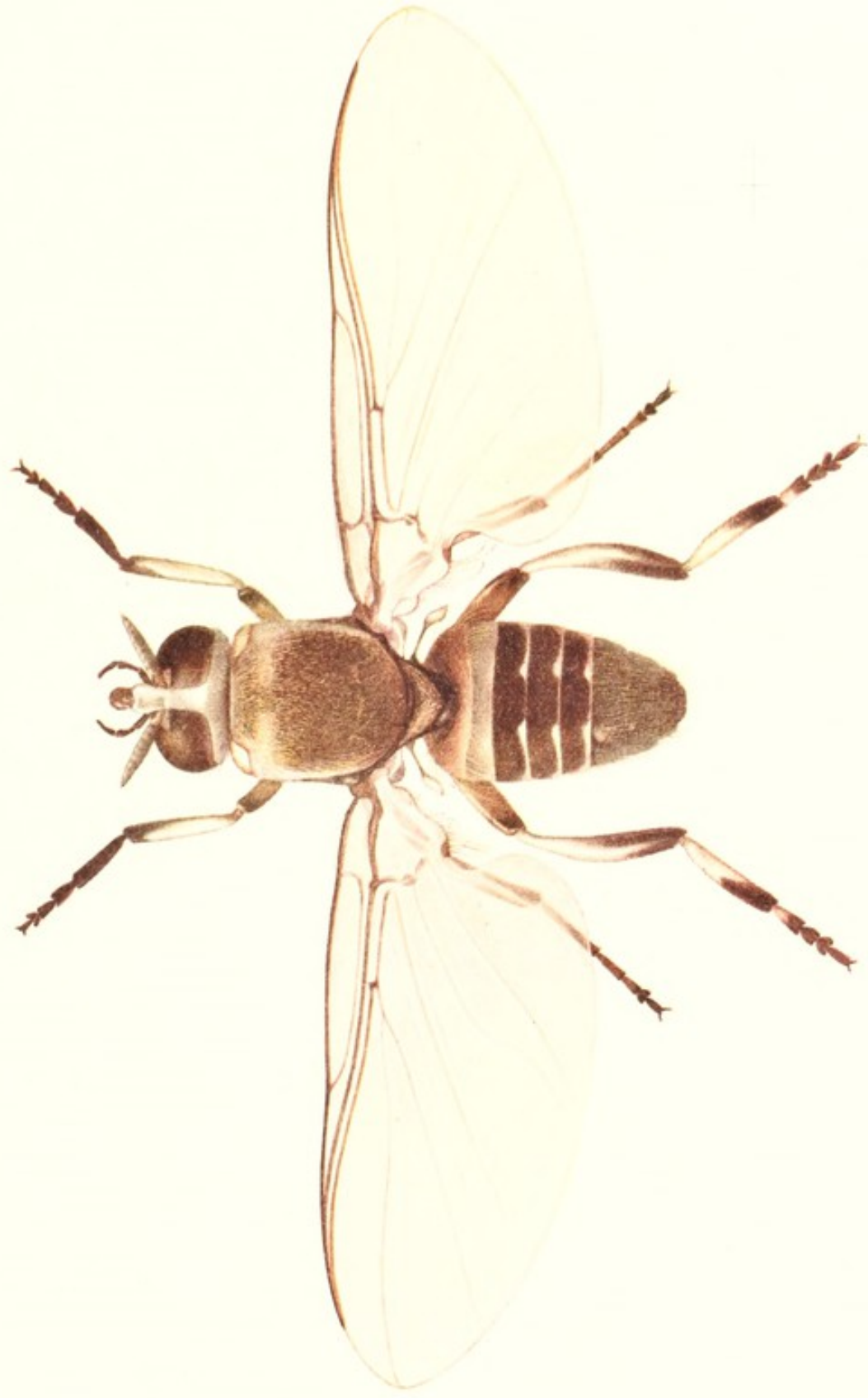
Orthopodomyia pulchripalpis (Female)



Theobaldia annulata (Female)



Culex pipiens (Female)



Simulium ornatum (Female)



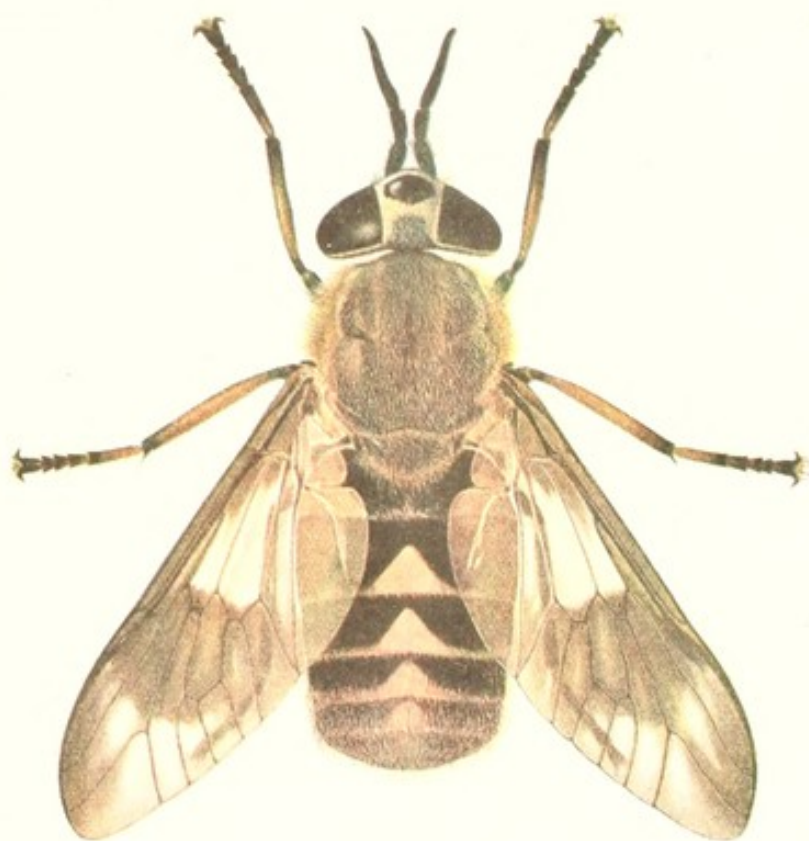
FIG. 1. *Chrysops caccutiens* (Male)



FIG. 2. *Chrysops caccutiens* (Female)



Chrysops quadrata (Female)



Chrysops relictus (Female)



Chrysops sepulchralis (Female)



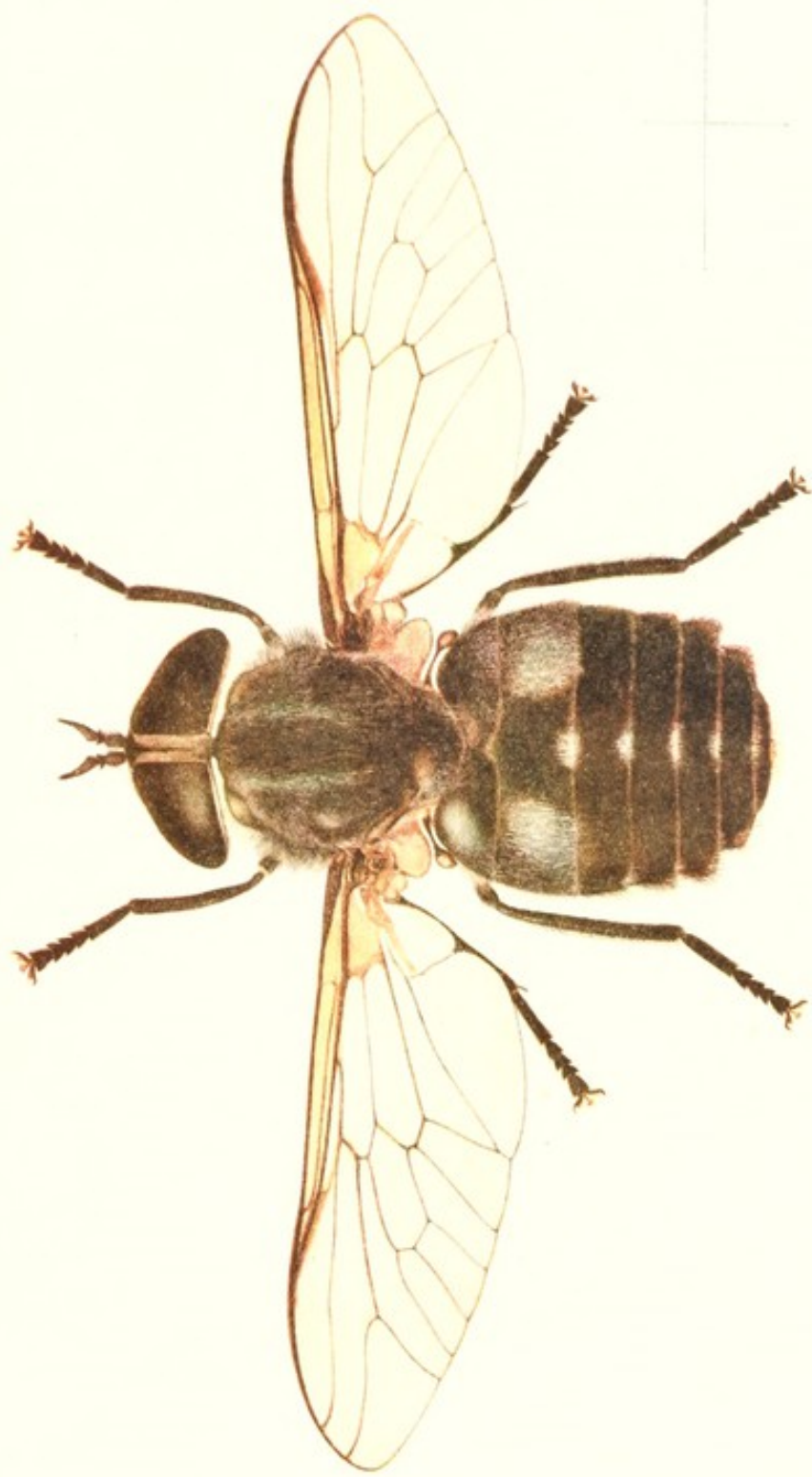
FIG. 1. *Haematopota pluvialis* (Male)



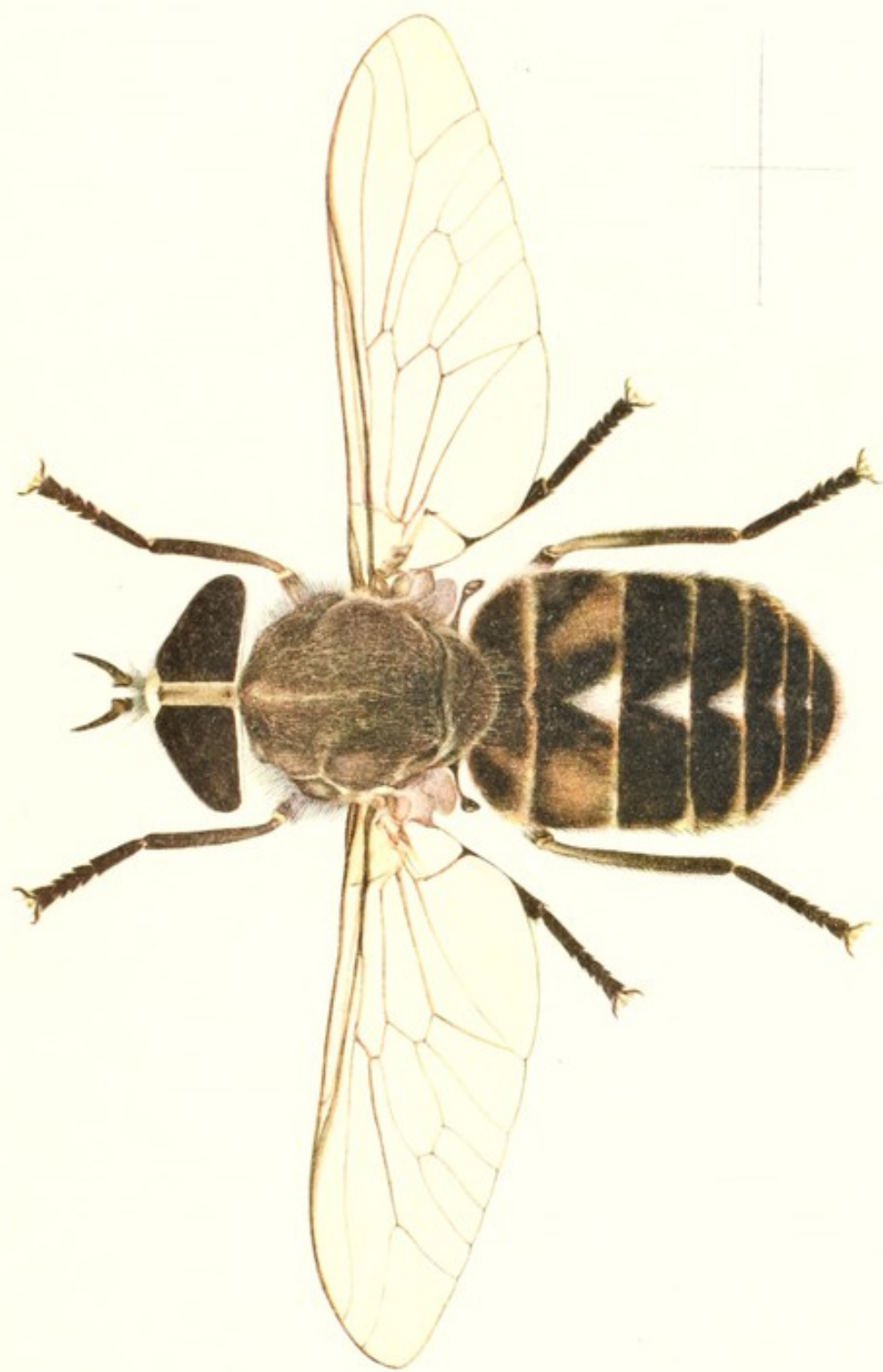
FIG. 2. *Haematopota pluvialis* (Female)



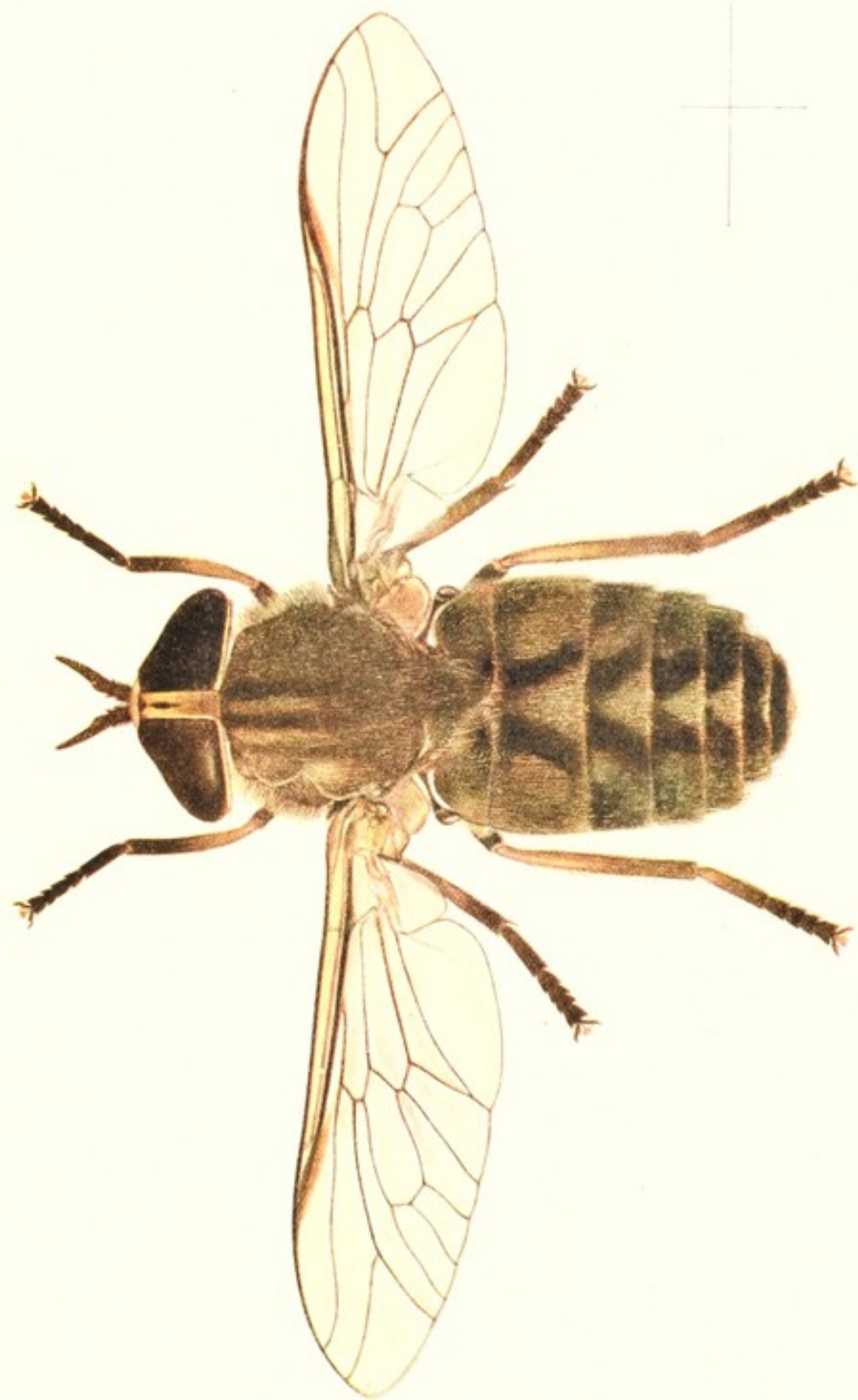
Haematopota crassicornis (Female)



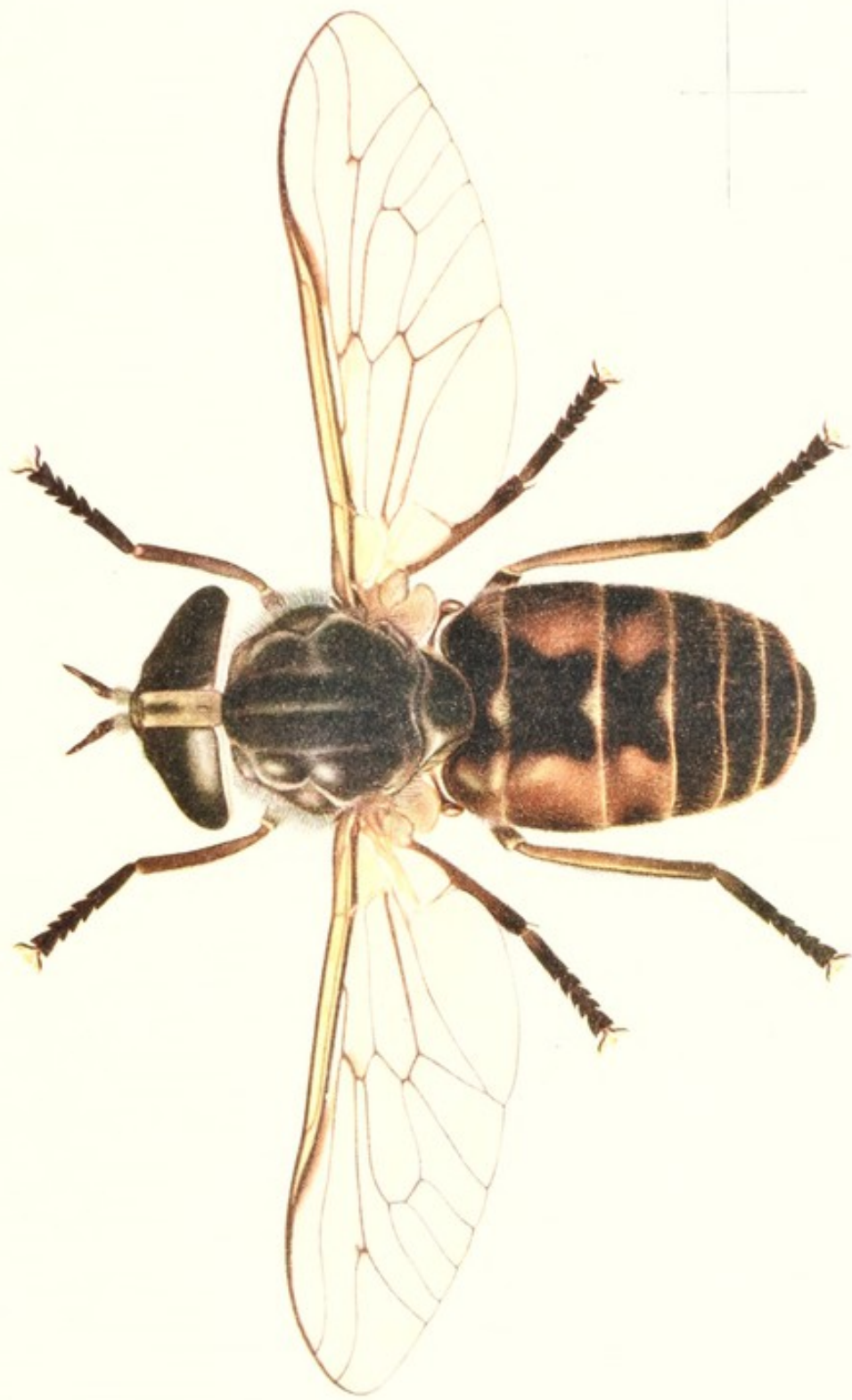
Tabanus micans (Female)



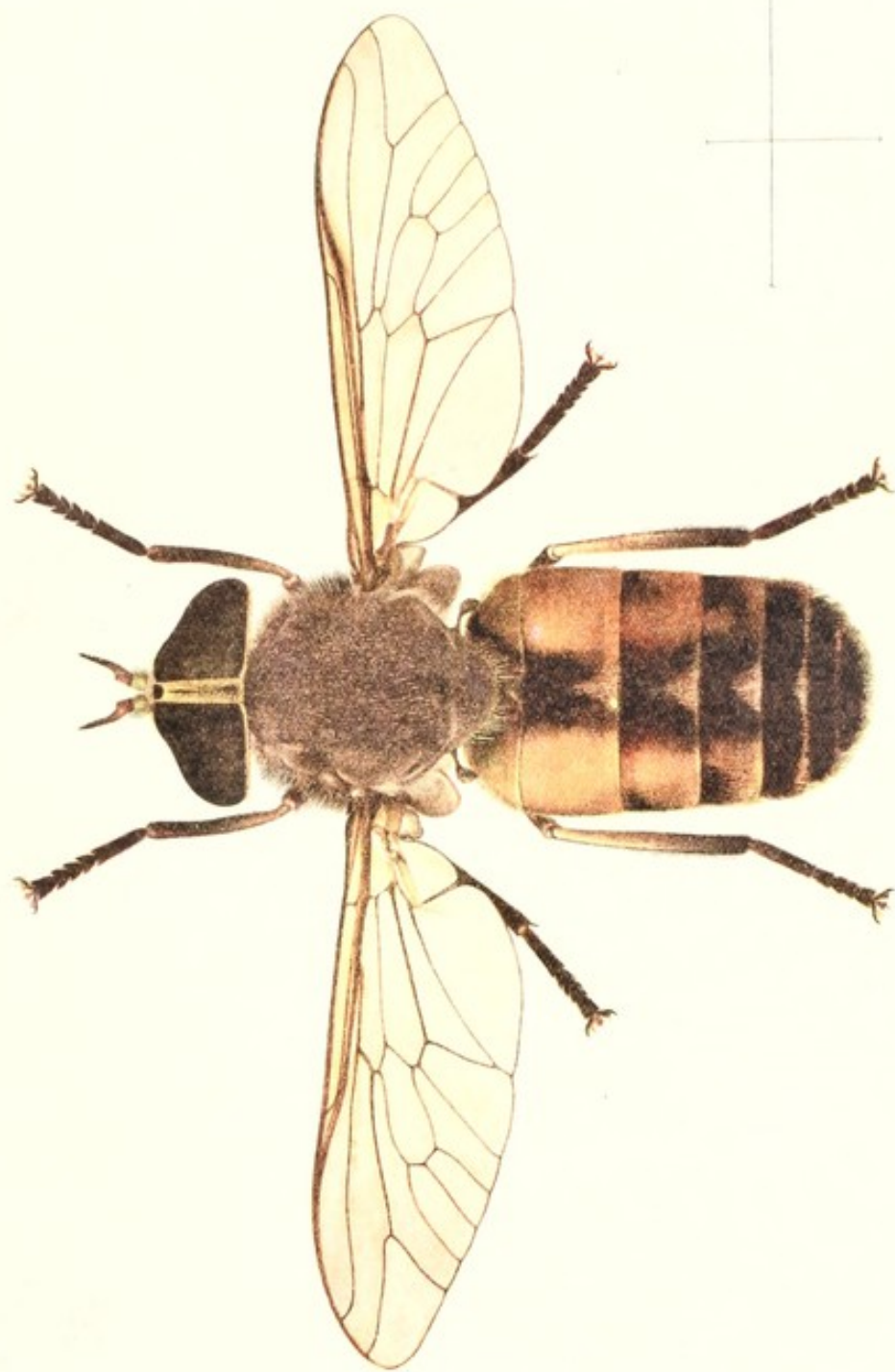
Tabanus ~~tropicus~~ bisignatus (Female)



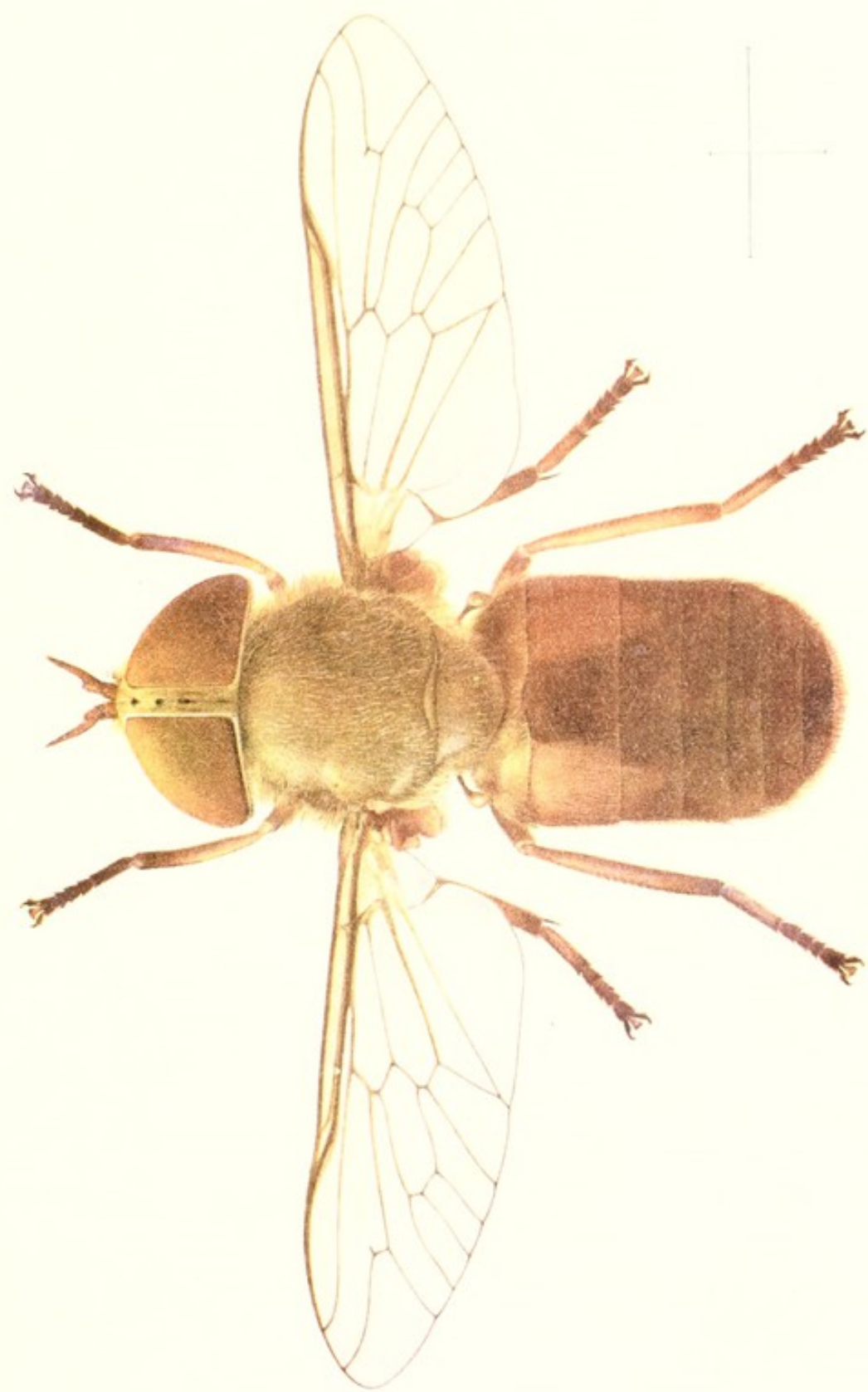
Tabanus montanus (Female)



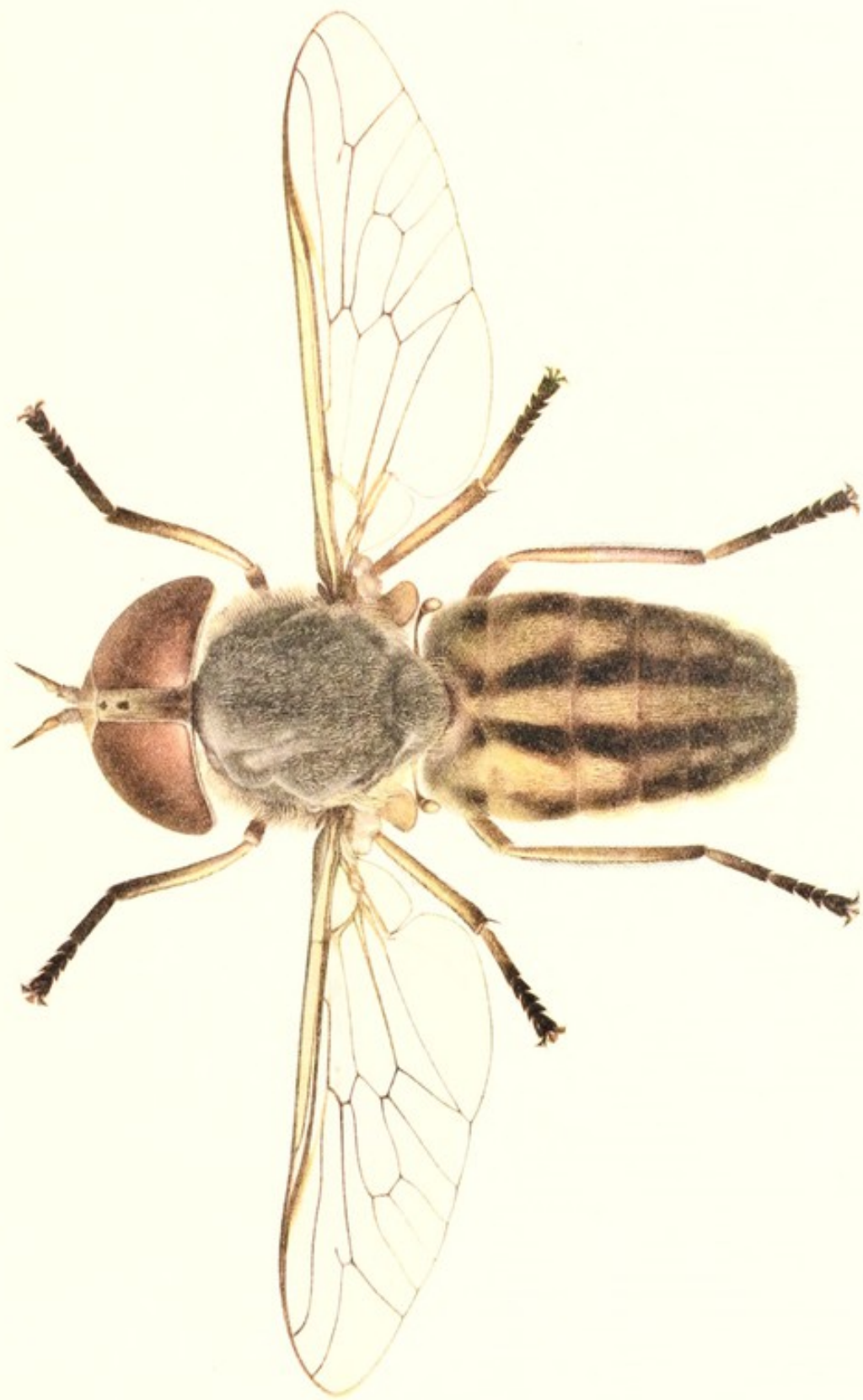
Tabanus luridus (Female)



distinguendus
Tabanus substriatus (Female)



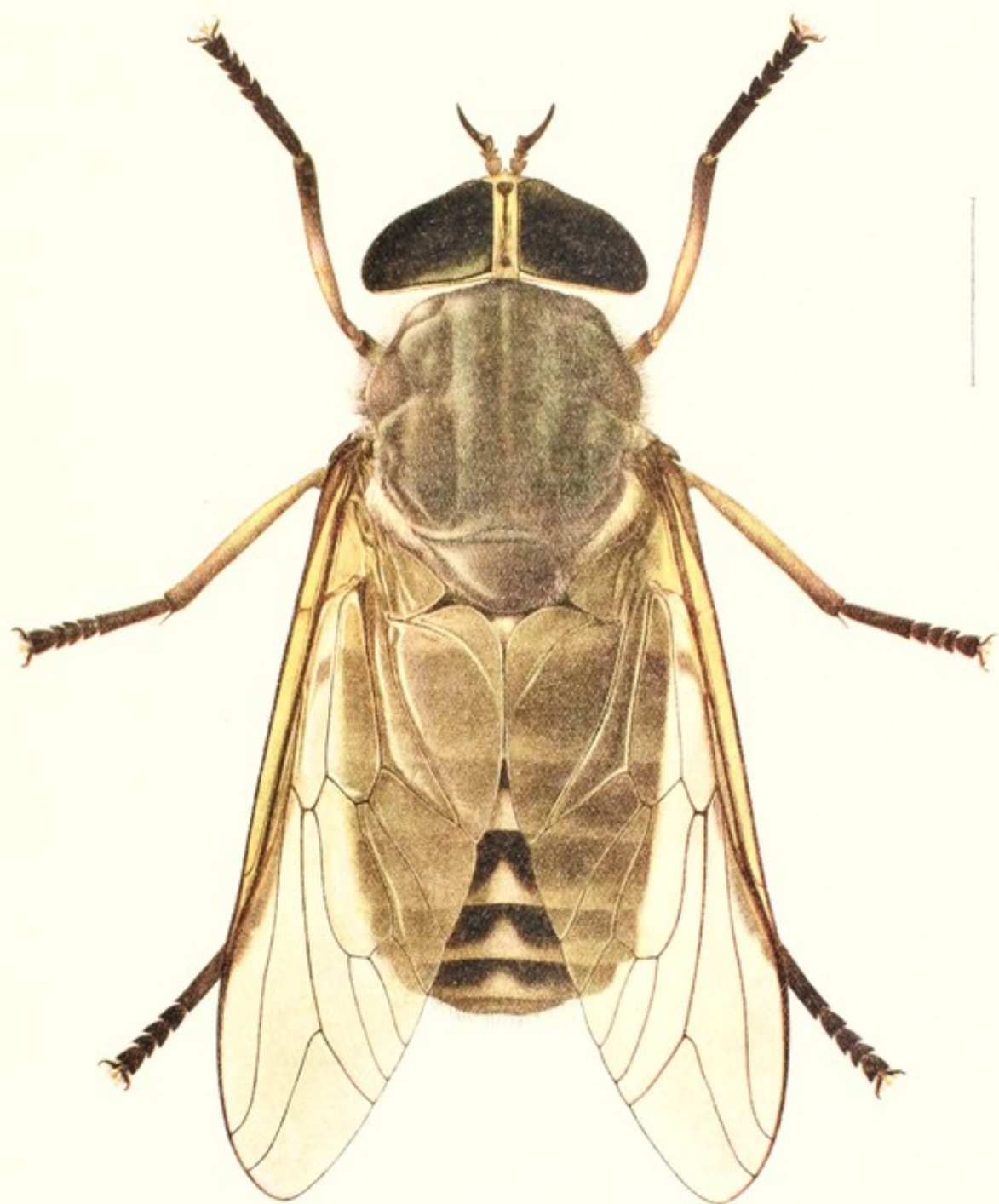
Tabanus fulvus (Female)



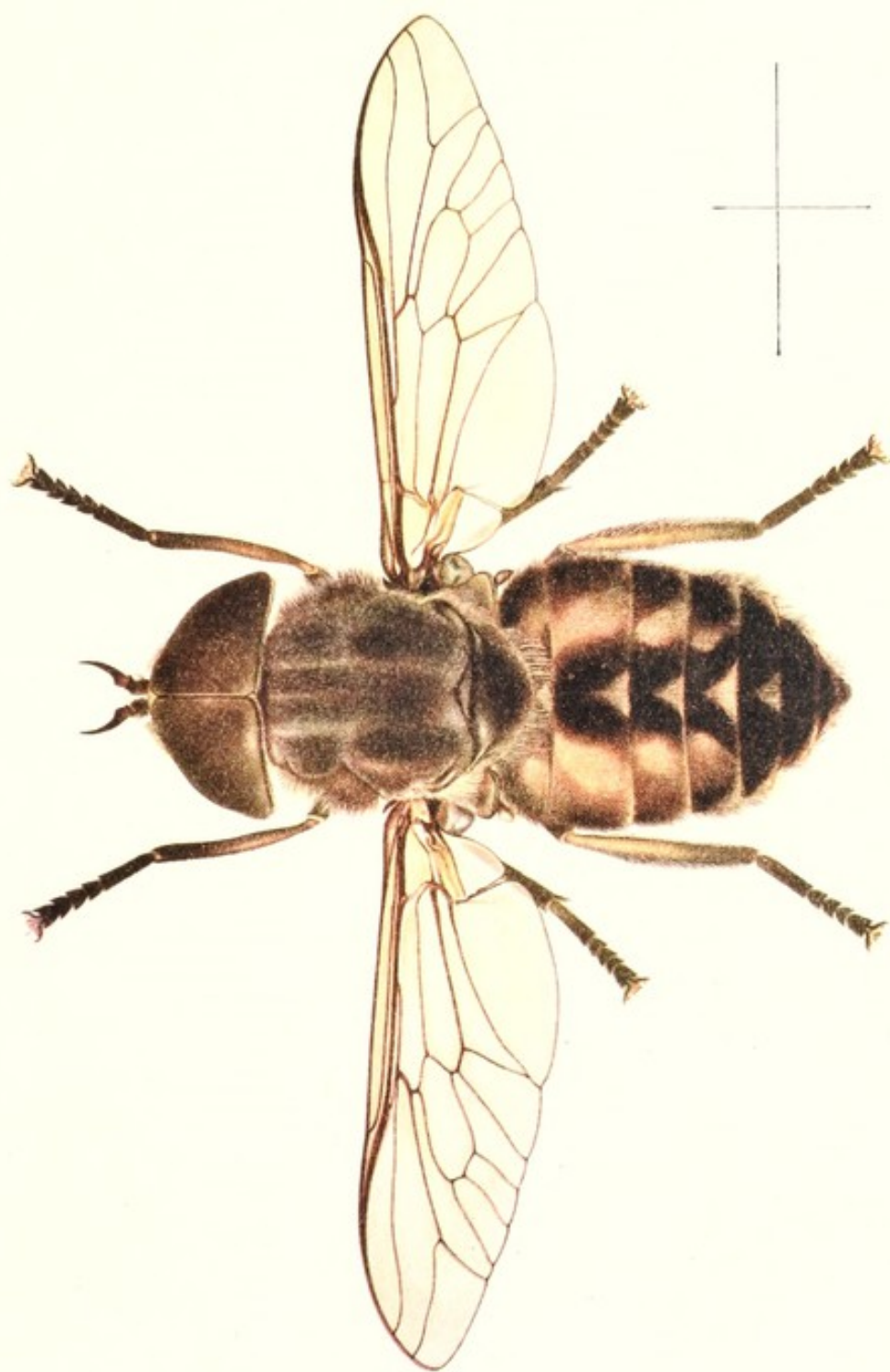
Tabanus nigrifacies (Female)



Tabanus ***verralli*** (Female)



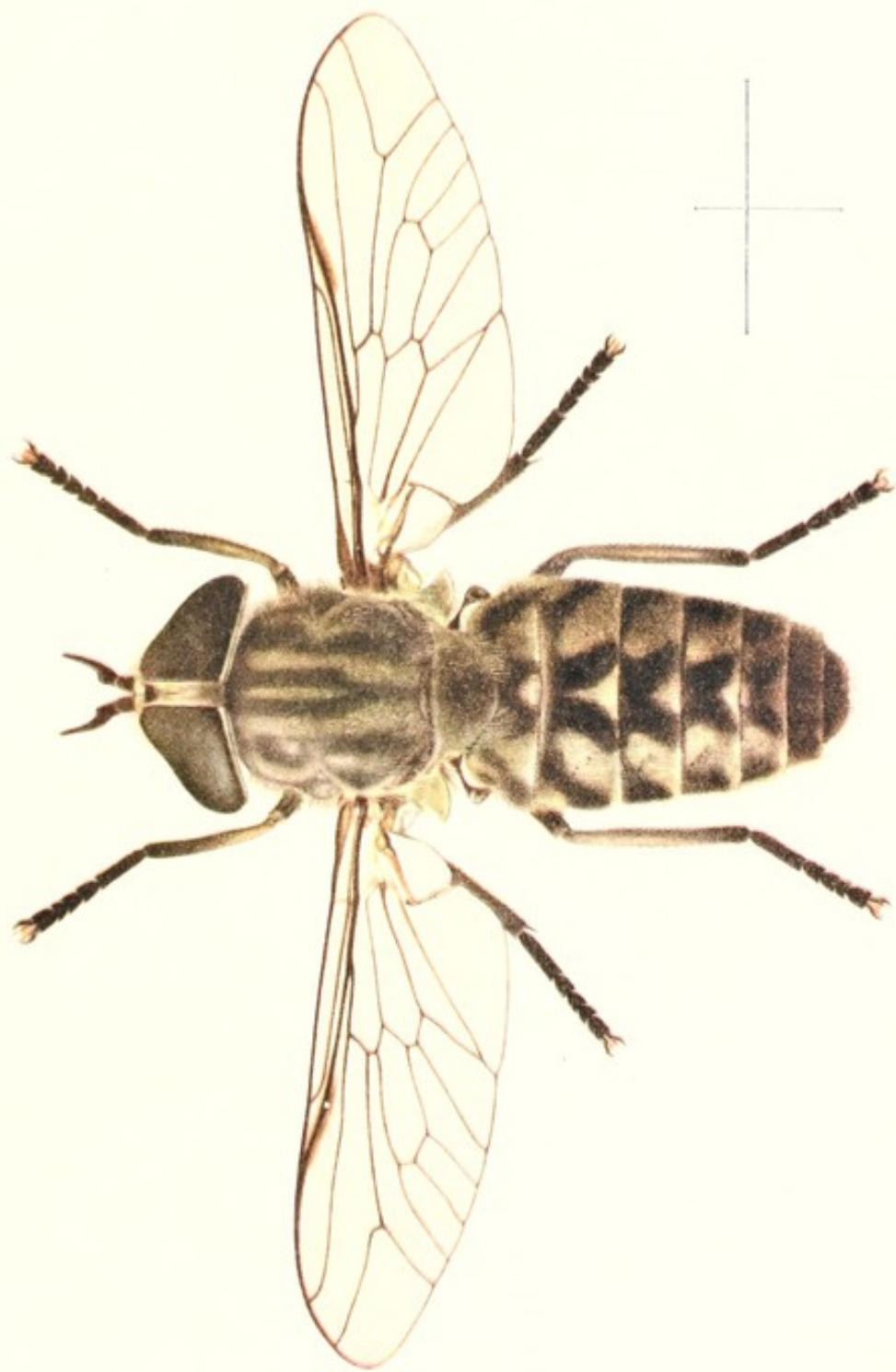
Tabanus sudeticus (Female)



Tabanus autumnalis (Male)



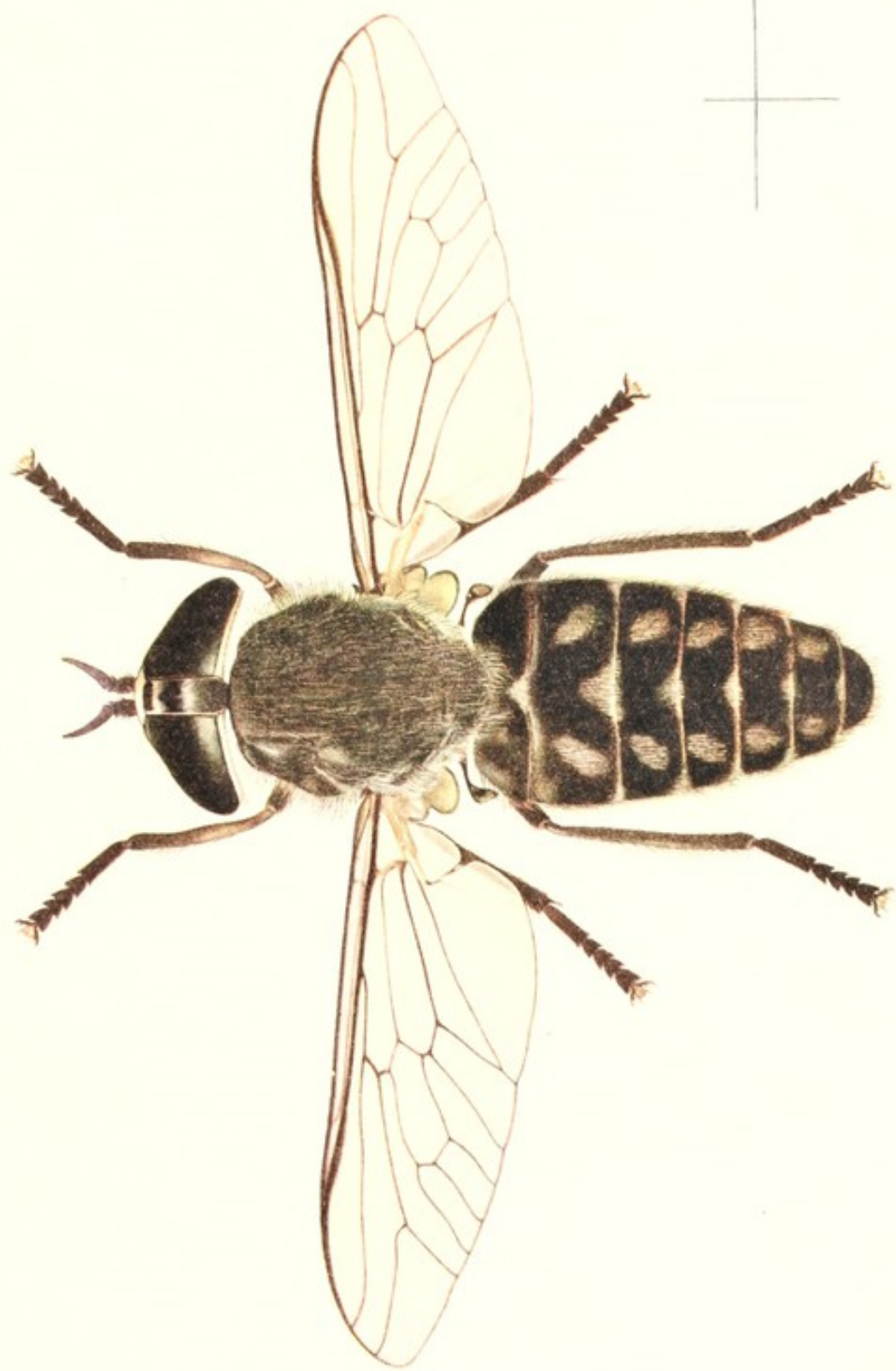
Tabanus autumnalis (Female)



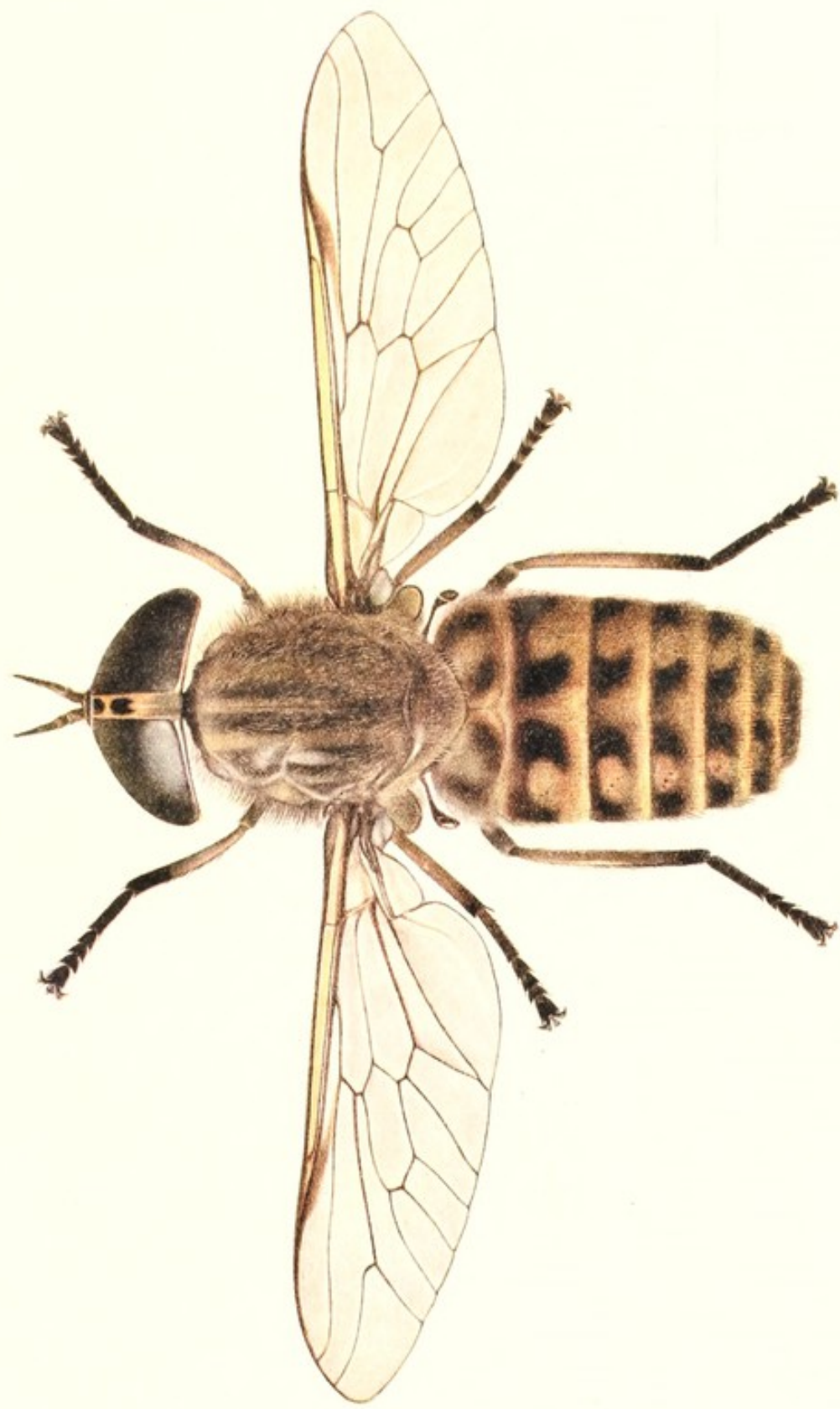
Tabanus bromius (Female)



Tabanus maculicornis (Female)



Tabanus cordiger (Female)



Tabanus glaucopsis (Female)



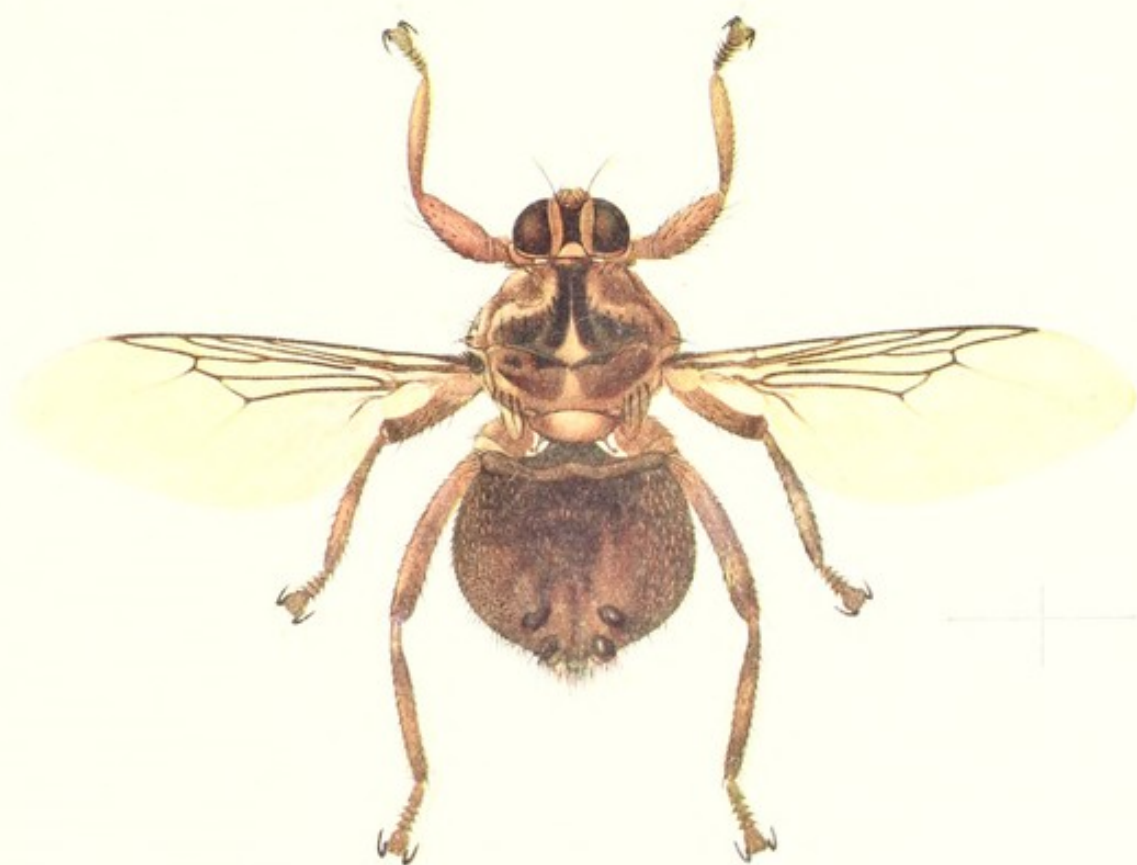
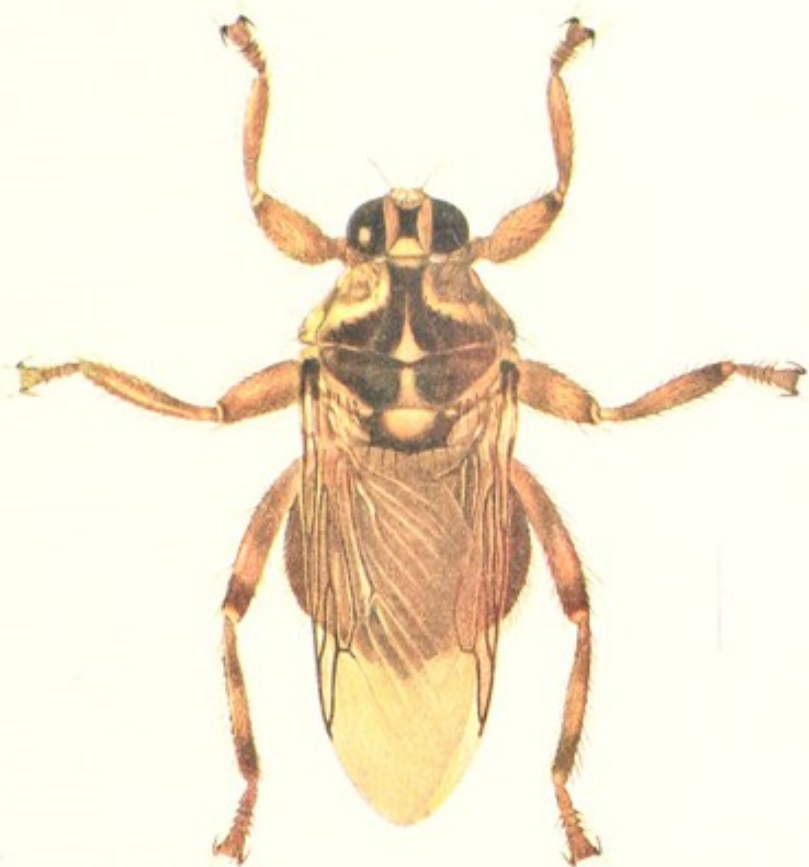
Stomoxys calcitrans (Female)



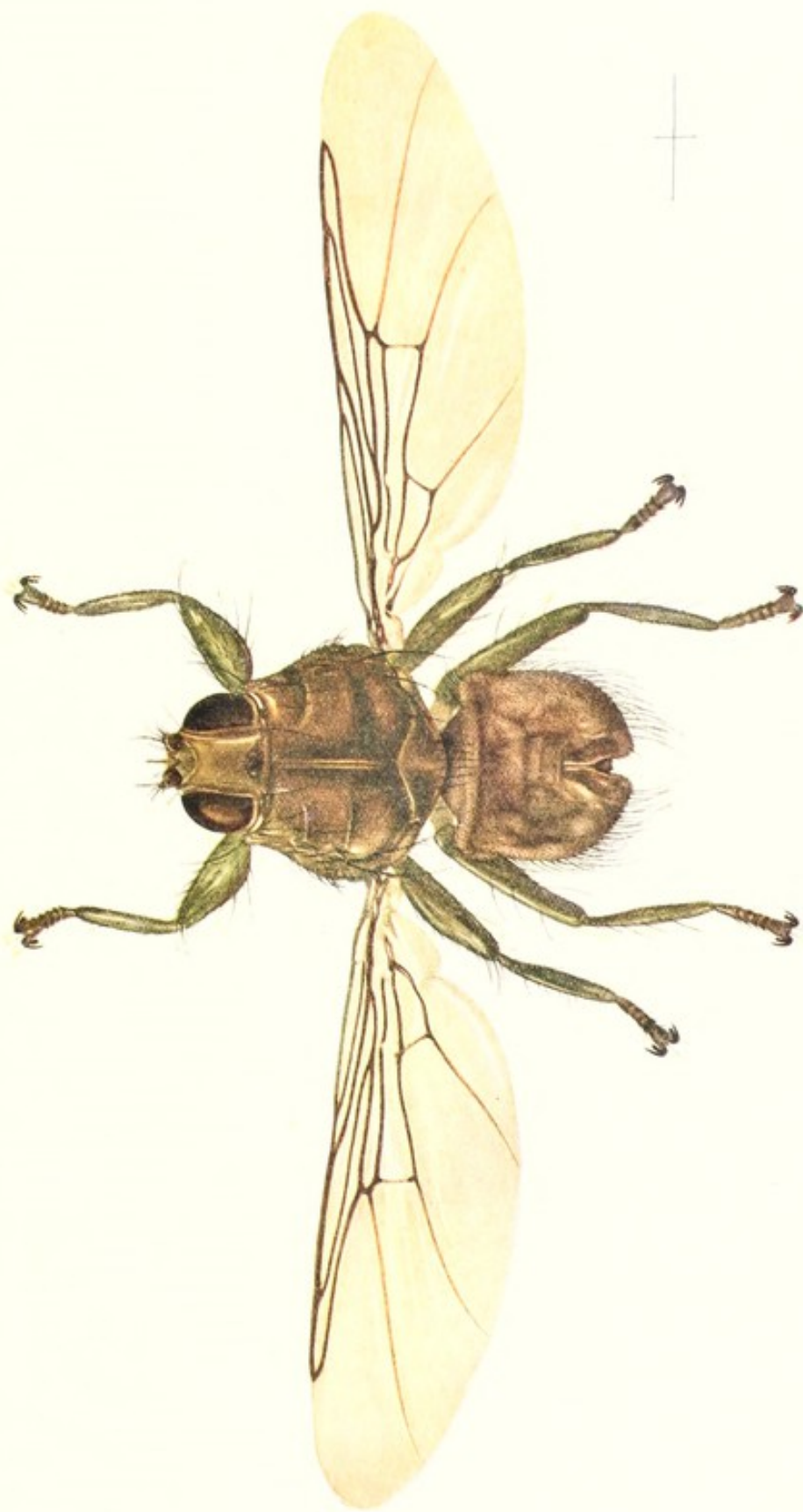
FIG. 1. *Haematobia stimulans* (Female)



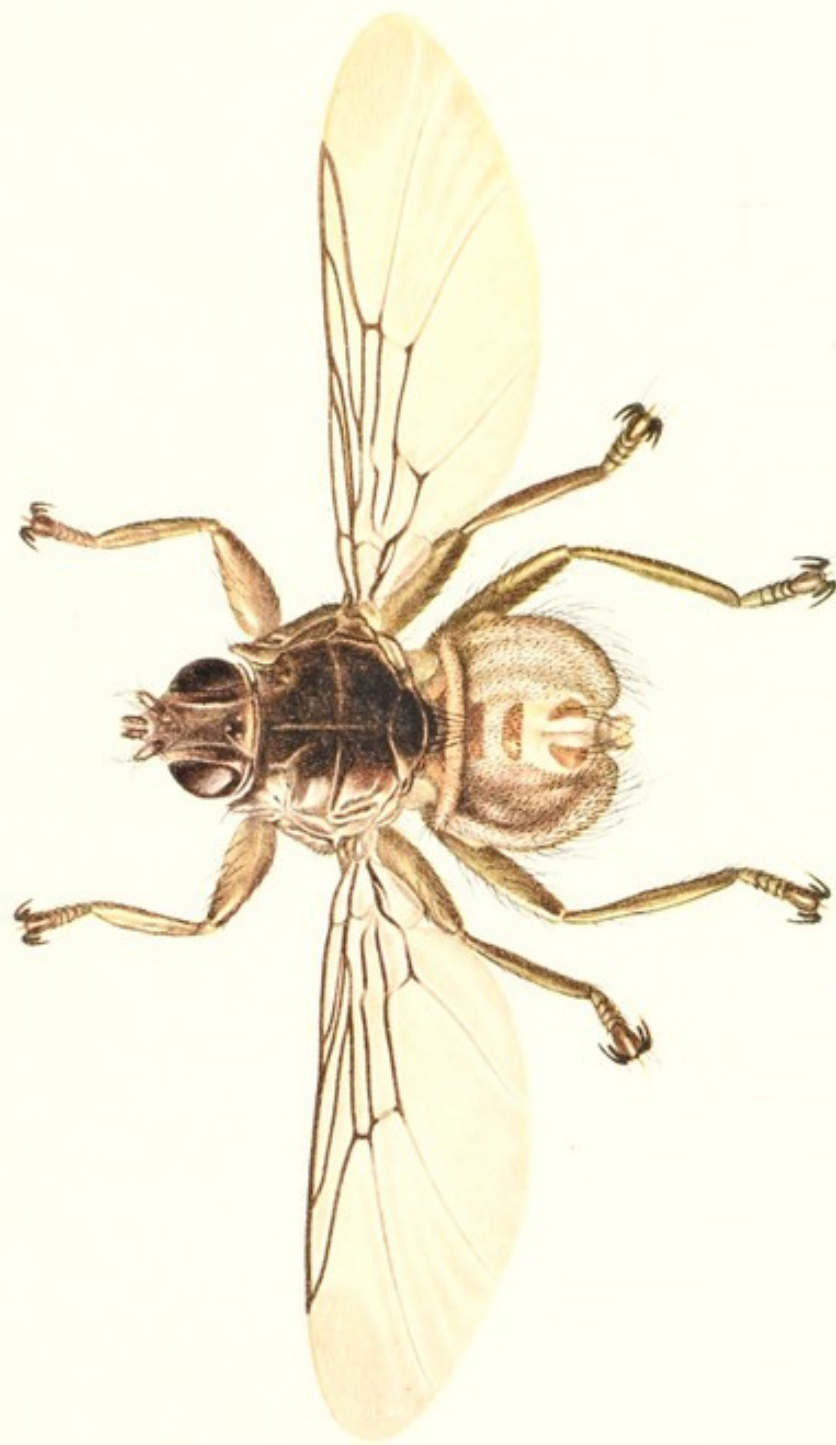
FIG. 2. *Lyperosia irritans* (Female)



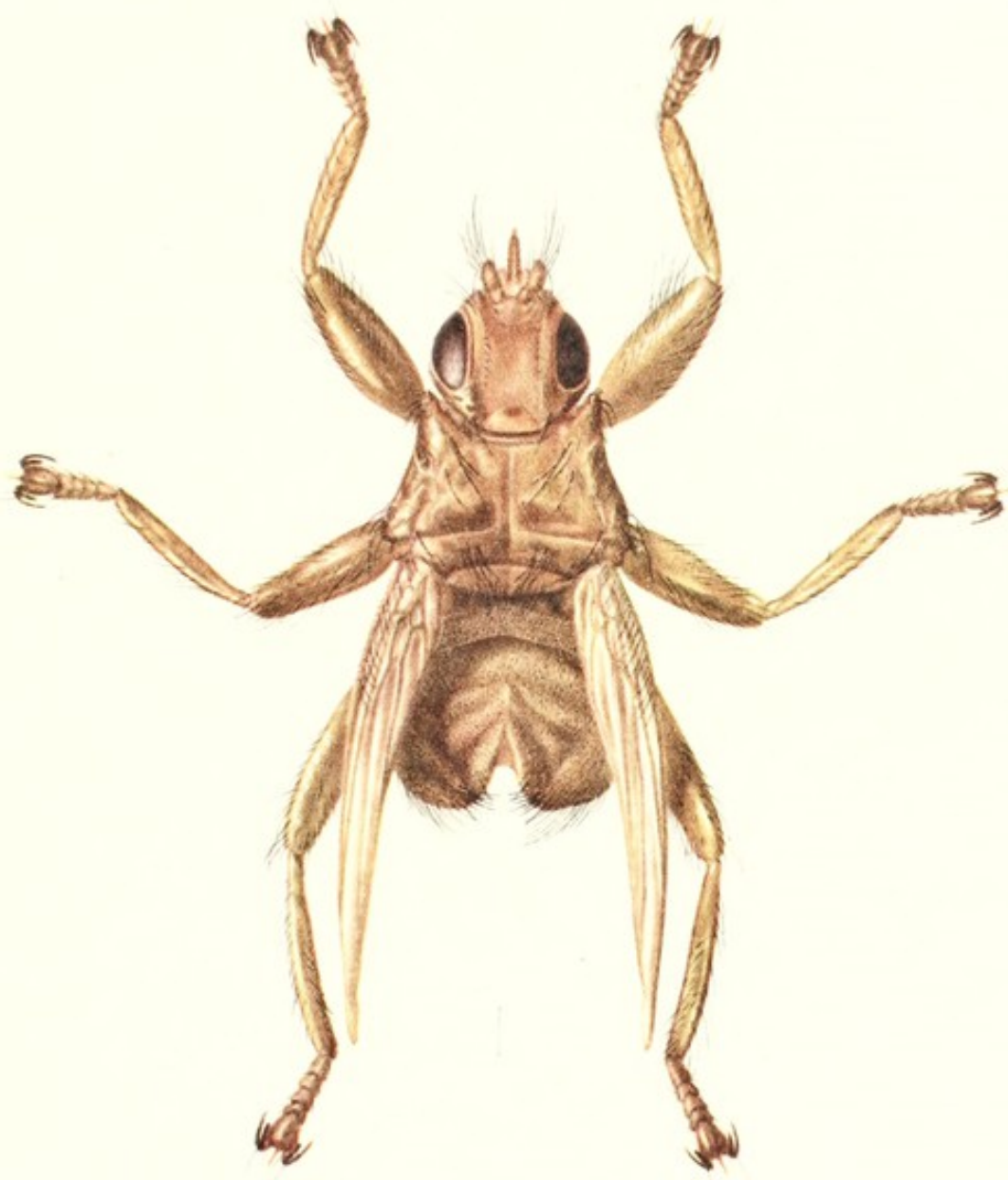
Hippobosca equina (Female)



Ornithomyia avicularia (Female)



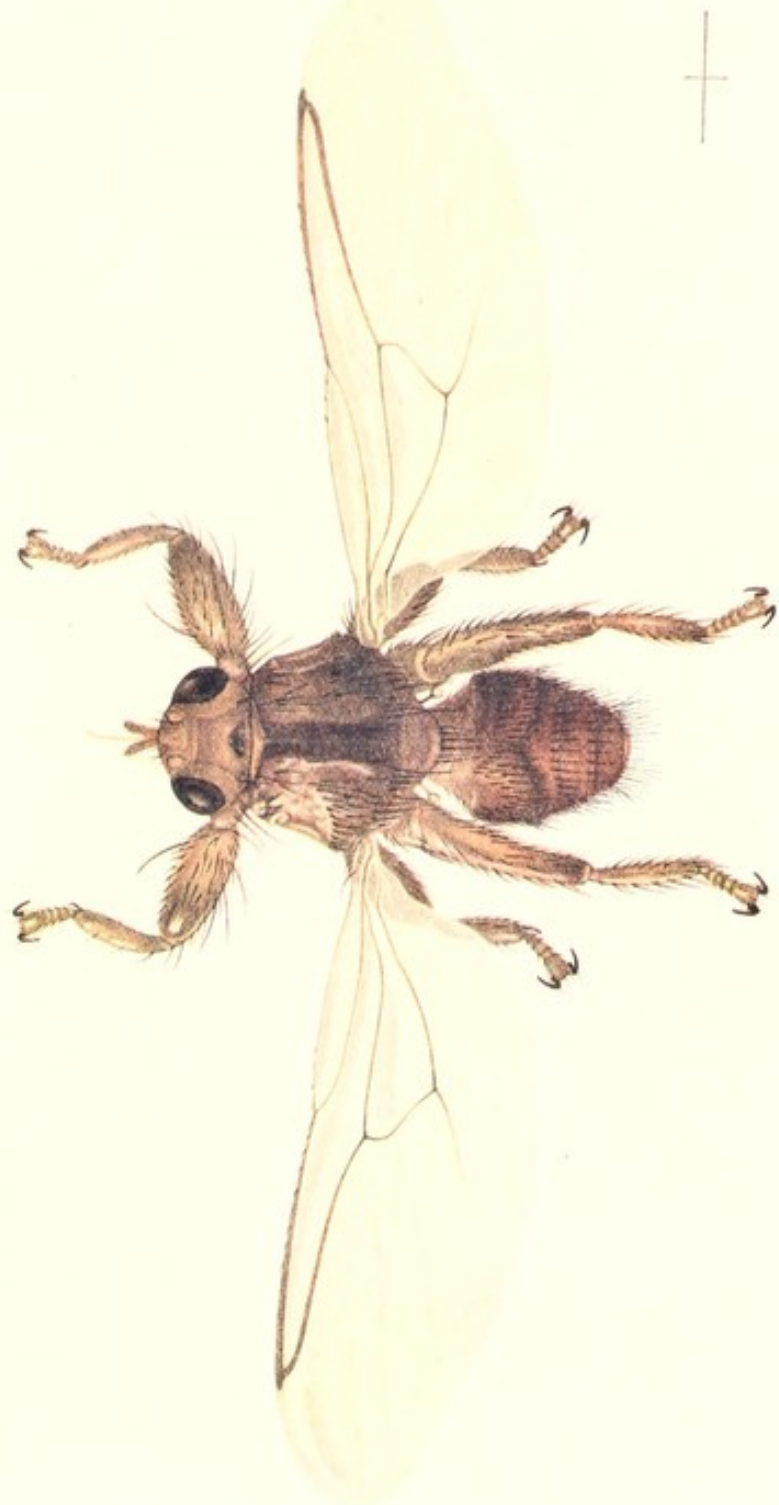
Ornithomyia lagopodis (Female)



Stenepteryx hirundinis (Female)



Crataerina pallida (Female)



Lipoptena cervi (Male)



FIG. 1. *Lipoptena cervi* (Female)



FIG. 2. *Melophagus ovinus* (Female)

