
The Phylogeny and Classification of *Anopheles*

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1. Introduction

Anopheles was introduced as a genus of mosquitoes in 1818 by Johann Wilhelm Meigen [1], a German entomologist famous for his revolutionary studies of Diptera. Little was done on the taxonomy of *Anopheles* until the discovery during the last two decades of the 19th century that mosquitoes transmit microfilariae and malarial protozoa, which initiated a drive to collect, name and classify these insects. In 1898, the Royal Society and the Rt. Hon. Joseph Chamberlain, Secretary of State for the Colonies of Britain, appointed a Committee to supervise the investigation of malaria. On 6 December 1898, Mr. Chamberlain directed the Colonies to collect and send mosquitoes to the British Museum (Natural History) (Figure 1), and in 1899 the Committee appointed Frederick V. Theobald to prepare a monograph on the mosquitoes of the world, which was published in five volumes between 1901 and 1910 [2–6]. As a consequence, many new generic names were introduced in an effort to classify numerous new mosquito species into seemingly natural groups. Theobald proposed 18 genera for species of *Anopheles* based on the distribution and shape of scales on the thorax and abdomen. Four of these proposed genera, *Cellia*, *Kerteszia*, *Nyssorhynchus* and *Stethomyia*, are currently recognized as subgenera of *Anopheles* and the other 14 are regarded as synonyms of one or other of subgenera *Anopheles*, *Cellia* or *Nyssorhynchus*. Theobald, however, was not the only person to propose generic names for species of *Anopheles*. During the first three decades of the 20th century, 37 genera (including the 18 recognized by Theobald) were established for species of *Anopheles* [7].

As additional new species were discovered, it became increasingly apparent that Theobald's system of classification was neither practical nor natural. Frederick Knab in North America, one of the early critics of Theobald's classification, stated that "the subject was made needlessly difficult by hasty work and by the sub-division of the old genus *Anopheles* into numerous ill-defined and fancifully differentiated genera. The intricacies of this 'system,' unwarranted from both a scientific and practical standpoint, even the trained entomologist could not tread with

safety, and to others it could be no less than hopeless or disastrous" [8]. Consequently, during the two decades following the completion of Theobald's monograph in 1910, significant changes were made toward a much more conservative system of classification, culminating in the reduction of 38 genus-group names (including *Anopheles*) to the recognition of the single genus *Anopheles*.

The current subgeneric classification of *Anopheles* is based primarily on the number and positions of specialized setae on the gonocoxites of the male genitalia (Figure 2), and this basis of classification has been accepted since it was introduced by Sir (Samuel) Rickard Christophers in 1915 [9]. Christophers proposed three generic subdivisions, which F.M. Edwards [10] and Francis Metcalf Root [11] formally recognized as subgenera *Anopheles*, *Myzomyia* (= *Cellia*) and *Nyssorhynchus*. Edwards adopted this system and added subgenus *Stethomyia* in his classical treatise on family Culicidae published in 1932 [12]. This system recognized *Kerteszia* as an informal group within subgenus *Nyssorhynchus*. *Kerteszia* was elevated to subgeneric status by W.H.W. Komp [13]. Subgenus *Lophopodomyia* was proposed by P.C.A. Antunes in 1937 [14] and subgenus *Baimaia* was introduced by Ralph E. Harbach and his colleagues in 2005 [15].

Genus *Anopheles* currently includes 465 formally named species that are disproportionately divided between seven subgenera: *Anopheles* (cosmopolitan, 182 species), *Baimaia* (Oriental, one species), *Cellia* (Old World, 220 species), *Kerteszia* (Neotropical, 12 species), *Lophopodomyia* (Neotropical, six species), *Nyssorhynchus* (Neotropical, 39 species) and *Stethomyia* (Neotropical, five species) [16]. Four of the subgenera, *Anopheles*, *Cellia*, *Kerteszia* and *Nyssorhynchus*, include the species that transmit human malarial parasites. Most vector species of *Anopheles* have been found to comprise complexes of sibling species.

2. Classification of genus *Anopheles*

The aim of classification is to group and categorize biological entities that share some unifying characteristics. Classification has been defined by Ernst Mayr & W.J. Bock [17] as "The arrangement of similar entities (objects) in a hierarchical series of nested classes, in which each more inclusive higher-level class is subdivided comprehensively into less inclusive classes at the next lower level." These classes (groups) are known as **taxa** (singular: **taxon**). The level of a taxon in a hierarchical classification is referred to as a **taxonomic rank** or **category**. Ideally, taxonomic categories should denote equivalent phylogenetic rank; however, in practice they are basically subjective groupings of subordinate taxa that are presumed to represent monophyletic groups of species that are assigned to taxonomic ranks based on shared morphological and biological characteristics that are not a measure of phylogenetic equivalence. For this reason, the taxonomic categories of genus *Anopheles*, including the formal rank of subgenus, should not be considered to represent equivalent phylogenetic ranks.

CIRCULAR.

Downing Street,

6th December, 1898.

Sir,

In my Circular despatch of the 19th of August, last, I referred to an intended investigation of Malaria.

A Commission has now been appointed for the purpose and is about to proceed to Africa.

The Commissioners will report, from time to time, to a Committee appointed jointly by the Royal Society and myself, who will exercise a general supervision over the enquiry.

It has been suggested by this Committee, that, in view of the possible connection of Malaria with mosquitoes, it is desirable to obtain exact knowledge of the different species of mosquitoes and allied insects in the various tropical Colonies. I will therefore ask you, if there are facilities for the purpose, to be good enough to take the necessary steps at your early convenience to have collections made of the winged insects in the Colony which bite men or animals.

I enclose a printed copy of directions which have been drawn up by the British Museum for the guidance of those who may be employed on the work, and would add that several specimens of each kind of insect should be obtained and that they should be sent direct to the British Museum (Natural History), Cromwell Road, London, S.W., to be examined and classified. A first series of the specimens will be retained by the Museum, whilst the duplicates will be available for distribution as may be desired.

As the question of the scientific investigation of Malaria is one to which I attach great importance, I trust that every effort will be made to carry out as speedily and as thoroughly as possible the directions contained in this despatch.

I have the honour to be,

Sir,

Your most obedient, humble Servant,

J. CHAMBERLAIN.

*The Officer Administering
the Government of*

Figure 1. Letter issued from Downing Street on 6 December 1898 directing the British Colonies to collect and send mosquitoes to the British Museum (Natural History).

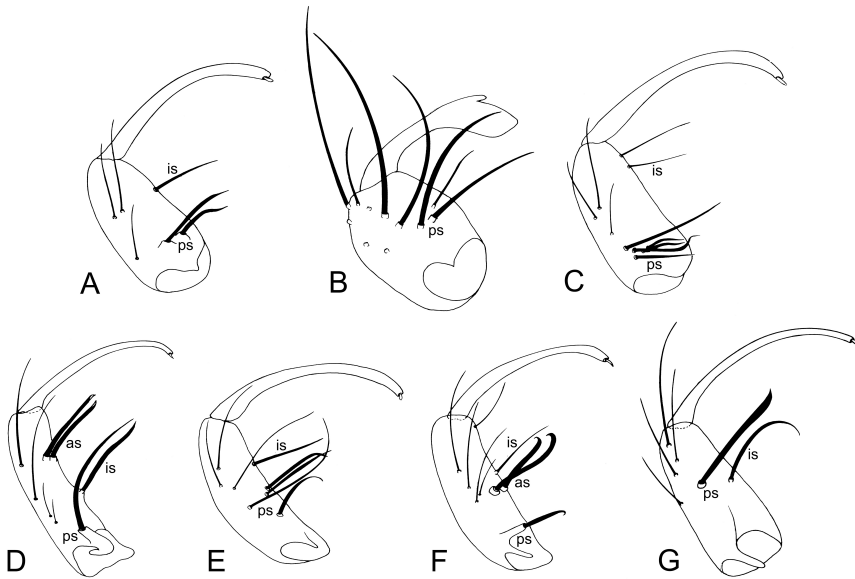


Figure 2. Subgenera of *Anopheles* – specialized setae on the gonocoxites of the male genitalia (after Harbach & Kitching [18]): A, *Anopheles*; B, *Baimaia*; C, *Cellia*; D, *Kerteszia*; E, *Lophopodomyia*; F, *Nyssorhynchus*; G, *Stethomyia*. as, accessory setae; is, inner seta; ps, parbasal seta(e).

Infrasubgeneric categories (taxonomic ranks below subgenus) have no formal status under the *International Code of Zoological Nomenclature* [19]. They are convenience categories only, often based on superficial similarities that may not indicate natural relationships. The informal categories used in the classification of *Anopheles* include Sections, Series, Groups, Subgroups and Complexes (see Appendix 1).

Unlike formal taxonomic categories, which precede the name of the taxonomic unit, for instance family Culicidae, genus *Anopheles* and species *gambiae*, the names of informal taxonomic categories follow the name of the taxonomic unit, for example the Pyrethrophorus Series, Hyrcanus Group or Gambiae Complex, which are written in Roman (i.e. non-italic) script with the first letter capitalized. It should be stressed that both formal and informal taxonomic entities are conceptual constructs invented by taxonomists for the purpose of creating some order in the diversity of species. For example, the species *gambiae* and the Hyrcanus Group, which are human-conceived taxonomic concepts, cannot be observed as entities or visualized under a microscope.

The internal classification of genus *Anopheles* (between genus and species levels) is based primarily on the schemes proposed by Edwards [12], John A. Reid & Kenneth L. Knight [20], Alexis Grjebine [21], M.T. Gillies & Botha de Meillon [22], Reid [23], Michael E. Faran [24] and Kenneth J. Linthicum [25]. These schemes were reviewed, amalgamated and updated in 1994 [26] and updated again in 2004 and 2012 [27,16 respectively]. The three largest subgenera, i.e. *Anopheles*, *Cellia* and *Nyssorhynchus*, are divided into hierarchical systems of informal taxo-

nomic categories (Appendix 1; examples shown in Figure 3). Subgenus *Anopheles* is divided into two Sections based on the shape of the pupal trumpet. The Laticorn Section was created for species with a wide funnel-shaped trumpet having the longest axis transverse to the stem, and the Angusticorn Section for species with a semi-tubular trumpet having the longest axis vertical more or less in line with the stem [20]. Subgenus *Nyssorhynchus* is divided into three Sections based on unique combinations of larval, pupal and adult characters [28]. Subgenus *Cellia* and the Sections of subgenera *Anopheles* and *Nyssorhynchus* are divided into Series, the larger Series are divided into species Groups, and some Groups are further divided into Subgroups and species Complexes. Most of the groupings at each level of classification are presumed to represent natural groups of species, thus implying phylogenetic relationships, but much additional basic taxonomic research is needed before the formal and informal taxa can be firmly established as monophyletic entities. The internal classification of the genus (subgenera and infrasubgeneric groups) is detailed in Appendix 1. An alphabetical list of all formally named, currently recognized species and their position in the classification is provided in Appendix 2. Similarly, all currently known sibling species complexes are listed in Appendix 3, and the unnamed and provisionally designated species of the complexes and their position in the classification are listed in Appendix 4.

3. Phylogeny of *Anopheles*

Anopheles is undoubtedly the most studied and best known genus of mosquitoes, largely because of their great impact on human health. As vectors of causative agents of malaria and filariasis, *Anopheles* mosquitoes have affected the lives of more humans than any other insects. As a matter of fact, *Anopheles* is one of few groups of eukaryote organisms that have had an impact on human evolution – the emergence of sickle cell anemia as a mode of resistance to malarial protozoa. As a result of more than a century of studies by medical entomologists, taxonomists and geneticists, 537 species of *Anopheles* are currently known and most have been formally named (87%) (Appendix 2), but until recently little work has been done to understand the evolution and phylogenetic relationships of these mosquitoes.



Figure 3. Hierarchical classification (from specific to general) of A. *Anopheles freeborni*, Freeborni Subgroup, Maculipennis Group, *Anopheles* Series, Angusticorn Section, Subgenus *Anopheles*; B. *Anopheles minimus*, Minimus Complex, Minimus Subgroup, Funestus Group, *Myzomyia* Series, Subgenus *Cellia*; C. *Anopheles albimanus*, Albimanus Series, Albimanus Section, Subgenus *Nyssorhynchus*.

The phylogenetic studies of anopheline mosquitoes conducted to date are summarized in Appendix 5. In view of the impact of malaria on human health, it is not surprising that most of these studies have dealt with species Groups, Subgroups and Complexes that include vectors of human malarial protozoa. It is obvious that the evolutionary relationships of malaria vectors and their closest allies have received more attention than other groups. However, none of these studies can be regarded as complete in terms of taxonomic coverage of any group, and the field of disease vector systematics presents many opportunities for further research. Phylogenetic patterns are used to interpret bionomic features such as differences in the nature of blood-feeding by adult females, feeding behavior and the occurrence of immature stages in aquatic habitats.

Mosquitoes probably evolved in the Jurassic [12,29,30] (146–200 Mya)¹, along with the early mammals, first birds and first flowering plants. Unfortunately, due to the paucity of mosquito fossils, there is no direct indication of the evolutionary history of anopheline mosquitoes. The second oldest fossil mosquito, *Paleoculicis minutus* [31] from the Late Cretaceous (66.0–100.5 Mya), has morphological features that indicate a closer affinity with culicine than anopheline mosquitoes, which suggests that this ancestral lineage is younger than the lineage that gave rise to subfamily Anophelinae. *Anopheles* (*Nyssorhynchus*?) *dominicanus* [32] and *An.* (?) *rottensis* [33] are the only fossil anopheline mosquitoes. The former is from the mid-Tertiary (about 15–45 Mya) and the latter is from the Late Oligocene of Germany (approximately 25 Mya). If the anopheline mosquitoes are indeed ancestral to all other Culicidae [18,34], it would appear from available fossil evidence that extant groups may have evolved in the Cenozoic Era (<66.0 Mya). From divergence times based on sequence data for nuclear protein-coding genes and fossil calibration points, it appears that major mosquito lineages date to the Early Cretaceous (100.5–145.0 Mya), and the ancestral lineage of anophelines may have appeared as early as the Jurassic (~145 Mya) [34].

Anopheles is the nominotypical genus of subfamily Anophelinae. In addition to *Anopheles* (cosmopolitan), the subfamily includes two other genera: *Bironella* (Australasian) and *Chagasia* (Neotropical). Cladistic analyses of morphological data and DNA sequences of various ribosomal, mitochondrial and nuclear genes strongly support the placement of *Chagasia* in an ancestral relationship to all other anophelines [18,34–41].

In 2000, Sallum et al. [40] performed the first phylogenetic analysis of subfamily Anophelinae, based on morphological characters. The results indicated that genus *Anopheles* is paraphyletic because it included genus *Bironella*. Subgenera *Kerteszia*, *Nyssorhynchus*, *Cellia*, *Lophodomomyia* and *Stethomyia*, along with genus *Bironella*, were found to be monophyletic taxa dispersed among various Series and species Groups of subgenus *Anopheles*. The Christya Series of subgenus *Anopheles* was placed with *Kerteszia* + *Nyssorhynchus* and this clade was sister to *Cellia* + all other anophelines except *Chagasia*.

Two years later, Sallum et al. [41] conducted a molecular analysis of anopheline relationships based on ribosomal (18S, 28S) and mitochondrial (COI, COII) DNA sequences. The results of

¹ Geological ages of eras and periods follow the geological timescale determined by the International Commission on Stratigraphy (<http://www.stratigraphy.org>).

that study cannot be compared directly with the results of their earlier study [40] because significantly fewer taxa were included in the analyses. Nevertheless, the molecular data corroborated the paraphyly of genus *Anopheles* relative to *Bironella* and the sister-group relationship of *Kerteszia* and *Nyssorhynchus*, and supported the monophyly of the other subgenera and genus *Bironella*, which was reconstructed as the sister to *Lophopodomysia* rather than *Stethomyia*.

In 2005, Harbach & Kitching [36] revised and expanded the phylogenetic analysis of Sallum et al. [40], with special consideration of the specialized setae of the male gonocoxites (Figure 2) that diagnose the subgenera. Parsimony analysis of the data set under implied weighting supported the monophyly of subgenera *Cellia*, *Kerteszia* and *Nyssorhynchus*, and the sister relationship of *Kerteszia* + *Nyssorhynchus*. Subgenus *Anopheles* was recovered as a polyphyletic lineage basal to a monophyletic clade consisting of *Kerteszia* + *Nyssorhynchus* and *Cellia* in a sister-group relationship. *Bironella*, *Lophopodomysia* and *Stethomyia* were firmly nested within subgenus *Anopheles*, which would be paraphyletic even if these taxa were subsumed within it. Subgenus *Baimaia*, represented by *An. kyondawensis*, was supported as the sister of *Bironella* + all other *Anopheles*. *Bironella* and *Stethomyia*, contrary to the earlier study of Sallum et al. [40], were also supported as monophyletic clades separate from subgenus *Anopheles*. The preferred cladogram of Harbach & Kitching (Figures 4 and 5) is taken here to represent the best available estimate of anopheline phylogeny and evolutionary relationships because it is based on a greater number of taxonomic groups and homologous characters than all other hypotheses published to date.

A later analysis of subgenus *Anopheles* by Collucci & Sallum [42] included 38 species representing the same Series (6) and species Groups (15) of the subgenus that were included in the study of Sallum et al. [40]. The data were analyzed using successive approximations character weighting (SACW) and implied weighting (IW). Most of the relationships between members of the subgenus were either moderately or poorly supported. The Laticorn Section was recovered as a monophyletic clade in the IW analysis, suggesting that the laticorn development of the pupal trumpet is a derived condition for subgenus *Anopheles*. In the SACW analyses, members of the group comprised a paraphyletic lineage relative to the Cycloleppteran Series. The Angusticorn Section was recovered as a polyphyletic assemblage in both analyses. These results are contradicted by those of Sallum et al. [40] and Harbach & Kitching [36] who found that neither section is monophyletic. Below the section level of classification, only the Lophoscelomyia and Arribalzagia Series were recovered as monophyletic assemblages. The Myzorhynchus Series was paraphyletic relative to the Cycloleppteran, Christya and Arribalzagia Series, and the *Anopheles* Series was polyphyletic. Surprisingly, the two species of the Cycloleppteran Series included in the analyses were not grouped together, suggesting that the series is not monophyletic. In contrast, the Arribalzagia, Christya, Cycloleppteran, Lophoscelomyia and Myzorhynchus Series were recovered as monophyletic assemblages in the IW analysis of Harbach & Kitching (Figure 4). Furthermore, with the removal of subgenus *Baimaia*, the remaining species of the *Anopheles* Series included in their analysis also formed a monophyletic group. With the exception of the Pseudopunctipennis Group, all the species groups represented in the analysis of Collucci & Sallum (*Aitkenii*, *Albotaeniatus*, *Culiciformis*,

Hyrceanus, Plumbeus, Umbrosus Groups) were recovered as monophyletic assemblages with moderate to strong support [the Pseudopunctipennis Group was also found to be polyphyletic in the study of Harbach & Kitching (Figure 4)]. The Hyrceanus Group was paired with *An. coustani*, which corroborates previous hypotheses of a close relationship between the Hyrceanus and Coustani Groups [20,36,40,43]. Unfortunately, the analyses of Collucci & Sallum are biased by the selection of outgroup taxa whose interrelationships with the ingroup taxa were unresolved in previous studies. Thus, the results of their study cast doubt on their assertion that subgenus *Anopheles* is monophyletic. Based on the relationships recovered by Harbach & Kitching, subgenus *Anopheles* would be monophyletic if subgenus *Lophopodomyia* were to be reduced to the status of a species Group of the Anopheles Series (Figure 4). The Anopheles Series is a morphologically diverse assemblage of species and informal taxonomic groups, a number of which at one time or another were deemed to merit recognition as subgenera [20]. Sallum et al. [40] also found the Anopheles Series to be polyphyletic, but with its members interspersed in a complexity of inter-group relationships rather than arrayed in a pectinate sequence (Figure 4).

All phylogenetic studies conducted to date have demonstrated the monophyly of subgenera *Cellia* [36,38–41], *Kerteszia* [36,38–41,44] and *Nyssorhynchus* [36,38–41], and the sister pairing of *Kerteszia* and *Nyssorhynchus* [36,40,41]. The sister relationship of *Cellia* and the two New World subgenera is not inconsistent with the molecular analyses of Sallum et al. [41] if *Lophopodomyia* + *Bironella* is excluded from the clade that contains *Kerteszia* + *Nyssorhynchus*, but it differs markedly from the results of their earlier study based on morphology and a larger number of taxa [40], which placed *Kerteszia* + *Nyssorhynchus*, along with *An. implexus* (Christya Series), in a sister-group relationship with *Cellia* + a clade comprised of *Bironella*, *Lophopodomyia*, *Kerteszia* and *Nyssorhynchus*. *Anopheles implexus* (Christya Series) is sister to the terminal clade formed by *Kerteszia*, *Nyssorhynchus* and *Cellia* in Figure 4.

4. Distribution and phylogeography of *Anopheles*

Interpreting the current distributions of anophelins in an evolutionary context is problematic. The supercontinent of Pangaea existed in the Late Paleozoic and Early Mesozoic Eras from about 300–200 Mya and gradually separated 200–145 Mya into the two supercontinents of Laurasia and Gondwana [45]. As noted above, evidence from DNA sequence data and fossil calibration points [34] indicates that ancestral anophelins diverged from ancestral culicines about 217 Mya (230–192 Mya), before the complete splitting of Pangaea. If this was the case, then the separation of *Anopheles* and *Bironella* about 54 Mya (75.8–37.1 Mya, end of the Cretaceous to near the end of the Eocene Epoch of the Cenozoic) [34] must have occurred after the separation of Gondwana into multiple continents, i.e. Africa, South America, India, Antarctica and Australia, in the Cretaceous. Atlantica (the land mass that comprised present-day South America and Africa) separated from eastern Gondwana (the land mass that comprised Antarctica, India and Australia) 150–140 Mya. South America started to separate from Africa in a south-to-north direction during the Middle Cretaceous (about 125–115 Mya) [46]. At the same time, Madagascar and India began to separate from Antarctica, and separated

from each other 100–90 Mya during the Cenomanian and Turonian Stages of the Late Cretaceous. India continued to move northward and collided with Eurasia about 35 Mya. Laurasia split to give rise to North America/Greenland and Eurasia about 60–55 Mya. Africa began to move northeastward toward Europe and South America moved northward to separate from Antarctica. North and South America were joined by the Isthmus of Panama during the Pliocene, approximately 3.7–3.0 Mya.

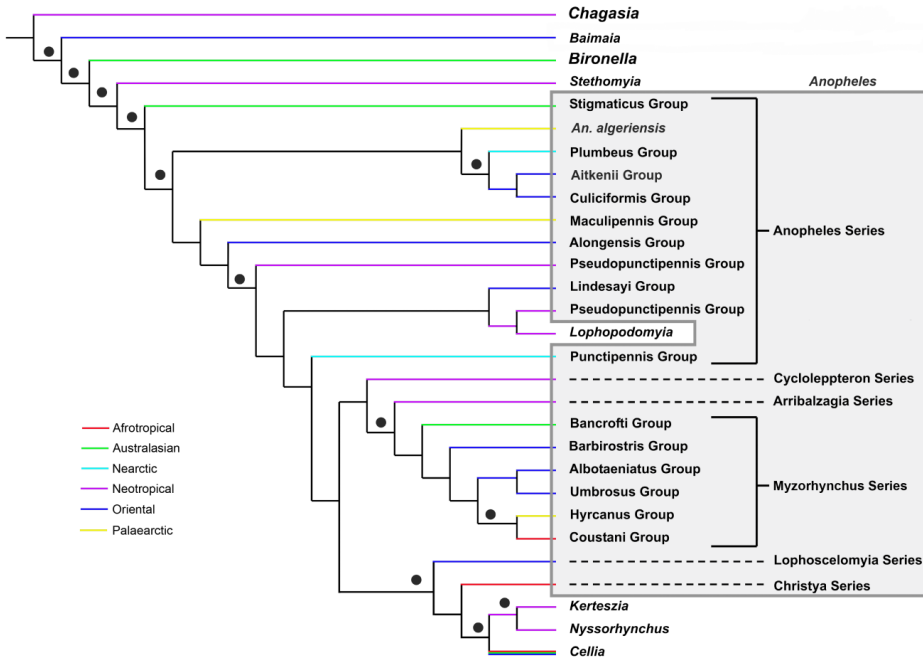


Figure 4. Phylogeny of subfamily Anophelinae, modified from Harbach & Kitching [36], indicating relationships within subgenus *Anopheles*. Filled circles indicate Bremer support values greater than 0.8.

Belkin [47] hypothesized that anophelines initially differentiated in the American Mediterranean Region. In concert with this postulate, Harbach & Kitching [36] suggested a possible New World origin of subfamily Anophelinae based on the basal placement of *Chagasia* relative to *Anopheles* + *Bironella* in their phylogeny of mosquito genera. Based on a phylogeny of 16 anopheline species inferred from sequences of two protein-coding nuclear genes and the Neotropical distribution of *Chagasia* and four of the seven subgenera of *Anopheles*, Krzywinski et al. [39] agreed with the hypothesis that South America was the center of origin of Anophelinae. However, as will be seen below, more recent studies suggest a different scenario for the evolution of the extant groups of the subfamily. This scenario closely reflects Christophers [48] insightful observations:

Subgenus *Anopheles* appears to be the oldest of the predominant subgenera, not only on [morphological grounds], but by reason of its worldwide distribution and the greater diversity and distinctness of its forms; almost every species of the subgenus appears to be as distinctive as are the species groups of subgenus *Myzomyia* [=Cellia], if not more so.

Nyssorhynchus appears to be a Neotropical development from some pre-*Anopheles* form, whilst the group *Arribalzagia* appears to be a highly specialized development of subgenus *Anopheles*.

Myzomyia shows every evidence of being a new and actively disseminating branch, as is suggested by its complete absence from the New World. Had it been once disseminated throughout North America it is unlikely that it would have been eliminated from the whole continent so completely as to leave not a single species in this area, though there is no actual proof that this did not occur. The apparent affinity between the group *Neomyzomyia* and subgenus *Nyssorhynchus* suggests an intermediate ancestor, though not necessarily one in the south, *i. e.*, such affinity does not prove or suggest a land-connection between Australia and South America, as the common ancestor may have been derived from the north and later eliminated. [next paragraph omitted]

The date of isolation of South America, judging by the history of mammals, would be from the middle of the Eocene, when connections between North and South America were severed, until the end of the Pliocene (*Zittel*). The anopheline fauna, therefore, arose from elements which pre-dated this period, and there were already subgenus *Anopheles*-like forms, as well as some earlier type from which *Nyssorhynchus* arose.

At some unknown period a similar special development took place, resulting in an early form (*Neomyzomyia*) of subgenus *Myzomyia*. This form appears to have once been distributed throughout the Oriental, Ethiopian [*i. e.* Afrotropical], and Australian Regions, and to have later undergone some regression, eventually remaining in greatest strength in the Australian Region.

Edwards, in reviewing the fossil remains of mosquitoes, notes that probably all the main divisions of the family [Culicidae] existed in Mid-Tertiary much as they do today, and with almost identical characters, and considers that, though no fossil *Anopheles* have been found, there can be no doubt from its morphology that this is also an old genus, probably older than any culicine form.

Based on the relationships shown in Figure 4, distributions of the principal group taxa (Appendix 6) and the geological dates listed above, it would appear that the ancestral lineage of *Anopheles* existed before the breakup of Pangaea and subsequently diversified into the modern subgenera and species after the separation of the continents. This would explain the cosmopolitan distribution and greater diversity of subgenus *Anopheles*, but not the earlier divergence of genus *Chagasia* and subgenus *Stethomyia*, which are confined to the Neotropical Region, the Oriental subgenus *Baimaia* and the Australasian genus *Bironella* (Figure 4). *Chagasia* possess several features that characterize species of subfamily Culicinae, including the strongly arched mesonotum, trilobed scutellum (Figure 6) and setae on the postpronotum. Based on these shared features, *Chagasia* has been considered an ancient group showing affinities with non-anophelines and phylogenetic analyses of morphological data and DNA sequences of various ribosomal, mitochondrial and nuclear genes strongly support its placement in an ancestral relationship to all other anophelines [33,35–41]. From the foregoing, however, it is inferred here that *Chagasia*, with only seven species, is a relic of a once more widely distributed taxon that is now confined to residual areas of South and Central America. It is also possible, although less likely, that *Chagasia*, as suggested by the late John N. Belkin for other mosquitoes [47], may have originated through hybridization between early anopheline and culicine forms.

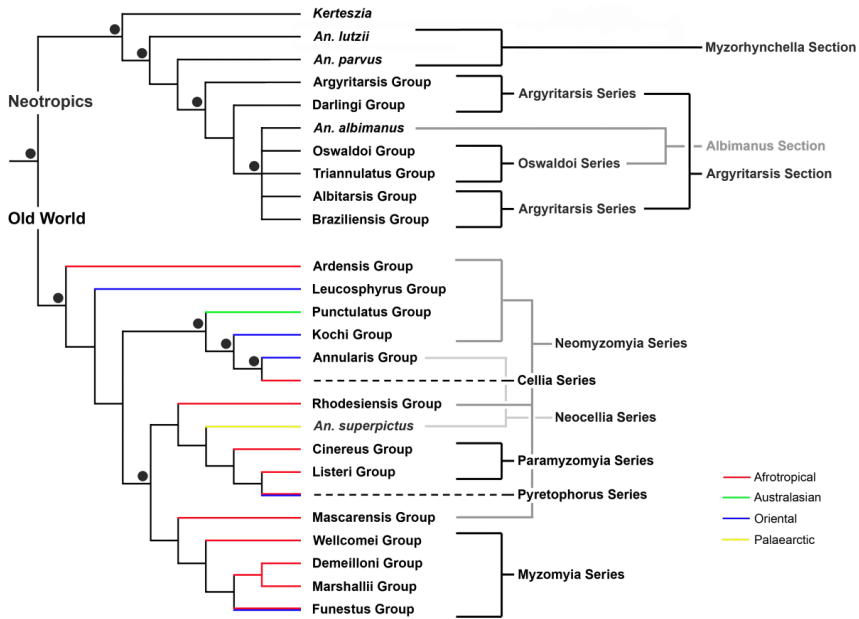


Figure 5. Phylogeny of subgenera *Cellia*, *Kerteszia* and *Nyssorhynchus*, modified from Harbach & Kitching [36], indicating relationships within subgenera *Cellia* and *Nyssorhynchus*. Filled circles indicate Bremer support values greater than 0.8.

Similarly, *Bironella* (as suggested by Christophers [48]), *Baimaia* and *Stethomyia*, with few species and restricted distributions, are also the remnants of once much more widely distributed forms. The isolation of ancestral members of subgenus *Anopheles* in South America also explains the uniqueness of the extant Neotropical fauna of the subgenus, especially the well-differentiated Arribalzagia Series. In accordance with this hypothesis, the following groups are also probably residual elements of once more widely distributed ancestral forms of subgenus *Anopheles*: the Afrotropical Christya Series (two species), the Australasian Atratipes (two species) and Stigmaticus (six species) Groups, the Oriental Alongensis (two species) and Culciformis (three species) Groups, the Oriental Lophoscelomyia Series (five species) and the Neotropical Cyclolepteron Series (two species). It is noteworthy that the extant members of the relict groups are not vectors of human malarial parasites.

As noted previously, subgenus *Anopheles* has an almost world-wide distribution. Species are found at elevations from coastal areas to mountainous terrain in temperate, subtropical and tropical areas, but are absent from the majority of the Pacific Islands, including the large ones of New Zealand, Fiji and New Caledonia. The sole species of subgenus *Baimaia* has been found only in forested hilly and mountainous areas between 14° and 17° north on either side of the

Thai-Myanmar border and at a location near the Thai-Laos border in Thailand, and is probably also a relict taxon that has retained generalized ancestral features of the male genitalia [36]. Most species of subgenus *Cellia* have distributions in the Afrotropical, Australasian and Oriental Regions, but some species occur in southern areas of the Palaearctic. Species of *Cellia* are conspicuously absent from the majority of the islands of the Pacific, including New Zealand, Fiji and New Caledonia. Species of subgenus *Kerteszia* are found in the Neotropical Region, from Veracruz State in Mexico through Central America and Atlantic South America, along the Andes and along the coast, to the States of Misiones in Argentina and Rio Grande do Sul in Brazil, and also occur south along the Pacific Coast of South America to the State of El Oro, Ecuador. The subgenus is absent from all islands of the West Indies except Trinidad, and from most of the vast expanse of the Amazon basin in South America [49]. Species of subgenus *Lophopodomyia* are known to occur in areas of Panama and northern South America (Brazil, Colombia, Ecuador, French Guiana and Venezuela). Species of subgenus *Nyssorhynchus* are restricted to the Neotropical Region, except for *An. albimanus*, which extends into the Nearctic Region (northern Mexico and along the Rio Grande River in Texas). Finally, species of subgenus *Stethomyia* principally occur in southern Central America (Costa Rica and Panama) and northern South America (Brazil, Colombia, French Guiana, Guyana, Suriname and Venezuela), but one or two species are known to occur on the islands of Trinidad and Tobago and as far south as Peru and Bolivia.

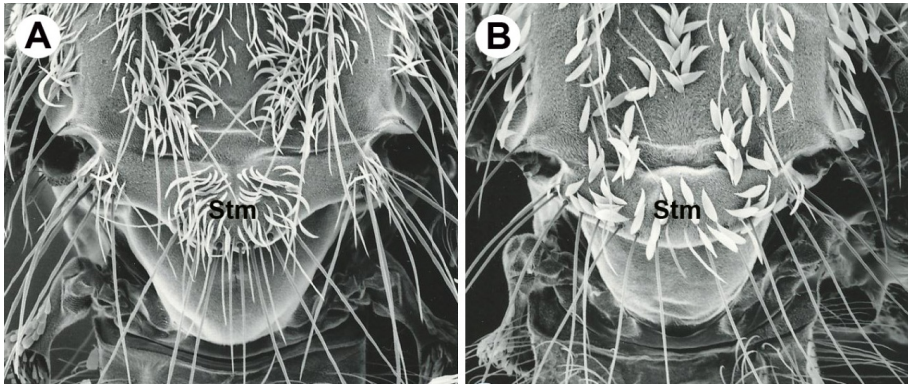


Figure 6. Two forms of the mosquito scutellum (Stm): A, trilobed scutellum of *Chagasia* and species of subfamily Culicinae; B, evenly rounded scutellum of *Anopheles*, with few exceptions. Original images from Harbach & Kitching [18].

Subgenera *Kerteszia*, *Lophopodomyia*, *Nyssorhynchus* and *Stethomyia*, and the Arribalzagia and Cyclolepteron Series of subgenus *Anopheles* are special to the Neotropical Region, where they probably originated following the separation of South America and Africa. The derived position of subgenera *Cellia* and *Kerteszia* + *Nyssorhynchus* relative to subgenus *Anopheles* (Figure 4) supports the hypothesis that the stem lineage of these subgenera originated in Gondwana and diverged following the separation of Atlantica to give rise to *Cellia* in Africa and *Kerteszia* and *Nyssorhynchus* in South America. It is interesting to note that *Lophopodo-*

myia and the Pseudopunctipennis Group are sister taxa in Figure 4, which is plausible in view of the hypothesized evolution of these groups from Neotropical ancestors. The Pseudopunctipennis Group is nearly restricted to the Neotropics, except for *An. franciscanus* and a minor extension of *An. pseudopunctipennis* into the Nearctic Region, which undoubtedly occurred relatively recently, after the land bridge formed to connect North and South America 3.7–3.0 Mya. Except for these two species, all *Anopheles* species in the Nearctic Region are members of the Anopheles Series of subgenus *Anopheles*. Half of the species of the Holarctic Maculipennis Group (24 species) occur in the Nearctic Region and the other half occur in the Palaearctic. This indicates that the Maculipennis Group must have evolved in the Northern Hemisphere prior to the separation of North America and Eurasia during the Paleocene and Eocene Epochs (60–55 Mya). The Plumbeus Group includes species in the Nearctic (2), Neotropical (4) and Palaearctic (3) Regions. Its position in the cladogram shown in Figure 4 is based on *An. judithae*, a Nearctic species. This group may be what paleontologists call a “stem group” [50], a paraphyletic or polyphyletic assemblage of species that share features of extinct taxa. The spotted distribution of these “living fossil” species suggests that their extinct relatives, ancestral forms of the Anopheles Series, existed before the separation of Pangaea. This bodes well with Christophers & Barraud’s 1931 hypothesis [51] that the eggs of species of the Plumbeus Group are primitive compared to other species of subgenus *Anopheles*.

Species in subgenus *Cellia* are confined to the Eastern Hemisphere, with members in the Afrotropical, Australasian, Oriental and Palaearctic regions (Figure 5, Appendix 6). The Afrotropical Region is characterized by a large number of species of subgenus *Cellia* and relatively few species of subgenus *Anopheles*. The Myzomyia Series is especially dominant, but species of the Neocellia, Neomyzomyia and Pyretophorus Series also occur in the region. The Myzomyia, Neocellia and Pyretophorus Series are represented in the Afrotropical and Oriental Regions, but no species, species groups or subgroups of these series (with the exception of the Minimus Subgroup) are common to both regions (see Appendix 6). The Myzomyia Series is a dominant group in Africa, where *An. funestus* is a principal malaria vector [52,53]. Related species of the Funestus Group, including *An. minimus* and other members of the Minimus Subgroup, are major vectors of malarial parasites in southern Asia [52,54]. Evidence from phylogenetic analyses of mitochondrial DNA (ITS2 and D3 sequences) indicates that the Funestus Group originated in the Afrotropical Region [55]. The Neocellia Series also includes several important malaria vectors in southern Asia, notably *An. stephensi* and members of the Maculatus Group [52,54]. The Pyretophorus Series includes the formidable malaria vectors of the Gambiae Complex in Africa and important vectors of the Sundaicus and Subpictus Complexes in Southeast Asia [53,54]. The morphology-based phylogeny of Anthony et al. [56] indicates that the Pyretophorus Series originated in Africa and suggests that the capacity to vector malarial parasites is an ancestral condition subsequently lost independently in several lineages.

The anopheline fauna of the Australasian Region also shows evidence of isolation, but not to the degree indicated by the Neotropical fauna. The isolation appears to be more recent, corresponding to the separation of Australia from Antarctica between 37.0–33.5 Mya. The region includes a preponderance of species of the Neomyzomyia Series of subgenus *Cellia*,

which may signal a relatively recent arrival from the Oriental Region, with some diversification. Members of the *Neomyzomyia* Series are the only *Anopheles* in the South Pacific [47]. Species groups of the series are confined to the Afrotropical (*Ardensis*, *Mascarensis*, *Pauliani*, *Ranci*, *Rhodesiensis* and *Smithii* Groups), Australasian (*Punctulatus* Group, *Lungae* Complex and unassigned species) or Oriental Region (*Kochi*, *Leucosphyrus* and *Tessellatus* Groups) (Appendix 6). The *Neomyzomyia* Series has been regarded as the most primitive series of subgenus *Cellia* based on egg morphology and the reduced or non-existent cibarial armature of females [57–59], and is thought to have originated in Africa and subsequently disperse eastward to the Oriental and Australasian Regions [52,59]. None of the African species of the *Neomyzomyia* Series, except for *An. nili*, are major vectors of malaria. In comparison, most species of the Oriental *Leucosphyrus* and Australasian *Punctulatus* Groups of the *Neomyzomyia* Series are important vectors of both primate and human malarial parasites. The *Cellia* and *Paramyzomyia* Series of subgenus *Cellia* are restricted to the Afrotropical Region, except for *An. pharoensis* (*Cellia* Series) and *An. multicolor* (*Paramyzomyia* Series) which occur in adjacent arid areas of the Palaearctic (Sahara and Middle East). It seems reasonable to hypothesize that those series that are presently represented by groups in the Afrotropical, Australasian and Oriental Regions arose before eastern Gondwana (Antarctica, India and Australia) fragmented. The *Mascarensis*, *Pauliani* and *Ranci* Groups are confined to Madagascar, which supports the hypothesis that the ancestral forms of at least these groups of the *Neomyzomyia* Series existed before Madagascar separated from India 100–90 Mya.

Human malaria probably evolved in Africa along with its mosquito hosts and other primates. Modern humans arose in Africa about 200,000 years ago and dispersed into Eurasia [60], reaching Australia about 40,000 years ago. Migration into the New World occurred about 15–20 millennia ago, and most of the Pacific Islands were colonized by four thousand years ago. The point here is that the rise and dispersal of modern humans occurred long after the formation of the continents and the evolution of the major groups of *Anopheles*. Consequently, it seems reasonable to assume that human malarial parasites accompanied humans during their migration out of Africa and were passed on to species of *Anopheles* in other regions that had the ecological, physiological and behavioural attributes required to propagate infections and maintain transmission. These taxa were surely already adapted to feeding on primates, including the ancestors of *Homo sapiens*, and were capable of developing and transmitting the *Plasmodium* species specific to those hosts.

Comprehensive information on the dominant malaria vectors of the world, most of which are presumably recently evolved members of sibling species complexes (Appendix 3), is summarized in a series of publications (and a chapter of this book) by M. Sinka and a team of regional experts and technical advisors – the Americas [61], Africa, Europe and the Middle East [53], the Asia-Pacific Region [54] – that culminated in a thorough review of the principal malaria vector taxa of the world [62]. At present, 96 formally named species of *Anopheles* are members of 26 sibling species complexes (Appendix 4). Twenty of these nominal species actually consist of more than one species, which all together comprise a total of 67 species. Excluding the name-bearing type species, the 58 species, plus five other unnamed species that

are not members of species complexes, a total of 72 species, have yet to be given formal Latin names (Appendix 4).

5. Conclusion

A more robust phylogeny of *Anopheles* mosquitoes than is currently available may be of use in the fight against malaria. Foley et al. [37] suggested that it may help “by elucidating descent relationships of genes for refractoriness, insecticide resistance, and genetically determined ecological and behavioral traits important to malaria transmission.” Interrupting the life cycle of malarial parasites by genetically manipulating vector receptiveness to infection is a potential approach to malaria control. A natural classification of *Anopheles* predictive of biological and ecological traits could facilitate the manipulation of vector genomes by informing the dynamics of introduced genes. Obviously, co-evolutionary studies of parasites and vectors require phylogenies for the mosquitoes. This must far exceed the taxon-limited (exemplar-based) studies conducted to date as they do not provide a basis for gaining insights into interspecific and co-evolutionary relationships of vectors and parasites.

It seems fitting to end here with a comment concerning interspecific hybridization, which was mentioned above in relation to genus *Chagasia* in the Neotropical Region. Although anopheline species occur in sympatry in most ecosystems, hybridization has only been detected at very low levels between certain members of species complexes in subgenus *Cellia*, e.g. *An. gambiæ* with both *An. arabiensis* and *An. bwambæ* in Africa [63,64], *An. dirus* and *An. baimaii* in Thailand [65] and *An. minimus* and *An. harrisoni* in Vietnam [66]. However, as advocated by Belkin [47], hybridization could provide sufficient genetic variation to permit adaptation to new habitats. Hybridization may occur regularly between some species, particularly widely distributed species that are morphologically similar. It could have played a role in the speciation and evolution of *Anopheles* mosquitoes and the pathogens they transmit.

Appendix 1 — The internal classification of genus *Anopheles*

Subgenus	Section	Series	Group	Subgroup	Complex	Author
<i>Anopheles</i>						[1]
	Angusticorn					[20]
		Anopheles				[12]
					Claviger	[67]
			Alongensis			[68]
			Aitkenii			[10]
			Atratipes			[69]

Subgenus	Section	Series	Group	Subgroup	Complex	Author
			Culiciformis			[20]
			Lindesayi			[20]
					Gigas	[70]
					Lindesayi	[70]
			Maculipennis			[20]
				Maculipennis		[71]
				Quadrifasciatus		[71]
				Freeborni		[71]
			Plumbeus			[20]
			Pseudopunctipennis			[20]
			Punctipennis			[20]
					Crucians	[72]
			Stigmaticus			[20]
		Cyclolepteron				[12]
		Lophoscelomyia				[12]
			Asiaticus			[23]
				Asiaticus		[73]
				Interruptus		[73]
	Laticorn					[20]
		Arribalzagia				[74]
		Christya				[75]
		Myzorhynchus				[12]
			Albotaeniatus			[20]
			Bancroftii			[20]
			Barbirostris			[20]
				Barbirostris		[23]
					Barbirostris	[76]
				Vanus		[23]
			Coustani			[20]
			Hyrceanus			[77]
				Lesteri		[78]
				Nigerrimus		[78]

Subgenus	Section	Series	Group	Subgroup	Complex	Author
			Umbrosus			[79]
				Baezai		[73]
				Letifer		[23]
				Separatus		[73]
				Umbrosus		[73]
<i>Baimaia</i>						[15]
<i>Cellia</i>						[80]
		Cellia				[75]
			Squamosus			[21]
		Myzomyia				[75]
			Demeilloni			[22]
			Funestus			[81]
				Aconitus		[82]
				Culicifacies		[81]
				Funestus		[81]
				Minimus		[82]
					Fluviatilis	[83]
					Minimus	[84]
				Rivulorum		[81]
			Marshallii			[22]
					Marshallii	[85]
			Wellcomei			[22]
		Neocellia				[75]
			Annularis			[23]
					Annularis	[86]
					Nivipes	[87]
			Jamesii			[73]
			Maculatus			[88]
				Maculatus		[73]
				Sawadwongporni		[73]
		Neomyzomyia				[75]
					Annulipes	[89]

Subgenus	Section	Series	Group	Subgroup	Complex	Author
					Longirostris	[90]
					Lungae	[47]
			Ardensis			[22]
					Nili	[22]
			Kochi			[73]
			Leucosphyrus			[91]
				Hackeri		[92]
				Leucosphyrus		[93]
					Dirus	[94]
					Leucosphyrus	[92]
				Riparis		[93]
			Mascarensis			[26]
			Pauliani			[21]
			Punctulatus			[95]
					Farauti	[96]
			Ranci			[21]
				Ranci		[21]
				Roubaudi		[21]
			Rhodesiensis			[22]
			Smithii			[22]
			Tessellatus			[73]
		Paramyzomyia				[51]
			Cinereus			[22]
			Listeri			[22]
		Pyretophorus				[12]
					Gambiae	[97]
			Ludlowae			[73]
					Sundaicus	[98]
			Subpictus			[73]
					Subpictus	[99]
<i>Kerteszia</i>						[100]
					Cruzii	[101]

Subgenus	Section	Series	Group	Subgroup	Complex	Author
<i>Lophopodomyia</i>						[14]
<i>Nyssorhynchus</i>						[102]
	Albimanus					[103]
		Albimanus				[24]
		Oswaldoi				[24]
			Oswaldoi			[24]
				Oswaldoi		[24]
					Nuneztovari	[104]
				Strodei		[24]
					Benarrochi	[105]
			Triannulatus		Triannulatus	[24]
Argyritarsis						[103]
	Albitarsis					[25]
		Albitarsis				[25]
					Albitarsis	[106]
		Braziiliensis				[25]
	Argyritarsis					[25]
		Argyritarsis				[25]
		Darlingi				[25]
		Lanei				[25]
		Pictipennis				[25]
	Myzorhynchella					[107]
<i>Stethomyia</i>						[80]

Appendix 2

Alphabetical list of formally named species of *Anopheles* and their position in the classification of the genus. For species Complexes, see Appendices 3 and 4; for authorship of species, visit <http://mosquito-taxonomic-inventory.info/valid-species-list>.

Species	Subgenus	Section	Series	Group	Subgroup
<i>aberrans</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	

Species	Subgenus	Section	Series	Group	Subgroup
<i>acaci</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>acanthotorynus</i>	<i>Stethomyia</i>				
<i>aconitus</i>	<i>Cellia</i>		Myzomyia	Funestus	Aconitus
<i>ahomi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Vanus
<i>ainshamsi</i>	<i>Cellia</i>		Neocellia		
<i>aitkenii</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>albertoi</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Strodei
<i>albimanus</i>	<i>Nyssorhynchus</i>	Albimanus	Albimanus		
<i>albitarsis</i>	<i>Nyssorhynchus</i>	Argyritarsis	Albitarsis	Albitarsis	
<i>albotaeniatus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Albotaeniatus	
<i>algeriensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles		
<i>alongensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Alongensis	
<i>amictus</i>	<i>Cellia</i>		Neomyzomyia		
<i>anchietai</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>annandalei</i>	<i>Anopheles</i>	Angusticorn	Lophoscelomyia	Asiaticus	
<i>annularis</i>	<i>Cellia</i>		Neocellia	Annularis	
<i>annulatus</i>	<i>Cellia</i>		Neomyzomyia		
<i>annulipalpis</i>	<i>Anopheles</i>	Angusticorn	Cyclolepteron		
<i>annulipes</i>	<i>Cellia</i>		Neomyzomyia		
<i>anomaloxyllus</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>antunesi</i>	<i>Nyssorhynchus</i>	Myzorhynchella			
<i>apicimacula</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>apoci</i>	<i>Cellia</i>		Myzomyia		
<i>aquasalis</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>arabiensis</i>	<i>Cellia</i>		Pyretophorus		
<i>arboricola</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>ardensis</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>argenteolobatus</i>	<i>Cellia</i>		Cellia		
<i>argyritarsis</i>	<i>Nyssorhynchus</i>	Argyritarsis	Argyritarsis	Argyritarsis	
<i>argyropus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	
<i>artemievi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis

Species	Subgenus	Section	Series	Group	Subgroup
<i>arthuri</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Strodei
<i>aruni</i>	<i>Cellia</i>		Myzomyia	Funestus	Funestus
<i>asiaticus</i>	<i>Anopheles</i>	Angusticorn	Lophoscelomyia	Asiaticus	Asiaticus
<i>atacamensis</i>	<i>Nyssorhynchus</i>	Argyritarsis	Argyritarsis	Pictipennis	
<i>atratiipes</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Atratiipes	
<i>atroparvus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>atropos</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	
<i>aurirostris</i>	<i>Cellia</i>		Neomyzomyia		
<i>austeni</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>auyantepuiensis</i>	<i>Kerteszia</i>				
<i>azaniae</i>	<i>Cellia</i>		Myzomyia		
<i>azevedoi</i>	<i>Cellia</i>		Paramyzomyia	Cinereus	
<i>aztecus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	
<i>baezai</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	Baezai
<i>baileyi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Lindesayi	
<i>baimaii</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>baisasi</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>balabacensis</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>balerensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Albotaeniatus	
<i>bambusicolus</i>	<i>Kerteszia</i>				
<i>bancroftii</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Bancroftii	
<i>barberellus</i>	<i>Cellia</i>		Myzomyia		
<i>barberi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>barbirostris</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Barbirostris
<i>barbumbrosus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Vanus
<i>barianensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>beklemishevi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Quadrinaculatus
<i>belenrae</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrceanus	
<i>bellator</i>	<i>Kerteszia</i>				
<i>benarrochi</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Strodei
<i>bengalensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	

Species	Subgenus	Section	Series	Group	Subgroup
<i>berghei</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>bervoetsi</i>	<i>Cellia</i>		Myzomyia		
<i>boliviensis</i>	<i>Kerteszia</i>				
<i>borneensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>bradleyi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Punctipennis	
<i>braziliensis</i>	<i>Nyssorhynchus</i>	Argyritarsis	Albitarsis	Braziliensis	
<i>brevipalpis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	
<i>brevirostris</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	
<i>brohieri</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>brucei</i>	<i>Cellia</i>		Myzomyia	Funestus	Rivulorum
<i>brumpti</i>	<i>Cellia</i>		Cellia		
<i>brunnipes</i>	<i>Cellia</i>		Myzomyia		
<i>bulkleyi</i>	<i>Anopheles</i>	Angusticorn	Lophoscelomyia		
<i>bustamentei</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>buxtoni</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>bwambae</i>	<i>Cellia</i>		Pyretophorus		
<i>calderoni</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>caliginosus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>cameroni</i>	<i>Cellia</i>		Neomyzomyia	Rhodesiensis	
<i>campestris</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbistrostris	Barbistrostris
<i>canorii</i>	<i>Stethomyia</i>		Neomyzomyia	Smithii	
<i>carnevalei</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>caroni</i>	<i>Cellia</i>				
<i>carteri</i>	<i>Cellia</i>		Myzomyia	Demeilloni	
<i>chiriquiensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Pseudopunctipennis	
<i>chodukini</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	
<i>christyi</i>	<i>Cellia</i>		Pyretophorus		
<i>cinctus</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>cinereus</i>	<i>Cellia</i>		Paramyzomyia	Cinereus	
<i>claviger</i>	<i>Anopheles</i>	Angusticorn	Anopheles		
<i>clowi</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	

Species	Subgenus	Section	Series	Group	Subgroup
<i>colledgei</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Stigmaticus	
<i>collessi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	Letifer
<i>comorensis</i>	<i>Cellia</i>		Pyretophorus		
<i>concolor</i>	<i>Anopheles</i>	Angusticorn	Anopheles		
<i>confusus</i>	<i>Cellia</i>		Myzomyia	Funestus	Funestus
<i>corethroides</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Stigmaticus	
<i>costai</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>coustani</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>cracens</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>crawfordi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrceanus	Lesteri
<i>cristatus</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Riparis
<i>crispipalpis</i>	<i>Cellia</i>		Cellia		
<i>crucians</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Punctipennis	
<i>cruzii</i>	<i>Kerteszia</i>				
<i>crypticus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>cucphuongensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Alongensis	
<i>culicifacies</i>	<i>Cellia</i>		Myzomyia	Funestus	Culicifacies
<i>culiciformis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Culiciformis	
<i>cydippis</i>	<i>Cellia</i>		Cellia	Squamosus	
<i>daciae</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>dancalicus</i>	<i>Cellia</i>		Neocellia		
<i>darlingi</i>	<i>Nyssorhynchus</i>	Argyritarsis	Argyritarsis	Darlingi	
<i>daudi</i>	<i>Cellia</i>		Pyretophorus		
<i>deaneorum</i>	<i>Nyssorhynchus</i>	Argyritarsis	Albitarsis	Albitarsis	
<i>deemingi</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>demeilloni</i>	<i>Cellia</i>		Myzomyia	Demeilloni	
<i>diluvialis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Quadrinaculatus
<i>dirus</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>dispar</i>	<i>Cellia</i>		Neocellia	Maculatus	
<i>distinctus</i>	<i>Cellia</i>		Myzomyia	Wellcomei	
<i>domicola</i>	<i>Cellia</i>		Myzomyia		

Species	Subgenus	Section	Series	Group	Subgroup
<i>donaldi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Barbirostris
<i>dravidicus</i>	<i>Cellia</i>		Neocellia	Maculatus	Maculatus
<i>dthali</i>	<i>Cellia</i>		Myzomyia		
<i>dualaensis</i>	<i>Cellia</i>		Neomyzomyia		
<i>dunhami</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>dureni</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>earlei</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Freeborni
<i>eiseni</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Pseudopunctipennis	
<i>ejercitoi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Albotaeniatus	
<i>elegans</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>engarensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyranus	
<i>eouzani</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>epiroticus</i>	<i>Cellia</i>		Pyretophorus		
<i>erepens</i>	<i>Cellia</i>		Myzomyia	Wellcomei	
<i>erythraeus</i>	<i>Cellia</i>		Myzomyia		
<i>ethiopicus</i>	<i>Cellia</i>		Myzomyia		
<i>evandroi</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>evansae</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>faini</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>farauti</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	
<i>fausti</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>filipinae</i>	<i>Cellia</i>		Myzomyia	Funestus	Aconitus
<i>flavicosta</i>	<i>Cellia</i>		Myzomyia		
<i>flavirostris</i>	<i>Cellia</i>		Myzomyia	Funestus	Minimus
<i>fluminensis</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>fluviatilis</i>	<i>Cellia</i>		Myzomyia	Funestus	Minimus
<i>fontinalis</i>	<i>Cellia</i>		Myzomyia		
<i>forattinii</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>fragilis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>franciscanus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Pseudopunctipennis	
<i>franciscoi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Barbirostris

Species	Subgenus	Section	Series	Group	Subgroup
<i>freeborni</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Freeborni
<i>freetownensis</i>	<i>Cellia</i>		Myzomyia	Demeilloni	
<i>freyi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbistrotris	
<i>funestus</i>	<i>Cellia</i>		Myzomyia	Funestus	Funestus
<i>fuscicolor</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>fuscivenosus</i>	<i>Cellia</i>		Myzomyia	Funestus	Rivulorum
<i>gabaldoni</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>galvai</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>gambiae</i>	<i>Cellia</i>		Pyretophorus		
<i>garnhami</i>	<i>Cellia</i>		Myzomyia	Demeilloni	
<i>georgianus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Punctipennis	
<i>gibbinsi</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>gigas</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Lindesayi	
<i>gilesi</i>	<i>Lophopodomyia</i>				
<i>goeldii</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>gomezdelatorrei</i>	<i>Lophopodomyia</i>				
<i>gonzalezrinconesi</i>	<i>Kerteszia</i>				
<i>grabhamii</i>	<i>Anopheles</i>	Angusticorn	Cyclolepteron		
<i>grassei</i>	<i>Cellia</i>		Neomyzomyia	Pauliani	
<i>greeni</i>	<i>Cellia</i>		Neocellia	Maculatus	
<i>grenieri</i>	<i>Cellia</i>		Neomyzomyia	Pauliani	
<i>griveaudi</i>	<i>Cellia</i>		Neomyzomyia	Ranci	
<i>guarani</i>	<i>Nyssorhynchus</i>	Myzorhynchella			
<i>guarao</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>hackeri</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Hackeri
<i>hailarensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	
<i>halophylus</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Triannulatus	
<i>hamoni</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>hancocki</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>hargreavesi</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>harperi</i>	<i>Cellia</i>		Myzomyia	Marshallii	

Species	Subgenus	Section	Series	Group	Subgroup
<i>harrisoni</i>	<i>Cellia</i>		Myzomyia	Funestus	Minimus
<i>hectoris</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Pseudopunctipennis	
<i>heiheensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	
<i>hermsi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Freeborni
<i>hervyi</i>	<i>Cellia</i>		Neocellia		
<i>hilli</i>	<i>Cellia</i>		Neomyzomyia		
<i>hinesorum</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	
<i>hodgkini</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbistrotris	Barbistrotris
<i>homunculus</i>	<i>Kerteszia</i>				
<i>hughi</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>hunteri</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	
<i>hyrcanus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	
<i>implexus</i>	<i>Anopheles</i>	Laticorn	Christya		
<i>incognitus</i>	<i>Cellia</i>		Neomyzomyia		
<i>indefinitus</i>	<i>Cellia</i>		Pyretophorus	Subpictus	
<i>ininii</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>insulaeflorum</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>intermedius</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>interruptus</i>	<i>Anopheles</i>	Angusticorn	Lophoscelomyia	Asiaticus	Interruptus
<i>introlatus</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>inundatus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Quadrifasciatus
<i>irenicus</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	
<i>jamesii</i>	<i>Cellia</i>		Neocellia	Jamesii	
<i>janconnae</i>	<i>Nyssorhynchus</i>	Argyritarsis	Albitarsis	Albitarsis	
<i>jebudensis</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>jeyporiensis</i>	<i>Cellia</i>		Myzomyia	Funestus	
<i>judithae</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>karwari</i>	<i>Cellia</i>		Neocellia		
<i>keniensis</i>	<i>Cellia</i>		Myzomyia	Demeilloni	
<i>kingi</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>kleini</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	

Species	Subgenus	Section	Series	Group	Subgroup
<i>kochi</i>	<i>Cellia</i>		Neomyzomyia	Kochi	
<i>kokhani</i>	<i>Cellia</i>		Neomyzomyia		
<i>kolambuganensis</i>	<i>Cellia</i>		Neomyzomyia		
<i>koliensis</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	
<i>kompi</i>	<i>Stethomyia</i>				
<i>konderi</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>koreicus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	
<i>kosiensis</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>kweiyangensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	
<i>kyondawensis</i>	<i>Baimaia</i>				
<i>labranchiae</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>lacani</i>	<i>Cellia</i>		Neomyzomyia	Ranci	Roubaudi
<i>laneanus</i>	<i>Kerteszia</i>				
<i>lanei</i>	<i>Nyssorhynchus</i>	Argyritarsis	Argyritarsis	Lanei	
<i>latens</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>leesoni</i>	<i>Cellia</i>		Myzomyia	Funestus	Minimus
<i>lepidotus</i>	<i>Kerteszia</i>				
<i>lesteri</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	Lesteri
<i>letabensis</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>letifer</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	Letifer
<i>leucosphyrus</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>lewisi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	
<i>liangshanensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	
<i>limosus</i>	<i>Cellia</i>		Pyretophorus		
<i>lindesayi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Lindesayi	
<i>listeri</i>	<i>Cellia</i>		Paramyzomyia	Listeri	
<i>litoralis</i>	<i>Cellia</i>		Pyretophorus		
<i>lloreti</i>	<i>Cellia</i>		Myzomyia	Demeilloni	
<i>longipalpis</i>	<i>Cellia</i>		Myzomyia	Funestus	Funestus
<i>longirostris</i>	<i>Cellia</i>		Neomyzomyia		
<i>lounibosi</i>	<i>Cellia</i>		Neomyzomyia	Rhodesiensis	

Species	Subgenus	Section	Series	Group	Subgroup
<i>lovettae</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>ludlowae</i>	<i>Cellia</i>		Pyretophorus	Ludlowae	
<i>lungae</i>	<i>Cellia</i>		Neomyzomyia		
<i>lutzii</i>	<i>Nyssorhynchus</i>	Myzorhynchella			
<i>macarthuri</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Riparis
<i>machardy</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>maculatus</i>	<i>Cellia</i>		Neocellia	Maculatus	Maculatus
<i>maculipalpis</i>	<i>Cellia</i>		Neocellia		
<i>maculipennis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>maculipes</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>majidi</i>	<i>Cellia</i>		Myzomyia		
<i>malefactor</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>maliensis</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>manalangi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Vanus
<i>mangyanus</i>	<i>Cellia</i>		Myzomyia	Funestus	Aconitus
<i>marajoara</i>	<i>Nyssorhynchus</i>	Argyritarsis	Albitarsis	Albitarsis	
<i>marshallii</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>marteri</i>	<i>Anopheles</i>	Angusticorn	Anopheles		
<i>martinius</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>mascarensis</i>	<i>Cellia</i>		Neomyzomyia	Mascarensis	
<i>mattogrossensis</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>maverlius</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Quadrifasciatus
<i>mediopunctatus</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>melanoon</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>melas</i>	<i>Cellia</i>		Pyretophorus		
<i>mengalagensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Lindesayi	
<i>meraukensis</i>	<i>Cellia</i>		Neomyzomyia		
<i>merus</i>	<i>Cellia</i>		Pyretophorus		
<i>messeae</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>millecampsi</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>milloti</i>	<i>Cellia</i>		Neomyzomyia	Pauliani	

Species	Subgenus	Section	Series	Group	Subgroup
<i>minimus</i>	<i>Cellia</i>		Myzomyia	Funestus	Minimus
<i>minor</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>mirans</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Hackeri
<i>moghulensis</i>	<i>Cellia</i>		Neocellia		
<i>montanus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Albotaeniatus	
<i>mortiauxi</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>moucheti</i>	<i>Cellia</i>		Myzomyia		
<i>mousinhoi</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>multicinctus</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>multicolor</i>	<i>Cellia</i>		Paramyzomyia	Listeri	
<i>murphyi</i>	<i>Cellia</i>		Cellia		
<i>namibiensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>natalensis</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>nataliae</i>	<i>Cellia</i>		Neomyzomyia		
<i>neivai</i>	<i>Kerteszia</i>				
<i>nemophilous</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>neomaculipalpus</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>nigerrimus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	Nigerrimus
<i>nigritarsis</i>	<i>Nyssorhynchus</i>	Myzorhynchella			
<i>nilgircus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Lindesayi	
<i>nili</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>nimbus</i>	<i>Stethomyia</i>				
<i>nimpe</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	
<i>nitidus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	Nigerrimus
<i>nivipes</i>	<i>Cellia</i>		Neocellia	Annularis	
<i>njombiensis</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>noniae</i>	<i>Anopheles</i>	Angusticorn	Lophoscelomyia	Asiaticus	
<i>notanandai</i>	<i>Cellia</i>		Neocellia	Maculatus	Sawadwongporni
<i>notleyi</i>	<i>Cellia</i>		Neomyzomyia	Ranci	Roubaudi
<i>novaguinensis</i>	<i>Cellia</i>		Neomyzomyia		
<i>nuneztovari</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi

Species	Subgenus	Section	Series	Group	Subgroup
<i>obscurus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus		
<i>occidentalis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Freeborni
<i>oiketorakras</i>	<i>Lophopodomya</i>				
<i>okuensis</i>	<i>Anopheles</i>	Laticorn	Christya		
<i>omorii</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>oryzalimnetes</i>	<i>Nyssorhynchus</i>	Argyritarsis	Albitarsis	Albitarsis	
<i>oswaldoi</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>ovengensis</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>pallidus</i>	<i>Cellia</i>		Neocellia	Annularis	
<i>palmatus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>paltrinierii</i>	<i>Cellia</i>		Neocellia		
<i>paludis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>pampantai</i>	<i>Cellia</i>		Myzomyia	Funestus	Aconitus
<i>papuensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Stigmaticus	
<i>paraliae</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	Lesteri
<i>parangensis</i>	<i>Cellia</i>		Pyretophorus		
<i>parapunctipennis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Pseudopunctipennis	
<i>parensis</i>	<i>Cellia</i>		Myzomyia	Funestus	Funestus
<i>parvus</i>	<i>Nyssorhynchus</i>	Myzorhynchella			
<i>pattoni</i>	<i>Cellia</i>		Neocellia		
<i>pauliani</i>	<i>Cellia</i>		Neomyzomyia	Pauliani	
<i>peditaeniatus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	Lesteri
<i>perplexens</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Punctipennis	
<i>persiensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>peryassui</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>petragnani</i>	<i>Anopheles</i>	Angusticorn	Anopheles		
<i>peytoni</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>pharoensis</i>	<i>Cellia</i>		Cellia		
<i>philippinensis</i>	<i>Cellia</i>		Neocellia	Annularis	
<i>pholidotus</i>	<i>Kerteszia</i>				
<i>pictipennis</i>	<i>Nyssorhynchus</i>	Argyritarsis	Argyritarsis	Pictipennis	

Species	Subgenus	Section	Series	Group	Subgroup
<i>pilinosum</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>pinjaurensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>plumbeus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>pollicaris</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Barbirostris
<i>powderi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>powelli</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Stigmaticus	
<i>pretoriensis</i>	<i>Cellia</i>		Neocellia		
<i>pristinus</i>	<i>Nyssorhynchus</i>	Myzorhynchella			
<i>pseudobarbirostris</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Bancroftii	
<i>pseudojamesi</i>	<i>Cellia</i>		Neocellia	Jamesii	
<i>pseudomaculipes</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>pseudopictus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	
<i>pseudopunctipennis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Pseudopunctipennis	
<i>pseudosinensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	Nigerrimus
<i>pseudostigmaticus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Stigmaticus	
<i>pseudosundaicus</i>	<i>Cellia</i>		Pyretophorus		
<i>pseudotibiamaculatus</i>	<i>Lophopodomyia</i>				
<i>pseudowillmori</i>	<i>Cellia</i>		Neocellia	Maculatus	
<i>pujutensis</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Hackeri
<i>pulcherrimus</i>	<i>Cellia</i>		Neocellia		
<i>pullus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	
<i>punctimacula</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>punctipennis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Punctipennis	
<i>punctulatus</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	
<i>pursati</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcaus	Nigerrimus
<i>quadriannulatus</i>	<i>Cellia</i>		Pyretophorus		
<i>quadrimaculatus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Quadrimaculatus
<i>rachoui</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>radama</i>	<i>Cellia</i>		Neomyzomyia	Pauliani	
<i>rageaui</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>rampae</i>	<i>Cellia</i>		Neocellia	Maculatus	Sawadwongporni

Species	Subgenus	Section	Series	Group	Subgroup
<i>ranci</i>	<i>Cellia</i>		Neomyzomyia	Ranci	Ranci
<i>rangeli</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>recens</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Hackeri
<i>reidi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Vanus
<i>rennellsensis</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	
<i>rhodesiensis</i>	<i>Cellia</i>		Neomyzomyia	Rhodesiensis	
<i>riparis</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Riparis
<i>rivulorum</i>	<i>Cellia</i>		Myzomyia	Funestus	Rivulorum
<i>rodhaini</i>	<i>Cellia</i>				
<i>rollai</i>	<i>Kerteszia</i>				
<i>rondoni</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Strodei
<i>roperi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	Letifer
<i>roubaudi</i>	<i>Cellia</i>		Neomyzomyia	Ranci	Roubaudi
<i>ruarinus</i>	<i>Cellia</i>		Neomyzomyia	Rhodesiensis	
<i>rufipes</i>	<i>Cellia</i>		Neocellia		
<i>sacharovi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Maculipennis
<i>salbaii</i>	<i>Cellia</i>		Neocellia		
<i>samarensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	
<i>sanctiellii</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>saperoi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Albotaeniatus	
<i>saungi</i>	<i>Cellia</i>		Neomyzomyia		
<i>sawadwongporni</i>	<i>Cellia</i>		Neocellia	Maculatus	Sawadwongporni
<i>sawyeri</i>	<i>Nyssorhynchus</i>	Argyritarsis	Argyritarsis	Argyritarsis	
<i>scanloni</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>schueffneri</i>	<i>Cellia</i>		Neocellia	Annularis	
<i>schwetzi</i>	<i>Cellia</i>		Myzomyia		
<i>separatus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	Separatus
<i>seretsei</i>	<i>Cellia</i>		Paramyzomyia	Listeri	
<i>sergentii</i>	<i>Cellia</i>		Myzomyia	Demeilloni	
<i>seydéli</i>	<i>Cellia</i>		Myzomyia	Marshallii	
<i>shannoni</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		

Species	Subgenus	Section	Series	Group	Subgroup
<i>similissimus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	
<i>sinensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrceanus	
<i>sineroides</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrceanus	
<i>sintoni</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Culiciformis	
<i>sintonoides</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Culiciformis	
<i>smaragdinus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	Quadrifasciatus
<i>smithii</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>solomonis</i>	<i>Cellia</i>		Neomyzomyia		
<i>somalicus</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>splendidus</i>	<i>Cellia</i>		Neocellia	Jamesii	
<i>squamifemur</i>	<i>Lophopodomyia</i>				
<i>squamosus</i>	<i>Cellia</i>		Cellia	Squamosus	
<i>stephensi</i>	<i>Cellia</i>		Neocellia		
<i>stigmaticus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Stigmaticus	
<i>stookesi</i>	<i>Cellia</i>		Neomyzomyia		
<i>stricklandi</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>strodei</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Strodei
<i>subpictus</i>	<i>Cellia</i>		Pyretophorus	Subpictus	
<i>sulawesi</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Hackeri
<i>sundaicus</i>	<i>Cellia</i>		Pyretophorus	Ludlowae	
<i>superpictus</i>	<i>Cellia</i>		Neocellia		
<i>swahilicus</i>	<i>Cellia</i>		Cellia		
<i>symesi</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>takasagoensis</i>	<i>Cellia</i>		Neomyzomyia	Leucosphyrus	Leucosphyrus
<i>tasmaniensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Atratipes	
<i>tchedidii</i>	<i>Cellia</i>		Myzomyia		
<i>tenebrosus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	
<i>tessellatus</i>	<i>Cellia</i>		Neomyzomyia	Tessellatus	
<i>theileri</i>	<i>Cellia</i>		Myzomyia	Wellcomei	
<i>theobaldi</i>	<i>Cellia</i>		Neocellia		
<i>thomasi</i>	<i>Stethomyia</i>				

Species	Subgenus	Section	Series	Group	Subgroup
<i>tibiamaculatus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Pseudopunctipennis	
<i>tigertti</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Aitkenii	
<i>torresiensis</i>	<i>Cellia</i>		Neomyzomyia	Punctulatus	
<i>triannulatus</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Triannulatus	
<i>trinkae</i>	<i>Nyssorhynchus</i>	Albimanus	Oswaldoi	Oswaldoi	Oswaldoi
<i>turkhudi</i>	<i>Cellia</i>		Paramyzomyia	Cinereus	
<i>umbrosus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	Umbrosus
<i>vagus</i>	<i>Cellia</i>		Pyretophorus	Subpictus	
<i>vaneedeni</i>	<i>Cellia</i>		Myzomyia	Funestus	Funestus
<i>vanhoofi</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>vanus</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Barbirostris	Vanus
<i>vargasi</i>	<i>Lophopodomyia</i>				
<i>varuna</i>	<i>Cellia</i>		Myzomyia	Funestus	Aconitus
<i>vernus</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>veruslanei</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>vestitipennis</i>	<i>Anopheles</i>	Laticorn	Arribalzagia		
<i>vietnamensis</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	Lesteri
<i>vinckei</i>	<i>Cellia</i>		Neomyzomyia	Ardensis	
<i>walkeri</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Maculipennis	
<i>walravensi</i>	<i>Cellia</i>		Myzomyia		
<i>watsonii</i>	<i>Cellia</i>		Neomyzomyia		
<i>wellcomei</i>	<i>Cellia</i>		Myzomyia	Wellcomei	
<i>wellingtonianus</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Lindesayi	
<i>whartoni</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Umbrosus	Letifer
<i>willmori</i>	<i>Cellia</i>		Neocellia	Maculatus	
<i>wilsoni</i>	<i>Cellia</i>		Neomyzomyia	Smithii	
<i>xelajuensis</i>	<i>Anopheles</i>	Angusticorn	Anopheles	Plumbeus	
<i>xui</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Hyrcanus	
<i>yaeyamaensis</i>	<i>Cellia</i>		Myzomyia	Funestus	Minimus
<i>ziemanni</i>	<i>Anopheles</i>	Laticorn	Myzorhynchus	Coustani	

Appendix 3

Sibling species complexes of *Anopheles* – formally named and unnamed species. The Maculatus, Maculipennis and Punctulatus Complexes are now considered to be super-complexes referred to as “Groups” with subordinate complexes. Likewise, the Culicifacies Complex is considered to be a Subgroup.

Subgenus <i>Anopheles</i>	Subgenus <i>Cellia</i>	<i>latens</i>	<i>farauti</i> 5
Barbirostris Complex [76]	Annularis Complex [86]	<i>leucosphyrus</i>	<i>farauti</i> 6
<i>barbirostris</i>	<i>annularis</i> A	Longirostris	<i>farauti</i> 8
Claviger Complex [67]	<i>annularis</i> B	Complex [90]	<i>hinesorum</i>
<i>claviger</i>	<i>pallidus</i>	Genotype A	<i>irenicus</i>
<i>petragnani</i>	<i>philippinensis</i>	Genotype B	<i>torresiensis</i>
Crucians Complex [72]	<i>schueffneri</i>	Genotype C1	Subpictus Complex [95]
<i>bradleyi</i>	Annulipes Complex [89]	Genotype C2	<i>subpictus</i> A
<i>crucians</i> A	<i>annulipes</i> A	Genotype D	<i>subpictus</i> B
<i>crucians</i> B	<i>annulipes</i> B	Genotype E	<i>subpictus</i> C
<i>crucians</i> C	<i>annulipes</i> C	Genotype F	<i>subpictus</i> D
<i>crucians</i> D	<i>annulipes</i> D	Genotype G	Sundaicus Complex [97]
<i>crucians</i> E	<i>annulipes</i> F	Genotype H	<i>epiroticus</i>
<i>georgianus</i>	<i>annulipes</i> G	Lungae Complex [47]	<i>sundaicus</i>
Gigas Complex [70]	<i>annulipes</i> H	<i>lungae</i>	<i>sundaicus</i> B
<i>baileyi</i>	<i>annulipes</i> I	<i>nataliae</i>	<i>sundaicus</i> C
<i>gigas</i>	<i>annulipes</i> J	<i>solomonis</i>	<i>sundaicus</i> D
<i>gigas s.l.</i>	<i>annulipes</i> K	Maculatus Group [88]	<i>sundaicus</i> E
Lindesayi Complex [70]	<i>annulipes</i> L	<i>dispar</i>	Superpictus
<i>lindesayi</i>	<i>annulipes</i> M	<i>greeni</i>	Complex [110]
<i>mengalagensis</i>	<i>annulipes</i> N	<i>pseudowillmori</i>	<i>superpictus</i> A
<i>nilgiricus</i>	<i>annulipes</i> O	<i>willmori</i>	<i>superpictus</i> B
<i>wellingtonianus</i>	<i>annulipes</i> P	Maculatus Subgroup	
Maculipennis Group	<i>annulipes</i> Q	[73]	Subgenus <i>Kerteszia</i>
[20]	Culicifacies	<i>dravidicus</i>	Cruzii Complex [101]
<i>atropos</i>	Subgroup [108]	<i>maculatus</i>	<i>cruzii</i> A
<i>aztecus</i>	<i>culicifacies</i> A	Sawadwongporni	<i>cruzii</i> B
<i>lewisi</i>	<i>culicifacies</i> B	Subgroup [73]	<i>cruzii</i> C
<i>walkeri</i>	<i>culicifacies</i> C	<i>notanandai</i>	
Maculipennis	<i>culicifacies</i> D	<i>rampae</i>	
Subgroup [71]	<i>culicifacies</i> E	sawadwongporni	Subgenus
<i>artemievi</i>	Dirus Complex [93]	Marshallii Complex [85]	<i>Nyssorhynchus</i>
<i>atroparvus</i>	aff. <i>takasagoensis</i>	<i>hughi</i>	Albitarsis Complex [106]
<i>daciae</i>	<i>baimaii</i>	<i>kosiensis</i>	<i>albitarsis</i>
<i>labranchiae</i>	<i>cracens</i>	<i>letabensis</i>	<i>albitarsis</i> F
<i>maculipennis</i>	<i>dirus</i>	<i>marshallii</i>	<i>albitarsis</i> G
<i>martinius</i>	<i>elegans</i>	Minimus Complex [84]	<i>albitarsis</i> H
<i>melanoon</i>	<i>nemophilous</i>	<i>harrisoni</i>	<i>albitarsis</i> I
<i>messeae</i>	<i>scanloni</i>	<i>minimus</i>	<i>albitarsis</i> 1
<i>persiensis</i>	<i>takasagoensis</i>	<i>yaeyamaensis</i>	<i>deaneorum</i>
<i>sacharovi</i>	Fluviatilis Complex [83]	Nivipes Complex	<i>janconnae</i>
Quadrinaculatus	<i>fluviatilis</i> S	[70,87]	lineage nr
Subgroup [21]	<i>fluviatilis</i> T	<i>nivipes</i> cytotpe 1	<i>janconnae</i>
<i>beklemishevi</i>	<i>fluviatilis</i> U	<i>nivipes</i> cytotpe 2	<i>marajoara</i>
<i>diluvialis</i>	Gambiae Complex [96]	Nili Complex [22]	<i>oryzalimetes</i>
<i>inundatus</i>	<i>arabiensis</i>	<i>carnevalei</i>	Benarrochi
<i>maverlius</i>	<i>bwambae</i>	<i>nili</i>	Complex [105]
<i>quadrinaculatus</i>	<i>comorensis</i>	<i>ovengensis</i>	<i>benarrochi</i>
<i>smaragdinus</i>	<i>gambiae</i>	<i>somalicus</i>	<i>benarrochi</i> B
Freeborni	<i>melas</i>	Punctulatus Group [94]	Nuneztovari
Subgroup [71]	<i>merus</i>	<i>clowi</i>	Complex [104,111]
<i>earlei</i>	<i>quadrinaculatus</i>	<i>koliensis</i>	<i>goeldii</i>
<i>freeborni</i>	<i>quadrinaculatus</i> B	<i>punctulatus</i>	<i>nuneztovari</i> B/C
<i>hermsi</i>	Leucosphyrus	<i>rennellensis</i>	<i>nuneztovari</i> A
<i>occidentalis</i>	Complex [91]	sp. nr <i>punctulatus</i>	Triannulatus
	<i>baisasi</i>	Farauti Complex	Complex [112,113]
	<i>balabacensis</i>	[94,109]	<i>halophylus</i>
	<i>introlatus</i>	<i>farauti</i>	<i>triannulatus</i>
		<i>farauti</i> 4	<i>triannulatus</i> C

Appendix 4

Unnamed and provisionally designated members of species complexes and their position in the classification of genus *Anopheles* (Sections of subgenera *Anopheles* and *Nyssorhynchus* are omitted). Excluding nominotypical members, the list includes 72 species that require formal Latin names.

Species	Authors	Subgenus	Series	Group	Subgroup	Complex
<i>albitarsis</i> sp. F,G,H,I	[114,115]	<i>Nyssorhynchus</i>	Albitarsis	Albitarsis		Albitarsis
<i>annularis</i> sp. A,B	[86]	<i>Cellia</i>	Neocellia	Annularis		Annularis
<i>annulipes</i> sp. A–Q	[89]	<i>Cellia</i>	Neomyzomyia			Annulipes
<i>Anopheles</i> CP Form	[116]	<i>Nyssorhynchus</i>	Oswaldoi	Oswaldoi	Strodei	
<i>barbirostris</i> clades I–IV	[117]	<i>Anopheles</i>	Barbirostris	Barbirostris	Barbirostris	Barbirostris
<i>benarrochi</i> sp. B	[105]	<i>Nyssorhynchus</i>	Oswaldoi	Oswaldoi	Strodei	Benarrochi
<i>crucians</i> sp. A–E	[72]	<i>Anopheles</i>	Anopheles	Punctipennis		Crucians
<i>cruzii</i> sp. A,B,C	[118]	<i>Kerteszia</i>				
<i>culicifacies</i> sp. A–E	[108]	<i>Cellia</i>	Myzomyia	Funestus	Culicifacies	Culicifacies
<i>farauti</i> sp. 4,5,6	[109,119]	<i>Cellia</i>	Neomyzomyia	Punctulatus		Farauti
<i>fluviatilis</i> sp. S,T,U	[83]	<i>Cellia</i>	Myzomyia	Funestus	Minimus	Fluviatilis
<i>funestus</i> -like sp.	[120]	<i>Cellia</i>	Myzomyia	Funestus	Funestus	
<i>gigas</i> s.l. (Thailand)	[70]	<i>Anopheles</i>	Anopheles	Lindesayi		Gigas
<i>hyrcanus</i> sp. _{IR}	[121]	<i>Anopheles</i>		Hyrcanus		
<i>janconnae</i> , lineage nr	[122]	<i>Nyssorhynchus</i>	Albitarsis	Albitarsis		Albitarsis
<i>longipalpis</i> Type A	[123]	<i>Cellia</i>	Myzomyia	Funestus	Minimus	
<i>longipalpis</i> Type C	[123]	<i>Cellia</i>	Myzomyia	Funestus	Funestus	
<i>longirostris</i> Genotypes A,B,C1,C2,D,E,F,G,H	[90]	<i>Cellia</i>	Neomyzomyia			Longirostris
<i>marajoara</i> lineages 1,2	[124]	<i>Nyssorhynchus</i>	Albitarsis	Albitarsis		Albitarsis
<i>nivipes</i> (2 cytotypes)	[87]	<i>Cellia</i>	Neocellia	Annularis		Nivipes
<i>nuneztovari</i> sp. A	[125]	<i>Nyssorhynchus</i>	Oswaldoi	Oswaldoi	Oswaldoi	Nuneztovari
<i>nuneztovari</i> B/C	[104]	<i>Nyssorhynchus</i>	Oswaldoi	Oswaldoi	Oswaldoi	Nuneztovari
<i>punctulatus</i> , sp. nr	[126]	<i>Cellia</i>	Neomyzomyia	Punctulatus		

Species	Authors	Subgenus	Series	Group	Subgroup	Complex
<i>quadriannulatus</i> sp. B	[127]	<i>Cellia</i>	Pyretophorus			Gambiae
<i>subpictus</i> sp. A-D	[99]	<i>Cellia</i>	Pyretophorus	Subpictus		Subpictus
<i>sundaicus</i> sp. B-E	[98,128]	<i>Cellia</i>	Pyretophorus	Ludlowae		Sundaicus
<i>superpictus</i> sp. A,B	[110,129]	<i>Cellia</i>	Neocellia			Superpictus
<i>takasagoensis</i> , aff.	[130]	<i>Cellia</i>	Neomyzomyia	Leucosphyrus	Leucosphyrus	Dirus
<i>triannulatus</i> sp. C	[113]	<i>Nyssorhynchus</i>	Oswaldoi	Triannulatus		Triannulatus

Appendix 5

Phylogenetic studies of *Anopheles* mosquitoes. Groups included in the table are those recognized herein. None of the studies included all taxa that comprise the group investigated, but those marked with an asterisk (*) included the majority of species. Nucleotide sequences include *COI*, *COII*, *cyt b*, *ND4*, *ND5* and *ND6* from mitochondrial DNA (mtDNA); *D2*, *D3*, *18S*, *ITS1* and *ITS2* from ribosomal DNA (rDNA); *EF-1 α* , *G₆pd* and *white* from nuclear DNA.

Group	Data set	Authors
Genus <i>Anopheles</i>	Morphology	[40]
		[36]
	<i>cyt b</i> , <i>ND5</i> , <i>D2</i>	[38]
	<i>ND5</i> , <i>D2</i> , <i>G₆pd</i> , <i>white</i>	[39]
	<i>COI</i> , <i>COII</i> , <i>D2</i>	[41]
	<i>18S</i>	[131]
Subgenus <i>Anopheles</i>	Morphology	[42]
	<i>COII</i>	[37]
Anopheles Series		
Maculipennis Group	Chromosomes	[132]
	<i>ITS2</i>	[71]* [133,134]
Maculipennis Subgroup	<i>ITS2</i>	[135]
Freeborni and Quadri-maculatus Subgroups	<i>D2</i>	[136]
Myzorhynchus Series	<i>ITS2</i> , <i>COI</i> , <i>COII</i>	[137,139]
Barbirostris Complex	<i>ITS2</i> , <i>COI</i>	[117]
Hyrceanus Grou	<i>ITS2</i>	[139,140] [141]*

Group	Data set	Authors
	<i>ITS2, COI</i>	[142]
Subgenus <i>Cellia</i>	Chromosomes	[143,144]
	<i>COII</i>	[37]
Myzomyia Series	Chromosomes	[143,144]
	<i>COII, D3</i>	[82]
Funestus Group	<i>ITS2, COII, D3</i>	[55]*
	<i>COII, D3</i>	[81]*
Minimus Subgroup	<i>COII, D3</i>	[145]
Minimus Complex	<i>D3, ITS2</i>	[146]*
Neocellia Series	Chromosomes	[87]
Annularis Group	<i>ITS2, COII, D3, ND5</i>	[147]
	<i>D3, ITS2</i>	[148]
Maculatus Group	<i>ITS2, COII, D3</i>	[149–151]
Neomyzomyia Series	<i>ITS2, COI, COII, EF-1a</i>	[89]
Annulipes Complex	<i>COI, ND6</i>	[152]
Leucosphyrus Group		
Punctulatus Group	<i>ITS2</i>	[153]
	<i>18S</i>	[154]
Farauti Complex	<i>ITS1</i>	[109]
Pyretophorus Series	Morphology	[56]*
	Chromosomes	[144]
	<i>COII</i>	[37]
Gambiae Complex	Chromosomes	[155]
	rDNA, mtDNA	[156]
Sundaicus Complex	mtDNA	[157]
	<i>ITS2, D2, COI, ND4</i>	[158]
	<i>white</i>	[114]
	<i>cyt b, ITS2, COI</i>	[128]
Subgenus <i>Kerteszia</i>	Morphology	[44]
Subgenus <i>Nyssorhynchus</i>	<i>ITS2</i>	[159]
Albimanus Section	Morphology	[24]
Argyritarsis Section	Morphology	[25]
Myzorhynchella Section	<i>ITS2, COI, white</i>	[160]

Appendix 6

Summary of the formal and informal group taxa (species complexes omitted) of genus *Anopheles*. The zoogeographic distribution and the number of formally named and informally designated species (in parentheses) are given for each taxon. Minor extensions of one or more species of a group into an adjacent zoogeographic region are disregarded. C = cosmopolitan; NW = New World; OW = Old World; Af = Afrotropical; Au = Australasian; Ne = Nearctic; Nt = Neotropical; Or = Oriental; Pa = Palearctic.

- Subgenus *Anopheles***– C (191)
 Angusticorn Section – OW, NW (95)
 Anopheles Series – OW and NW (88)
 Alongensis Group – Or (2)
 Aitkenii Group – Or (13)
 Atratipes Group – Au (2)
 Culcififormis Group – Or (3)
 Lindesayi Group – Or (7)
 Maculipennis Group – Ne, Pa (20)
 Maculipennis Subgroup – Pa (10)
 Quadrifaculatus Subgroup – Ne (5), Pa (1)
 Freeborni Subgroup – Ne (4)
 Plumbeus Group – Ne (2), Nt (4), Pac (3)
 Pseudopunctipennis Group – Ne (7)
 Punctipennis Group – Ne (9)
 Stigmaticus Group – Au (6)
 Cyclolepton Series – Ne (2)
 Lophoscelomyia Series – Or (4)
 Unassigned – (1)
 Asiaticus Group – (4)
 Unassigned – (2)
 Asiaticus Subgroup – (1)
 Interruptus Subgroup – (1)
 Laticorn Section – Af, Au, Nt, Or, Pa (96)
 Arribalzagia Series – Ne (24)
 Christya Series – Af (2)
 Myzorhynchus Series – Af, Au, Or, Pa (70)
 Albotaeniatus Group – Or (4), Pa (1)
 Bancroftii Group – Au/Or (2)
 Barbirostris Group – Or (16)
 Unassigned – (2)
 Barbirostris Subgroup – (9)
 Vanus Subgroup – (5)
 Coustani Group – Af (9)
 Hyrcanus Group – Pa (26)
 Unassigned – (17)
 Lesteri Subgroup – (5)
 Nigerrimus Subgroup – (4)
 Umbrosus Group – Or (12)
 Unassigned – (5)
 Baezai Subgroup – (1)
 Letifer Subgroup – (4)
 Separatus Subgroup – (1)
 Umbrosus Subgroup – (1)
- Subgenus *Baimaia***– Or (1)
- Subgenus *Cellia***– OW (233)
 Cella Series – Af (8)
 Unassigned – (6)
 Squamosus Group – (2)
 Myzomyia Series – Af, Or (71)
 Unassigned – Af (16)
 Demeilloni Group – Af (7)
 Funestus Group – Af, Or (29)
 Unassigned – (1)
 Aconitus Subgroup – Or (5)
 Culcifacies Subgroup – Or (5)
 Funestus Subgroup – Af (7)
 Minimus Subgroup – Af (1), Or (6)
 Rivulorum Subgroup – Af (4)
 Marshallii Group – Af (15)
 Wellcomei Group – Af (4)
 Neocellia Series – Af, Or, Pa (24)
 Unassigned – Af, Or, Pa (14)
 Annularis Group – Or (7)
 Jamesii Group – Or (3)
 Maculatus Group – Or (9)
 Unassigned – (4)
 Maculatus Subgroup – (2)
 Sawadwongporni Subgroup – (3)
 Neomyzomyia Series – Af, Au, Or (121)
 Unassigned – Af, Au, Or (42)
 Ardensis Group – Af (18)
 Kochi Group – Or (1)
 Leucosphyrus Group – O (21)
 Hackeri Subgroup – (5)
 Leucosphyrus Subgroup – (13)
 Riparis Subgroup – (3)
 Mascarensis Group – Af (1)
 Pauliani Group – Af (5)
 Punctulatus Group – Au (13)
 Ranci Group – Af (5)
 Unassigned – (1)
 Ranci Subgroup – (1)
 Roubaudi Subgroup – (3)
 Rhodesiensis Group – Af (5)
 Smithii Group – Af (9)
 Tessellatus Group – Or (1)
 Paramyzomyia Series – Af, Pa (6)
 Cinereus Group – Af (2), Pa (1)
 Listeri Group – Af (2), Pa (1)
 Pyretophorus Series – Af (10), Or (12)
- Subgenus *Kerteszia***– Nt (14)
- Subgenus *Lophopodomya***– Nt (6)
- Subgenus *Nyssorhynchus***– Nt (38)
 Albimanus Section – (24)
 Albimanus Series – (1)
 Oswaldoi Series – (23)
 Oswaldoi Group – (21)
 Oswaldoi Subgroup – (14)
 Strodei Subgroup – (7)
 Triannulatus Group – (3)
 Argyratarsis Section – (14)
 Albitarsis Series – (8)
 Albitarsis Group – (7)
 Braziiliensis Group – (1)
 Argyratarsis Series – (6)
 Argyratarsis Group – (2)
 Darlingi Group – (1)
 Lanei Group – (1)
 Pictipennis Group – (2)
 Myzorhynchella Section – (6)
- Subgenus *Stethomyia***– Ne (5)

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Three new species of *Anopheles* were formally described and named while the book was in press: *An. (Anopheles) vanderwulpi* (= *An. barbirostris* clade II) [161]; *An. (Cellia) amharicus* (= *An. quadriannulatus* sp. B) and *An. (Cellia) coluzzii* (= molecular M form of *An. gambiae*) [162]. *Anopheles (Anopheles) kunmingensis* (Laticorn Section, Myzorhynchus Series, Hyrcanus Group) was inadvertently omitted from Appendix 2 during preparation of the chapter. Thus, the genus now includes 469 formally named species and 70 species that require formal Latin names.

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