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A revised, annotated checklist of the mosquitoes (Diptera, Culicidae) of Turkey

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Abstract

An updated checklist of the mosquitoes of Turkey is presented together with notes and annotations.

Introduction

The first list of the mosquitoes of Turkey is to be found in Martini's (1929-31) *Die Fliegen der palaearktischen Region.* A succession of workers, notably Akalin (1936), Irdem (1940; 1941; 1943), Süyev (1953), Parrish (1959), Gökberk (1961; 1970), Erel (1967), Postiglione *et al.* (1970; 1972; 1973), Coluzzi *et al.* (1974), Lane (1982; 1985; 1992) and Alten *et al.* (2000), have since added to or amended this list as new data became available.

Recent major taxonomic revision affecting genera, subgenera and species of the tribe Aedini (Reinert, 1999a, 1999b, 1999c, 2000a, 2000b, 2000c, 2000d) places western Palaearctic members of this tribe in the genus *Aedes* (containing the subgenera *Aedes, Aedimorphus, Fredwardsius* and *Stegomyia*) or the genus *Ochlerotatus* (containing the subgenera *Finlaya, Ochlerotatus* and *Rusticoidus*). Thus, the 50 currently recognised endemic species of mosquito in Turkey are now placed in the genera *Anopheles* (10), *Aedes* (3), *Ochlerotatus* (15), *Culex* (13), *Culiseta* (6), *Coquillettidia* (1), *Orthopodomyia* (1) and *Uranotaenia* (1).

The revised list presented here will undoubtedly lengthen as morphological studies are reinforced by cyto-genetic, iso-enzyme and/or DNA sequencing analysis, and as more field data become available.

CHECKLIST

SUBFAMILY ANOPHELINAE

Genus *Anopheles* Meigen, 1818

subgenus *Anopheles* Meigen, 1818

algeriensis Theobald, 1903	
claviger (Meigen, 1804)	(Note 1)
hyrcanus s.l. (Pallas, 1771)	(Note 2)
maculipennis Meigen, 1818	(Note 3)
marteri Senevet & Prunelle, 1927	(Note 4)
plumbeus Stephens, 1828	
sacharovi Favre, 1903	(Note 3)
subalpinus Hackett & Lewis, 1935	(Note 3)

subgenus *Cellia* Theobald, 1902

pulcherrimus Theobald, 1902	(Note 5)
superpictus Grassi, 1899	

doubtful and unconfirmed records

subgenus *Anopheles* Meigen, 1818

melanoon Hackett, 1934	(Note 3)

subgenus *Cellia* Theobald, 1902

multicolor Cambouliu, 1902	(Note 6)
sergentii (Theobald, 1907)	(Note 6)

recorded from Northern Iraq, but not Turkey (Note 7)

subgenus *Cellia* Theobald, 1902

An. stephensi Liston, 1901

SUBFAMILY CULICINAE

Tribe Aedini

Genus *Aedes* Meigen, 1818

subgenus *Aedes* Meigen, 1818

cinereus Meigen, 1818

subgenus *Aedimorphus* Theobald, 1903

vexans (Meigen, 1830)

subgenus *Stegomyia* Theobald, 1901

cretinus Edwards, 1921 (Note 8)

extinct

subgenus *Stegomyia* Theobald, 1901

aegypti (Linnaeus, 1762) (Note 9)

Genus *Ochlerotatus* Lynch Arribálzaga, 1891

subgenus *Finlaya* Theobald, 1903

echinus (Edwards, 1920)

geniculatus (Olivier, 1791)

subgenus *Ochlerotatus* Lynch Arribálzaga, 1891

caspius s.l. (Pallas, 1771) (Note 10)

communis (De Geer, 1776)

detritus s.l. (Haliday, 1833) (Note 11)

dorsalis (Meigen, 1830)

excrucians (Walker, 1856)

flavescens (Müller, 1764)

nigrocanus (Martini, 1927) (Notes 12, 13)

phoniciae (Coluzzi & Sabatini, 1968)

pulchritarsis (Rondani, 1872) (Note 12)

zammitii (Theobald, 1903)

subgenus *Rusticoidus* Shevchenko & Prudkina, 1973

lepidonotus (Edwards, 1920)

refiki (Medschid, 1928)

rusticus (Rossi, 1790) (Note 14)

Tribe Culicini

Genus *Culex* Linnaeus, 1758

subgenus *Barraudius* Edwards, 1921

modestus Ficalbi, 1890

pusillus Macquart, 1850

subgenus *Culex* Linnaeus, 1758

laticinctus Edwards, 1913

mimeticus Noé, 1899

perexiguus Theobald, 1903 (Note 15)

pipiens Linnaeus, 1758 (Note 16)

theileri Theobald, 1903 (Note 17)

torrentium Martini, 1925

tritaeniorhynchus Giles, 1901

subgenus *Maillotia* Theobald, 1907

deserticola Kirkpatrick, 1925

hortensis Ficalbi, 1889

subgenus *Neoculex* Dyar, 1905

martinii Medschid, 1930

territans Walker, 1856 (Note 18)

Erroneous record

subgenus *Lasiosiphon* Kirkpatrick, 1924

adairi Kirkpatrick, 1926 (Note 19)

Tribe Culisetini

Genus *Culiseta* Felt, 1904

subgenus *Allotheobaldia* Brölemann, 1919

longiareolata (Macquart, 1838)

subgenus *Culicella* Felt, 1904

fumipennis (Stephens, 1825)

morsitans (Theobald, 1901)

subgenus *Culiseta* Felt, 1904

annulata (Schrank, 1776) (Note 20)

Tribe Mansoniini

Genus *Coquillettidia* Dyar, 1905

subgenus *Coquillettidia* Dyar, 1905

richiardii (Ficalbi, 1889) (Note 21)

Tribe Orthopodomyiini

Genus *Orthopodomyia* Theobald, 1904

pulcripalpis (Rondani, 1872)

Tribe Uranotaeniini

Genus *Uranotaenia* Lynch Arribálzaga, 1891

subgenus *Pseudoficalbia* Theobald, 1912

unguiculata Edwards, 1913

NOTES ON CHECKLIST

1. First recorded as *An. bifurcatus* or *An. amaurus*, *An. claviger* is widely distributed in Turkey. Examination of larvae from several localities in the Marmara, Aegean, Mediterranean and south-eastern Anatolia regions (i.e. in the hottest parts of the country), and of museum specimens in the collections of the Malaria Institute in Adana, failed to detect *An. petragnani*, the western Mediterranean member of the Claviger Complex (Postiglione *et al.*, 1972).

2. The Hyrcanus Group comprises a large number of species with a combined distribution covering the Oriental and Palaearctic Regions. It includes several malaria vectors, including some in the western Palaearctic. Though well studied in the Oriental Region and in the Far Eastern Palaearctic (e.g. Reid, 1968; Harrison, 1972, 1973; Harrison *et al.*, 1973, 1990; Xu & Feng, 1975; Takai & Kanda, 1986; Chow, 1991; Baimai *et al.*, 1993), the few investigations made in the western Palaearctic have been fragmentary and inconclusive.

Several western Palaearctic forms differing in certain aspects of adult morphology and behaviour (Livadas & Sphangos, 1941; Ward, 1972; Postiglione *et al.*, 1973; Critescu *et al.*, 1975; Gutsevich, 1976; Ramsdale & Haas, 1978; Ramsdale & Snow, 2000) include the named forms *flerowi, mahmouti, marzinovski, mesopotamiae, pictus* and *popovi* currently treated as synonyms (Knight & Stone, 1977). Another, *pseudopictus* Grassi, 1899 reported from widely separated localities in the Mediterranean Basin and formerly treated as a synonym of *hyrcanus*, was elevated to species status (Glick, 1992). Because of the dearth of information, Reid (personal communication, 1968) suggested the embracing term *'An hyrcanus'* be used for all western Palaearctic forms pending the accumulation of data permitting adoption of meaningful specific and/or subspecific names for each taxon.

Laboratory crosses showed that some western Palaearctic forms are reproductively isolated, but that two populations respectively from southern France and southern Anatolia are conspecific (Ross Institute, 1976; 1977). At least two Anatolian populations and two Afghanistan populations are morphologically separable (Postiglione *et al.*, 1973; Ross Institute, 1976; 1977). Furthermore, in these and other countries the taxon is a confirmed or suspected vector of malaria (Zahar, 1974, 1990a, 1990b; Onori *et al.*, 1975; Anufrieva *et al.*, 1977; Ramsdale & Haas, 1978).

In the absence of knowledge of the true status of the different Western Palaearctic forms, behavioural, phenological, ecological and vectorial data continue to be applied to an agglomeration of species, Reid's *'An. hyrcanus'*. In view of the large numbers of people vulnerable to attack from *An. hyrcanus* when sleeping outdoors during the hot months, and the current expansion of irrigation for intensive crop production taking place in south-eastern Anatolia, accumulation of knowledge on the vectorial status of each of the *hyrcanus* species present and of means of distinguishing each is of particular concern to the eastern Mediterranean area.

Old records from Turkey are of the *mahmuti* (Martini, 1929-31), *sinensis* (Parrish, 1959), and *hyrcanus* type forms (Akalin, 1936; Süyev, 1953; Parrish, 1959).

3. As currently understood the Maculipennis Complex includes nine Palaearctic species, *atroparvus, beklemishevi, labranchiae, martinius, melanoon, messeae, maculipennis, sacharovi* and *subalpinus* (White, 1978; as modified by Cianchi *et al.*, 1981; Zulueta *et al.*, 1983), the last three of which occur in Turkey.

A consequence of former conflicting taxonomic opinion is that distributional records of individual species from many parts of Eurasia contain anomalous records from outside the normal distributions of the various members of the Complex (Ramsdale & Snow, 2000). With regard to Turkey, early records of *messeae* were misidentifications of *subalpinus* (Postiglione *et al.*, 1972, 1973); some records of *melanoon*, formerly regarded as conspecific with *subalpinus*, may have been cryptic examples of the latter (females of *subalpinus* may occasionally lay a batch of dark eggs). In all cases where eggs attributed to *melanoon* were re-examined, identification proved to have been made on wetted eggs, which obscured the deck patterns. These patterns were found to re-appear as the liquid coating evaporated (C.D. Ramsdale, personal observation).

4. Two morphological variants of this taxon were described as different species, *Anopheles marteri* from Algeria, and *An. sogdianus* Keshishian from Tadzikhstan. A third form from Spain, *An. marteri* var. *conquensis* Torres Cañamares was assigned to synonymy with the type form by Shahgudian (1956), who additionally reduced *sogdianus* to subspecies ranking. Reappraisal of the taxon led to *sogdianus* being assigned to synonymy (Ribeiro *et al.*, 1985). In the absence of chromosomal or isoenzyme analysis, this may be the most appropriate interim conclusion. At the same time, as noted by Shahgudian (1956) and Ribeiro *et al.* (1985), existing data suggest that the two forms may be allopatric, with the *sogdianus* form having a more northerly distribution. All specimens examined in Turkey were morphologically similar to Shahgudian's description of *sogdianus* (Postiglione *et al.*, 1973).

5. *Anopheles pulcherrimus* is a marsh breeding species with a distribution centred on the lowlands north and south of the Hindu Kush (Boyd, 1949). It is intermittently recorded from the vicinity of the Halbur Çay, a tributary of the Dicle (Tigris), where these rivers form the borders between the Silopi sector of Turkey, northern Iraq and north-east Syria. This area and the south flowing Khabur River of eastern Syria (which flows south from the Midyat Sector of Turkey to join the Euphrates), represent the current northeastern limits of the distribution of *An. pulcherrimus* (Christophers, 1920; Leeson, 1950; Abdel-Malek, 1958). The adults are capable of extremely long flights and, at the northern end of the Persian Gulf, have been found on board a ship anchored more than 15 km from the nearest land (Wright, 1918). Until now it is only reported from the Turkish – Iraqi frontier during years when autumn rains are sufficiently heavy to create long lasting marshes suitable for autumn oviposition and larval over-wintering. The growing use of flood irrigation in both Syria and Turkey, and consequent proliferation of potential over-wintering sites, extends the areas receptive to this species, particularly in south-east Anatolia. *Anopheles pulcherrimus* is a confirmed vector of malaria in parts of Afghanistan, Turkestan and Iraq (Badawy, 1970; Onori *et al.*, 1975; Anufrieva *et al.*, 1977; Sergiev *et al.*, 1993).

6. *Anopheles multicolor* and *An. sergentii* were each recorded once only during surveys in the Çükürova (Irdem, 1940, 1941). Their inclusion in Süyev's and Parrish's lists do not represent separate records and the presence of neither species has been confirmed in almost 60 years, even though this is the best studied part of the country. As stated by Postiglione *et al.* (1973) it must be concluded that neither species is part of the endemic fauna of Turkey.

Anopheles multicolor is a halophilic North African desertic species with a distribution extending eastwards through Arabia to western Pakistan. The only records from north of the Mediterranean are from the most arid part of Spain and date from the middle of the last century (Encinas Grandes, 1982). In the countries east of the Mediterranean, there are records from Israel, southern Lebanon, southern Syria, Jordan, southern Iraq and southern Iran (Zahar, 1974).

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The distribution of the desertic *An. sergentii* extends from Pakistan, through Arabia and North Africa to the Canary Islands. It is absent from mainland Europe (Ramsdale & Snow, 2000) but was recorded in the Mediterranean island of Pantellaria (d'Alesandro & Sacca, 1967); the most northerly records in the Eastern Mediterranean are from Israel, Jordan and Lebanon (Zahar, 1974).

7. Although not recorded from Turkey, *An stephensi*, an urban malaria vector with a distribution extending from India to Iraq and the Gulf States, should be mentioned here. This species extended its range during the past century, and probably also much earlier (Zulueta, 1987). During the early 1900s its distribution extended from the Indian subcontinent along the coastal belt of the Persian Gulf into the southern-most part of Iraq. In 1918 it was not found north of Al Amarah (31°55'N) (Christophers & Short, 1921). In the 1940s and 1950s it was found in several places in the alluvial plain around and north of Baghdad (at ca. 33° 30'N and at altitudes of up to 183m) (Macan, 1950; Pringle, 1954). Observations during the malaria eradication campaign showed that it was established in northern Iraq in the vicinity of Kirkük (35°30'N, altitude 400m) and at a similar latitude at Zannar on the Syrian border (Zahar, 1990). Political unrest has precluded entomological work in this area for a long time and there are no recent data. The arrival of *An. stephensi* in southern Turkey may not be imminent, but it is worthy of note that Kirkük is within 250 km of the town of Cizre in Turkey, and at the same altitude.

Most Oriental species capable of overwintering do so in the larval stage, which may be an important factor limiting their northern distribution. However, according to de Zulueta & Muir (1969), there is some indication that *An. stephensi* females may undergo gonotrophic dissociation in the northern extremities of the distribution. It might also be added that, due in great part to human activities, ecological change over the past century has been greater than during the several preceding millennia.

8. *Aedes cretinus* is recorded from Greece (Crete, Attica, Macedonia) (Edwards, 1921; Samanidou-Voyadjoglou & Darsie, 1993; Samanidou, 1998), Cyprus (Nicosia) (Lane, 1982), Turkey (Antalya, open and wooded coast) (Sahin, 1981; Lane, 1982, 1985; Alten *et al.*, 2000) and Georgia (Black Sea coast) (Gutsevich *et al.*, 1971). Its presence in southern Ukraine (Crimea) was thought probable by Gutsevich *et al.* (1971), but Gornostaeva (2000) considers its presence in European Russia to be doubtful. It was found to be plentiful in the vicinity of Athens (Samanidou, 1998) and Antalya (Alten *et al.*, 2000). Elsewhere, despite its rather wide distribution it seems to be a rarely encountered species, a factor probably accounting for the paucity of biological information. Larvae have been found in tree holes together with those of *An. plumbeus, Oc. geniculatus* and *Or. pulcripalpis.* (Gutsevich *et al.*, 1971).

9. There are no recent records of *Ae. aegypti* in Turkey. However, the possibility of its re-appearance should not be forgotten. Furthermore, establishment of *Ae. albopictus* (Skuse) in Italy, Albania and France has obvious implications for other Mediterranean countries, including Turkey. An efficient vector of many arboviruses, *Ae. albopictus* is already involved in disease transmission in North America (Mitchell, 1995; Mitchell *et al.*, 1998), and its arrival in the Mediterranean inevitably increases receptivity in this region. Though the harsh winters of the Turkish uplands may exclude it from much of the interior of the country, all the rich, populous lowlands are suitable for colonisation.

Aedes albopictus is not Europe's only recently imported species. *Ochlerotatus atropalpus* (Coquillett) arrived in Italy by the same route (Romi *et al.*, 1997) and it is possible that other species may take advantage of tyre-borne or other means of transport. Turkey is just as receptive to immigrant species as other countries engaged in international commerce.

10. The Caspius Complex in Europe contains two sibling species (Cianchi *et al.*, 1980), currently designated Species A and Species B, but their separate distributions have not yet been determined. Autogenous and anautogenous forms separable by esterase assay occur in Egypt (Gad *et al.*, 1992), but it is not known if these are behavioural characteristics of different species.

11. The Detritus Complex (Pasteur *et al.*, 1977) comprises two sibling species, *Oc. detritus* (Haliday), type locality Holywood, County Down, Ireland, and *Oc. coluzzii* (Rioux *et al.*), type locality Salins-de-Giraud, Basse-Camargue, France, each with slightly different ecological requirements (Rioux *et al.*, 1998). There is no information on the species present in Turkey.

12. Discussing what was then regarded as the Caspius Group of species, Coluzzi & Sabatini (1968) remarked that the salt marsh Caspius/Dorsalis subgrouping possesses narrow postpronotal scales, whilst in the more specialized sea shore rock pool Mariae and tree hole Pulchritarsis subgroupings these are broad. However, they were of the opinion that scale formation may be a secondary manifestation of ecological adaptations because, overall, the Mariae and Caspius subgroupings exhibit greater morphological affinity. Later, Zavortink (1972) moved related New World tree hole species into a Pulchritarsis Section within the subgenus *Ochlerotatus* of the genus *Aedes*. Later, Danilov (1982) moved the Russian species of the Pulchritarsis Complex from *Ochlerotatus* to the subgenus *Finlaya*. Comprehensive morphological studies (Reinert, 1999a, 1999b, 1999c, 2000a, 2000b, 2000c, 2000d) have resulted in a major revision of the tribe Aedini in which a revised subgenus *Finlaya* is placed in the genus *Ochlerotatus*. Morphological characteristics of these subgenera indicate that both *pulchritarsis* and *nigrocanus* should be included in the subgenus *Ochlerotatus*.

13. *Oclerotatus nigrocanus* is known only from a holotype male collected in Turkey by Dr Vögel in 1926 and described by Martini (1927). Originally lodged in Hamburg, the holotype is currently in the Natural History Museum, London (Mattingly, 1954). Because identification was made on a single damaged specimen, Minar (1991) considered it a doubtful species, stating that it is probably a junior synonym of *pulchritarsis*, but did not list it as such. However, after re-examination and comparison with *Oc. pulchritarsis*, Lane (1992) stated that *nigrocanus* is patently a separate taxon and accordingly restored its species status.

There is a curious story regarding the data labels attached by Vögel to this unique specimen. One of these gave the site of collection as "zwischen Afyon und Eskischehir im Zug, 1926" (Lane, 1994). These are two western Anatolian stations roughly 110 linear, or 160 rail kms apart on the then important but meandering 1300 km long, Haydarpasha–Aleppo railway). In 1926, before the modernisation of communications, this was the most important of the few railway lines in Turkey. A branch straggling across the plateau from Eskishehir to the then still quite small town of Ankara, and a short spur from Alayunt to Kütahya, were the only connecting lines at that time and passengers coming from these places would have had to change trains (Lewis, 1965). The type locality given by Martini (1929-31) is "Anatolisch Bahn, Türkei". There is no indication of the direction of travel of the train on which this mosquito was a passenger. It may have boarded at any station between the Bosphorus and Syria, giving a type locality about 350-500 km long if travelling from Haydarpasha on the Bosphorus, or about 800-950 km long if coming from the direction of Aleppo.

14. Recorded as *diversus* by Süyev (1953) and Erel (1967), as *diversus* var. *subtrichurus* by Martini (1929-31) and Süyev (1953), as *rusticus* and as *rusticus* var. *subtrichurus* by Parrish (1959).

15. The most comprehensive information about the Culex Univittatus Complex in south-west Asia and southern Europe is that of Harbach (1988, 1999) who, on distributional evidence plus the examination of specimens from Turkey, Greece, and Italy, regards *Cx. perexiguus* as being the only member of this complex present in the Palaearctic Mediterranean Subregion.

16. A unique record of *Cx. quinquefasciatus* (Parrish, 1959) is included in the list of *Cx. pipiens* records. Turkey is outside the normal range of *Cx. quinquefasciatus* and this old record probably refers to *Cx. pipiens*. Urban *Cx. pipiens* (feeding on humans and breeding in hypogeal or other more or less enclosed situations) is the ubiquitous Turkish urban pest mosquito and was the most plausible vector in foci of Bancroftian filariasis transmission in various parts of the country.

17. *Culex tipuliformis* Theobald is a synonym of *Culex vagans* Wiedemann, an Oriental species with a distribution extending west to Pakistan and Iran. However, Kirkpatrick (1924-1925) in Egypt erroneously applied this name to *Culex theileri* Theobald, a mosquito with a wide Afrotropical, southern Palaearctic and northern Oriental distribution. In recording *Cx. tipuliformis*, Irdem (1939), Süyev (1953) and Erel (1967) were following Kirkpatrick in applying this name to *Cx. theileri*.

18. Records of the Nearctic *Culex apicalis* Adams in Europe (mostly pre-1950) refer to the Holarctic *Cx. territans* Walker (Mattingly, 1953). *Culex sergentii* Theobald was synonymised with *Cx. impudicus* Ficalbi by Mattingly (1955). The record of *Cx. sergentii* (*Cx. apicalis*) by Erel (1967) obviously refers to *Cx. territans*.

19. The subgenus *Lasiosiphon* contains a single species, *Cx. adairi* (synonym *pluvialis),* with a distribution extending from Egypt to Equatorial Africa. Sūyev (1953) included '*pluvialis* (?)' in his list of Turkish mosquitoes without any explanation. He was obviously doubtful about the record and did not give any background information. There has not been a confirmatory record in the 48 years since then. Turkey is well outside the normal distribution of this species, and the record may safely be regarded as erroneous.

20. *Culiseta subochrea* has been variously regarded as a variant or as a subspecies of *Cs. annulata,* or as a separate species (e.g. Wesenberg-Lund, 1920-21; Edwards, 1921; Stone *et al.*, 1959; Knight & Stone, 1977; Maslov, 1989). The taxon was last elevated to species status by Ribeiro *et al.* (1977), an action noted by Ward (1984) and which has general acceptance. The biology of the two species is similar and both may be found throughout Europe and south-west Asia. *Culiseta subochrea* is relatively rare in Britain, where *Cs. annulata* is a common mosquito (Cranston *et al.*, 1987), but is the more prevalent of the two in Iran (Zaim & Cranston, 1986). It would be surprising, therefore, if *Cs. subochrea* were not additionally present in Turkey, despite the absence of specific records.

21. Recorded as *Mansonia richiardii* var. *martinii* by Martini (1929-31), and as *Mansonia richiardii* by Sūyev (1953) and Parrish (1959). A further Mediterranean species, *Cq. buxtoni*, is present in Romania (Nicolescu, 1995) and Ukraine (Gutsevich *et al.*, 1971) to the north of Turkey, and in Syria and Israel (Parr, 1943) to the south. Though not yet recorded, this species may be expected to occur in Turkey.

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Les moustiques de l'Afrique méditerranéenne. Scientific content by Jacques Brunhes, Adel Rhaim, Bernard Geoffroy, Guy Angel, Jean-Paul Hervy and others.

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This **CD-ROM** requires a minimum specification of a Pentium PC with 32 Mb RAM using Windows 95, 98 or NT. It is designed for the identification of the 73 species of mosquito currently recorded from the North African coast (Morocco, Algeria, Tunisia, Libya and Egypt) and also serves as a training program in mosquito identification and a database for the mosquitoes of the area. It was developed by the Institut de recherche pour le développement (IRD), formerly ORSTOM. As two-thirds of the mosquitoes included in this key are also found in Europe, this CD-ROM will be of interest to almost all readers of this journal.

Clear and concise instructions guide the user through the program culminating in identifications in which the user has confidence due to the facility of cross-checking. To assist the user, a help facility is available to explain the screen symbols and provide subsidiary information. However, the navigation on the program is very rigid and it is not possible to move between different areas of the program.

The main screen allows the user to identify larvae or adults to the level of either genus or species and to access information about larval or adult instars within these taxa. The information section on genera has headings of features (morphological characters); bioecology; distribution map; larval illustration and adult illustration. The information section on species covers classification of the Culicidae, nomenclature and synonymy, life cycles of anophelines and culicines, larval and adult morphology, identity cards of all the species, distribution and country lists, biogeographical origins, bioecological peculiarities, medical and veterinary interest and a bibliography.

Identification is achieved by selecting from a series of characters. An advantage of this key over conventional dichotomous keys is that a number of features can be considered. Also if one character is not apparent or is unclear then it is still possible to proceed with the identification. Confirmation of the identification is provided by an "identification card", and access to further corroborative evidence is available in the form of details of distribution, bioecology and morphology of the selected species. The morphology option is accompanied by illustrations of all of the characters with identification features highlighted. In total there are over five hundred original illustrations that help guide the user through the identification options. Unfortunately it is not possible to print any of these identification cards or illustrations and, in general, the CD allows little opportunity for interaction. There is an extensive glossary containing terms relating to taxonomy, morphology, ecology and parasites transmitted by mosquitoes, which can be referred to at almost any stage of the program.

The program is not only a very valuable tool for identification for entomologists and ecologists, but also a good instruction aid for those who teach on courses in biodiversity and vector biology. This is an excellent key and will be appreciated and valued by its users.

Keith Snow