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# Malaria and its vectors in Turkey

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**Abstract**

The mosquitoes of Turkey are listed and discussed together with a commentary of the malaria situation, both current and in the recent past. The problems and prospects for the control of malaria are presented.

## Introduction

Situated between latitudes $36^0$-$42^0$ N and longitudes $26^0$-$55^0$ W, Turkey is a Mediterranean country on the edge of the European continent. Anatolia (Asia Minor) forms a bridge linking Europe and Asia. Its varied topography and its geological and geomorphological features contribute to greatly contrasting landscapes and climatic zones, and to a highly diverse endemic flora and fauna (Demirsoy, 1996).

## The mosquitoes of Turkey

An early study, and the first to incorporate light traps as a sampling device in Turkey (Parrish, 1959), reported the presence of 55 mosquito species (13 *Anopheles*, 19 *Aedes*, 16 *Culex*, 4 *Culiseta*, 1 *Mansonia*, 1 *Orthopodomyia* and 1 *Uranotaenia*). Although the presence of all taxa was not confirmed and others have since undergone name changes, this paper remains valuable as it represents the earliest comprehensive review of the mosquitoes of Turkey. Later, entomological studies carried out over a period of approximately 15 years (1957-72) during the WHO-assisted malaria eradication programme provided more detailed information, principally about the genus *Anopheles*. During this period, *An. subalpinus* (Postiglione *et al.*, 1969) and *An. pulcherrimus* (Postiglione *et al.*, 1973) were recorded for the first time and *Ae. melanoon* and *An. messeae* were found to be absent. Records of *Ae. melanoon* (of which *subalpinus* was at that time thought to be a subspecies) represented misidentifications due to improper preparation of eggs before examination, whilst records of *An. messeae* had been misidentifications of *An. subalpinus*. Similarly, the old records of *An. sinensis* refer to *An. hyrcanus*. At the same time, because thirty years of collecting in the Çukurova had failed to confirm the unique records of *An. multicolor* and *An. sergentii*, both were removed from the list of Turkish mosquitoes.

During this period, re-examination of *An. mariae* from Turkey showed that there were, in fact, two allopatric species of the Aedes Mariae Complex (neither of them *Ae. mariae* s.s., which has a western Mediterranean distribution), *Ae. zammitii* on the Aegean and Mediterranean coasts west of Antalya, and *Ae. phoeniciae* on the Mediterranean coast east of Antalya (Coluzzi *et al.*, 1974). A few other species recorded by older workers have undergone name changes, have been lost to synonymy, or are no longer found, but the current checklist is remarkably similar to that of Parrish (1959).

For the purpose of recording mosquito distribution, the country is currently divided into four ecologically distinct regions as under (see Figure 1):

I. European Turkey and the Anatolian coastal plains, usually under 500m altitude and varying in width from about 50 km to quite narrow coastal strips.
II. Central Anatolia, comprising a series of valleys and undulating plateau with altitudes up to about 1200m, and separated by numerous isolated or ranges of mountains.
III. Eastern Anatolia comprising high plateau up to about 2000m altitude and mountains up to more than 5000m.
IV. South-eastern Anatolia comprising the northern extremities of the great Middle Eastern plain, and the valleys of the Rivers Firaat (Euphrates) and Dicle (Tigris) where they penetrate and deeply dissect the plateaux bordering this plain. Altitudes vary from 400m on the southern frontier and about 1000m at the Keban Barrage.

The current checklist of mosquitoes and their distribution according to region is shown in Table 1.

**Table 1. Mosquito species found in Turkey**

See Figure 1 for explanation of regions

**Genus** *Anopheles*
Subgenus *Anopheles*
*algeriensis* Theobald, 1903 (I, II, III, IV)
*claviger* (Meigen, 1804) (I, II, III, IV)
*hyrcanus* (Pallas, 1771) (I, II, III)
*maculipennis* Meigen, 1818 (I, II, III, IV)
*marteri* Senevet & Prunelle, 1927 (I, II)
*plumbeus* Stephens, 1828 (I, II, III)
*sacharovi* Favre, 1903 (I, II, III, IV)
*subalpinus* Hackett & Lewis, 1935 (I)

Subgenus *Cellia*
*pulcherrimus* Theobald, 1902 (IV)
*superpictus* Grassi, 1899 (I, II, III, IV)

**Genus** *Aedes*
Subgenus *Aedes*
*cinereus* Meigen, 1818 (I)

Subgenus *Aedimorphus*
*vexans* (Meigen, 1830) (I, II, III)

Subgenus *Finlaya*
*echinus* (Edwards, 1920) (I, II, III)
*geniculatus* (Olivier, 1791) (I, II)

Subgenus *Ochlerotatus*
*annulipes* (Meigen, 1830) (I)
*caspius* s.l. (Pallas, 1771) (I, II, IV)
*communis* (De Geer, 1776) (I)
*detritus* s.l. (Haliday, 1833) (I)
*dorsalis* (Meigen, 1830) (I, II)
*excrucians* (Walker, 1856) (II)
*flavescens* (Müller, 1764) (I, II)
*nigrocanus* Martini, 1927 (I)
*phoeniciae* Coluzzi & Sabatini, 1968 (I, IV)
*zammitii* (Theobald, 1903) (I, II)

Subgenus *Rusticoidus*
*lepidonotus* Edwards, 1920 (I, II)
*refiki* Medschid, 1928 (I)
*rusticus* (Rossi, 1790) (I)

Subgenus *Stegomyia*
*aegypti* (Linnaeus, 1762) (I)
*cretinus* Edwards, 1921 (I)

**Genus** *Coquillettidia*
Subgenus *Coquillettidia*
*richiardii* (Ficalbi, 1889) (I, II)

**Genus** *Culex*
Subgenus *Barraudius*
*modestus* Ficalbi, 1889 (I, II)
*pusillus* Macquart, 1850 (I)

Subgenus *Culex*
*laticinctus* Edwards, 1913 (I)
*mimeticus* Noe, 1899 (I, II)
*perexiguus* Theobald, 1903 (I, II)
*pipiens* Linnaeus, 1758 (I, II, III, IV)
*theileri* Theobald, 1903 (I, II)
*torrentium* Martini, 1925 (I)
*tritaeniorhynchus* Giles, 1901 (I, II, IV)
*vagans* Wiedemann, 1828 (I, II, III, IV)

Subgenus *Maillotia*
*deserticola* Kirkpatrick, 1924 (I)
*hortensis* Ficalbi, 1889 (I, II, III)

Subgenus *Neoculex*
*martinii* Medschid, 1930 (I)
*territans* Walker, 1856 (I)

**Genus** *Culiseta*
Subgenus *Allotheobaldia*
*longiareolata* (Macquart, 1838) (I, II, III, IV)

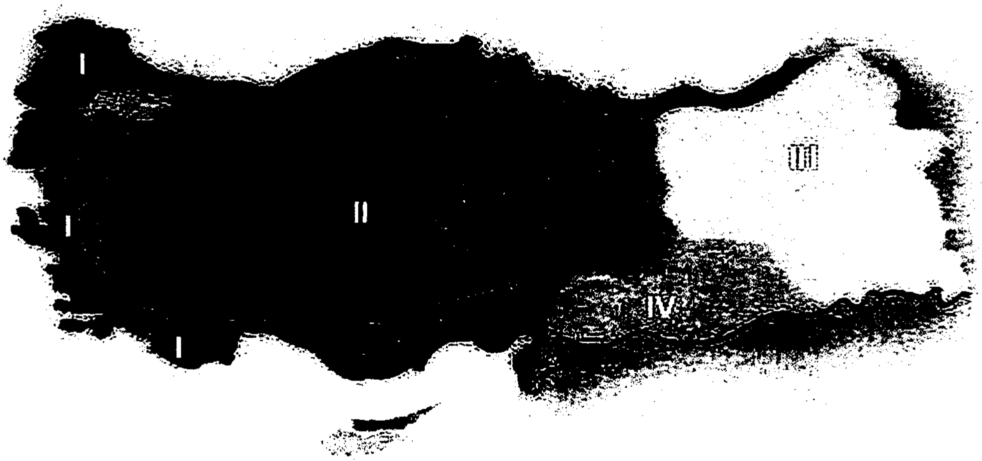
Subgenus *Culicella*
*fumipennis* (Stephens, 1825) (I)
*morsitans* (Theobald, 1901) ( I, IV)

Subgenus *Culiseta*
*annulata* (Schrank, 1776) (I, II, III)

**Genus** *Orthopodomyia*
*pulcripalpis* (Rondani, 1872) (I)

**Genus** *Uranotaenia*
Subgenus *Pseudoficalbia*
*unguiculata* Edwards, 1913 (I, II, III, IV)

## Map of Turkey Showing the Four Topographical Areas




- **I** **Coastal Plain Area**
- **II** **Anatolia Area**
- **Eastern Anatolia Area**
- **IV** **Southern Anatolia Area**

**Malaria vector species**

There can be no doubt that *An. sacharovi* is the most important malaria vector in Turkey (Erel, 1973; Postiglione *et al.*, 1973; Ramsdale & Haas, 1978; Kasap *et al.*, 1981; 1989; Kasap & Kasap, 1983; Merdivenci, 1984; Jetten & Takken, 1994). In Europe the aquatic stages of *An. sacharovi* are typically found in stagnant brackish waters, but in Turkey they are found in any suitable water, fresh or brackish, where horizontal vegetation is present (Jetten & Takken, 1994). An isolated record exists of *An. sacharovi* at an altitude of 1720m (Gökberk, 1961), but the species is unable to establish itself at this altitude (Postiglione *et al.*, 1973). *An. sacharovi* is the dominant species in all currently malarious areas or where serious resurgences of malaria have occurred after the interruption of transmission. Alten & Çaglar (1998) consider that, because of incomplete hibernation, it is necessary to control adult *An. sacharovi* during the winter.

*An. superpictus* is an important vector in Turkey, ranking next in importance to *An. sacharovi.* Because of its exophilic and zoophilic tendencies the vectorial role of *An. superpictus* varies according to the local situation (Postiglione *et al.*, 1973; Merdivenci, 1984; Alten & Çaglar, 1998).

*An. maculipennis* and *An. subalpinus* are regarded as less efficient vectors, but were the only species present in high densities in the formerly malarious plains of Biga, bordering the Marmara Sea, and in certain other areas in Turkey. However, their roles in many places were obscured by the simultaneous presence of *An. sacharovi* and/or *An. superpictus.*

*An. claviger* is the most widely distributed *Anopheles* in Turkey but is not considered to be more than an occasional vector (Postiglione *et al.*, 1972; 1973). Because of its extra-domestic habits, *An. hyrcanus* is not usually regarded as a dangerous mosquito in the Mediterranean region. However, the practice of sleeping in fields under makeshift shelters during the summer months is widespread amongst cotton pickers. This species is often present in these situations, especially where rice is additionally cultivated, and most probably plays a significant role in malaria transmission in parts of Turkey (Ramsdale & Haas, 1978), and also elsewhere (Sergiev *et al.*, 1993).

Distribution maps for the *Anopheles* of Turkey were given by Postiglione *et al.* (1973), and these remain essentially true for each species.

**Insecticide Resistance**

Populations of *An. sacharovi, An. maculipennis* and *An. subalpinus* from widely separated areas of Turkey are highly resistant to insecticides, containing more than 90% DDT and dieldrin resistant individuals, whilst *An. hyrcanus* is resistant to DDT and dieldrin in the Çukurova (Ramsdale, 1975). Widespread vector resistance to organochlorine insecticides and the presence also of organophosphate and carbamate resistance in *An. sacharovi* has been demonstrated (Ramsdale *et al.*, 1980; WHO, 1990). The incidence of insecticide resistance seems to be related to agricultural use of insecticides. *An. superpictus,* the larvae of which develop in water not contaminated by agricultural applications, remains normally susceptible to all insecticides (Ramsdale, 1975; Ramsdale *et al.*, 1980; WHO, 1986).

**Malaria**

Three malaria parasite species, *Plasmodium falciparum, P. malariae* and *P. vivax* were formerly endemic in Turkey. Nowadays, occasional imported cases of *falciparum* malaria are observed, but all indigenous cases of malaria are of *P. vivax* (Ramsdale & Haas, 1978; WHO, 1990; Alten & Çaglar, 1998). *P. malariae* is a rather rare parasite, and there is evidence indicating that *An. sacharovi* is refractory to infection with many strains of *P. falciparum* (Dashkova & Rasnicyn, 1982). However, the possibility of these parasite species re-appearing in Turkey must be kept in mind, with the added danger of some imported parasites being of drug resistant strains. *P. vivax* is already showing signs of becoming resistant to drugs: primaquine therapy has to be applied for 28 days and the same parasite is expected to gain enhanced tolerance of chloroquine. Occasional imported cases of drug resistant *P. falciparum* are currently being observed in Turkey (Kasap *et al.*, 1989).

**Causes of resurgent malaria in Turkey**

As a result of the malaria eradication programme, which started in 1957, the incidence of malaria decreased annually until, by 1973, the total number of malaria cases detected had fallen to 2438 in the whole country. With the decline of malaria as a major problem resources were diverted to other public health projects to the extent that the malaria service was unable to respond appropriately to a deteriorating epidemiological situation. Resurgences of malaria occurred in various areas from which the disease had apparently disappeared and, because the malaria service was unable to act swiftly and decisively, many of the gains of 20 years of effort were lost (Ramsdale & Haas, 1978). The annual number of malaria cases detected in Turkey during 1975-1998 is shown in Table 2.

**Table 2. Annual distribution of malaria cases in Turkey (1975 - 1998)**

| Year | No. of cases | Year | No. of cases |
|---|---|---|---|
| 1975 | 9828 | 1987 | 20134 |
| 1976 | 37320 | 1988 | 16245 |
| 1977 | 115512 | 1989 | 12112 |
| 1978 | 87867 | 1990 | 8680 |
| 1979 | 29324 | 1991 | 12218 |
| 1980 | 34154 | 1992 | 18676 |
| 1981 | 54415 | 1993 | 47210 |
| 1982 | 62038 | 1994 | 84345 |
| 1983 | 66681 | 1995 | 82096 |
| 1984 | 55020 | 1996 | 60884 |
| 1985 | 47311 | 1997 | 35456 |
| 1986 | 37899 | 1998 | 36842 |

**Remedial measures taken after 1978**

On the basis of conditions suitable for malaria transmission, Turkey falls naturally into three epidemiological regions, a region where transmission is improbable (mean daily temperatures never exceed 20$^0$C), another where conditions are favourable for the transmission only of *P. vivax* (mean daily temperatures rise above 20$^0$C, but never exceed 24$^0$C), and a region where conditions are suitable for transmission of both parasites, being especially favourable for *P. vivax* transmission (mean daily temperatures exceed 24$^0$C for a significant part of the year) (Ramsdale & Haas, 1978; Akdur, 1997).

Areas of greatest malaria susceptibility are regions of irrigated crop cultivation where the occurrence of breeding water depends on agricultural practice (Postiglione *et al.*, 1973; Ramsdale & Haas, 1978).

Following the previous studies, Turkey was separated into epidemiological strata according to the then perceived level of malariogenic potential (WHO, 1990):

- Stratum 1A represents the most important area of endemic malaria in Turkey and covers the administrative zones of Mersin, Adana and Hatay.
- Stratum 1B covers the whole of South-eastern Anatolia.
- Stratum 2 covers the western part of Mediterranean coast, the Aegean littoral and European Turkey, where there is a risk of local epidemics (i.e. considered to be at risk because of fairly frequent autochthonous cases).
- Stratum 3 covers mainly the environs of the cities of Central Anatolia where local malaria cases are detected (i.e. there are no epidemics regionally but local cases can be seen).
- Stratum 4 covers the north-eastern part of Turkey and the provinces of the Black Sea Region, where the risk of malaria transmission is considered to be very low.

These strata are currently undergoing modification because increased incidence of malaria in Stratum 1B is causing a greater problem than in Stratum 1A.

After reorganisation of the antimalaria programme in 1977, an intensive control campaign was initiated in 1978. Generally, mosquito control has been carried out by the Ministry of Health, Municipalities, Provincial Government, and private organisations, using mechanical, chemical and biological methods according to epidemiological requirements.

This campaign involved a second treatment for all people who had suffered from malaria in 1977. In addition, there were two applications of malathion house spraying during the year, replacement of fuel-oil (used until March-April, 1978) by temephos for larviciding, wide distribution in all irrigated areas of the larvivorous fish, *Gambusia affinis*, implementation of mass drug distribution, and increased routine surveillance activities throughout the year. In 1984, malathion was replaced by pirimiphos-methyl, and some winter insecticidal fogging and spraying was carried out on a local basis (a case of malaria had been detected in a baby under the age of one (Ünsal *et al.*, 1982) in January). Biological control measures, based on employment of *Bacillus thuringiensis* H-14 and larvivorous fish, were continued, as were surveillance activities.

Data collected in 1987 showed considerable reduction in the number of recorded malaria cases to about 36% of the total recorded in 1984. During 1985-89, pirimiphos-methyl continued to be used for house spraying and temephos for larviciding. Afterwards there was a switch from the residual insecticides employed, either to other organophosphates or pyrethroids. Since 1998 larvicidal *Bacillus* preparations and Insect Growth Regulators have been added to the control armaments.

**Prospects for the future**

Increases in the number of malaria cases between 1991 and 1996 were mostly related to population movements from the south-east of the country to the western provinces and also within the south-eastern region (WHO, 1990; Ministry of Health, 1994). According to the classical interpretation of the periodicity of epidemic malaria, Alten & Çaglar (1998) predict epidemic episodes at 10-12 year intervals, related to decreases of immune levels in the people.

Today, malaria is still one of the most important health problems in Turkey and probably will remain so in the foreseeable future for the following reasons:

- The world's endemic malaria regions are also regions of rapid population increase, as is the case in Turkey, where the population at risk of malaria will soon reach 3 million.
- Increasing population movements in and between malarious regions in the pursuit of opportunities in trade and transport, and due to greater migratory movements.
- Malaria and mosquitoes have become urbanised due to population movements into and around built up areas and consequent physical merging of rural and urban areas, making malaria and vector control more difficult.
- Agricultural development increases the availability of water for irrigation in the epidemic regions, and creates new mosquito habitats.
- An effect of global warming will be enlargement of tropical and sub-tropical regions at malaria risk.
- Mosquito and parasite control are made more difficult by continuing vector resistance to insecticides and parasite resistance to prophylactic and remedial drugs.

The proposed "South-eastern Anatolian project" will create 22 dams, 19 hydroelectric plants and 2 conveyance tunnels on the upper Firaat (Euphrates) and Dicle (Tigris) rivers and permit the irrigation of an additional 1.8 million hectares of agricultural land This multi-sectorial, integrated regional developmental scheme is one of the most ambitious developmental projects in the world.

It is recognised that the changes introduced by dam construction and other water resource projects may create or aggravate health risks in different ways, especially regarding incidence of malaria, filariasis, leishmaniasis, and schistosomiasis. Cases of malaria and cutaneous leishmaniasis in Sanli Urfa in south-eastern Anatolia already show signs of being affected. An outbreak of cutaneous leishmanaiasis between 1981-84 in Urfa and neighbouring areas of Iraq and Syria involved 1670 cases (Desjeux, 1991). Leishmanaiasis transmission virtually ceased in Turkey during the operational period of the malaria eradication programme, but the disease is once more a Public Health problem. Being aware of this fact, the establishment of a special Tropical Medical Institute based in Sanli Urfa and Diyarbakir is under way and is now almost complete.

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You are cordially invited to attend and participate in the13th European Meeting of the Society for Vector Ecology (SOVE), to be held in Belek, Antalya, Turkey from 24-29 September 2000, to discuss the latest developments in vector ecology.

There will be plenary sessions, oral communications, workshops and poster sessions on all aspects related to vectors, including taxonomy, genetics, ecology, molecular biology, vector-parasite interactions, public education and vector control. There will be also a session for the mosquito systematics initiative known as MOTAX.

Accompanying persons are welcome.

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