

## ARTICLES

Relationships of Adult and Larval Anatomy in the Supraspecific Classification of the Genus Culex in Southeast Asia (Diptera: Culicidae)

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The supraspecific classification of the genus Culex has remained virtually unchanged since the monumental work of Edwards (1932). Some groups of this genus with limited regional distributions have more recently been critically examined in light of modern taxonomic concepts (for example: Colless (1965) re-evaluated the subgenus Lophoceraomyia in Malaya not only with consideration to adult and immature characters, but to biological features as well; and Sirivanakarn (1968) refined the classification of species in the same subgenus from New Guinea). But most of the supposed phylogenetic relationships within the genus continue to be based primarily on the anatomy of the male terminalia. In addition to characters of the terminalia, Edwards did incorporate to some degree features of the male antenna and palpus and recognized the anatomy of the female to be of limited importance; however, no consideration was given to either the biology or the anatomy of the immature stages.

In more recent years a new awareness of the need to thoroughly understand all stages of each species has been stimulated in no small measure by the works of Carpenter and LaCasse (1955) and Belkin (1962). This new emphasis on individual rearings with extensive descriptions of immature stages presents the systematist with new criteria upon which to construct a scheme of classification which more realistically reflects probable phylogenetic relationships of species and species groups. Let us consider the classification of Southeast Asian Culex. The existing classification (see Table 1, column A) is based on Edwards except for supraspecific relationships within the subgenus Lophoceraomyia. The eight subgenera (Thaiomyia and Acalleoemyia being monotypic) probably encompass over 120 species in Southeast Asia alone.

In preparing a working classification of the genus in Southeast Asia based exclusively on fourth stage larvae, we find that four subgenera can be conveniently recognized (see Table 1, column B). Subgenus I is identified as the Jamesia group of the subgenus Lutzia on the basis of the predatory adaptations, the characteristic siphon and the large size, to name only three of the anatomical distinctions.

Subgenus II includes portions of three subgenera which are recognized in the existing classification; Lophoceraomyia, Neoculex, and Mochthogenes. Group 1 includes the subgenera Mochthogenes and Neoculex (only species of Edwards' group C have adequately described larvae in Southeast Asia). Several authors (Mattingly and Marks, 1955, and Belkin, 1962) have pointed out the arbitrary nature of the six groups which have been proposed within the subgenus Neoculex. Edwards distinguished the subgenus

Mochthogenes from his group C of Neoculex only on the basis of the length of the male palpus. Group 2 is composed of three subgroups: subgroup A includes the Fraudatrix group of the subgenus Lophoceraomyia; subgroup B includes the Mammilifer subgroup of the Mammilifer group of the subgenus Lophoceraomyia; and subgroup C consists of the Brevipalpus subgroup of the Mammilifer group of the subgenus Lophoceraomyia in the existing classification. The distinctions between these rather natural groupings of species have been recently pointed out by Colless (1965) and Sirivanakarn (1968). But predatory adaptations of the larvae of the Brevipalpus subgroup and their affinity to pitcher plant habitats suggests a need to separate this group of species from the other members of the subgenus Lophoceraomyia.

Subgenus III also consists of three subgenera: Culiciomyia, Acalleoemyia, and Thaiomyia. Group 1 includes the Fragilis group of the subgenus Culiciomyia and the monotypic subgenus Acalleoemyia. Although the saddle of segment X in the larva of Acalleoemyia is incomplete, other diagnostic features of chaetotaxy and anatomy provide no distinction from Edwards' Fragilis group (or group A). Group 2 consists of the monotypic subgenus Thaiomyia, which differs from group 1 in the absence of a pecten and in the number of tufts on the grid.

Subgenus IV corresponds to the subgenus Culex in the existing classification and on the basis of larvae alone, can be subdivided into four groups. Group 1 is equivalent to the existing Piapiens group; group 2 corresponds to the Vishnui and Gelidus subgroups of the Sitiens group of the subgenus Culex; group 3 includes the Sitiens subgroup of the Sitiens group; and group 4 incorporates the Bitaniorhynchus subgroup of the Sitiens group. Each of these four groups are readily separated by the shape and size of head hair 1-C as well as by other anatomical features.

Now, if we were to combine the existing classification (based almost exclusively on characters of the male terminalia) and the working classification (based exclusively on the anatomy and chaetotaxy of the fourth stage larva), we could conceivably establish a scheme of classification which reflects phylogenetic relationships more accurately than either classification alone (see Table 1, column c).

The subgenus Lutzia remains unchanged from the existing classification and in Southeast Asia incorporates Edwards' Jamesia group. Subgenus Neoculex in the combined classification is composed of Edwards' group C of Neoculex and the subgenus Mochthogenes. These two groups have been combined not only on the basis of the fourth stage larva, but also with consideration to the male terminalia (particularly the phallosome). There will undoubtedly be modifications to and subdivisions of this subgenus when all stages of the fauna are known throughout the range of the component parts.

Although it is felt that modifications in groupings are indicated, the subgenus Lophoceraomyia continues to be recognized as an integral unit due to the striking characteristics of the male. The characterization of the Fraudatrix group and the Mammilifer group of the existing classification is certainly valid and useful in defining phylogenetic affinities. However, the predatory nature and adaptations of the larvae, the unique larval habitat, and the distinctive anatomical features of the male terminalia warrant recognition of the Brevipalpus group at a level distinct from both the Fraudatrix and Mammilifer groups. The subgenus Lophoceraomyia has, therefore, been divided into three groups: the Fraudatrix group; the Mammilifer group; and the Brevipalpus group. Sirivanakarn (1968) has further divided species of the subgenus Lophoceraomyia from New Guinea and the Bismarck Archipelago into species complexes. Additional subdivisions of the groups in Southeast Asia would

probably best be withheld until the subgenus is studied as a unit throughout its geographical range of distribution.

The subgenus Culiciomyia can be divided into three groups each of which had previously been accorded subgeneric status. The Fragilis group is identical to Edwards' Fragilis group (or group A) of the subgenus Culiciomyia. The Obscurus group is based on the monotypic subgenus Acalleoemyia and separation is made on the basis of the distinctive basimere of the male terminalia and the short male palpus. The Dispectus group is based on the monotypic subgenus Thaiomyia. Perhaps the latter group should actually be included within the Fragilis group, but the absence of the pecten, more than 10 tufts on the grid, and the absence of lanceolate scales on the male palpus would indicate a separate distinction. Study of the Ethiopian fauna (group B of Edwards') will undoubtedly throw additional light on species relationships within Culiciomyia, and additional subgroupings may well be indicated.

Five groups are recognized within the subgenus Culex. The Pipiens group remains unchanged from the existing classification. Each subgroup of the Sitiens group in the existing classification is elevated to group status to recognize more clearly its independence. It is felt that distinctions in the larva, male terminalia, and chaetotaxy and scaling of the female are sufficiently great to indicate separate and equal ranking. In this classification, only one species (C. (Culex) gelidus Theobald) has been included in the Gelidus group; the other species from Southeast Asia previously included in the Gelidus subgroup (C. (Culex) whitmorei (Giles) has been transferred to the Vishnui Group.

In the above discussion, the utilization of larval characters seems to more clearly define phylogenetic relationships than the previous supraspecific classification based on male terminalia alone. This tentative classification is used as an example of what lies in store when both adult and immature stages are considered in erecting a classification scheme reflecting phylogenetic affinities. It would probably be undesirable to propose a formal modification of the existing supraspecific classification of the genus Culex without comprehensive study of the world-wide fauna of the genus. Similarly, establishment of subgroups or species complexes has been deferred pending consideration of the complete fauna.

#### LITERATURE CITED

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Table 1

A TENTATIVE SUPRASPECIFIC CLASSIFICATION OF THE GENUS CULEX IN SOUTHEAST ASIA INCORPORATING LARVAL CHARACTERS

A - EXISTING CLASSIFICATION (Based primarily on the adult male)	B - WORKING CLASSIFICATION (Based on larval characters)	C - COMBINED CLASSIFICATION
1. Subgenus <u>Lutzia</u>	1. Subgenus I ( <u>Jamesia</u> group of the subgenus <u>Lutzia</u> )	1. Subgenus <u>Lutzia</u>
2. Subgenus <u>Neoculex</u>	2. Subgenus II Group # 1 (Subgenera <u>Neoculex</u> and <u>Mochthogenes</u> ) Group # 2	2. Subgenus <u>Neoculex</u>
3. Subgenus <u>Mochthogenes</u>	2. Subgenus II Group # 1 (Subgenera <u>Neoculex</u> and <u>Mochthogenes</u> ) Group # 2	3. Subgenus <u>Lophoceraomyia</u> <u>Fraudatrix</u> Group <u>Mammillifer</u> Group <u>Brevipalpus</u> Group
4. Subgenus <u>Lophoceraomyia</u> <u>Fraudatrix</u> Group <u>Mammillifer</u> Group <u>Brevipalpus</u> Subgroup <u>Mammillifer</u> Subgroup	2. Subgenus II Group # 1 (Subgenera <u>Neoculex</u> and <u>Mochthogenes</u> ) Group # 2 Subgroup A ( <u>Fraudatrix</u> group of <u>Lophoceraomyia</u> ) Subgroup B ( <u>Mammillifer</u> subgroup of <u>Lophoceraomyia</u> ) Subgroup C ( <u>Brevipalpus</u> subgroup of <u>Lophoceraomyia</u> )	4. Subgenus <u>Culiciomyia</u> <u>Fragilis</u> Group <u>Obscurus</u> Group <u>Dispectus</u> Group
5. Subgenus <u>Thaiomyia</u>	3. Subgenus III Group # 1 ( <u>Fragilis</u> group of sub- genus <u>Culiciomyia</u> and subgenus <u>Acalleoemyia</u> ) Group # 2 (Subgenus <u>Thaiomyia</u> )	5. Subgenus <u>Culex</u> <u>Pipiens</u> Group <u>Vishnui</u> Group <u>Gelidus</u> Group <u>Sitiens</u> Group <u>Bitaeiorhynchus</u> Group
6. Subgenus <u>Culiciomyia</u>	3. Subgenus III Group # 1 ( <u>Fragilis</u> group of sub- genus <u>Culiciomyia</u> and subgenus <u>Acalleoemyia</u> ) Group # 2 (Subgenus <u>Thaiomyia</u> )	5. Subgenus <u>Culex</u> <u>Pipiens</u> Group <u>Vishnui</u> Group <u>Gelidus</u> Group <u>Sitiens</u> Group <u>Bitaeiorhynchus</u> Group
7. Subgenus <u>Acalleoemyia</u>	3. Subgenus III Group # 1 ( <u>Fragilis</u> group of sub- genus <u>Culiciomyia</u> and subgenus <u>Acalleoemyia</u> ) Group # 2 (Subgenus <u>Thaiomyia</u> )	5. Subgenus <u>Culex</u> <u>Pipiens</u> Group <u>Vishnui</u> Group <u>Gelidus</u> Group <u>Sitiens</u> Group <u>Bitaeiorhynchus</u> Group
8. Subgenus <u>Culex</u> <u>Pipiens</u> Group <u>Sitiens</u> Group <u>Vishnui</u> Subgroup <u>Sitiens</u> Subgroup <u>Gelidus</u> Subgroup <u>Bitaeiorhynchus</u> Subgroup	4. Subgenus IV Group # 1 ( <u>Pipiens</u> group) Group # 2 ( <u>Vishnui</u> and <u>Gelidus</u> subgroups) Group # 3 ( <u>Sitiens</u> subgroup) Group # 4 ( <u>Bitaeiorhynchus</u> subgroup)	5. Subgenus <u>Culex</u> <u>Pipiens</u> Group <u>Vishnui</u> Group <u>Gelidus</u> Group <u>Sitiens</u> Group <u>Bitaeiorhynchus</u> Group