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MOSQUITO STUDIES IN THE INDIAN SUBREGION

Part I Taxonomy—A brief review

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INTRODUCTION

Ever since the important discoveries in the last few decades of the last century that mosquitoes play the role of vectors of human diseases, these tiny insects have received special attention of entomologists, health workers and sanitarians all the world over. As an immediate consequence of this, basic research, particularly in the field of mosquito taxonomy, received a great impetus and entomologists set about the task of describing and naming all the different species that hitherto lay in obscurity. The Indo-Pakistan subcontinent, birth place as it was of Ross's discovery, started very late, so much so that at the time when Theobald published his Monograph of World Culicidae which contained a whole treasure of information on mosquitoes from other parts of the world, only very few species were known from India. But fortunately this state of affairs did not last very long and soon workers in India also engaged themselves in a similar pursuit, a description of which will be attempted in the following pages.

WORK ACCOMPLISHED BETWEEN 1900–1934

Neither is it the aim of this review nor is it possible to circumscribe within the space of these few pages the voluminous work turned out in the sub-continent during the half century. Therefore, with a view to presenting a picture of the ground so far covered by various workers under different disciplines of mosquito studies in the area, it is intended to give here as brief an account as possible, which is by no means exhaustive. The object of such a study in retrospect is no other than to provide basis for comparison with what has been done in other countries and to envisage important gaps in our knowledge of the different aspects of the subject, relating to the fauna of this region so that efforts may be made to fill them up.

The main heads are: (1) Taxonomy (2) Bionomics (3) Control and such other problems that intrude themselves during these investigations. In the present communication it is proposed to deal with taxonomy and the other subjects will be treated subsequently.

Taxonomy: — Mosquito Taxonomy in India remained in slack waters for a long time. Even Giles's plea for collective investigation of Indian Culicidae, which appeared in 1901 the year that saw the publication of Theobald's Monograph of World Culicidae, did not have the desired effect. But soon it was felt that the fell disease malaria, which is aptly

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described as the 'disease slow to kill, hard to cure and quick to incapacitate', was the human malady that took a very heavy toll of life and cost India a great deal in terms of annual revenue. Hence it was given top priority among the insect-borne diseases and consequently work started on mosquitoes of the genus *Anopheles*. A full-fledged research institute started functioning under the name of the Malaria Survey of India (later redesignated as the Malaria Institute of India) first at Kassauli and then at New Delhi. The main function of the institute was to train doctors in malariology giving them a smattering of knowledge of the malaria parasite *Plasmodium*, and the identification of important mosquito vectors and their control. But side by side with this the institute embarked upon problems of basic research such as the taxonomy of anopheline adults and larvae. Before a monographic work on *Anophelinae* by Sir S. Rickard Christophers (1933) embodying the results of all the taxonomic studies in the country was published, James and Liston's (1904) volume on Anophelines of India was largely used as the guide to the identification of species. What was perhaps more fascinating for the taxonomist was the study of the culicine mosquitoes with a number of genera and an enormous wealth of new material turning up almost every day. About two years before *Edwards' Synopsis of Adult Oriental Culicine Mosquitoes* (1922) was published in two parts, Capt. P. J. Barraud had received a Commission under the Indian Research Fund Association to make a general survey of the mosquitoes of India. This investigation unearthed such a large number of culicine mosquitoes new to science that Barraud started publishing a series of papers entitled "A Revision of the Culicine Mosquitoes of India" in the Indian Journal of Medical Research and continued to do so for over a decade from 1923 onwards until in 1934 appeared his Fauna of British India (including Ceylon and Burma) devoted to the two tribes Megarhinini and Culicini. The publication of these two great works of the *Fauna* marked a land-mark in the history of mosquito studies in the sub-continent.

By this time as many as 43 anopheline and 245 culicine mosquitoes had come to be known from the area. This account of the major works on the taxonomy of Indian Culicidae will remain incomplete without mention of Puri's (1931) excellent work on the larvae of anopheline mosquitoes of India. Note-worthy among the earlier works are the Annotated Catalogue of Culicidae and the Critical Review of the Genera in Culicidae by Brunetti (1907–1920) published from the Indian Museum.

Therefore it would appear that quality as well as quantity of work thus produced not only brought the mosquito investigation of the area in line with such great works, for example, as that of Edwards in Africa and other parts of the world and of Howard, Dyar and Knab in the Americas, but also it proved of immense practical value to mosquito workers in India and abroad. It may also be pointed out here that in connection with the study of new and more reliable taxonomic characters, Christophers and Barraud's (1923) work on the male genitalia of *Anopheles* and that of the former on the structure and development of the female genital organs and hypopygium of the adult (Christophers 1923) are valuable contributions to basic research on mosquitoes. Christophers (1922) also studied development and structure of the terminal abdominal segments and hypopygium of the adult mosquito to establish homologies with the terminal segments of the larva. Barraud and Covell (1927) and later on Barraud (1928) alone studied the morphology of the buccal cavity of mosquito with a view to determining characters of diagnostic importance for species, as similar studies on sandflies by Adler and Theodor (1926) had proved of immense value from a taxonomic viewpoint. Among other works, Christophers (1906)

paper on the importance of larval characters in the classification of mosquitoes, that of Sinton and Covell (1927) on the relationship of morphology of buccal cavity to the classification of anopheline mosquitoes, and Christophers and Barraud's (1931) description of the eggs of Indian Anophelines are worth mentioning.

Having thus briefly summarised the taxonomic work accomplished in the Indian Subregion from 1900 to 1934 the progress made from then onwards will now be considered.

FROM THE YEAR 1934 ONWARDS

The year 1934 marks the end of an era of very active taxonomic research on Culicidae by virtue of which mosquitoes became one of the best known groups of insects in the area. It will be seen that the number of species described registered a sharp rise from 30 to 288 during this period, but the only addition made from 1934–1959 is as follows:

1. *Anopheles habibi* Mulligan and Puri 1936.
2. *A. stephensi mysorensis* Sweet and Rao 1937.
3. *Culex* (*Culex*) *parainfantulus* Menon 1944. (since sunk as a synonym of *infantulus* Edwards by Mattingly 1959).
4. *Uranotaenia hussaini* Qutubuddin 1946
5. *C.* (*Culiciomyia*) *stylifurcatus* Carter and Wijesundara 1948 (synonymised by Mattingly (1955a) with *spathifurca* Edw.).
6. *C.* (*Mochthogenes*) *campilunati* C. and W. 1948.
7. *Aëdes* (*Aëdes*) *seculatus* Menon 1950.
8. *Uranotaenia mattinglyi* Qutubuddin 1951.
9. *Aëdes* (*Aëdes*) *petroelephantus* Wijesundara 1951.
10. *Aëdes* (*Aëdes*) *spermathecus* Wijesundara 1951.
11. *Aëdes* (*Aedes*) *carteri* Wijisundara 1951 (sunk as synonym of *seculatus* Menon by Stone, 1956 (1957).
12. *Aëdes* (*Stegomyia*) *patricease* Mattingly 1955b
13. *Culex* (*Neoculex*) *quettensis* Mattingly 1955b
14. *C.* (*Culex*) *afridii* Qutubuddin 1956.
15. *Heizmannia reidi* Mattingly 1957b
16. *Aëdes* (*Paräedes*) *menoni* Mattingly 1958b

Before we proceed to look for the lacunae as they exist at present in our knowledge of the group, it is desirable to make alterations and additions to Barraud's Fauna of British India which are necessitated by the discovery of the above mentioned species. These changes are suggested in the following:

I. Genus **Uranotaenia** Lynch Arribalzaga 1891

Insert the following sentence under couplet 22 on page 61:

Pleurae uniformly pale ..... *husaini*

Delete couplet 23 and instead write the following:

23. Eye margins pale but not conspicuously so ..... *recondita*
Eye margins with few or no pale scales except at sides ..... *novobscura*
Eye margins *distinctly* whitish..... *mattinglyi*

II. Genus **Aëdes** Meigen 1818

1. Subgenus: **Stegomyia**

On p. 220, substitute *patriciae* for *flavopictus*

2. Subgenus: **Aëdes**

On p. 279, in couplet 9 delete the third line and insert in its place, "apex of coxite not ending in a finger-like process".....9a

Between couplets 9 and 10 insert the following:

9a Apex of coxite wide and truncate. Process on inner side, long, slender and elbowed. Style slender and curved with small pointed terminal appendage..... *indicus*
Apex of coxite produced into a snout-like process carrying two short spines. Inner process of coxite stumpy, bearing a pair of strong spines. Style large and sickle-like with no terminal appendage..... *seculatus*

The above is mainly adopted from Menon (1950)

III. Genus **Culex** Linnaeus 1758

1. Subgenus **Neoculex**

On page 334, under couplet 10 add:

Dorsum of abdomen: First tergite dark, II-IV segments with very distinct pale apical bands, with median anterior prolongations forming rather regular triangles, V-VII with wide apical pale bands.....*quettensis*

The above is drawn from Mattingly (1955b)

2. Subgenus **Culex**

On page 388, in couplet 4 instead of *bitaeniorhynchus* write 5, and instead of 5 write 6 thus renumbering the present couplets 5 as 6 and 6 as 7 and so on, and between the couplets 4 and 5 add the following:

5. Abdomen with apical pale bands ..... *bitaeniorhynchus*
Abdomen with basal pale bands ..... *afridii*

Besides the above, the following brief account will bring up-to-date our knowledge of the mosquitoes of the subregion.

This relates to the change of a generic name or the lowering of the rank of a genus or the raising of that of a subgenus; the shifting of a species from one genus or subgenus to another, the discovery of the early stages or the unknown sex of a species etc. It may be mentioned here that such a change or discovery has not necessarily been made or effected by a worker located in the subregion, although it does apply to a species or a genus occurring in the area. For the sake of brevity no attempt has been made here to mention new locality records of species, which are not very many.

In briefly describing these discoveries relating to anophelines, as far as possible chro-

nological arrangement has been adopted.

Baisas (1935) described the pupa of *Anopheles pseudobarbirostris*, and in 1938 that of *A. insulaeflorum*. Sweet and Rao (1937) detected differences in the eggs of the two forms of *A. stephensi*; one of which viz., *mysoriensis* is now regarded as a subspecies of the former. Crawford (1938) studied the pupae of *Anopheles aconitus*, *kochi*, *leucosphyrus*, *philippinensis*, *tessellatus*, *vagus*, *ramsayi*, and *maculatus* which were not described before. D. Abrera (1944) described eggs of *A. gigas* var. *refutans* and *A. varuna*. Abraham (1947) described a new species *A. kyondawensis* from Burma, in larval stage, the adult being still unknown. Reid (1949) resurrected *A. elegans* from the synonymy of *leucosphyrus*. Colless (1956) described its egg and pupa.

Reid (1953) figured the larva and pupa of *A. peditaeniatus* and raised *A. hyrcanus* var. *nigerrimus* to the status of a species. This account will remain incomplete without mention of the very detailed study by Colless (loc. cit.) of the *leucosphyrus* group of mosquitoes in Singapore, which will serve as a useful guide for workers on the group in the subregion.

For the culicines, as far as possible, Barraud's arrangement of genera is adhered to although on many occasions it has been disturbed. The additions to our knowledge made during the period are as follows: —

The genus *Megarhinus*, Robineau-Desvoidy has been renamed as *Toxorhynchites* Theobald (1901) (See 1959 Int. Comm. Zool. Nomencl. Opinion 548). Stone et al (1959) adopted the name *Malaya* Leicester for *Harpagomyia* Meijere 1909. Stone (1957) after examining Theobald's type of *Uranotaenia atra* in the Hungarian Museum discovered that owing to the omission by Theobald (1905) in his description of the type of a very important character viz., the entirely dark *postpronotum* and the large dark spot in front of the wing base on the *scutum*, Taylor (1914) was misled and described *U. nigerrima* as distinct from *atra*. But since the latter name was constantly applied to a different species it became necessary to resurrect a name to replace *atra* of authors and not Theobald. Such a name is *lateralis* hence the species known as *atra* in the Indian subregion is actually *U. lateralis* Ludlow 1905.

Theobaldia Nevcu-Lemaire is now replaced by *Culiseta* Felt (see Stone et al, 1959). On the discovery of the larva of *Culiseta indica* by Qutubuddin (1952), he constructed a key for the identification of the larvae of the three species found in the subregion. Iyengar (1935) described the egg of *Ficalbia* (*Ficalbia*) *minima*. Menon (1938) described the egg of *Ficalbia hybrida*. Mattingly (1957a) described egg, larva and pupa of *minima* and the larvae and pupae of *chamberlaini*, *hybrida*, *luzonensis* and *fusca* and transferred the last species from the subgenus *Etorleptiomyia* to *Ravenalites* Doucet 1950. This subgenus, was invalid since no type had been selected. Its author, however, validated it by selecting *F.* (*R.*) *roubaudi* as the genotype (See Foreward in Mattingly, 1957a). Mattingly also provisionally distinguished the Indian form of *chamberlaini* as ssp. *clavipalpus* Theo., and recognised *intermedia* Barraud as a distinct species. *F. aurea* is now shown to occur in Assam. The generic name *Taeniorhynchus* which was abandoned in favour of *Mansonia* has been finally suppressed (See 1959 Opinion Int. Comm. Zool. Nomencl. 20 pt 17, Pp. 185–198 London). Menon (1940) gave a synoptic table for the identification of the Indian species of the subgenus *Mansonioides*. Knight and Chamberlain (1948) used a new nomenclature for describing the chaetotaxy of the pupae of *M. uniformis*, *Aedomyia catasticta*,

Malaya genurostris, Armigeres malayi, Culex (Lutzia) halifaxi, and *Aedes (Finlaya) niveus.* Carter (1950) described the egg of *Mansonia uniformis* and the larva and pupa of *annulifera.* Bonne-Wepster (1954) figured and described the larva of *M. (Coquillettidia) crassipes.* Knight and Mattingly (1950) raised *Orthopodomyia anopheloides* var. *andamanensis* to the status of a species, and described the larvae and pupae of *albipes, flavithorax* and *flavicosta* using Knight and Chamberlain's (loc. cit.) chaetotaxy for pupae. Lacasse and Yamaguti (1950) described the pupae of *M. (C.) ochracea, Aëdes albopictus, Aëdes (Aedimorphus) alboscutellaris, Culex (Lutzia) vorax, C. (Lophoceratomyia) rubithoracis, C. (L.) infantulus,* (by synonymising *parainfantulus* Menon with this species), Mattingly (1949) has extended its distribution to the Indian subregion), *C. (Culiciomyia) pallidothorax, C. (Culex) bitaeniorhynchus, sitiens, vishnui, mimeticus, whitmorei* and *Uranotaenia bimaculata.* Sicart (1952) figured and described the larva of *Aëdes (Ochlerotatus) pulchritarsis.* Knight and Laffoon (1946) figured the pupa of *Aëdes (Finlaya) poicilus.* Qutubuddin (1954) figured and described the larva, pupa and the male terminalia of *Aëdes (Finlaya) lophoventralis.* He employed Belkin's (1950) nomenclature for larval chaetotaxy and that of Knight and Chamberlain (loc. cit.) for the pupal. Chow and Mattingly (1951) described the early stages of *A. (F.) albocinctus* and *albotaeniatus* var. *mikiranus* and figured their male terminalia.

Knight (1947–48) described the male terminalia *A. (F). chrysolineatus.* Carter and Wijesundra (1948) described the larvae of *A. (F.) harveyi, A. (Aedimorphus) jamesi,* the previously unknown larva and pupa of *Hodgesia bailyi*; the larvae of *Culex (Culiciomyia) edwardsi,* and *fuscifurcatus*; and a new species *Culex (Mochthogenes) campilunati.* They also discovered the adult of *Tripteroides dofleini* which species was known only by larva and pupa. Bonne-Wepster and Brug (1939) described the larva, and later on Colless (1958) described the male and larva of *A. (F.) niveoides.* Peters and Dewar (1956) described pupae of *Aëdes (Christophersiomyia) annulirostris, thomsoni,* the larvae of *Culex (Lophoceratomyia) plantaginis, C. (Culex) barraudi, C. (Culex) whitei, Uranotaenia compestris* and *annandalei.* Mattingly (1958a) described the larva and pupa of *Aëdes (Rhinoskusea) longirostris.* Knight and Hull (1952) described the larva of *A. (Stegomyia) desmotes.* Rajagopalan (1956) described the larva and pupa of *A. (S.) w-albus.* Penn (1949) figured and described the pupae of *Aëdes scutellaris, albolineatus, A. (Aedimorphus) vexans* and those of *Culex (Lophoceratomyia) fraudatrix, uniformis, C. (Culiciomyia) fragilis, C. (Culex) sitiens,* and *Anopheles karwari.* Senevet and Andarelli (1958) described the pupa and *Anopheles karwari.* Senevet and Andarelli (1958) described the pupa of *Aëdes vittatus.*

Mattingly (1958a) transferred *Aëdes ostentatio* from *Aedimorphs* to the subgenus *Paraedes.* According to Stone et al (1959) the subgeneric name *Neomelaniconion* Newstead 1907 (Feb. 1) enjoys priorty over *Banksinella* Theo. 1907 (Feb. 23) and therefore should be protected. Qutubuddin (1945) published a description based on a single female (from Hyderabad Deccan) which he identified as *Aëdes (Diceromyia) periskeletus* which species has been previously known only from the male sex. While it closely answered to Barraud's description of the male it differed in the head markings and the coloration of the proboscis.

Mattingly (1959) figured and described the pupa *Aëdes iyengari.* Stone and Knight (1958) have given the new name of *Aëdes (Aëdes) lankaensis* to *ceylonicus* Edwards. Wijesundara (1951) described the female of *Aëdes (Aëdes) yerburyi* which was not known before and also described three new species of the subgenus viz., *A. petroelephantus, sper-*

mathecus, and *carteri* the last of which is synonymised with *seculatus* Menon by Stone (1956–1957). Unfortunately the descriptions are not available here to be included in the identification key for subgenus *Aëdes* given by Barraud (1934); *sigmoides* has been sunk by Causey (1937) as the synonym of *Aëdes dux*.

In a letter to Stone and others Mattingly (1958) suggested that Edward's species *Aëdes* (*Cancraedes*) *kanaraensis* should be transferred to *Diceromyia* (Stone et al, 1959). Mattingly (1958b) lowered the rank of the genus *Paraedes* Edward 1934 to that of a subgenus under *Aëdes* and described a new sp. *Aëdes* (*Paraedes*) *menoni* Mattingly. Mattingly (1957b) described a new species *Heizmannia reidi* from Sukna West Bengal, and figured the larva of *indica* and synonymised *funerea* with *scintillans*. He is also of the opinion that one of the two species, viz., *discrepans*, which Barraud had provisionally referred to the Neotropical genus *Haemagogus* has its correct place in the genus *Heizmannia* and the other, *tripunctatus* Theo., should be *Aëdes tripunctata*. Mattingly (1949) figured the pupa of *Heizmannia himalayensis* for the first time. Mattingly and Qutubuddin (1952) figured the undescribed male terminalia of *Armigeres theobaldi* and *conjugens*, and showed these two species to be annectant between the two subgenera *Armigeres* and *Leicesteria*. *Armigeres* (*Leicesteria*) *flavus* was transferred to the subgenus *Leicesteriomyia* (see Stone et al, 1959). Bonne-Wepster (1934) described the male of *Armigeres* (*Leicesteria*) *annulipalpis* (Theo.). Galliard and Ngu (1949) figured the larva of *C.* (*Mochthogenes*) *khazani* and *malayi*. Baisas (1938) described the pupa of *C.* (*Culex*) *gelidus*, and Colless (1955) the previously unknown larva of *hutchinsoni*.

CONCLUSIONS AND DISCUSSION

Taxonomy: It is clear from the above brief review of work done since Barraud that the number of new species added in the last twenty five years is extremely low. This retardation in the pace of increase is surely not, as may be suggested, due to the fact that exhaustive collecting has been done in the area and it held no further promise of new material. This may be true to an extent in so far as the Indian anophelines are concerned. On the other hand, it may be said without fear of contradiction that the set-back suffered in respect to culicines is due to lack of efforts made during the period. Edward's remarks made in his Editorial Preface to Barraud's Fauna, that many new species may be awaiting discovery in certain parts of India, give point to this statement. This is further borne out by the researches carried out in the contiguous Indo-Malayan subregion where efforts made by R. M. Bohart, Baisas, Stone, Knight, Mattingly, Colless and others have proved very fruitful and an enormous amount of new material has come to light. Some of Colless's (1955, 1957a, 1958) species, discovered in Singapore, belonging to the *vishnui* and *bitaeniorhynchus* groups, particularly *pseudovishnui*, *pseudositiens* and perhaps in *Aëdes niveus* subgroup, and those of Mattingly's (1957b, 1958a) in *Heizmannia* and *Cancraedes* from the Indo-Malayan subregion may be awaiting discovery in the area. In fact Colless (1957a) states that there is evidence of the existence of two distinct forms of *vishnui* in India and closer examination of the Indian material is needed before the relationships of forms within the species can finally be decided. Rao and Rajagopalan (1957) seem to have considerable amount of undescribed material in their collection from southern India. Moreover, Mattingly (1957b) states that the British Museum has a number of undescribed species of *Heizmannia* from Assam.

A second fact that emerges from the above review is that barring a few publications very little attention has been paid during this period to the taxonomy of the group by those located in the subregion. Therefore, whatever addition is made to our knowledge is through the labour of either the American and British workers from the United States National Museum and the British Museum respectively or by those working in the Philippines, Japan, New Guinea, and of late in Singapore. Besides this, there are still a large number of species of which the larvae and pupae are either not isolated in the Indian subregion or are still unknown. Nor is anything known about the first, second and the third stage larvae of these species. Further a detailed study of even the known larvae and pupae using Belkin's (1950, 1952) setal chaetotaxy for the larva and pupa and Knight and Chamberlain's (loc. cit.) nomenclature for the pupa is yet to be made. No work on the eggs of any group of culicine mosquitoes exists to compare with that of Christophers and Barraud (loc. cit.) on anopheline eggs or that of Craig (1956) on the eggs of Nearctic aedine mosquitoes. This state of affairs is really unfortunate particularly when we know that Mattingly (1954b) sounded the note of caution that "final identification must await the examination of early stages and of adults of both sexes" even in the case of common species.

Apart from the solitary example of *A. stephensi* type and the subspecies *mysoriensis* which show remarkable differences in egg measurements, biology, biting habits and transmission of malaria no knowledge has been gained as to the occurrence of sibling species or species complexes in other groups in the Indian subregion. The *Culex pipiens* complex has been the subject of intensive study in Europe, America, Africa, and Australia as a result of which many interesting facts have come to be known which throw light on the various aspects of its study. But still many issues need clarification. Roubaud and Ghelelovitch (1959) have recently studied the maxillary indices of the complex in Europe. In view, however, of the great medical importance of this group of mosquitoes and the many intricate problems associated with the complex in all parts of the world, a Committee was formed at the suggestion of Prof. Swellegrebel under the chairmanship of Mr. P. F. Mattingly of the British Museum (with Prof. O. Theodor, Prof. C. Jucci, Lt. Cdr. K. L. Knight and Dr. H. Laven as members) to report on the conclusions so far reached from previous stuides and to recommend for future research with particular reference to standardization of techniques and the securing of collaboration on an international basis. This committee has made its recommendations for a world-wide study on lines suggested in the report (See Knight, 1953). No attempt has been so far made to study this species complex in the Indian subregion where *C. pipiens fatigans*, an important member of this group, is a very common widespread domestic mosquito and is the classical vector of *filariasis* in many parts of the area. At least three intraspecific forms of this subspecies are known to occur in the Ethiopian region (See Mattingly, 1956). Nothing is known about the existence or otherwise of such forms in the area under discussion. Nor do we know whether *C. pipiens molestus*, the autogenous, heterodynamic member of the complex has been introduced also into the coastal areas of the subregion as it was into Southern Australia during the last war. Only a large scale dissection of male terminalia and measurement of male palps and a sustained study of the larval characters will reveal the truth about it.

Now about *Aëdes aegypti* (L.), the equally important and perhaps almost equally common mosquito in the area. Mattingly (1957c) recognizes three distinct forms of this species, viz., *Aëdes aegypti* sens. str., the type form 2. *Aëdes aegypti* ssp. *formosus* (Walker) 3. *A. aegypti* var. *queenslandensis* Theo. Of these, ssp. *formosus* is confined entirely to

Africa south of Sahara. Var. *queenslandensis* is reported by Barraud to occur in the Punjab and a form resembling it from Bangalore. Mattingly (1957c) thinks it is probably common in parts of India. Since 1934 no attempt has been made to study in detail and map the distribution of the species *sens-lato* in the area. Mattingly (1957c) is inclined to think that Barraud's statement: "Generally distributed throughout the Indian region" is contradicted by the accompanying map itself at least in southern India where, with only three exceptions, it has been shown to occur on or near the coast. Regarding the occurrence of the two forms in the Indian subregion one can deduce from Mattingly's (1957c) statement that the type form, as far as can be judged, is less common over most of the Mediterranean area and in Australia and perhaps India than in the Indo-Malayan and Pacific areas and in parts of the New World, and that var. *queenslandensis* as mentioned above is probably common in parts of India. This has to be confirmed by a detailed survey. Before leaving the subject of *Aëdes aegypti* it seems worth while to mention here that while var. *queenslandensis* throughout its range is purely a domestic and rural species, wild populations of type form have been described by Haddow (1945, and 1948) in Africa. In regard to altitudinal distribution, it is known to occur in Africa from sea level on coastal belts to a height of 8000 ft. No data regarding its occurrence and infiltration into forests nor about its vertical distribution in the area under discussion are available. For further detailed information on this very important, common, and at the same time problematic species, the reader is referred to Mattingly (1957c, 1958c).

Thus it is clear that the situation, as it stands at present, calls for a thorough study of the distribution and taxonomy of this very important mosquito inside the area.

In regard to other data of interest to the taxonomist of the group, very little information is recorded, for instance, in respect to the occurrence of any natural sympatric or allopatric hybridizations, nor has the possibility of such a phenomenon occurring in nature been surmised by hybridization experiments in laboratory in the area under discussion except, of course, the single example of *Anopheles subpictus*×*A. vagus*. While Toumanoff (1937, 1938, 1939, 1950; See Mattingly, 1956) succeeded in obtaining hybrids by crossing *Aëdes aegypti* and *Aëdes albopictus* in Indo-China, in Mac-Gilchrist's (1913) experiments copulations between the same species in Calcutta were found to be unproductive, suggesting thereby the existance of some difference in the two populations (See Mattingly, 1956). Hybridizations in nature are known to occur in many species in other areas, for instance, between members of the *C. pipiens* group in Australia viz., *molestus* and *globocoxitus* (See Mattingly, 1956) and amongst those of the European *Anopheles maculipennis* complex and the American dark winged anophelines which have been confirmed by experimental hybridization by Maryon et al (1951) and by Barr (1954) respectively.

Zoogeography: Strictly speaking the Indian subregion as shown in the Eagle Clarke and Grimshaw's Atlas of Zoogeography includes the whole of W. Pakistan, a part of southern Iran represented by a tongue-like coastal strip reaching the Persian gulf, and the whole of India (excluding a portion of Assam), E. Pakistan and Ceylon. Thus the area under review slightly differs from the Indian subregion in as much as while from the former the strip from Persia is excluded, the whole of Assam and Burma are included in it. This is precisely the area treated by Barraud as "British India" for the purpose of his work on the megarhines and culicines although he has also given the distribution of a large number of species outside this area. The zoogeography of the mosqui-

toes of the area, which contains half of the total number of oriental species in so far as culicines are particularly concerned, is imperfectly worked out. About 30 % of the species occurring in the area are known to be endemic to it. The rest of the fauna is eastern Oriental in character with an admixture of Palaearctic and Ethiopian species in the north and west and with Malayan or eastern Oriental element in the southern, eastern and north-eastern regions (See Barraud, 1934). In the north the Mediterranean element is represented by a number of species (See Mattingly, 1957c) and more precisely various south-western species not found elsewhere unless in Assam show Malayan affinities (Mattingly in litt). A very thorough study will be necessary before we have a clear picture before us in respect to the affinities of the Indian mosquito fauna with the Palaearctic and Ethiopian on the one hand and the Indo-Malayan and Indo-Chinese subregions on the other. Secondly the distribution records of various species within the area are not numerous enough to permit demarcation of faunal provinces and districts as exemplified by mosquitoes as, for instance, has been done in case of the Ethiopian subregions. Last though not least, no attempt whatsoever has been made to study mosquito distribution in the area in relation to the geological formations which, in case of certain very important species of the genus *Aëdes*, are known to have very distinct correlation.

In conclusion it may be briefly pointed out here that in view of the various gaps envisaged in the mosquito taxonomy of the area, the fauna stands in dire need of revision and checking at the hand of the works accomplished during the last twenty five years in other parts of the world, some of which have been mentioned above. This revision will have to be done with the modern dynamic rather than the time-honoured static concept of species in mind. To explain this I can do no better than to quote Bates (1949): "Part of the species problem then consists in determining what is meant by the term. If the definition "sexually isolated populations" is accepted, the recognition of species in a given locality depends on the discovery of morphological discontinuities serving to mark this sexual isolation. Experimental procedures are necessary where there is doubt as to the significance of the morphological discontinuities or where anomalies in behaviour indicate the possibility of cryptic species. The question next arises: How did the sexual isolation of these species come about? which is essentially the problem of the origin of species. This also involves taxonomy, because we need not only recognize the end stage of sexually isolated populations, but also to recognise intermediate partially isolated populations — subspecies — and to deal in some manner with intraspecific variation."

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REFERENCES

(Those marked with an asterisk were not seen in the original)

D'Abrera, V. St. E. 1944. The eggs of the Ceylon anopheline mosquitoes. Jour. Malar. Inst. India **5**: 337–359.

Adler, S. and O. Theodor. 1926. On the *minutus* group of the genus *Phlebotomus* in Palestine. Bull. Ent. Res. **16**: 399–405.

*Baisas, F. E. 1935. Notes on Philippine mosquitoes V. The pupal characters of anophelines under *Myzorhynchus* series and group *Neocellia* with further comments on the larvae and adults of *sinensis*. Bur. Hlth. Philipp., Mon. Bull. Manila, **15**: 291–339.

———— 1938. Notes on Philippine mosquitose VII. A *Culex* (*Culex*) with banded proboscis and tarsi. B– *Anopheles*: The pupae of three rare species; the *leucosphyrus* subgroup. Bur. Hlth. Philipp., Mon. Bull. Manila, **22** (1): 27–49.

Barr, A. R. 1954. Hybridization experiments with some American dark-winged anophelines. Expt. Parasit. **3**: 445–457.

Barraud, P. J, 1928. The morphology of the buccal cavity in anopheline and culicine mosquitoes. Indian. Jour. Med. Res. **15**: 671–679.

———— and G. Covell. 1927. The morphology of the buccal cavity of the mosquito. Far. East. Assoc. Trop. Med. 17th Congress. Trans. **3**: 98–102.

———— 1934. The fauna of British India. Vol. V, Diptera Family Culicidae: Tribes Megarhinini and Culicini. 463 pp. Taylor and Francis, London.

Bates, M. 1949. The natural history of mosquitoes. Macmillan Co., New York.

Belkin, J. N. 1950. A revised nomenclature of the chaetotaxy of mosquito larvae (Diptera: Culicidae). Amer. Midl. Nat. **44**: 678–698.

———— 1952. The homology of the chaetotaxy of immature mosquitoes and a revised nomenclature for the chaetotaxy of the pupa. Ent. Soc. Wash., Proc. **54**: 115–130.

Bonne-Wepster, J. 1934. New mosquitoes (Diptera) from the Netherlands East Indies. Stylops **3**: 272–276.

———— 1954. Synopsis of a hundred common non-anopheline mosquitoes of the Greater and lesser Sundas, the Moluccas, and New Guinea. R. Trop. Inst. Amsterdam, Spec. Publ. **3**: 1–147.

Brunetti, E. 1907, 1912, 1914, 1920. See P. J. Barraud 1934 for detailed reference.

*Carter, H. F. 1950. The genus *Taeniorhynchus* Lynch Arribalzaga (Diptera: Culicidae) with special reference to the bionomics and relation to disease of the species occurring in Ceylon. Ceylon Jour. Sci. (B) **24**: 1–26.

*———— and D. P. Wijesundara. 1948. Notes on some Ceylon culicine mosquitoes. Ceylon Jour. Sci. (B) **23**: 135–151.

Causay, O. R. 1937. Some anopheline and culicine mosquitoes of Siam with remarks on malaria control in Bangkok. Amer. Jour. Hyg. **25**: 400–420.

Chow, C. Y. and P. F. Mattingly, 1951. The male genitalia and early stages of *Aëdes* (*Finlaya*) *albocinctus* Barr and *Aëdes* (*F.*) *albotaeniatus* var. *mikaranus* Edw. with some notes on related species. R. Ent. Soc. Lond., Proc. (B) **20**: 80–90.

Christophers, S. R. 1906. On the importance of larval characters in the classification of mosquitoes. Sci. Mem. San. Dept. India, n. s. **25**: 1–18.

———— 1922. The development and structure of the terminal abdominal segments and hypopygium of the mosquitoes with observation on the homologies of the terminal segments of the larva. Indian Jour. Med. Res. **10**: 530–570.

———— 1923. The structure and development of the female genital organs and hypopygium of the mosquito. Indian Jour. Med. Res. **10**: 698–720.

———— 1933. The fauna of British India including Ceylon and Burma: Diptera Family Culicidae Tribe Anophelini. Vol. **4**, 371 pp., Taylor and Francis, London.

Christophers, S. R. and P. J. Barraud. 1923. Descriptive terminology of the male genitalic characters of mosquitoes. Indian Jour. Med. Res. **10**: 827–835.

———— 1931. The eggs of Indian *Anopheles* with descriptions of the hitherto undescribed eggs of a number of species. Malar. Surv. India, Rec. **2**: 161–192.

Colless, D. H. 1955. Notes on the culicine mosquitoes of Singapore I. Three new species of *Culex* (Diptera, Culicidae) and a redescription of *Culex hutchinsoni* Barraud. Ann. Trop. Med. Parasit. **49**: 311–319.

———— 1956. The *Anopheles leucosphyrus* group. R. Ent. Soc. Lond., Trans. **108**: 37–116.

———— 1957 a. Notes on the culicine mosquitoes of Singapore II. The *Culex vishnui* group (Diptera: Culicidae) with descriptions of two new species. Ann. Trop. Med. Parasit. **51**: 87–101.

———— 1957 b. Notes on the culicine mosquitoes of Singapore III. Larval breeding places. Ann. Trop. Med. Parasit. **51**: 102.

———— 1958. Notes on the culicine mosquitoes of Singapore IV. The *Aëdes niveus* subgroup (Diptera, Culicidae): Introduction and description of five new species and one new sub-species. Ann. Trop. Med. Parasit. **52**: 468–483.

*Craig, G. B. Jr. 1956. Classification of eggs of Nearctic aedine mosquitoes (Diptera, Culicidae). Doctoral thesis, University of Illinois, 128 pp.

Crawford, R. 1938. Some anopheline pupae of Malaya with a note on pupal structure. 110 pp.

*Doucet, J. 1950. Le culicines de Madgascar (Diptera). Inst. Sci. Madgascar, Mem. (A) 4(1): 39–65.

Edwards, F. W. 1922. A synopsis of adult Oriental culicine (including megarhine and sabethine) mosquitoes. Indian Jour. Med. Res. **10**: 249–293 and 430–475.

———— 1941. Mosquitoes of the Ethiopian Region III. Culicine adults and pupae. Brit. Mus. (*Nat. His.*) Lond. 490 pp.

Galliard, H. and Dang van Ngu. 1949. Culicines du Tonkin II. Les genres *Ficalbia* et *Mochthogenes*. Ann. Parasit. hum. Comp. **24**: 495–502.

Giles, G. M. 1901. A plea for the collective investigation of Indian Culicidae with suggestion as to most points for inquiry and a prodromus of species known to the author. Bomb. Nat. Hist. Soc., Jour. **3**: 592–600.

Haddow, A. J. 1945. On the mosquitoes of Bawamba County, Uganda: Description of Bawamba with special reference to mosquito ecology. Zool. Soc. Lond., Proc. **115**: 1–13.

———— 1948. The mosquitoes of Bawamba County, Uganda VI. Mosquito breeding in plant axils. Bull. Ent. Res. **39**: 185–212.

Iyengar, M. O. T. 1935. Eggs of *Ficalbia minima* Theo. and notes on breeding habits of *Ficalbia*, Bull. Ent. Res. **26**: 423–425.

James, S. P., and W. G. Liston. 1904. A monograph of the Anopheles mosquitoes of India. 1st ed. Thacker, Spink and Co. London, 132 pp.

Knight, K. L. 1947–1948. The *Aëdes* (*Finlaya*) *chrysolineatus* group of mosquitoes (Diptera: Culicidae). Ent. Soc. Amer., Ann. **40**: 624–649.

———— 1953. Suggestions for the measurement of variation on the *Culex pipiens* Complex. IXth International Congr. Ent., Trans. **5**: 297–300.

———— and R. W. Chamberlain. 1948. A new nomenclature for the chaetotaxy of

the mosquito pupa, based on a comparative study of the genera (Diptera: Culicidae). Helminth. Soc. Wash., Proc. **15** (1): 1–18.

Knight K. L. and W. B. Hull. 1951. The Aëdes mosquitoes of the Philippine Islands 1: Keys to the species of the subgenera *Mucidus*, *Ochlerotatus*, *Finlaya* (Diptera: Culicidae). Pacif. Sci. **5**: 211–251.

———— and J. L. Laffoon. 1949. The Oriental species of the *Aëdes* (*Finlaya*) *kochi* group (Diptera: Culicidae). Amer. Ent. Soc., Trans. **72**: 203–225.

———— and P. F. Mattingly. 1950. The *Orthopodomyia anopheloides* subgroup of mosquitoes (Diptera: Culicidae). Ent. Soc. Wash., Proc. **52**: 1–20.

*Lacasse, W. J. and S. Yamaguti. 1950. Mosquito fauna of Japan and Korea. 268 pp. App. 1. The female terminalia of the Japanese mosquitoes. 7 pp. App. II. Organization and function of malaria detachments. 213 pp., 3rd Ed., illus., Off. Surgeon, 8th U. S. Army, Kyoto, Japan.

Mattingly, P. F. 1949. Notes on some Oriental mosquitoes. R. Ent. Soc. Lond., Proc. (B) **18**: 219–228.

———— 1954a. Notes on the subgenus *Stegomyia* (Diptera: Culicidae) with a description of a new species. Ann. Trop. Med. Parasit. **48**: 259–270.

———— 1954b. The past present and future of mosquito studies in the Belgian Congo. Mus. Congo. Tervuren, Ann. Zool. **1**: 464–468.

———— 1955a. In Iyengar, M. O. T. and M. A. U. Menon Appendix pp. 9–10 Of: Mosquitoes of the Maldive Islands. Bull. Ent. Res. **46**: 1–10.

———— 1955b. Le sousgenre *Neoculex* (Diptera: Culicidae) dans la sousregion mediterraneene I Espece, sousespece et synonymie nouvelles. Ann. Parasit. hum. Comp. **30**: 375–388.

———— 1956. Species hybrids in mosquitoes. R. Ent. Soc. Lond., Trans. **108**: 21–36.

———— 1957a. The culicine mosquitoes of the Indo-Malayan area Part I, Genus *Ficalbia*. Brit. Mus. (Nat. Hist.), London.

———— 1957b. The culicine mosquitoes of the Indo-Malayan area Part II, Genus *Heizmannia*. Brit. Mus. (Nat. Hist.), Lond.

———— 1957c. Genetical aspects of the *Aëdes aegypti* Problem I, Taxonomy and Bionomics. Ann. Trop. Med. Parasit. **51**: 392–408.

———— 1958a. The culicine mosqutioes of the Indo-Malayan area Part III. Genus *Aëdes* Meigen subgenera *Paraedes* Edw., *Rhinoskusea* Edw. and *Cancraedes* Edw. Brit. Mus. (Nat. Hist.), London.

———— 1958b. A revision of *Paraedes* Edw. and *Cancraedes* Edw. (Diptera: Culicidae). R. Ent. Soc. Lond., Proc. (B) **27**: 76–83.

———— 1958c. Genetical aspects of the *Aëdes aegypti* problem II, Disease relationships, genetics and control. Ann. Trop. Med. Parasit. **52**: 5–17.

———— 1959a. The culicine mosquitoes of the Indo-Malayan area Part IV, Genus *Aëdes* Meigen, subgenera *Skusea* Theo., *Diceromyia* Theo., *Geoskusea* Edw., and *Christophersiomyia* Barraud. Brit. Mus. (Nat. Hist.), London.

Mattingly, P. F. and M. Qutubuddin. 1952. The hitherto undescribed male of *Armigeres* (*Armigeres*) *theobaldi* Barraud (Diptera: Culicidae). R. Ent. Soc. Lond., Proc. (B) **21**: 92–93.

Menon, M. A. U. 1938. The egg of *Ficalbia* (*Mimomyia*) *hybrida* Leic. Malar. Inst. India, Jour. **1**: 185–186.

———— 1940. A description and comparative study of the fourth instar larvae of *Mansonia* (*Mansonioides*) *uniformis* (Theo.), *M.* (*M.*) *anuulifera* (Theo.) including a synoptic table of the larvae of Indian species of the subgenus *Mansonioides* Theo. 1907 (Diptera: Culicidae). Jour. Malar. Inst. India **3**: 179–184.

———— 1944. On a new species of the subgenus *Lophoceratomyia* Theobald 1905 (Diptera: Culicidae). Jour. Malar. Inst. India. **5**: 389–393.

———— 1950. The male of a new species of the subgenus *Aëdes* Meigen 1818 (Diptera: Culicidae). R. Ent. Soc. Lond., Proc. (B) **19**: 139–141.

Penn, G. H. 1949. The pupae of the mosquitoes of New Guinea. Pacif. Sci. **3**: 3–85.

Peters, W., and S. C. Dewar. 1956. A preliminary record of megarhine and culicine mosquitoes of Nepal with notes on their taxonomy (Diptera: Culicidae). Indian Jour. Malar. **10**: 37–51.

Puri, I. M. 1931. Larvae of anopheline mosquitoes with full description of those of the Indian species. Indian Med. Res. Mem. **21**.

Qutubuddin, M. 1945. A description of the hitherto unknown female of *Aëdes* (*Dicleromyia*) *periskletus* (Giles) from Hyderabad. Nat. Acad. Sci., India, Proc. **15**: 33–35.

———— 1946. A new species of *Uranotaenia* (Diptera: Culicidae) from Hyderabad Deccan. Indian Jour. Ent. **8**: 117–118.

———— 1951. *Uranotaenia mattinglyi* sp. n., a new species of mosquito (Diptera: Culicidae) from Hyderabad (Deccan) India. R. Ent. Soc. Lond., Proc. (B) 107–109.

———— 1952. A description of the hitherto unknown larva of *Theobaldia indica* Edwards (Diptera: Culicidae), with a key to the larvae of the Pakistan species of *Theobaldia* Neveu-le maire, 1902, R. Ent. Soc. Lond., Proc. (B) **21**: 37–40.

———— 1954. The early stages and male terminalia of *Aëdes* (*Finalaya*) *lophoventralis* (Theo.) (Diptera: Culicidae). Ann. Trop. Med. Parasit. **48**: 135–141.

———— 1956. *Culex* (*Culex*) *afridii* sp. n. a new species of mosquito (Diptera: Culicidae) from Dacca, East Pakistan. Mosq. News. **16**: 140–142.

Rajagopalan, P. K. 1956. Larva and pupa of *Aëdes* (*Stegomyia*) *w-albus* Theo. (Diptera: Culicidae). Indian Jour. Med. Res. **44**: 481–489.

Rao, T. R. and P. K. Rajagopalan. 1957. Observations on mosquitoes of Poona District, India with special reference to their distribution, seasonal prevalence and the biology of adults. Indian Jour. Malar. **2**: 1–53.

Reid, J. A. 1949. A preliminary account of the forms of *Anopheles lencosphyrus* Dönitz (Diptera: Culicidae). R. Ent. Soc. Lond., Proc. (B) **18**: 42–53.

———— 1953. The *Anopheles hyrcanus* group in south-east Asia (Diptera: Culicidae). Bull. Ent. Res. **44**: 5–76.

*Roubaud, E. and S. Ghellilovitch. 1959. Les indices maxillaires dans l'interpretation du complexe biologique, chez le moustique commun, Europeen *Culex pipiens* L. Acad. des. Sci. Compt. Rend. **248** (25): 3510–3513.

Senevet, G. and L. Andarelli. 1958. Les genre *Aëdes* en Afrique du Nord II–Les nymphes. Inst. Pasteur Alger., Arch. **36**: 266–286.

Sicart, M. 1952. Description et etude de *Aëdes pulchritarsis* (Rondani) recolte en Tunisie. Arch. Inst. Pasteur. Tunisie Bull. Soc. Nat. Tunis. **5**: 95–101.

Sinton J. A. and G. Covell. 1927. The relation of the morphology of the buccal cavity to the classification of anopheline mosquitoes. Indian Jour. Med. Res. **20**: 301.

Stone, A. 1957. Corrections in the taxonomy, and nomenclature of mosquitoes (Diptera: Culicidae). Ent. Soc. Wash., Proc. **58**: 333–344.

———— 1957. Notes on types of mosquitoes in the Hungarian National Museum (Diptera: Culicidae). Ent. Soc. Amer., Ann. **50**: 171–174.

————, K. L. Knight and Helle Starcke. 1959. A synoptic catalog of the mosquitoes of the world (Diptera: Culicidae). The Thomas Say Foundation, Vol VI, Entomological Society of America.

Sweet, W. C. and B. A. Rao. 1937. Races of *Anopheles stephensi* Liston. Indian Med. Gaz. **72**: 665.

Taylor, F. H. 1914. Culicidae from Papua. Ent. Soc. Lond., Trans. **1914**: 185–205.

Theobald, F. V. 1905. Genera Insectorum Diptera. Fam. Culicidae. Fascicle **26**, 50 pp., 2 pls, Belgium.

*Wijesundara, D. P. 1951. Notes on species of the subgenus *Aëdes* Meigen (sens-str.) in Ceylon with description of three new species. Ceylon Jour. Sci. (B) **24**: 173–179.

RECENT LITERATURE ON PACIFIC INSECTS

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Madar, v. J. 1960. Zur Frage der zoogeographischen Verbreitung der *Chaetocnema concinnicollis* Baly mit Beschreibung zweier neuen Halticinen-Formen (Halticinae, Col.). Mushi **33** (7): 47–49, 3 figs.

Manson, D. C. M. 1959. An insect and a mite new to New Zealand. New Zeal. Ent. **2** (4): 31–32.

Marples, R. R. 1959. The Dictynid spiders of New Zealand. Roy. Soc. New Zeal., Trans. **87** (3–4): 333–361.

Mattingly, P. F. 1957. The Culicine Mosquitoes of the Indo-Malayan Area, Part 1. Genus *Ficalbia* Theob. Brit. Mus. (Nat. Hist.). 61 pp., 23 figs. Part 2. Genus *Heizmannia* Lud. 57 pp., 32 figs. 1958. Part 3. Genus *Aedes* Meig., subgenera *Paraedes* Ed., *Rhinoskusea* Ed. and *Cancaraedes* Ed., 62 pp., 23 figs. 1959. Part 4. Genus *Aedes* Meig., subgenera *Skusea* Theob. *Diceromyia* Theob., *Geoskusea* Ed. and *Christophersiomyia* Barr., 61 pp., 24 figs.

McAlpine, D. K. 1958. A key to the Australian families of Acalyptrate Diptera (Insecta) Austrl. Mus., Rec. **24** (12): 183–189.

Michener, C. D. 1960. Notes on the Biology and Supposed parthenogenesis of Halictine bees from the Australian region. Kansas Ent. Soc., Jour. **33** (2): 85–96, 3 figs.

Miyamoto, S. 1959. Veliidae of Japan and adjacent territory. III. A new species of *Pseudovelia* Hoberlandt from Japan, with description of its larval stages. Kontyû **27** (1): 81–85, 1 pl.

———— 1960. Aquatic and semiaquatic Heteroptera from Shansi Province, North China (Hemiptera). Mushi **33** (10): 73–84, 21 figs.

———— 1960. A new Strepsipteron from Shansi, North China, *Mengenilla sinensis* Miyamoto. Mushi **33** (5): 37–38, figs.

———— and T. Hidaka. 1960. Entomological results of the scientific survey to the Tokara Islands. III. Hemiptera-Heteroptera. Kontyû **28** (1): 42–47, 2 figs.