

NOTES ON THE SPECIES OF THE GENUS *MUSCA*, LINNAEUS—PART I.

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Of the many insects which we now know to be dangerous menaces to the health of man, the house-fly, *Musca domestica*, has few (if any) equals, but the facts relating to its germ-transmitting capacity are unfortunately still very incomplete. In the case of those Anopheline mosquitos which transmit the parasites of malaria, and the tsetse-flies, which infect man and other animals with trypanosomes, we are in a position to estimate the inefficiency and loss of life directly attributable to them, for in each case we know most of the species directly responsible for the dissemination of these parasites. But in the case of the house-fly we have no conclusive proof that *Bacillus typhosus*, for instance, is carried by one, or more than one, species of *Musca*. Further, by the time the cases are diagnosed, the infected flies have either died or disappeared, and it is rarely possible to trace the infection to them. It is true, however, that many observers have recorded the finding of pathogenic bacteria in, and on, species of *Musca*, but the final proof of the identity of these bacteria has invariably been faulty. Yet in spite of these discrepancies there is no doubt, from everyday practical observation the world over, that one, and more than one, species of *Musca* regularly carry the bacilli of the enteric fever, cholera and dysentery groups, as well as many other pathogenic organisms, especially the virus of trachoma, from infected material and deposit them on food and the human body. In investigating outbreaks of infectious diseases the house-fly should always be considered as a possible vector of the causal organisms.

The fact that the CULICIDAE contain among their members many serious pests has led to an intensive study of the species of the world, resulting in numerous valuable monographs and papers describing the species, and every medical man is now able to determine with certainty almost any species for himself. So also in the case of the tsetse-flies we have Austen's complete handbook available for the determination of the species; and similarly with many other insect pests. This systematic work on these important insects is very necessary, for it facilitates further biological studies, and, more particularly, accurate information on their relation to disease-causing germs.

But when we come to consider the all-important house-fly, *Musca domestica* and its allies, we find that although there are many valuable papers and books dealing with this species from the disease standpoint, there is no systematic work of any value which would enable the sanitary officer in the tropics to determine with accuracy the species which may call for enquiry during the course of his work. He cannot help but call all the species of *Musca* by the specific name *domestica*, for he believes that a house-fly with a striped thorax is *Musca domestica* all the world over. And there is every reason that he should do so, for in such an authoritative work as that on "The House Fly, *Musca domestica*, L." by the late Dr. Gordon Hewitt, we have a definite statement that the house-fly found throughout the world, and especially in tropical countries, is *Musca domestica*, L., and this statement has been accepted and copied by all subsequent writers on the subject. I propose to question it. That both the sexes of one of the species of *Musca* found in the tropics are very similar to *Musca domestica* is quite true, but when we come to compare the male with the male

of *domestica*, we find that the front of the former is at least half as wide as that of the latter. Were this only the case in a few specimens, I should be prepared to accept Dr. Hewitt's statement regarding the world-wide distribution of *Musca domestica*, but after examining hundreds of specimens of males of this tropical species, and comparing them with typical males of *domestica* caught in Great Britain, which I assume are conspecific with the Linnaean species, I find that in not a single specimen from India which I have examined is the front as wide as that of the male *domestica*. It is true that the width of the front of this form varies to a small extent, and so does that of the typical male *domestica*, but on the one hand I have yet to see a specimen of *domestica* from Great Britain with a front as narrow as that of this tropical form, and on the other hand a specimen of this tropical form with a front as wide as that of the typical *domestica*.

I am quite prepared to find a typical male of *domestica* taken at any of the tropical ports visited by ships from Europe, for everyone who has travelled in the East knows that large numbers of *domestica* are regularly carried to such ports, and leave the ships on their arrival at their destinations. In this way it is possible *Musca domestica* has been carried to the ports of the world, and has now become established there. But I must admit that the examination of the specimens in the National collection from the localities mentioned by Dr. Hewitt have not convinced me that this is the case.

It is true that Major Austen and other authorities have drawn attention to this narrow-fronted male house-fly and have determined it as *domestica*, L. But when we find a form exhibiting a character which is constant, I think we are justified in regarding it as distinct. And the width of the front in the males of the species of this genus is a constant character, and one of the most reliable for purposes of determination. In using this character it is very necessary to point out that great care must be taken in noting whether the front has collapsed, which it often does in the case of specimens pinned too soon after hatching and before the chitin has hardened. It should be remembered that just below the front there is an opening through which the ptilinum is protruded and later invaginated. If the insect is pinned before the edges of the ptilinal opening have sufficiently hardened, the whole front is very apt to collapse inwards; it then appears to be very much narrower than it really is, and it is only when such a specimen is macerated in caustic potash that the exact width of the front can be determined with accuracy. Further it is important to note that in comparing the front of one specimen with another it is very necessary to take into account their relative sizes. It is always better to compare the width of the front with the entire width of the head, or with that of one eye, rather than give it in linear measurement.

It may be thought that the question regarding the true identity of this tropical and subtropical house-fly is only of academic interest, and not worth further investigation, but I may point out that the biological connection of particular species of insects with certain disease-causing bacteria is now regarded as of a much more specific nature than has been thought to be the case hitherto. As a good example, I may draw attention to the case of the tropical rat-flea, *Xenopsylla cheopis*, which is the invertebrate host of *Bacillus pestis*. Until recently it was thought that there was only one species of the genus *Xenopsylla* found on rats in India, but a more careful study of rat-fleas has enabled Mr. Charles Rothschild to separate the Indian *cheopis* into three distinct species, one of which, *X. astia*, has undoubtedly been confused with *cheopis* in the past. It is thought by Cragg and Hurst that the absence of plague in certain areas is due to the larger percentage of *astia* found on rats as compared with the numbers of *cheopis*. If this is the case, then we have a clear indication that *astia* is not a good host for the extracorporeal life of *Bacillus pestis*. In the same way there may be a much more intimate connection between certain disease-causing bacteria and a particular species of *Musca* rather than with the others

which may feed side by side with it. For these reasons, then, I consider it is important to determine the true identity of this tropical house-fly. But in order to settle this question beyond any further doubt, it will be necessary to examine and compare the external genitalia of both sexes with that of *Musca domestica*, and to do this a large number of specimens from many parts of the world will be required, and this is one of the reasons I have raised this point, in the hope that this material will be collected. I have already begun the study of the external genitalia of the Indian species in order to compare it with that of *domestica*.

But the genus *Musca* contains another important group of species which have a direct bearing on the health of valuable stock animals, and which have in the past been confused with *Musca domestica*. The species I refer to, largely if not entirely, feed on blood and serous and pustular discharges, and are exclusively outdoor insects. Anyone who has watched a milch cow being tormented by hundreds of specimens of *Musca autumnalis* can hardly doubt that, apart from the possibility of their carrying disease germs, they must reduce the milk-producing capacity of the animal simply through wearing it out, as it constantly tries to drive them away. That flies do in this way so worry a cow as very materially to reduce the quantity of milk it produces, has been proved beyond any doubt by observers in America. These species of *Musca* regularly follow the true biting flies, sucking up any remains of blood that exudes when the latter withdraw their proboscides. They also regularly feed on the discharge from sores, cuts, eyes and the nose. We know nothing of the germ-carrying capacity of these species, and until all have been systematically studied, and veterinary officers and others are able to recognise them, we never shall.

During the last 15 years I have almost continuously studied all the stages of many of the species of this genus, and observed their habits in the field, for I am a strong believer in combining systematic studies with field observations. I have no doubt whatever that such field work gives one a much truer picture of the individual species than mere microscopic study of the dried insect. Field observations, in conjunction with studies of the breeding habits and the larvae, as well as microscopic studies of the adults, are the only means that I know of for coming to a final conclusion regarding some of the species of this genus. But as an isolated observer in the tropics, without access to the scattered literature on the subject, I have been severely handicapped in my systematic studies of the species. I have in the first instance had to depend on others for determinations of the species, and also on the inaccurate references to them in the general literature of the subject. As a result many errors have crept into my papers, and for the benefit of those who may use them I will draw attention to them in these notes.

Recently I had the first opportunity of studying the specimens in the National Collection at the British Museum, comparing them with the Indian species, studying many types, and lastly of consulting the complete literature on the subject. And I would like to take this opportunity of thanking Major E. E. Austen, D.S.O., for all the facilities and help he gave me. I have no hesitation in saying that were it not for his extensive knowledge of the subject, which he freely placed at my disposal, I could never have done as much as I was able to in the short time available. My own collection, together with the splendidly arranged and rich National Collection, has enabled me to unravel almost all the important synonymy. I have critically examined all Walker's types, as well as Bigot's, which Mr. Collin kindly lent me for the purpose, and for which I wish to take this opportunity of thanking him. Although I fully realise that much has yet to be worked out before it will be possible to be certain of the true identity of some of the species of the older writers, I consider that my study of this extensive material is sufficiently important to call for immediate publication.

But my main reason for publishing these notes is to draw the attention of medical and veterinary officers, and others, to the importance of collecting more material, for in spite of the many thousands of specimens which I have examined, I have no hesitation in saying that my revision of the genus will not be as complete as I should like it to be. I would, therefore, earnestly appeal to all who have opportunities of collecting species of *Musca* to send them to me at the Zoological Department, Edinburgh University, or to Dr. Guy A. K. Marshall, C.M.G., Director, Imperial Bureau of Entomology, British Museum (Natural History), Cromwell Road, when sending other entomological material; I shall be glad to exchange any Indian species for others.

As many of the types of the older writers, such as those of Robineau-Desvoidy and Macquart, are either lost or in very bad preservation, it is most important to try to secure specimens from the localities from which their types were obtained, and the localities will be mentioned in these notes. In order to facilitate the collection of this material, it may be useful to give some notes on the species as a whole, and also to indicate the special lines along which the collecting should be carried out.

For practical purposes, the species of the genus *Musca* fall into two natural groups as follows: (1) The house-fly group, and (2) the wild species group.

(1) *The House-fly Group.*

In this group are included all those species which are cosmopolitan in habit, but are mainly found in and around human dwellings, on food in bazaars, about butcheries, offal, rubbish of all kinds and night-soil trenches. The four important species are *Musca domestica*, *Musca domestica* (atypical), *Musca nebulosa* and *Musca humilis*. The first is the common European house-fly and the type of the genus, and *M. domestica* (atypical), *M. nebulosa* and *M. humilis* are the important tropical and subtropical species. Specimens of this type of house-fly are urgently wanted from as many localities as possible. *Musca humilis* is a very characteristically marked species, and can be easily recognised; but when we come to *Musca domestica* (atypical) and *Musca nebulosa* it is not possible at present to give a definite opinion regarding them. A series of specimens from the different parts as well as specimens from inland towns must first be available for microscopic study. Specimens taken *in copula* would be most useful. Larvae and flies hatched from them are the best material for comparative study. If the observer has not the time to pin the specimens they will do equally well if they are placed in match-boxes without any cotton-wool. Such specimens are quite suitable for the study of the external genitalia.

In collecting these species it is important to note exactly where the specimens were caught, whether on food, indoors, or in bazaars; and in this connection it should be noted that this type of *Musca* may be seen on cattle and horses in company with specimens of those of the next group. There should be no difficulty in collecting the larvae of the house-fly in any locality. When mature they should be placed in some earth in a cigarette tin, the lid of which is perforated with small holes, and allowed to pupate. At the same time some specimens should be preserved by dropping them into boiling water in a test-tube, and then placing them in a tube containing 70-80 per cent. alcohol. As soon as those in the tin have pupated, the puparia should be collected and placed in dry tubes, and 36 hours after the flies have hatched out they should be pinned along with their puparia; the latter are most useful in correctly associating the larvae with their respective adults. A good series of males and females collected in this way would be most valuable for comparative study.

(2) *The Wild Species Group.*

Some years ago I drew attention to the peculiar habit of *Musca pattoni*, Austen, which feeds on the blood that exudes from the punctures made by biting flies, and on the serous fluid which exudes from cuts, sores and particularly from cowpox

vaccine scarifications, on the bellies of calves. Since then, in collaboration with Major Cragg, I.M.S., I have described several other Indian species that have a similar habit. Looked at with the naked eye, the species of this group closely resemble *Musca domestica*. I have never seen a single specimen of any of these species caught in the bazaars in India, and with the single exception of *Musca humilis*, they are found only on animals, sitting about on plants, and on cow-dung. They are all necessarily intermittent feeders, and flit about from one animal to another, never staying long at one spot; and herein lies their importance as the possible carriers of trypanosomes such as those which cause nagana and surra. I would, therefore, particularly like to draw the attention of veterinary officers practising in the tropics to these haematophagous species of the genus *Musca*. They abound in all tropical countries, and specimens can always be caught on animals, as well as on dead game.

All the Indian species I have studied breed in cow-dung, either when it is dropped in the fields, or when piled up in heaps around cowsheds, etc. The larvae of all the species in any given locality can be easily collected by scooping up patches of cow-dung about 24 hours old, and placing it on earth in a tin tray with sides up which the larvae cannot crawl. There is no need to disturb the dung, but the tray should be placed in the sun every day, and the earth at the sides of the tray regularly examined for pupating larvae. Such larvae are of a characteristic creamy white colour, and do not contain any food. They should be collected, some preserved as noted above, and the remainder allowed to pupate in earth in a cigarette tin. The puparia should be dealt with as noted above, always remembering to pin the puparium of each specimen under it. The mature larvae of most of the species leave the dung to pupate, but others may stay just under it, so that it is necessary towards the end of the observation to turn over the dung and examine it for puparia. The puparia of several of these species are almost white, while others are of a greyish colour.

THE ORIENTAL SPECIES.

In addition to the specimens from this region in the National Collection, I have re-examined my own extensive collection consisting of about 2,500 specimens, the majority of which have been bred from larvae, most of the species being represented by long series in perfect preservation. I am able then to note the variations in external characters, a point of considerable importance in determining an atypical specimen; and anyone who has examined many species of this genus will have noted the great difficulty often experienced in giving a name to an odd specimen which is in some respects atypical, or greasy. I also have a long series of bazaar flies collected from all the larger towns in North India.

In these notes I propose recording my preliminary studies of the Oriental species, but it should be understood that as more material becomes available for macroscopic and microscopic study, it may be necessary to revise any previous conclusion, so that these notes must not be considered to represent the final revision of the Oriental species, but rather a preliminary contribution in that direction. In collaboration with Mr. Senior-White, I am now preparing a paper in which all the Oriental species will be described and illustrated; we hope to be able to include in it a simple yet accurate key for the determination of these species.

1. *Musca nebulo*, Fabricius.

Synonyms: *Musca determinata*, Walker.

? *Musca multispina*, Awati.

In 1910, Major Austen determined the common Madras house-fly for me as *Musca nebulo*, and since then I have always referred to this species under that name. Fabricius, in his short and wholly inadequate description of this species, states that the type, a female, is from "India Orientalis," and was given him by Professor

P. C. Abildgaard. In order to discover the exact locality from which the type was obtained, Major Austen kindly searched the literature to see whether this Professor P. C. Abildgaard was ever in India, but beyond the fact that he was a Veterinary Surgeon, and interested in natural history, there is nothing to show whether he had travelled in India. The exact locality from which the type of *Musca nebulo* came must then, in the meantime, remain doubtful. I think, however, that it can be safely assumed that it was obtained from some large Indian town. Wiedemann, who evidently examined the type, does not give any information on this point. His somewhat fuller description, however, fits this common Indian house-fly very well. Short of examining the type I see no reason to doubt Major Austen's determination of its identity, and consider it is best to retain this name for it.

I have carefully, and repeatedly, examined the type of Walker's *determinata*, a female in bad preservation, from the East Indies (not the West Indies as erroneously stated in my paper on the Mesopotamian house-flies), and after comparing it with typical specimens of the Madras house-fly (*M. nebulo*), have come to the conclusion that it is identical with it. There seems to be no means of discovering from what part of India the type of *determinata* was obtained, but the town of Calcutta seems to be the most probable locality. In my paper on the Mesopotamian house-flies referred to above, the species there described as *Musca determinata*, Walker, is not conspecific with Walker's type, but is the next species recorded in these notes.

Although I have not had an opportunity of examining the type of Awati's *Musca multispina*, I have little doubt from his description of the female that it is *Musca nebulo*.

I have examined many hundreds of specimens of *nebulo* from many localities in India, Burma, Assam and Ceylon, and find that though it varies to some extent in colour and markings, it is a very distinct species and cannot be confused with either *Musca domestica* or *Musca domestica* (atypical) noted below. The majority of the specimens when in good preservation have white cheeks, a grey thorax and yellowish abdomen, with silvery tessellation. In the male the frons is narrow, about as broad as the width of the third antennal segment (antero-posteriorly), and although in some specimens it is a trifle narrower, and in others a little wider, I have not seen a single specimen whose frons in any way approaches the width of the frons of the male *Musca domestica*.

I shall be glad to receive any specimens of this species from any area outside India, so as to compare them with those found in various parts of India.

2. *Musca domestica*, L. (atypical).

Synonyms: *Musca biseta*, Hough.

Musca divaricata, Awati.

Musca determinata, Patton (*nec* Walker).

This species, which for the lack of a better name I propose in the meantime calling *Musca domestica* (atypical), is the one which comes very near the true European *Musca domestica*, so far as external characters are concerned; it is one of the other important house-flies of India. Both sexes have been described by Awati under the name *divaricata*, and this observer points out that it closely resembles *nebulo* (*multispina*, Awati), but can be distinguished by noting that it is a much yellower fly than *nebulo*, and the abdomen is not nearly so silvery. The frons of the male of this species is about as wide as that of the male *nebulo*, and is from a quarter to one-fifth the width of the eye. I have not seen a single specimen of the male of this species with a frons as wide as in the male of *domestica*. I consider it is therefore distinct on this character alone. It is, however, not possible at present to give

it a name, and it will be necessary to compare the external genitalia of both sexes with those of *domestica*, L., as well as with those of specimens from other tropical countries. I believe the following will prove to be this atypical form of *domestica*:—

1. *Musca sanctae-helenae*, Macquart, Saint Helena.
2. *Musca lateralis*, Macquart, Mauritius.
3. *Musca basilaris*, Macquart, Brazil, Mexico.
4. *Musca frontalis*, Macquart, Algeria.
5. *Musca analis*, Macquart, Chili.
6. *Musca consanguinea*, Rondani, America, Mexico.
7. *Musca senegalensis*, Macquart, Senegal.
8. *Musca flavinervis*, Thomson, Ross's Island.
9. *Musca antiquissima*, Walker, Australia.
10. *Musca callewa*, Walker, South Africa.
11. *Musca vicaria*, Walker, New Zealand.

I have examined Bigot's types of *Musca pampasiana* (Buenos Ayres), *Musca flavifacies* (New Caledonia), and *Musca atrifrons* (Cuba), and consider that they are all specimens of this form. There seems very little hope of getting any further light on Macquart's species, as Mr. Collin tells me that his types are in bad preservation.

When examining these atypical forms of *domestica* in the National Collection, Major Austen drew my attention to its occurrence in Greece in company with the typical *domestica*, but exactly where this species first makes its appearance in the Palaearctic Region, I am not at present able to say. I hope those who have opportunities of examining and collecting specimens of *Musca* from Europe will be on the look-out for this narrow-fronted male *domestica*, and send me specimens.

I have no doubt that Hough's *Musca biseta* is this species; it is common in Aden and most probably in Somaliland.

3. *Musca humilis*, Wiedemann.

- Synonyms: *Musca primitiva*, Walker.
Musca conducens, Walker.
Musca praecox, Walker.
Musca angustifrons, Thomson.
Musca bivittata, Thomson.
Musca niveisquama, Thomson.
Musca eutaeniata, Bigot.
Musca promisca, Awati.

This strikingly marked species is the most important tropical house, bazaar and camp fly. It is of peculiar interest, as in its habits it links the house-fly with the wild haematophagous species. Its larvae may be found in a great variety of food-stuffs, in isolated patches of cow-dung, horse-dung and human excrement; also in cow-dung and horse-dung when piled in heaps, in night-soil trenches, and in decaying vegetable matter. I have also bred it in dog's dung and in the decomposing bodies of rabbits. As it commonly breeds in patches of cow-dung when dropped in the field, the adults are frequently found on cattle and horses far from human dwellings. Under these conditions they feed on the discharge coming from sores, and from the eyes and noses of cattle. As often as not, the specimens which hatch out of larvae in isolated patches of cow-dung are very small, and they are most irritating pests in the fields, swarming about one's head, as do the adults of *Hydrotaea irritans* in the summer months in Europe.

In India it swarms in the bazaars, where it may be seen on food-stuffs of all kinds, as well as on human beings, particularly around the eyes of children. In Mesopotamia it was quite common to see the eyes of small children covered with the females of this species, and this explains how the eyes of adults become infected with various pathogenic bacteria.

Musca humilis is very widely distributed, probably more so than any other species of the genus. I have seen specimens from many parts of Africa, Palestine, Mesopotamia, Persia, and from the whole of India to China in the East.

The late Professor Stein examined Wiedemann's type of *humilis*, as well as Thomson's types of *angustifrons* and *bivittata*, and says all three are the same species. Until I can for myself examine these types I accept this determination.

I have examined Walker's type of *Musca conducens*, a male collected by Wallace at Macassar, Celebes; it is in good condition and is a small example of *M. humilis*. Walker's type of *M. praecox*, a headless male from Ceram, Malasia, is exactly similar, and is also a small specimen of *M. humilis*. Walker's type of *M. primitiva*, a female from Fu-chau-fu, South China, is a typical specimen of *M. humilis*.

Bigot's collection of *Musca*, fifty-three specimens, contains six males of his *Musca eutaeniata* from "the Indies," chiefly from Pondichery and Cochin China, all of which are rather small, but typical specimens of *M. humilis*. It will be remembered that Brauer examined these specimens, and came to the conclusion that like eight of the other specimens of *Musca* in Bigot's collection (Brauer's numbers 257 to 265, inclusive) they were "*Musca* ead.n. (wie die ersten 9 wohl *domestica*)." It is quite clear from this that Brauer had a very vague knowledge of the species of the genus *Musca*, otherwise he would never have called these six specimens of *M. humilis* (*eutaeniata*), *domestica*. This is a warning not to accept the determination of types by others as final without oneself examining them. Stein states that *M. niveisquama*, Thomson, is identical with *M. domestica*, L. Major Austen has, however, drawn my attention to Thomson's description of this species, in which he clearly states that *niveisquama* is similar to his *angustifrons*, and has two black thoracic stripes. It is quite possible that *niveisquama* is *Musca pumila*, Macquart.

Awati gives *angustifrons* as a synonym for his *Musca promisca*, and his description of this species makes it quite clear that it is *M. humilis*. This author, when describing the three species, *Musca nebulo* (*multispina*), *M. domestica* atypical (*divaricata*), and *M. humilis* (*promisca*), states that in the case of *nebulo* there are "two or more spines on the humeral vein which may be present on both wings or on one of them only;" in the case of *M. domestica* atypical (*divaricata*), he says there is "only one spine on the humeral vein," and in *M. humilis* also only one spine on this vein. In his remarks at the end of the description of *M. divaricata* he says: "There are always more than one spine on the humeral vein in *Musca multispina*, whereas in *Musca divaricata* there are never more than one." By the humeral vein Awati evidently refers to the large basal root vein from which arise the subcostal and radial (subcostal; 1st longitudinal) veins just before the small humeral transverse vein joins this root vein to the costal. In all the species of *Musca* which I have examined, there are always one or more small curved bristles situated on the inner side of the vein. I have made a careful examination of the number of bristles present on the veins of hundreds of specimens of *Musca nebulo*, *M. domestica* (atypical) and *M. humilis*, and in a long series of *domestica* (atypical) in the National Collection a large percentage had two bristles on the right root vein, and only one on the left; a few, on the other hand, had two on the left vein and only one on the right. The majority, however, had only one bristle on each vein. In the case of a long series of *nebulo*, I find that a few have two bristles on the left vein and one on the right, while some have two on the right and only one on the left. But, and this is important in view of Awati's statement that in this species there are always two bristles on this root vein on both sides, I find that the majority of the specimens of *nebulo* only have one bristle on each root vein; this also applies to *humilis*.

Musca humilis can always be recognised by noting that it is a much greyer fly than the two others noted above; that in the female the black thoracic stripes are united behind the suture, forming one broad stripe, but are separated in front of the suture; in the male the stripes on each side have coalesced to form one broad

black stripe, which diverges posteriorly away from the central grey stripe; the abdomen in the female is quite unlike that of the male, and is yellowish grey with black stripes and bands; that of the male yellowish with silvery patches and a central black stripe. The frons of the female is wide, that of the male a little narrower than the frons of the male *nebulo*.

It would be interesting to know if this species has found its way to any part of the New World.

4. **Musca sp. incerta** ("Textbook of Medical Entomology," Patton and Cragg, p. 334).

This distinct species was bred in 1910 from larvae collected from the contents of the stomach and intestines of sheep slaughtered at the slaughter-house, Saidapet, Madras, and since then another good series has been obtained from the same source; it also breeds in horse-dung. It will be described as a new species in a forthcoming paper on some new Indian species of the genus *Musca*.

On a superficial examination it may be mistaken for *Musca nebulo*, but it will be noted that the ground-colour of the thorax is darker and is of a bluish colour. It has four black thoracic stripes, and the male frons is much narrower than that of the male *nebulo*, the eyes being separated only by a fine black line. The abdomen in both sexes is much more orange-coloured, and in the male there are no marginal silvery patches on the apparent second segment; in the male *nebulo* these silvery patches are always well marked.

5. **Musca pumila**, Macquart.

Synonyms: *Musca minor*, Macquart.
Musca vetustissima, Walker.
Musca humilis, Stein (*nec* Wiedemann).
Musca corvina, Froggatt (*nec* Fabricius).

I first bred this species from larvae collected from human excrement in 1910 in Madras, and in 1920 obtained a large number from the same source. Mr. Senior-White has collected it in Ceylon. I have received a number of specimens from Australia, sent me by Mr. Taylor, Mr. Froggatt, Mr. Hill and Dr. Ferguson, and all are identical with the species in the National Collection determined by Major Austen as *Musca pumila*. There is also a specimen in Bigot's collection from Australia labelled *Musca pumila*, Macquart. As it is superficially like *M. humilis* it has been mistaken for that species. In both sexes the thoracic markings are exactly similar to those of *M. humilis*, but the ground-colour of the thorax is markedly blue, whereas in *humilis* it is yellowish grey. The abdomen in the female is also bluish, with black stripes and bands. So far I have not seen the typical *Musca humilis* from Australia, and *Musca pumila* seems to take its place.

6. **Musca ventrosa**, Wiedemann.

Synonyms: *Musca xanthomela*, Walker.
Musca pungoana, Karsch.
Musca nigrithorax, Stein.
Musca kasauliensis, Awati.
Musca hilli, Johnson & Bancroft.

This small species, with its dark thorax with four stripes and orange-yellow abdomen, is a true haematophagous *Musca*, and is mainly seen on animals, and on foliage near them. Wiedemann's types of *ventrosa* came from Sumatra and China. I have examined the type, a female, of Walker's *Musca xanthomela* from Macassar, Celebes, and find it is a typical specimen of *ventrosa*; Stein's *nigrithorax* from Samarang and Batavia, and Karsch's *Musca pungoana* from Pungo Ndongo, Portuguese West Africa, are also this species.

I have examined the paratypes of *Musca hilli*, Johnson & Bancroft, and except for some dark markings on the apparent second and third abdominal segments, they are identical with the Indian specimens of *ventrosa*, in many of which there are also some dark markings on the same segments. I can see no reason at present for considering *M. hilli* to be a distinct species, but hope to compare the external genitalia of the Australian and Indian specimens to settle its identity.

Awati gives his *Musca kasauliensis* as a synonym of *M. nigrithorax*, and there seems to be no doubt that his species is *M. ventrosa*.

Musca ventrosa is widely distributed in India, Burma, Assam and Ceylon, and is also common in Africa; it breeds in cow-dung.

7. *Musca albomaculata*, Macquart.

Synonyms: *Musca dorsomaculata*, Macquart.

Musca convexifrons, auctores (*nec* Thomson).

Musca setigera, Awati.

This species was determined for me by Professor Bezzi as *Musca convexifrons*, Thomson. It is one of the common haematophagous species, and has been fully described in collaboration with Major Cragg, I.M.S. On comparing Thomson's description of *convexifrons* with it I have come to the conclusion that the Indian species long known under this name is not Thomson's species. The discrepancies are as follows: Thomson says that his specimen, a male from China, measures 6 mm., but the largest Indian specimens I have seen measure only 5.5 mm.; and further, he says that his species is like *Musca autumnalis*, de Geer (*corvina*, F.), which is quite unlike the Indian species. In order to settle this point I recently sent a typical male to Professor Sjöstedt for comparison with Thomson's type, and Dr. Roman has kindly given me a note as the result of his examination and comparison of the two species; from this it is quite clear that the Indian species is not *Musca convexifrons*. Dr. Villeneuve tells me that he has compared this Indian *Musca* with Macquart's types of *Musca albomaculata* and *M. dorsomaculata* and finds they are identical. I accept this determination for the present. I have very little doubt that Thomson's *convexifrons* is the species known as *Musca fergusonii*, Johnson & Bancroft (*australis*, Macquart, *nec* Boisduval), a species which is widely distributed in Australia, as well as in the many neighbouring islands, and presumably extends to China. At any rate, this species is very like *Musca autumnalis*, de Geer. If this should eventually prove to be the case, the Australian species must in future be known as *Musca convexifrons*, Thomson.

8. *Musca pattoni*, Austen.

Synonym: *Musca spinosa*, Awati.

This species has been fully described by Austen, and the types are in the National Collection. It is widely distributed in India, Burma, Assam and Ceylon, but I have not seen any specimens from any locality outside India. Awati has described the female under the name of *Musca spinosa*.

9. *Musca gibsoni*, Patton & Cragg.

Synonym: *Musca latiparaffrons*, Awati.

This species was described by me in collaboration with Major Cragg, I.M.S. It is especially abundant in hill stations on animals. The female has been described by Awati under the name *Musca latiparaffrons*.

10. *Musca spinohumera*, Awati.

The female of this larviparous species has been fully described by Awati. Mr. Senior-White recently collected a large number on cattle at Pusa and noted that it is haematophagous in habit. He also observed that it deposited one larva at a time, thus confirming Awati's observations; the puparium is very like that of *Musca pattoni*, and is of a dirty white colour.

I have examined this collection, which also contains the male, and compared both sexes with those of *M. pattoni* and with the types of *M. mesopotamiensis*, Patton. Though *M. spinohumera* superficially resembles *M. pattoni*, they are quite distinct, the one being oviparous and the other larviparous. *Musca spinohumera* is, however, closely related to *M. mesopotamiensis*, but there are some good characters by which they can be distinguished, and here again one is oviparous and the other larviparous. I have not seen *M. spinohumera* from South India, and it appears to be peculiar to Northern India.

Awati mentions *M. corvina*, Fabricius, as a synonym of his *spinohumera*, evidently meaning the form which the late Professor Portchinsky referred to as *Musca corvina*, Fabricius (*vivipara*). It will be remembered that Portchinsky pointed out that there were two types of *M. corvina* in Russia, one which he called *M. corvina ovipara*, found in Northern Russia, which lays stalked eggs and has a white puparium, and the other, *M. corvina vivipara*, which deposits larvae and has a brown puparium, and is only found in the Crimea. In the paper on "Certain haematophagous species of the Genus *Musca*" (Ind. J. Med. Res., i, no. 1, 1913), in collaboration with Major Cragg, I.M.S., attention was drawn to the observations of Portchinsky in a footnote on page 12, and after examining a good series of both forms, it was concluded that they were distinct species. To quote our words, "From our knowledge of the oviparous *convexifrons* (spined eggs and white puparium), *pattoni* (spined eggs and dirty grey puparium), and the larviparous *bezzii*, it appears to us that Portchinsky has confused two distinct species of *Musca*, one entirely oviparous and the other entirely larviparous." Since then I have studied all the stages of the oviparous species now known as *Musca autumnalis*, de Geer, in the South of England, and observed that it lays its stalked eggs singly in patches of fresh cow-dung dropped in the field, and that the puparium is white. But with regard to the larviparous species, Major Austen has drawn my attention to the curious fact that there is no description of it in any of Portchinsky's writings, and yet I find that Schnabl and Dziedzicki in their work, "Die Anthomyiden," speak of it as *Musca larvipara*, Portchinsky (*olim Musca corvinoides*, in litt. Schnabl & Dziedzicki). As they partly describe the male, the species must in future be known as *Musca larvipara*, Schnabl & Dziedzicki, and not Portchinsky.

As my material of this species is old and not in good preservation, I shall be glad to exchange any Indian species for fresh material.

11. *Musca bezzii*, Patton & Cragg.

Synonym: *Musca pilosa*, Awati.

This large handsome fly is very common in all the Indian hill stations, and also at the foot of the hills. It is purely haematophagous in habit, and is only found on and around animals. The female deposits one larva at a time, in the second stage, on patches of fresh cow-dung.

M. bezzii belongs to the *lusoria* group, but is distinct from that species. The male has a dark thorax and yellowish abdomen, with silvery patches and stripes. The female is greyish, with black bands and stripes.

12. **Musca (Pristirhynchomyia ; Philaematomyia) lineata**, Brunetti.

This small haematophagous species is widely distributed in India, and is always found on and near cattle in the fields. It is not a true blood-sucker in the sense that it can draw blood, but it has moderately well-developed prestomal teeth, and can certainly scratch a clot off the skin and suck up any fluid under it. It thus shows an early change towards the true scratching proboscis, so well seen in the case of *Musca crassirostris*, Stein, which is able to draw blood with the aid of its prestomal teeth.

It will be remembered that in the typical *lineata*, the rather narrow thoracic stripes are distinctly separated, whereas in what appears to be a variety which I bred in Coonoor from cow-dung, and which Mr. Senior-White has also bred from the same source in Ceylon, the thoracic stripes are distinctly broader, and in the male almost, if not entirely, coalescent behind the suture; in addition, the front of the males of this variety is much narrower than in the typical *lineata*. I am not able to express a definite and final opinion as to the identity of this variety, but as I have the larvae of both the species, as well as a large number of adults, I hope to do so shortly. I may, however, point out that the male is quite easily mistaken for a small specimen of *Musca humilis*, but it is certainly not that species.

13. **Musca cingalaisina**, Bigot.

Synonyms: *Musca pollinosa*, Stein.

Musca (Philaematomyia) indica, Awati.

I have examined the type of Bigot's *cingalaisina*, a female without a head, from Ceylon, and have no hesitation in saying it is a typical specimen of *Musca indica*, Awati. I have examined hundreds of specimens of this most interesting species from many parts of South India and from Ceylon collected by Mr. Senior-White. It is extremely common in Ceylon, and though neither Mr. Senior-White nor I have ever caught it on cattle in the act of sucking blood, it is unquestionably a blood-sucker, and can draw blood with the aid of its prestomal teeth. Mr. Senior-White is now engaged in studying its feeding habits, which appear to be very peculiar. In localities where it occurs it can be caught in large numbers sitting about on leaves, etc., and on fresh cow-dung, on which it deposits its third-stage larva. It is very curious that although it can be seen on cow-dung close to a cow, it has never been seen either by Mr. Senior-White or myself actually on the animal. Awati also states he has not seen it sucking blood.

I have no doubt whatever that Stein's *pollinosa* is this species, and it appears to be common in Batavia, Samarang and Tandjong Priok, in the Dutch East Indies. Brauer came to the conclusion that the type of *cingalaisina* was a specimen of *Musca domestica*, a remarkable determination.

14. **Musca (Ptilelepis) inferior**, Stein.

Synonym: *Philaematomyia gurneyi*, Patton & Cragg.

In a recent paper Bezzi has made this species the type of a new genus, *Ptilelepis*, mainly basing it on the presence of dark hairs on the inner portions of the squamae. He also gives some additional characters, the majority of which, however, are in my opinion not generic characters, but are common to many of the other species of *Musca*. He mentions "Eyes bare, rather distant in the male. Parafrontal hairs of the female arranged in more than one row," and other characters based on chaetotaxy. The presence, absence and arrangement of bristles and hairs are not reliable characters on which to base genera. Further, I would point out that the characters of the proboscis, such as, "thickened basally with chitinous terminal teeth," are common

to several species, and that there are three bristles on the radial root vein and not one, as mentioned by Bezzi. It is true, as Bezzi points out, that the presence of long hairs on the posterior portion of the upper surface of the squamae is unique in this species, but I do not consider this to be of generic importance.

Musca inferior is a true blood-sucker and is widely distributed in India, but it is never seen in large numbers and is easily missed. It can always be recognised by noting that as soon as it settles on the skin of an animal it begins to suck blood at once, whereas *Musca bezzii*, which closely resembles it, flits about from one spot to another. I have one male specimen, which was caught on a patch of human excrement. It probably breeds in cow-dung and is almost certainly larviparous.

15. *Musca* (*Philaematomyia*) *crassirostris*, Stein.

Synonym: *Philaematomyia insignis*, Austen.

Musca crassirostris is one of the most important cattle pests in India, and it would be well to name it the "Cattle Fly." I have little doubt that it very materially reduces the quantity of milk of Indian milch cows, owing to its vicious biting habits and incredible numbers. I have repeatedly seen the legs of a cow covered with large numbers of this fly, and the animal then spends a great amount of its time driving them off. These animals are often forced to lie down and curl their legs under their bodies, in order to protect themselves from the attacks of *M. crassirostris*.

It is interesting to note that it lays a relatively large egg, which hatches out in a very short time, suggesting that some development has already commenced while the egg was still in the ovary.

It is widely distributed in the Oriental Region, and is also found in many parts of Africa, and I have little doubt that when it is more carefully looked for will be found in many other localities. I see no reason for placing this species in a distinct genus, *Philaematomyia*, on the structure of the proboscis alone, for I now know five species that have this type of proboscis, which are otherwise typical specimens of *Musca*.

In a paper that is now in preparation I hope to describe five new species of *Musca* from India (inclusive of No. 4 noted above), one of which has well-developed prestomal teeth. I have now received specimens of the typical *Musca domestica* from Kashmir, as well as *M. tempestiva*, Fallén, and *M. vitripennis*, Meigen, all collected by Dr. Bains Prashad; and including these, there are now 22 good species of the genus *Musca* found in India. So far, I have not seen a single specimen of *M. albina*, Wiedemann, from any part of India, although the type is said to have come from the East Indies. This species has been sent to me from Egypt, and Bezzi records it under the name *speculifera* from Djerba, Tunis. I have not seen any species which could be identified as *Musca minuta*, Awati, *M. negriabdomina*, Awati, or *M. striatecta*, Awati. I shall be very glad of any specimens of *Musca* from any locality in the Oriental Region, and hope that those who have opportunities of collecting these flies will do so and send them to me, so that the revision of this group may be satisfactorily completed.

THE AUSTRALASIAN SPECIES.

Although the National Collection is not very rich in material from the Australasian Region, it contains several types and paratypes, which have enabled me to settle the identity of some of the doubtful species. I have also been able to supplement this collection with a number of specimens of most of the species sent me from time to time by Mr. F. H. Taylor, Mr. W. W. Froggatt (Entomologist to the Government of New South Wales), Dr. Eustace W. Ferguson (Department of Public Health, Sydney), Professor T. Harvey Johnson, and Mr. G. F. Hill (Entomologist to the Australian

Institute of Tropical Medicine). Mr. Hill in particular recently sent me a valuable collection of MUSCIDAE from various localities. I wish to take this opportunity of thanking these gentlemen for the trouble they have taken in collecting and sending all these specimens.

The revision of the species from the Australasian Region has been most difficult, owing to the great confusion existing as to the correct names of even the commonest species; most, if not all, of these have been described by the older authors, but unfortunately their descriptions are for the most part valueless, if not actually misleading. It is for this reason that I would earnestly appeal to those who have opportunities of collecting species of *Musca*, to let me have as many specimens as possible. I would particularly like large numbers of house-flies from any part of the Region, either in 80 per cent. alcohol or packed in matchboxes. It will only be by comparing large numbers of specimens of the species from as many localities as possible with those from other regions, particularly the Oriental, that it will be possible to settle the true identity of the species of the older authors. And it would be most unfortunate if my final revision were to be incomplete merely for the want of sufficient material. Larvae and flies bred from them are the best material for the comparative studies I now have in hand.

1. ***Musca domestica***, L. (typical).

Synonym: *Musca vicaria*, Walker.

Of the 58 specimens of this species in the National Collection from various parts of Australia, and from the Sandwich, Samoan, Solomon and Fiji Islands, I have provisionally determined 21 (including the type of Walker's *vicaria*, a female from New Zealand), as belonging to this species. And I have specimens in my own collection which are undoubtedly this species.

2. ***Musca domestica***, L. (atypical).

Synonym: *Musca antiquissima*, Walker.

The remaining 36 specimens in the National Collection (including the type of Walker's *Musca antiquissima*, a male), belong to the form of *domestica* in which the male has a front much narrower than that of the typical form. Most of the specimens in my own collection conform to this type, so that it would appear that it is one of the common house-flies of Australia; its true identity will only be arrived at by examining microscopic preparations of the external genitalia of both sexes and comparing them with the similar form from other regions. I should be glad of some hundreds of specimens of this species.

3. ***Musca pumila***, Macquart.

Synonyms: *Musca minor*, Macquart.

Musca vetustissima, Walker.

Musca autumnalis (*corvina*), Froggatt (*nec de Geer*).

Musca humilis, Stein, Bezzi (*nec Wiedemann*).

This species is identical with a *Musca* bred by me more than 10 years ago in Madras. It has been confused with *Musca humilis*, Wiedemann. It appears to be a troublesome bush fly in Australia, and I have four small females sent me by Mr. Froggatt with a note that they were caught in tents. There are three specimens, one male and two females, in the National Collection from Cloncurry, Queensland, collected by Dr. Priestly, who notes that it is a troublesome fly, settling on the human eye and probably carrying the bacteria of eye diseases. In Australia it appears to have taken the place of *Musca humilis*. The Australian specimens differ slightly from the Indian in that the frontal stripe of the male is usually a little broader, but this is a variable character.

4. *Musca terrae-reginae*, Johnson & Bancroft.

I have seen only six specimens, five females and one male, of this species, sent me by Mr. Hill and Prof. Johnson, as well as the paratypes deposited in the National Collection by the latter. I am not able with this very meagre material to come to a definite conclusion regarding the true identity of this species. It will be impossible to discover what *Musca prisca*, Walker, really is, as the type (a female from New Zealand) is unfortunately a greasy specimen, and was evidently in this condition when Walker described it; it should never have been described. One thing is certain, it is a species with four black thoracic stripes and may quite well be *Musca terrae-reginae*. I hope to re-examine it more critically, and to compare it with *M. terrae-reginae*, but if this examination does not lead to any definite conclusion, I propose to drop this name altogether. More specimens of *M. terrae-reginae* are, however, required in order to compare it with some of the Indian species with which it is allied.

5. *Musca ventrosa*, Wiedemann.

Synonyms: *Musca xanthomela*, Walker.
Musca pungoana, Karsch.
Musca nigrithorax, Stein.
Musca kasauliensis, Awati.
Musca hilli, Johnson & Bancroft.

In my notes on the Oriental species I pointed out that I had examined the paratypes of *Musca hilli*, Johnson & Bancroft, deposited in the National Collection by Prof. Johnson, and considered it to be identical with *Musca ventrosa*, Wiedemann. Mr. Hill recently sent me a long series of *M. hilli*, and among them a couple which have been determined by Prof. Johnson, and though most of these specimens show varying amounts of dark stripes on the apparent third and fourth abdominal segments, they appear to be identical with Indian specimens of *M. ventrosa*. The final determination will depend on a comparative study of the external genitalia of both sexes, which I now have in hand. It may be that *Musca hilli* is a good species.

6. *Musca convexifrons*, Thomson.

Synonyms: *Musca australis*, Macquart (*nec* Boisduval).
Musca fergusonii, Johnson & Bancroft.
Musca lusoria, Bezzi (*nec* Wiedemann).

In my notes on the Oriental species I have pointed out that *Musca fergusonii*, Johnson & Bancroft, is the species known as *Musca convexifrons*, Thomson. It will be remembered that Thomson described as his type a male from China, and that for a long time it was believed to be identical with a common Oriental species, which is recorded above under the name of *Musca albomaculata*, Macquart. But I was convinced that the Oriental species was distinct from Thomson's *M. convexifrons*, and was for a long time puzzled as to the identity of Thomson's species. I now, however, have no doubt whatever that it is the common Australian haematophagous *Musca* recently re-described by Johnson and Bancroft under the name *Musca fergusonii*. Mr. Hill recently sent me a long series, some of which were collected on Palm and Magnetic Islands, and I have been able to compare it with *Musca lusoria*, Wiedemann, and *Musca bezzii*, Patton & Cragg. In *Musca convexifrons* there are normally two bristles on the basal portion of the radial vein, sometimes three; in *M. lusoria* there are normally four bristles, sometimes more and sometimes less; and in *M. bezzii* there are normally five. *M. convexifrons* differs in many other respects from both these species.

These six species of *Musca* represent all those known to me from the Australasian Region, but I have no doubt that there are several others which have yet to be discovered. It is to be regretted that I have no specimens of *Musca* from any part of New Zealand, and I trust that those who are interested in this important group of flies will send me material from this part of the region.

In my next series of notes I shall record my studies of the species of *Musca* from the Ethiopian Region, a very large collection of which Dr. Guy A. K. Marshall has kindly placed at my disposal.