The Use of Thoracic Setae as a Taxonomic Tool and as an Aid in Establishing Phylogenetic Relationships in Adult Female Aedes Mosquitoes of North America

Part II
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Discussion

At the beginning of this study we used Rohlf's (1963b) listing of the generally accepted classification of the genus Aedes of North America north of Mexico. This classification is basically that of Edwards (1932) with slight modifications as proposed by Belkin and McDonald (1957), Pratt (1956), Knight and Marks (1952) and Ross (1947).

The data from the 1,470 specimens representing the sixty-three species of Aedes mosquitoes which were examined during this study are summarized in Table I. The species are arranged according to the classification noted above except for the pulchritarsis-varipalpus group which is designated as Group X in the subgenus Ochlerotatus.

Of the setal groups shown in Figure I the setae on the subspiracular area (ssp), postspiracular area (psp), posterior pronotum (ppn) and lower mesepimeron (lme) show the most striking differences in number and arrangement. Aedes varipalpus is the only species having setae in the subspiracular area, and purpureipes is the only species which lacks setae in the post-spiracular area. On the posterior pronotum the setae are usually confined to the posterior margin except in impiger and nigripes in which the setae are almost uniformly scattered to the anterior margin of that sclerite. The lower mesepimeral setae are characteristically absent in many species.

Figure 3 shows the location of the probasisternal area of the thorax. Aedes taeniorhynchus is the only species with setae on the probasisternum (pb).

While the setae on the scutellum do not vary in arrangement, some of the setae on the mesonotum show very distinct subgeneric and species differences. A number of species lack a portion of the acrostichal setae in the anterior acrostichal area (aa) as shown in Figure 4. We have named this the "acrostichal gap." Some species lack a portion of the dorsocentral setae in the anterior dorsocentral area (da), also shown in Figure 4. We have named this the "dorsocentral gap."

All species having the dorsocentral gap also have the acrostichal gap and lack the lower mesepimeral setae. But species having the acrostichal gap may or may not have the dorsocentral gap and lower mesepimeral setae. Other species lack the lower mesepimeral setae but have neither the acrostichal nor the dorsocentral gaps.

The specimens within each species showed some size variation. See Table I where the size average (S.A.) and size range (S.R.) for the thorax of each specimen in each species is given in millimeters. We considered the possibility that the size of the specimen might influence the number of setae present on the various thoracic areas. However, size comparisons showed that specimens of identical size demonstrate as much variation in setal numbers as specimens of unequal size. No direct correlation could be established between the number of setae present and the size of the specimens within a particular species. On the other hand, a comparison of the average size of the species showed that smaller species tend to have fewer setae than larger species although the correlation is not absolute.

Comparison of Subgenera

At the present time the subgenera of Aedes mosquitoes are separated chiefly on the basis of the form of the male palpi and the characters of the male genitalia. No reliable subgeneric characters have been reported in the literature for separating the females or the larvae. Thoracic setal characters appear to have limited value in subgeneric classification of the females. The subgenera Stegomyia and Kompia can be separated from most of the species of other subgenera by a distinctly smaller number of setae on most of the thoracic areas. These two subgenera can be separated from each other by the absence of the dorsocentral gap in Stegomyia and the absence of the postspiracular setae in Kompia. There do not appear to be any reliable setal characters for separating the six subgenera Aedes, Aedimorphus, Culicelsa, Feltianus, Finlaya and Ochlerotatus. However, the subgenera Aedes and Aedimorphus can be separated from each other on the basis of the number of setae on the anterior pronotum and the sternopleuron. Feltianus can be separated from all of the subgenera except Ochlerotatus by the number of setae on the upper and lower mesepimeron.

Comparison of Species

The subgenus Ochlerotatus is the largest of the subgenera of North American Aedes mosquitoes. It comprises fifty of the sixty-three species used in this study. There is much variation in the number and arrangement of setae among the species in this subgenus. Group B (stimulans group) is composed of eleven species: aloponotum, barri, cantator, excrucians, fitchii, flavescens, grossbecki, increpitus, riparius, squamiger and stimulans. The species in this group are very similar in the number and arrangement of setae. The group is characterized by the absence of the acrostichal gap (except grossbecki) and the absence of the dorsocentral gap. The species and the specimens within the species are variable in regard to the presence or absence of the lower mesepimeral setae. Only two specimens of aloponotum were available to the authors for study and thus it is difficult to determine the similarities and differences of this species relative to the other species in this group. The validity of this species is in question; many workers consider it a synonym of excrucians. The number of posterolateral setae usually will separate barri from flavescens and squamiger from flavescens. The number of acrostichal setae usually separates grossbecki from the other species of this group. The number of dorsocentral setae will usually separate barri and riparius from flavescens and riparius from squamiger. The number of setae on the scutellum usually will separate barri from flavescens. The number of propleural setae usually will separate grossbecki from increpitus, squamiger from flavencens, and increpitus from riparius. The number of postspiracular setae usually separates squamiger from the other species. The presence of the acrostichal gap in grossbecki distinguishes it from the other species of this group.

Group C (fulvus group) has two North American representatives: bimacultatus and fulvus pallens. Only the latter species was available to us for use in this study. Aedes fulvus pallens can be characterized by the absence of lower mesepimeral setae and the absence of the acrostichal and dorsocentral gaps. This species has a heavily pigmented pattern in the integument on the posterolateral area. The posterolateral setae are confined to this pigmented pattern. No other unusual setal characters exist in this species.

Group E (dorsalis group) contains four species: campestris, canadensis, dorsalis and melanimon. This group is characterized by the presence of lower mesepimeral setae (except canadensis), the presence of the acrostichal gap (except canadensis) and the absence of the dorsocentral gap. The acrostichal gap is much more evident in melanimon than in campestris and dorsalis because in the latter two species the gap is sometimes invaded by widely spaced setae. The tendency in this group is for canadensis to have the smallest number of setae with melanimon and campestris next in order; dorsalis has the largest number of setae. In most cases there is an overlap between canadensis and melanimon, and between campestris and dorsalis. Aedes canadensis can be distinguished from the other species by its lack of both the lower mesepimeral setae and the acrostichal gap. In addition the number of posterolateral setae usually separates canadensis from the other species.

Group X (pulchritarsis-varipalpus group) is composed of five species: monticola, muelleri, sierrensis, varipalpus and deserticola. Aedes deserticola was recently described by Zavortink (1969); we had no specimens available for study. This group is characterized by the absence of lower mesepimeral setae (3 of 30 specimens of sierrensis had lower mesepimeral setae) and the absence of both the acrostichal and dorsocentral gaps. In these characterizations this group is identical to Group C (fulvus group). The number of posterolateral setae will separate monticola from the other species of this group. The number of dorsocentral setae will separate monticola from varipalpus. The number of setae on the scutellum, anterior pronotum and upper mesepimeron will separate monticola and muelleri from sierrensis and varipalpus. The number of propleural and prealar setae will separate monticola from sierrensis. The number of sternopleural setae will separate monticola from muelleri. Aedes varipalpus is a unique species in that it possesses subspiracular setae. This setal character will separate varipalpus not only from the other species in this group but from all other species examined in this study.

Group F (scapularis group) is composed of eight species: atlanticus, dupreei, infirmatus, scapularis, thelcter, tormentor, tortilis and trivittatus. We were unable to obtain specimens of tortilis for use in this study. This group is characterized by the absence of the lower mesepimeral setae and the presence of the acrostichal and dorsocentral gaps. The numbers of setae in various setal groups can be used to separate certain species in this group from one another.

Group G (communis group) is the largest group of the subgenus Ochlerotatus in North America and is composed of twenty-three species: aboriginis, abserratus, aurifer, cataphylla, communis, decticus, diantaeus, hexodontus, impiger, implicatus, intrudens, nigripes, niphadopsis, pionips, pullatus, punctodes, punctor, rempeli, schizopinax, spencerii, sticticus, thibaulti and ventrovittis. Only two specimens of rempeli, a rare and recently described species, were examined. This group is not easily characterized because of the variation in the number and arrangement of setae among the species. Two of the species, aurifer and thibaulti, are identical to the species comprising Group F (scapularis group) in that they both exhibit the absence of the lower mesepimeral setae and the presence of the acrostichal and dorsocentral gaps. Another species, spencerii, is unusual since it is the sole member of the group which lacks the lower mesepimeral setae and the dorsocentral gap, but possesses the acrostichal gap. The other species lacking the lower mesepimeral setae are decticus, diantaeus, sticticus and ventrovittis. The remainder of the species in this group can be characterized as possessing lower mesepimeral setae and lacking the acrostichal and dorsocentral gaps. Five species in this group have an unusually large number of setae. These species are: aboriginis, impiger, nigripes, punctodes and ventrovittis. One species, decticus, stands out because it tends to have a lower number of setae. It must be noted that only six specimens of decticus were studied and that a larger sample might result in more overlap with the other species. A good deal of overlap occurs in this group; however, many species differ from one another by the number of setae on one or more thoracic areas.

The subgenus Feltianus is composed of two species: bicristatus and trichurus. These two species are characterized by the presence of lower mesepimeral setae but an absence of both the acrostichal and dorsocentral gaps. In these characters the species in this subgenus are identical to the species in the subgenus Culicelsa. However, bicristatus and trichurus tend to have a higher number of upper and lower mesepimeral setae (especially bicristatus) than nearly all of the other species studied. The number of upper mesepimeral and usually the number of lower mesepimeral setae will separate bicristatus from trichurus.

The subgenus Culicelsa is composed of four species: mitchellae, nigromaculis, sollicitans and taeniorhynchus. These species are very similar in the number and arrangement of the setae. This subgenus lacks both the acrostichal and dorsocentral gaps. The specimens within each species vary as to the presence or absence of lower mesepimeral setae. The species nigromaculis, sollicitans and taeniorhynchus are essentially the same in their setal characteristics with one exception. Aedes taeniorhynchus is unique among North American Aedes mosquitoes in that it has setae on the probasisternum. To our knowledge this setal group has not been reported by any other worker. In this subgenus mitchellae tends to have the lowest number of setae and sollicitans tends to have the highest. The number of setae on the posterolateral, anterolateral, scutellar, prealar and upper mesepimeral areas will separate mitchellae from nigromaculis.

The subgenus Kompia is monotypic with purpureipes as the sole representative. This species lacks setae in the postspiracular area and on the lower mesepimeron, and has the acrostichal and dorsocentral gaps. The number of setae present is characteristically small. In this respect purpureipes is very similar to aegypti, subgenus Stegomyia.

The subgenus Aedes has cinereus as the only North American representative. This species is characterized by the usual absence of lower mesepimeral setae and by the absence of the acrostichal and dorsocentral gaps.

The subgenus Aedimorphus has vexans as the only North American representative. The species is characterized by the usual absence of lower mesepimeral setae and by the absence of the acrostichal and dorsocentral gaps. Aedes cinereus and vexans are very similar in the number of setae they possess. However, these two species can usually be separated by the number of setae on the anterior pronotum and the sternopleuron.

The subgenus Finlaya has four North American representatives: atropalpus, hendersoni, triseriatus and zoosophus. Only the first three were used in this study. These three species are characterized by the absence of lower mesepimeral setae, the presence of the acrostichal gap and the presence of the dorsocentral gap in two of the three species; the dorsocentral gap is very distinct in atropalpus but completely absent in hendersoni. In triseriatus this gap is intermediate between atropalpus and hendersoni in that it is sometimes invaded by several widely spaced setae. In this subgenus the species are very similar in the number of

setae they possess. Aedes atropalpus and triseriatus are very similar to hendersoni but differ from each other by the number of setae on the anterior pronotum, propleuron and sternopleuron. In nearly every case the number of setae in hendersoni is intermediate between atropalpus and triseriatus.

The subgenus Stegomyia contains only one North American representative, aegypti. This species is characterized by the absence of lower mesepimeral setae, the presence of the acrostichal gap and the absence of the dorsocentral gap. It is also distinctive in having a smaller number of setae than any other species used in this study with the exception of purpureipes, subgenus Kompia.

Phylogeny and Classification of North American Aedes Mosquitoes as Indicated by Adult Thoracic Setal Patterns

The number and arrangement of setae are under genetic control. Even though no study has been conducted to determine the genetic influence on setal patterns in mosquitoes such investigations have been carried out on Drosophila. These studies have disclosed that each of the groups of abdominal and thoracic setae on the adult fly is under the control of one or more genes. Inasmuch as the production of setae is controlled by genes it seems highly probable that the setae are valuable as classification or phylogenetic characters. Also, it would appear likely that the setae are involved in the overall adaptive fitness of the mosquito. There is a possibility that they serve as aids in protective coloration and sexual recognition, or perhaps as sensory structures. It is probable that the number and arrangement of the setae on the various thoracic areas are under the influence of genes which produce manifold effects. For example, in Drosophila the gene which is responsible for vestigial wings also causes a number of other effects such as a change in the shape of the spermatheca, modification of the halteres, and reduced fecundity; it also causes certain setae on the dorsal side of the fly to stand erect instead of lying horizontal. Because there are a number of different groups of setae on the thorax which vary in number and arrangement it is probable that a number of different genes are involved. Consequently, species with strikingly different setal patterns must also differ qualitatively in their genes. Conversely, species with similar or identical setal patterns must have a greater number of genes in common. In view of such genetic differences or similarities setal characters should be useful in determining phylogenetic affinities. Indeed such is the case because certain thoracic setal groups are important in distinguishing genera of mosquitoes. Therefore, it would seem reasonable that thoracic setal patterns might also be useful in determining phylogenetic relationships of species within the genera.

The genus Aedes contains a variety of species which are strikingly different in general appearance. It is at the subgeneric level of

classification that similar species are formally grouped together. Within a subgenus some species are more similar than others and thus are assigned to groups and even subgroups.

The present study based on thoracic setal patterns in the adult female mosquito tends to be in general agreement with that listed by Rohlf (1963b) as the currently accepted classification. However, in our opinion the results of this investigation indicate that some modifications should be made.

Stegomyia is a well established subgenus and contains many species. On the basis of the setal patterns it is distinct from the other subgenera, but very similar to the subgenus Kompia and some members of the subgenera Finlaya and Ochlerotatus.

Kompia is not recognized as a subgenus by some workers. Vargas (1949), Carpenter and LaCasse (1955) and Stone, et al. (1959) placed purpureipes in Ochlerotatus. However, Aitken (1941) and Pratt (1956) considered Kompia as a valid subgenus. Belkin and McDonald (1957) noted the similarities between purpureipes and the pulchritarsis-varipalpus group of Ochlerotatus but because of some unique characters they recognize Kompia as a monotypic subgenus which was probably derived from the pulchritarsis-varipalpus group. Craig (1956) observed that the eggs of purpureipes were very similar to Stegomyia and certain species in Finlaya. The thoracic setal patterns found in purpureipes indicate that it is a distinct subgenus, but that it is very close to Stegomyia and similar to some species of Finlaya as suggested by Craig (1956). The setal patterns of purpureipes also show some similarities to the pulchritarsis-varipalpus group of Ochlerotatus, but the similarities between them are not as great as indicated by Belkin and McDonald (1957). As a matter of fact purpureipes shows more similarities to the scapularis group in Ochlerotatus than to the pulchritarsis-varipalpus group.

The two subgenera Aedes and Aedimorphus are well established, and each is comprised of a number of species according to Stone, et al. (1959). However, the number and arrangement of setae in these two subgenera are almost identical. The differences between them are no greater, and not as great in some cases, as the differences between very closely related species within any of the groups in the subgenus Ochlerotatus. On the basis of setal characters Aedes and Aedimorphus would not be considered as subgenera separate from each other or from Ochlerotatus and Culicelsa. It is interesting that Rohlf (1963b) using larval and adult characters in a numerical taxonomic study was also unable to find subgeneric differences between the North American species of Aedes and Aedimorphus. Also, Edwards (1932) points out that vexans and cinereus show similarities in the larval stage and the structure of the male genitalia. Rohlf (1963a) found Aedes and Aedimorphus similar to Ochlerotatus in the larval stages but similar to Stegomyia as adults. We could find no similarities between the two subgenera Aedes and Aedimorphus and the subgenus Stegomyia on the basis of adult thoracic setal patterns. We are not inclined to recommend a change in the classification of cinereus and vexans until more species have been studied in the two subgenera to which they are

presently assigned. Both of these subgenera are represented by many species in other regions of the old world.

Edwards (1932) considered trichurus and bicristatus as closely related to Aedes (Ochlerotatus) rusticus (Rossi), a European species These three species comprise Group H (rusticus group) of Ochlerotatus in Edwards' classification. Pratt (1956) listed trichurus and bicristatus as being in the subgenus Feltianus. Carpenter and LaCasse (1955) and Stone, et al. (1959) list these two species as belonging to Ochlerotatus. Barr (1958) considered trichurus a member of the communis group of Ochlerotatus. Rohlf (1963b) placed bicristatus in the communis group and listed trichurus as a separate group in Ochlerotatus. Rohlf's suggestion concerning trichurus has been criticized by Barr and Chapman (1964) and Nielsen (1969). Data on comparative serology obtained by Downe (1963) indicated a fairly close relationship between communis and trichurus. On the basis of thoracic setal characters we find no justification for considering trichurus and bicristatus as members of a separate subgenus. They very possibly do belong to the communis group of Ochlerotatus but until we have had the opportunity to examine the European rusticus we have followed Edwards' (1932) classification and leave them in the rusticus group of Ochlerotatus.

The subgenus Culicelsa is not well established as a taxonomic category and is still open to dispute. Edwards (1932) considered the four species involved as a group (taeniorhynchus group) in the subgenus Ochlerotatus. He used differences in the male genitalia and scale patterns of the tarsi and thorax as the criteria for this group designation. Ross (1947) considered the group to be a subgenus based on female genitalia. Craig (1956) considered the group to be of subgeneric rank based on the characteristic of the egg. Carpenter and LaCasse (1955) and Stone, et al. (1959) listed this group in the subgenus Ochlerotatus. Rohlf (1963a, 1963b) noted the larvae overlapped the scapularis group of Ochlerotatus and that the adults were closer to Finlaya than Ochlerotatus. A study of the setal characters of Culicelsa does not support its subgeneric rank, but suggests that the species assigned to this subgenus belong in Ochlerotatus. We prefer to follow Edwards (1932) regarding the classification of this group.

The subgenus Finlaya is a well established category composed of many species, mostly Old World. However, there is still debate concerning two North American species, sierrensis and varipalpus, which have been placed in this subgenus. Edwards (1932) placed varipalpus in Finlaya chiefly on the basis of breeding habits and some male characters. Aedes sierrensis, a closely related species, was described by Ludlow (1905) as Taeniorhynchus sierrensis, but subsequently was listed as a synonym of varipalpus by Edwards (1932). Carpenter and LaCasse (1955) listed varipalpus in the subgenus Finlaya and also considered sierrensis a synonym of varipalpus. Craig (1956) assigned the species of the varipalpus complex to Finlaya based on the structure of the chorion of the egg. Belkin and McDonald (1956) compared specimens of the varipalpus complex from the Pacific Coast states of California, Oregon and Washington with the specimens from this complex in Arizona. They found the specimens from these two geographical areas to be very similar but distinct enough to be

considered separate species. They resurrected the name Aedes sierrensis (Ludlow, 1905) and applied it to the specimens from the Pacific Coast states. The name Aedes varipalpus (Coq.) was retained for the Arizona species. Belkin and McDonald (1957) pointed out similarities in larval and adult stages between species of the varipalpus complex in North America and the species of the pulchritarsis complex of Europe. Aedes pulchritarsis (Rondani) is in the subgenus Ochlerotatus. Belkin and McDonald (1957) considered varipalpus and sierrensis as members of the pulchritarsis-varipalpus group in that subgenus. Stone, et al. (1959) placed varipalpus and sierrensis in Ochlerotatus. Rohlf (1963b) placed varipalpus and sierrensis in Finlaya on the basis of larval and adult characters. Trebatoski and Haynes (1969) placed triseriatus and sierrensis in Finlaya based on paired affinities of isoenzymes. It is important to note, however, that no Ochlerotatus species were included in their study. Cupp and Horsfall (1969) cite morphological, behavioral, cytochemical and parasitic evidences for assigning sierrensis to Finlaya. In the classification used at the beginning of this study only the species atropalpus, hendersoni, triseriatus and zoosophus were considered as North American species in the subgenus Finlaya. Only the first three species were examined in this study. On the basis of setal characters there appears to be no justification for placing species of the varipalpus complex in Finlaya. O'Meara and Craig (1970) have recently described a new subspecies in the atropalpus complex, Aedes atropalpus nielseni. They divided the remainder of the complex into three additional subspecies, Aedes a. atropalpus from the eastern and northern United States and Canada, Aedes a. epactius from the southern United States and Mexico and Aedes a. perichares from Central America. Our material was from Utah (nielseni) and Quebec (atropalpus). No distinction is made between these two populations in the setal data in Table 1. Knight and Marks (1952) noted that from a morphological standpoint Finlaya is most closely related to Ochlerotatus. Rohlf (1963a, 1963b) came to the same conclusion using numerical taxonomy on larval and adult characters. By using setal characters as a criterion, we can be even more specific about the relationship between Finlaya and Ochlerotatus. In North American species the relationship appears to be between the subgenus Finlaya and the scapularis group of the subgenus Ochlerotatus.

The subgenus Ochlerotatus is well established as a taxonomic category. It is composed of many species which show considerable difference in the number and arrangement of setae. This variation makes it impossible to use setal characters to separate Ochlerotatus from most of the other subgenera. Also, because of this variation the setal characters have limited use in distinguishing the groups of similar species. However, all of the species in the scapularis group share distinctive setal characters which set it apart from the other groups of Ochlerotatus. The communis group contains two species, aurifer and thibaulti, which are identical to the species in the scapularis group in the arrangement of certain setal patterns. It is interesting to note that Rohlf (1963a) found thibaulti to be close to the scapularis group based on a numerical taxonomic study of adult characters. Based on thoracic setal characters aurifer and thibaulti should be removed from the communis group and placed in the scapularis group. There is the possibility that the similarity of aurifer and thibaulti to the species in the scapularis group are indicative of a close relationship between the

scapularis and communis groups, and of these two groups to the subgenus Finlaya. In the stimulans group grossbecki is the only species which has the acrostichal gap. We consider it as belonging to a separate group, although it has similarities to the dorsalis group (excluding canadensis), and may have affinities with that group. In the dorsalis group canadensis does not conform to the setal characters of the other species of this group. Therefore, we recommend the removal of canadensis from the dorsalis group. Nielsen (1955) concluded on the basis of the structure of the male genitalia that canadensis was distinct enough to have a separate group designation. Rohlf (1963b) concluded canadensis was closer to the communis group than the dorsalis group and transferred the species into the former group. The setal characters do not clearly indicate its proper classification, and although canadensis is similar to some members of the communis group there are sufficient differences that we have placed it in a separate group close to the communis group. Of the four Aedes species in Group X monticola and muelleri are very similar and sierrensis and varipalpus are very similar. We do not observe setal characters which would justify placing any of these species in the subgenus Finlaya as some authors have suggested. In the communis group spencerii does not conform well to the setal characters of the other species of the group after the removal of aurifer and thibaulti. The setal characters of spencerii are very similar to the dorsalis group. Again it is interesting to note that Rohlf (1963a) found spencerii close to the dorsalis group in the adult stage but close only to idahoensis in the larval stage. In this study we consider idahoensis as a subspecies of spencerii (Nielsen and Rees, 1959; Stone, 1961). Despite the similarities there are sufficient differences to preclude placing spencerii in the dorsalis group. In view of this we believe spencerii appears to warrant a separate group designation. Rohlf (1963b) found bimaculatus and fulvus pallens different enough from the other Aedes species he studied to warrant more than a separate group designation. Consequently he elevated them to a subgeneric rank. We have studied the setal patterns of fulvus pallens and are unable to find justification, using this criterion, for considering this species as belonging to a separate subgenus. Until we have studied bimaculatus we are inclined to regard fulvus pallens as a separate group in the subgenus Ochlerotatus.

Our results, based on thoracic setal characters, suggest modifications in the placement of Aedes species in the various subgenera and and groups. Therefore, we have proposed a classification in Table II incorporating these changes. We realize that much additional data from other sources needs to be examined before a truly acceptable classification can be achieved.

Table II. Proposed Classification for the Aedes Species of North America Included in This Thoracic Setal Study. (Letters in parentheses refer to Edwards, 1932 groups)

Subgenus Ochlerotatus Lynch-Arribalzaga

Group 1 (A) taeniorhynchus group
- taeniorhynchus (Wiedemann)
- mitchellae Dyar
- nigromaculis (Ludlow)
- sollicitans (Walker)

Group 2 (B) stimulans group
- aloponotum Dyar
- barri Rueger
- cantator (Coquillett)
- excrucians (Walker)
- fitchii (Felt & Young)
- flavescens (Muller)
- increpitus Dyar
- riparius Dyar & Knab
- squamiger (Coquillett)
- stimulans (Walker)

Group 3
- grossbecki Dyar & Knab

Group 4 (C) fulvus group
- fulvus pallens Ross

Group 5 (E) dorsalis group
- campestris Dyar & Knab
- dorsalis (Meigen)
- melanimon Dyar

Group 6 X pulchritarsis-varipalpus group
- monticola Belkin & McDonald
- muelleri Dyar
- sierrensis (Ludlow)
- varipalpus (Coquillett)

Group 7 (F) scapularis group
- atlanticus Dyar & Knab
- aurifer (Coquillett)
- dupreei (Coquillett)
- infirmatus Dyar & Knab
- scapularis (Rondani)
- thelcter Dyar
- thibaulti Dyar & Knab
- tormentor Dyar & Knab
- trivittatus (Coquillett)

Table 11. (cont.)

Group 8 (G) communis group
aboriginis Dyar
abserratus (Felt & Young)
cataphylla Dyar
communis (DeGeer)
decticus Howard, Dyar & Knab
diantaeus Howard, Dyar & Knab
hexodontus Dyar
impiger (Walker)
implicatus Vockeroth
intrudens Dyar
nigripes (Zetterstedt)
niphadopsis Dyar & Knab
pionips Dyar
pullatus (Coquillett)
punctodes Dyar
punctor (Kirby)
rempeli Vockeroth
schizopinax Dyar
sticticus (Meigen)
ventrovittis Dyar

Group 9
canadensis (Theobald)

Group 10
spencerii (Theobald)

Group 11 (H) rusticus group
bicristatus Thurman & Winkler
trichurus (Dyar)

Subgenus Kompia Aitken
purpureipes Aitken

Subgenus Aedes Meigen
cinereus Meigen

Subgenus Aedimorphus Theobald
vexans (Meigen)

Subgenus Finlaya Theobald

Group B (terrens group)
atropalpus (Coquillett)

Group H (geniculatus group)
hendersoni Cockerell
triseriatus (Say)

Subgenus Stegomyia Theobald
aegypti (Linnaeus)

SUMMARY AND CONCLUSIONS

Sixty-three Aedes mosquito species represented by 1,470 female specimens from the United States and Canada were used as study material. These specimens represented all of the subgenera of Aedes mosquitoes occurring in North America. The thorax of each specimen was separated from the other body parts and bleached in 10% potassium hydroxide. After the bleaching process the thorax was examined under an 80X stereoscopic microscope. The number and arrangement of the setal follicles on the pleuron, probasisternum, mesonotum and scutellum were recorded. Original drawings were prepared to show the location and distribution of setae on the thorax (Figs. 1-4). The thorax of each specimen was measured in order to determine whether or not the size of the mosquito influences the number of setae present.

The mean, standard deviation and range in the number of setae as indicated by the number of setal follicles on the various thoracic areas of each species are presented in Table I. Each subgenus was compared on the basis of similarities and differences in number and arrangement of the thoracic setae. Also each group and the species within each group in the subgenus Ochlerotatus were compared in the same manner.

A discussion of the taxonomic and phylogenetic importance of thoracic setal patterns is presented. A proposed classification of the Aedes mosquitoes of North America (north of Mexico) was constructed for those species included in this study (Table II).

The opinions expressed in this paper are based on the assumption that the samples used are reasonably good representatives of the populations from which they were taken. Most of the samples consisted of thirty specimens of each species. In the case of certain rare species fewer specimens were available.

The knowledge of the number and arrangement of thoracic setae as contained in this investigation has provided additional and mostly new adult characters for use in elucidating the phylogenetic relationships among the Aedes mosquitoes of North America.

The conclusions drawn from this study are:

1. Certain subgenera and species groups can be distinguished by using the number and arrangement of setae on the thorax of the female.

2. In many cases setal characters can be used in separating adult females of species which are sometimes difficult to distinguish using existing keys. In the case of rubbed or "flightworn" specimens the setal characters are especially valuable.

3. Generally speaking, larger species tend to have more setae than smaller species, but within each species the size of the specimen does not appear to influence the number of setae present.

4. Setal characters appear to have value in indicating phylogenetic affinities among the subgenera and groups of mosquitoes. In general, the present study based on thoracic setal patterns in the adult female mosquito tends to be in agreement with the currently accepted classification shown in Table I. However, the results of this investigation indicate that some modifications should be made in the current classification (see Table II).

In our opinion the following changes should be made:

1. Aedes grossbecki should be removed from the stimulans group and considered as a member of a separate group.

2. Aedes canadensis should be removed from the dorsalis group and placed in a separate group.

3. Aedes aurifer and Aedes thibaulti should be removed from the communis group and placed in the scapularis group.

4. Aedes spencerii should be removed from the communis group and considered as a member of a separate group.

5. The subgenus Feltianus should be reduced to a group (rusticus group) in the subgenus Ochlerotatus.

6. The subgenus Culicelsa should be reduced to a group (taeniorhynchus group) in the subgenus Ochlerotatus.

7. Kompia should be considered a valid subgenus.

8. Members of the Aedes varipalpus complex should be considered as belonging to Ochlerotatus and not Finlaya.

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APPENDIX I

Localities from Which the Aedes Mosquito Species Used in This Study were Collected

Species	Localities
aboriginis Dyar	Washington - British Columbia
abserratus (Felt & Young)	New Jersey, New York, Vermont
aegypti (Linnaeus)	Arkansas, Georgia, Kansas
aloponotum Dyar	Oregon
atlanticus Dyar & Knab	Delaware, Florida, Georgia
atropalpus (Coquillett)	Utah - Quebec
aurifer (Coquillett)	Connecticut, Massachusetts, New Jersey, Rhode Island
barri Rueger	Minnesota
bicristatus Thurman & Winkler	California
campestris Dyar & Knab	Idaho, Nevada, Utah, Wyoming - Saskatchewan
canadensis (Theobald)	Colorado, Connecticut, Georgia, Idaho, Illinois, Kansas, Missouri, New Jersey, Rhode Island, Wyoming - Quebec
cantator (Coquillett)	Delaware, Massachusetts, Rhode Island - New Brunswick
cataphylla Dyar	Arizona, Idaho, Utah, Wyoming
cinereus Meigen	Colorado, Idaho, Illinois, Rhode Island, Utah, Wyoming - New Brunswick, Quebec
communis (DeGeer)	Alaska, California, Colorado, Idaho, Massachusetts, Montana, New Jersey, Utah, Washington, Wyoming - Quebec
decticus Howard, Dyar & Knab	Massachusetts
diantaeus Howard, Dyar & Knab	Wyoming - Alberta, Northwest Territories
dorsalis (Meigen)	California, Colorado, Idaho, South Dakota, Utah - Saskatchewan
dupreei (Coquillett)	Alabama, Arkansas, Florida, Louisiana, North Carolina

Species	Localities
excrucians (Walker)	Delaware, Idaho, Illinois, Massachusetts, New Jersey, Rhode Island, Utah, Wyoming - New Brunswick, Ontario, Quebec, Saskatchewan
fitchii (Felt & Young)	Arizona, California, Colorado, Idaho, Illinois, Massachusetts, Utah, Wyoming - Saskatchewan
flavescens (Muller)	Colorado, Utah, Wyoming - Saskatchewan
fulvus pallens Ross	Louisiana, South Carolina, Texas
grossbecki Dyar & Knab	Delaware, Louisiana
hendersoni Cockerell	Colorado, Missouri
hexodontus Dyar	Alaska, California, Colorado, Utah, Washington, Wyoming - Northwest Territories
impiger (Walker)	Montana, Utah - Northwest Territories
implicatus Vockeroth	Colorado, Idaho, Utah
increpitus Dyar	California, Idaho, Utah, Wyoming - Saskatchewan
infirmatus Dyar & Knab	Florida
intrudens Dyar	Massachusetts, Montana, Rhode Island, Utah, Washington, Wyoming - Saskatchewan
melanimon Dyar	California, Colorado, Montana, Nevada, New Mexico, South Dakota, Utah, Wyoming
mitchellae Dyar	Delaware, Florida, Georgia, South Carolina
monticola Belkin & McDonald	Arizona
muelleri Dyar	Arizona
nigripes (Zetterstedt)	Alaska - Northwest Territories
nigromaculis (Ludlow)	California, Colorado, Idaho, Montana, South Dakota, Utah, Wyoming - Saskatchewan
niphadopsis Dyar & Knab	Idaho, Nevada, Utah
pionips Dyar	Montana, Wyoming - Alberta, Labrador, Northwest Territories, Saskatchewan
pullatus (Coquillett)	Colorado, Idaho, Montana, Utah, Wyoming
punctodes Dyar	Alaska
punctor (Kirby)	Massachusetts, New Jersey, Wyoming - Quebec, Saskatchewan
purpureipes Aitken	Arizona
rempeli Vockeroth	Northwest Territories
riparius Dyar & Knab	Minnesota - Manitoba, Saskatchewan

Species	Localities
scapularis (Rondani)	Venezuela
schizopinax Dyar	California, Idaho, Nevada, Utah
sierrensis Ludlow	California, Montana
sollicitans (Walker)	Delaware, Florida, Illinois, Indiana, New Jersey, Rhode Island
spencerii (Theobald)	Colorado, Idaho, Montana, Utah, Wyoming - Saskatchewan
squamiger (Coquillett)	California
sticticus (Meigen)	Idaho, Missouri, Tennessee, Utah, Washington - British Columbia
stimulans (Walker)	Colorado, Idaho, Massachusetts, Montana, New Jersey, Wyoming - Ontario
taeniorhynchus (Wiedemann)	Delaware, Florida, New Jersey, Rhode Island
thelcter Dyar	Texas
thibaulti Dyar & Knab	Delaware
tormentor Dyar & Knab	Florida, Georgia
trichurus (Dyar)	Minnesota, Montana - Saskatchewan
triseriatus (Say)	Delaware, Georgia, Kansas, New Jersey, Virginia
trivittatus (Coquillett)	Colorado, Idaho, Illinois, Kansas, New Jersey, New Mexico, South Dakota
varipalpus (Coquillett)	Utah
ventrovittis Dyar	California
vexans (Meigen)	Arizona, Idaho, Massachusetts, Nevada, New Jersey, Rhode Island, Utah, Wyoming - Saskatchewan