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Mosquitoes (Diptera: Culicidae) of North Khorasan Province, Northeastern Iran and the Zoogeographic Affinities of the Iranian and Middle Asian Mosquito Fauna

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ABSTRACT

In order to study mosquitoes in North Khorasan Province, northeastern Iran and assess the zoogeographic affinities of the Iranian and Middle Asian fauna, mosquito surveys were conducted in the province during 2005-2009. Adult mosquitoes were collected from resting sites and while landing on human and dog bait by means of aspirator. Larvae were collected by means of pipette and dipper using the standard dipping technique. In total, 1,336 mosquito specimens, including 682 adults and 654 third- and fourth-instar larvae, were collected. Fourteen species representing five genera were identified: *Anopheles claviger*, *An. maculipennis*, *An. superpictus*, *An. pulcherrimus*, *Culex hortensis*, *Cx. mimeticus**, *Cx. modestus**, *Cx. perexiguus**, *Cx. pipiens**, *Cx. theileri*, *Cx. tritaeniorhynchus*, *Culiseta longiareolata*, *Ochlerotatus caspius** and *Uranotaenia unguiculata* (asterisks indicate new occurrence records for the province) based on morphology and *An. maculipennis* based on the internal transcribed spacer 2 ribosomal DNA (ITS2 rDNA) sequence. The data show that 65% of the anopheline fauna of Middle Asia occurs in Iran, however at least 15 *Anopheles* taxa found in Iran are not recorded in Middle Asia. Only seven (28%) of the aedine mosquitoes recorded in Middle Asia are found in Iran and three species that occur in Iran are not found in Middle Asia. About 77% of the Middle Asian species of *Culex* occur in Iran whereas the Iranian fauna includes nine species that are not recorded in Middle Asia. The species of *Coquillettidia*, *Culiseta* and *Uranotaenia* that are found in Iran are also found in Middle Asia.

Key words: *Anopheles*, arboviruses, dirofilariasis, ITS2 rDNA, malaria, setariasis

INTRODUCTION

The mosquito fauna of Iran includes 64 species and 3 subspecies classified in seven genera (based on the traditional classification of the tribe Aedini) and the unverified records of 12 other species (Azari-Hamidian, 2007). Recently, Oshaghi *et al.* (2008) identified *Anopheles superpictus* Grassi as a complex of three species (informally designated species X, Y and Z) and Djadid *et al.* (2009) proposed a new species of the Hyrcanus Group based on DNA sequence data.

West Nile and Sindbis viruses, which are transmitted by mosquitoes, have been reported in Iran (Naficy and Saidi, 1970; Saidi *et al.*, 1976; Sharifi *et al.*, 2010). The mosquito-borne nematodes of the genera *Setaria* Viborg (setariasis) and *Dirofilaria* Railliet and Henry (dirofilariasis) (Spirurida: Onchocercidae) occur in the country (Eslami, 1997; Azari-Hamidian *et al.*, 2007) and some mosquito-borne arboviruses, such as Japanese encephalitis and Rift Valley fever viruses, may possibly occur in the WHO Eastern Mediterranean Region, which includes Iran (WHO, 2004). There are doubtful old records of Dengue fever virus in Iran (Foote and Cook, 1959), but no documented recent records. *Anopheles maculipennis* Meigen and *Culex theileri* Theobald are known vectors of *Setaria labiatopapillosa* (Alessandrini) and *Dirofilaria immitis* (Leidy), respectively, in Ardebil Province, northwestern Iran (Azari-Hamidian *et al.*, 2009). Seven species of the genus *Anopheles* Meigen (*An. culicifacies* Giles s.l., *An. dthali* Patton, *An. fluviatilis* James s.l., *An. maculipennis* s.l., *An. sacharovi* Favre, *An. stephensi* Liston and *An. superpictus*) are known malaria vectors in Iran and *An. pulcherrimus* Theobald is considered a potential vector in the southeastern area of the country (Edrissian, 2006). Eshghy (1977) observed *Plasmodium* oocysts in *An. multicolor* Comboulieu in Sabzevar, Razavi Khorasan Province, but sporozoites have not been found in this species and it is not considered to be a vector in Iran. Recently, Djadid *et al.* (2009) considered *An. hyrcanus* (Pallas) to be a potential vector of malaria based on nested PCR identification of plasmodia in this species in Guilan Province.

In 2004, the very large province of Khorasan in northeastern Iran was divided into three provinces: North Khorasan, Razavi Khorasan and South Khorasan. There are a few scattered and mostly old unpublished documents concerning mosquitoes in the area that is now North Khorasan Province. *Anopheles marteri* Senevet and Prunnelle was recorded in Bojnord (Institute of Malariology and Parasitology, 1953) and five species, *An. claviger* (Meigen), *An. maculipennis*, *An. multicolor*, *An. superpictus* and *An. pulcherrimus*, were recorded in the area (School of Public Health, 1970). Saebi (1987) noted four species in Bojnord County (*An. claviger*, *An. maculipennis*, *An. multicolor* and *An. superpictus*) and two species in Shirvan County (*An. maculipennis* and *An. superpictus*). Gaffary (1954) mentioned the occurrence of *An. fluviatilis* s.l. and *An. moghulensis* Christophers in northeastern Iran, but there are no verified records of these species in that area of the country. Also Djadid *et al.* (2007) reported *An. maculipennis* based on the internal transcribed spacer 2 (ITS2) sequence (GenBank accession AY730264) from Bojnord [as Bojnord]. Hence, based on the available documentation, six anopheline species are considered to have been recorded in North Khorasan Province. Zaim (1987) found seven culicine species in the former Khorasan Province (*Cx. arbieeni* Salem, *Cx. laticinctus* Edwards, *Cx. mimeticus* Noè, *Cx. pipiens* Linnaeus, *Cx. territans* Walker, *Culiseta subochrea* (Edwards) and *Ochlerotatus caspius* (Pallas) s.l.); however, there are no locality data for the collections. Based on distributional maps published by Zaim *et al.* (1985, 1986), *Culex hortensis* Ficalbi, *Cx. theileri*, *Cx. tritaeniorhynchus* Giles, *Culiseta longiareolata* (Macquart) and *Uranotaenia unguiculata* Edwards have been found in North Khorasan Province. Other than these there are no published records for the mosquito fauna of North Khorasan Province.

North Khorasan Province is bordered by the Republic of Turkmenistan and Middle Asia in the north. Traditionally, Middle Asia includes the republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan (Fig. 1). The territory of Middle Asia includes semi-desert, desert and mountainous areas; however, the northern areas of Kazakhstan belong to the West Siberian lowland (Ejov, 2008). Gutsevich *et al.* (1974), Gutsevich and Dubitskiy (1987) and Ward (1987) studied the Middle Asian mosquito fauna as a part of the former Soviet Union. Some investigations on anopheline species, especially malaria vectors, were conducted after the collapse of the former

USSR, however little information is available for species of *Anopheles* (*Cellia*) in Middle Asia (Ejov, 2005, 2008). In total, 62 species representing nine genera, including *Anopheles* (17), *Aedes* Meigen (2), *Aedimorphus* Theobald (1), *Coquillettidia* Dyar (1), *Culex* Linnaeus (13), *Culiseta* Felt (5), *Dahlia* Reinert, Harbach and Kitching (1), *Ochlerotatus* Lynch Arribálzaga (21) and *Uranotaenia* Lynch Arribálzaga (1), are recorded in five countries of Middle Asia (Gutsevich *et al.*, 1974; Gutsevich and Dubitskiy, 1987; Mamednyazov, 1995; Tarbinsky, 1996; Mamednyazov and Yerokhin, 2005; Ejov, 2008). There are some doubtful old records of *An. fluviatilis* s.l. and *An. moghulensis* in Middle Asia (as Turkistan or Kazakh SSR) (Knight and Stone, 1977), however they are not considered as members of the Middle Asian fauna in the present article because there are no recent verified reports of these species in the territory (Gutsevich *et al.*, 1974; Gutsevich and Dubitskiy, 1987; Mamednyazov, 1995; Tarbinsky, 1996; Mamednyazov and Yerokhin, 2005; Ejov, 2008).

As mentioned above, data on the mosquitoes of North Khorasan Province are mostly old and scattered. Hence, our purpose was to survey the mosquitoes of the province to foster further investigations and assess the zoogeographic affinities of the Iranian and Middle Asian fauna.

MATERIALS AND METHODS

Study area: North Khorasan Province is located in northeastern Iran between 36°37'–38°17' N latitudes and 55°53'–58°20' E longitudes with an area of more than 28,400 km². The province is bordered by Turkmenistan in the North, Razavi Khorasan Province in the east and southeast, Semnan Province in the southwest and Golestan Province in the west (Fig. 1). It includes seven counties, Bojnord, Esfarayen, Faruj, Garmeh, Jajarm, Maneh and Samalghan and Shirvan, with a population of more than 811,000 inhabitants (according to the 2006 census). The province has desert and mountainous areas and receives about 250 mm of rainfall annually.



Fig. 1: Map of Iran (highlighting the position of North Khorasan Province) and Middle Asia (Lambert Conformal Conic Projection map); maps are not the same scale

Specimen and data collection: Mosquito sampling was carried out during 2005 (July), 2006 (July and August), 2007 (September), 2008 and 2009 (July, August, September). Mosquito larvae were collected by means of pipette and dipper using the standard dipping technique (350 mL dipper); adults were collected from resting sites and while landing on human and dog bait by means of aspirator. The specimens were collected in different climatic areas of five of the seven counties: Bojnord, Esfarayen, Faruj, Maneh and Samalghan and Shirvan. They were transferred to the Medical Arthropod Museum, Department of Medical Entomology and Vector Control (DMEVC), School of Public Health (SPH), Tehran University of Medical Sciences (TUMS) where the project was conducted. Larvae were preserved in lactophenol and microscope slides were prepared using de Faure's medium. Adult mosquitoes were pinned. The adults and third- and fourth-instar larvae were identified using the keys of Gutsevich *et al.* (1974), Harbach (1988) and Azari-Hamidian and Harbach (2009). The mosquito generic abbreviations follow Reinert (2009), which reflects the current formal classification of the family Culicidae (<http://mosquito-taxonomic-inventory.info/>). The specimens collected during the study were deposited in the Medical Arthropod Museum, DMEVC, SPH, TUMS.

Molecular identification of species: The specific identity of five adult mosquitoes, morphologically identified as *Anopheles maculipennis* s.l. [collected in Babaaman (37°28' N 57°26' E), Bojnord County, North Khorasan Province] was determined by sequencing the ITS2 region of ribosomal DNA (GenBank accession FJ210892). PCR reaction mixes and thermocycler parameters were those described previously by Linton *et al.* (2001). The ITS2 region was amplified using the universal 5.8S forward (5'-ATC ACT CGG CTC GTG GAT CG-3') and 28S reverse (5'-ATG CTT AAA TTT AGG GGG TAG TC-3') primers (Collins and Paskewitz, 1996). Sequences were edited and aligned using Sequencher™ version 4.8 (Genes Codes Corporation, Ann Arbor, Michigan, USA) and similarities with sequences in GenBank were assessed using FASTA search (<http://www.ebi.ac.uk/fasta33/>). Template DNA from this study is retained in the Molecular Systematics Laboratory of the Natural History Museum, London, for future reference.

RESULTS

In total, 682 adult mosquitoes representing 10 species of four genera were collected and identified based on morphology: *Anopheles maculipennis* s.l., *An. pulcherrimus*, *An. superpictus*, *Culex modestus* Ficalbi, *Cx. perexiguus* Theobald, *Cx. pipiens*, *Cx. theileri*, *Cx. tritaeniorhynchus*, *Ochlerotatus caspius* s.l. and *Uranotaenia unguiculata* (Table 1, 2). The ITS2 sequences obtained from the five mosquitoes identified morphologically as *An. maculipennis* s.l. (GenBank accession FJ210892) shared 100% identity with *An. maculipennis* from Iran (Djadid *et al.*, 2007; GenBank accessions AY730267-AY730268), Greece (Patsoula *et al.*, 2007; DQ118166) and Romania (Nicolescu *et al.*, 2004; AY634548 and AY634550).

The adult specimen of *Ur. unguiculata* was collected only from resting sites and those of *An. pulcherrimus* and *Cx. perexiguus* during night landing catches on human and on human and dog bait, respectively. The remaining species were collected during both resting and night landing catches (Table 2).

Six hundred and fifty-four larvae representing 11 species of five genera were collected: *An. claviger*, *An. maculipennis*, *An. superpictus*, *Cx. hortensis*, *Cx. mimeticus*, *Cx. modestus*, *Cx. pipiens*, *Cx. theileri*, *Cs. longiareolata*, *Oc. caspius* s.l. and *Ur. unguiculata* (Table 1).

Table 1: Relative abundance of adult and larval mosquitoes collected in North Khorasan Province, Iran, 2005-2009

Taxon	Adults		Larvae	
	n	%	n	%
<i>An. claviger</i>	-	-	3	0.4
<i>An. maculipennis</i>	27	4.0	19	2.9
<i>An. pulcherrimus</i>	1	0.1	-	-
<i>An. superpictus</i>	68	10.0	60	9.2
Total Anopheles	96	14.1	82	12.5
<i>Cx. hortensis</i>	-	-	58	8.8
<i>Cx. mimeticus</i>	-	-	9	1.4
<i>Cx. modestus</i>	17	2.5	2	0.3
<i>Cx. perexiguus</i>	14	2.1	-	-
<i>Cx. pipiens</i>	35	5.1	66	10.1
<i>Cx. theileri</i>	291	42.7	15	2.3
<i>Cx. tritaeniorhynchus</i>	20	2.9	-	-
Total Culex	377	55.3	150	22.9
<i>Cs. longiareolata</i>	-	-	283	43.3
<i>Oc. caspius</i> s.l.	208	30.5	132	20.2
<i>Ur. unguiculata</i>	1	0.1	7	1.1
Total Culicinae	586	85.9	572	87.5
Total	682	100.0	654	100.0

Table 2: The adult mosquitoes collected by different methods in North Khorasan Province, Iran, 2005-2007

Species	Collection method					n	%
	Resting catch	Night landing catch on		Reared immature			
		Human	Dog				
<i>An. maculipennis</i>	23	1	3	-	27	4.0	
<i>An. pulcherrimus</i>	-	1	-	-	1	0.1	
<i>An. superpictus</i>	56	2	10	-	68	10.0	
<i>Cx. modestus</i>	1	14	2	-	17	2.5	
<i>Cx. perexiguus</i>	-	1	13	-	14	2.1	
<i>Cx. pipiens</i>	20	11	4	-	35	5.1	
<i>Cx. theileri</i>	7	156	127	1	291	42.7	
<i>Cx. tritaeniorhynchus</i>	15	2	3	-	20	2.9	
<i>Oc. caspius</i> s.l.	6	70	132	-	208	30.5	
<i>Ur. unguiculata</i>	1	-	-	-	1	0.1	
Total	129	258	294	1	682	100.0	

Culex mimeticus, *Cx. modestus*, *Cx. perexiguus*, *Cx. pipiens* and *Oc. caspius* s.l. are recorded from North Khorasan Province for the first time. *Anopheles pulcherrimus*, *Cx. perexiguus* and *Cx. tritaeniorhynchus* were collected only as adults and *An. claviger*, *Cx. hortensis*, *Cx. mimeticus* and *Cs. longiareolata* only as larvae (Table 1). Fourteen species representing five genera were collected overall (Table 1). Places where specimens of each species were collected are summarized below and the species collected in each of the five counties of North Khorasan Province are listed in Table 3.

Table 3: Distribution of mosquitoes collected in five counties of North Khorasan Province, Iran, 2005-2009

Species	County				
	Bojnord	Esfarayen	Faruj	Maneh and Samalghan	Shirvan
<i>An. claviger</i>	*	-	-	-	*
<i>An. maculipennis</i>	*	-	-	*	*
<i>An. marteri</i>	*	-	-	-	-
<i>An. multicolor</i>	*	-	-	-	-
<i>An. pulcherrimus</i>	-	-	-	*	-
<i>An. superpictus</i>	*	*	-	*	*
<i>Cx. hortensis</i>	*	*	-	*	*
<i>Cx. mimeticus</i>	*	-	-	*	-
<i>Cx. modestus</i>	*	-	-	*	-
<i>Cx. perexiguus</i>	-	-	-	*	-
<i>Cx. pipiens</i>	*	-	-	*	*
<i>Cx. theileri</i>	*	-	*	*	-
<i>Cx. tritaeniorhynchus</i>	-	-	-	*	-
<i>Cs. longiareolata</i>	*	-	*	*	*
<i>Oc. caspius</i> s.l.	*	-	-	*	-
<i>Ur. unguiculata</i>	*	-	-	*	*

Anopheles multicolor in Bojnord County and *An. maculipennis* in Shirvan County are based on Saebi (1987) and *An. marteri* in Bojnord County is based on records of the Institute of Malariology and Parasitology (1953). *: Present, -: Absent

Anopheles claviger-Shirvan County: Eslamabad (2 larvae); Bojnord County: Firoozeh (1 larva).

Anopheles maculipennis-Maneh and Samalghan County: Shoorak (2♀), Kashkabad (1♀, 11 larvae), Hassegah (4♀); Bojnord County: Babaaman (20♂, 2 larvae), Bojnord (5 larvae), Sangsaar (1 larva).

Anopheles pulcherrimus-Maneh and Samalghan County: Hassegah (1♀).

Anopheles superpictus-Maneh and Samalghan County: Kashkabad (62♀), Hassegah (1♀), Mehmanak (1♀), Borj (2♀), Keykanloo (2♀), Mohammadabad (1 larva), Kalimani (4 larvae); Esfarayen County: Rooeen (18 larvae); Bojnord County: Bachehdareh (19 larvae), Ayerghayeh (6 larvae), Firoozeh (4 larvae), Babaaman (1 larva), Armodli (6 larvae); Shirvan County: Eslamabad (1 larva).

Culex hortensis-Esfarayen County: Rooeen (32 larvae); Maneh and Samalghan County: Kashkabad (7 larvae), Mohammadabad (3 larvae) Kalimani (4 larvae); Shirvan County: Glian (2 larvae); Bojnord County: Firoozeh (4 larvae), Ayoob (3 larvae), Oshtoot (1 larva), Ayerghayeh (2 larvae).

Culex mimeticus-Maneh and Samalghan County: Borj (5 larvae); Bojnord County: Firoozeh (4 larvae).

Culex modestus-Maneh and Samalghan County: Hassegah (11♀), Kashkabad (4♀); Bojnord County: Babaaman (2♀, 1 larva), Sangsaar (1 larva).

Culex perexiguus-Maneh and Samalghan County: Kashkabad (14♀).

Culex pipiens-Maneh and Samalghan County: Kashkabad (3♀), Shoorak (2♀), Hassegah (1♀); Bojnord County: Bojnord (29♀), Babaaman (18 larvae) Yengeghale (27 larvae); Shirvan County: Glian (18 larvae), Eslamabad (3 larvae).

Culex theileri-Maneh and Samalghan County: Kashkabad (210♀), Hassegah (75♀), Keykanloo (1♀); Bojnord County: Bojnord (1♀, 7 larvae), Babaaman (4♀, 7 larvae); Faruj County: Segonbad (1 larva).

Culex tritaeniorhynchus-Maneh and Samalghan County: Kashkabad (3♀), Hassegah (17♀).

Culiseta longiareolata-Maneh and Samalghan County: Kashkabad (1 larva); Shirvan County: Glian (25 larvae); Bojnord County: Ayoob (33 larvae), southern Ayoob (94 larvae), Cheheldokhtar Ayerghayeh (5 larvae), Yooghan Borj (22 larvae), Firoozeh (4 larvae), Oshtoot (61 larvae), Ayerghayeh (6 larvae); Faruj County: Segonbad (32 larvae).

Ochlerotatus caspius s.l.-Maneh and Samalghan County: Kashkabad (202♀), Hassegah (5♀), Keykanloo (1♀); Bojnord County: Babaaman (3 larvae), Ghazi (129 larvae).

Uranotaenia unguiculata-Maneh and Samalghan County: Hassegah (1♀); Bojnord County: Babaaman (5 larvae); Shirvan County: Eslamabad (2 larvae).

DISCUSSION

In total, 1,336 mosquito specimens (682 adults and 654 third- and fourth-instar larvae) representing 14 species and five genera were collected in North Khorasan Province during the surveys and identified based on morphology and ITS2 sequence. Four of the six species of *Anopheles* previously recorded in the province, including *An. claviger*, *An. maculipennis*, *An. pulcherrimus* and *An. superpictus*, were collected. *Anopheles marteri* and *An. multicolor*, which were recorded in unpublished documents (Institute of Malariology and Parasitology, 1953; School of Public Health, 1970; Saebi, 1987), were not found. Gaffary (1954) mentioned the possible occurrence of *An. fluviatilis* s.l. and *An. moghulensis* in northeastern Iran, but their occurrence in this area of the country has never been verified—they have only been found in southern and southeastern Iran, respectively (Saebi, 1987).

Of the species of the Maculipennis Group, only *An. maculipennis* has been recorded in northeastern Iran, based on molecular data (GenBank accession AY730264; Djadid *et al.*, 2007). The ITS2 sequences of the *An. maculipennis* specimens analyzed in the present study (GenBank accession FJ210892 from Bojnord) have a 90% overlap with the sequence obtained by Djadid *et al.* (2007) and this region shares 99% identity; however, they share 100% similarity with many other sequences for this species from Iran (AY730267-AY730268; Djadid *et al.*, 2007), Greece (DQ118166; Patsoula *et al.*, 2007) and Romania (AY634548 and AY634550; Nicolescu *et al.*, 2004). Seven species of the Maculipennis Group are listed in the most recent checklist of Iranian mosquitoes (Azari-Hamidian, 2007). There are no records for *An. martinius* (Shingarev) in the country; but its occurrence in northeastern Iran seems possible in view of its presence in Kazakhstan, Turkmenistan and Uzbekistan (Ejov, 2008). *Anopheles maculipennis* is a rare species in Middle Asia. It has been recorded only from Kopet Dag in southern Turkmenistan, adjoining Iran. *Anopheles messeae* Falleroni has been recorded in Kazakhstan, Kyrgyzstan and Turkmenistan, *An. artemievi* Gordeyev, Zvantsov, Goryacheva, Shaikevich and Yezhov in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan and *An. beklemishevi* Stegnii and Kabanova in Kazakhstan (Ejov, 2008; Bezzhonova, Personal Communication). Also, Tarbinsky (1996) previously reported *An. beklemishevi* in Kyrgyzstan. The type localities of *An. artemievi* and *An. martinius* are in Kyrgyzstan (Ejov, 2008) and Uzbekistan (Knight and Stone, 1977), respectively. *Anopheles artemievi*, *An. beklemishevi* and *An. martinius* have not been recorded in Iran (Azari-Hamidian, 2007). Country records for other anopheline species are as follow: *Anopheles algeriensis* Theobald, *An. barianensis* James, *An. claviger*, *An. hyrcanus*,

An. multicolor, *An. plumbeus* Stephens, *An. pulcherrimus* and *An. superpictus* have been recorded in Turkmenistan (Mamednyasov, 1995) and the recent report of *An. sergentii sergentii* in southern Turkmenistan is noteworthy (Mamednyasov and Yerokhin, 2005). Mamednyasov (1995) mentioned *An. barianensis*, a species similar to *An. plumbeus*, in Turkmenistan, but Gutsevich *et al.* (1974) had explained previously that the specimens from Tajikistan are typical *An. plumbeus*. Gutsevich *et al.* (1974) and Gutsevich and Dubitskiy (1987) did not mention *An. barianensis* in the checklist of the mosquitoes of the former U.S.S.R. In addition to its distribution in the Palaearctic Region, this species also occurs in India and Pakistan (Knight and Stone, 1977) of the Oriental Region. It seems that the presence of this species in Middle Asia is doubtful and needs to be verified.

Tarbinsky (1996) mentioned the occurrence of *An. algeriensis*, *An. claviger*, *An. hyrcanus*, *An. pulcherrimus* and *An. superpictus* in Kyrgyzstan. The type locality of *An. chodukini* Martini of the Hyrcanus Group is Tashkent, Uzbekistan and *An. algeriensis*, *An. claviger*, *An. hyrcanus*, *An. pulcherrimus* and *An. superpictus* have been found in the country (Gutsevich *et al.*, 1974; Ejov, 2005, 2008). Within Middle Asia, *An. marteri sogdianus* Keshishian and *An. lindesayi* Giles are only recorded from Tajikistan (the type locality of *An. marteri sogdianus* is Stalinabad, Tajikistan), however Gutsevich and Dubitskiy (1987) doubted the occurrence of *An. lindesayi* and a subspecies of *An. marteri* in Middle Asia. Other anophelines recorded from Tajikistan include *An. algeriensis*, *An. claviger*, *An. hyrcanus*, *An. plumbeus*, *An. pulcherrimus* and *An. superpictus* (Gutsevich *et al.*, 1974; Ejov, 2005, 2008). Finally, Gutsevich *et al.* (1974) recorded *An. hyrcanus*, *An. pulcherrimus* and *An. superpictus* in Kazakhstan. In total, 17 anopheline species (13 in the subgenus *Anopheles* and four in the subgenus *Cellia*) have been recorded in Middle Asia. Six of these species, *An. artemievi*, *An. beklemishevi* and *An. martinius* of the Maculipennis Group and *An. barianensis*, *An. chodukini* and *An. lindesayi*, have not been found in Iran; hence, 65% of the anopheline fauna of Middle Asia occurs in the country. However, at least 15 *Anopheles* species (and some unnamed sibling species) are known to occur in Iran, especially southern areas, which are not recorded in Middle Asia (Azari-Hamidian *et al.*, 2006; Azari-Hamidian, 2007). Except for *An. barianensis* and *An. lindesayi*, the species of the subgenus *Anopheles* recorded in Middle Asia are exclusively Palaearctic (Gutsevich *et al.*, 1974; Knight and Stone, 1977). *Anopheles lindesayi* (including four of its nominal subspecies) is mainly Oriental, but it is also recorded in Afghanistan and the eastern Palaearctic (China, Japan and Korea) (Gutsevich *et al.*, 1974; Knight and Stone, 1977). Two species of the subgenus *Cellia*, *An. multicolor* and *An. pulcherrimus*, are found in the Palaearctic and western Oriental (India and Pakistan) Regions. The distribution of *An. multicolor* also extends into the Afrotropical Region (Yemen). *Anopheles sergentii* and *An. superpictus* are Palaearctic and Oriental (Pakistan) species, but *An. sergentii macmahoni* Evans is Afrotropical (Gutsevich *et al.*, 1974; Knight and Stone, 1977). Species of the Hyrcanus Group in the western Palaearctic Region include *An. chodukini*, *An. pseudopictus* Grassi and *An. hyrcanus* (and its different forms and/or synonyms), but the taxonomic status of these nominal forms needs to be studied in detail (Azari-Hamidian *et al.*, 2006). There are no records of *An. pseudopictus* in Middle Asia. Gutsevich *et al.* (1974) and Gutsevich and Dubitskiy (1987) considered the three forms to be a single polytypic species, i.e. *An. hyrcanus*. Recently, Ponçon *et al.* (2008) suggested that *An. hyrcanus* and *An. pseudopictus* may belong to a single species in southeastern France and Djadid *et al.* (2009) proposed a new species of the group in southwestern Iran based on molecular evidence. *Anopheles maculipennis* and *An. superpictus* are known malaria vectors in Iran and *An. pulcherrimus* and *An. hyrcanus* are considered to be probable vectors in the southeastern and northern areas of the country, respectively (Edrissian, 2006; Djadid *et al.*, 2009). *Anopheles*

martinius, *An. pulcherrimus* and *An. superpictus* are assumed to be malaria vectors in Turkmenistan (Amangeldiev, 2001). This is important in view of the autochthonous cases of malaria in the area of Turkmenistan that borders Iran (Ejov, 2005). *Anopheles messeae* is a known malaria vector in Kazakhstan and Kyrgyzstan and *An. pulcherrimus* and *An. superpictus* are probable vectors in Tajikistan and Uzbekistan (Ejov, 2008). *Anopheles maculipennis* is a vector of *Setaria* nematodes in northwestern Iran (Azari-Hamidian *et al.*, 2009).

The five species of the subfamily Culicinae previously recorded in North Khorasan Province, *Cx. hortensis*, *Cx. theileri*, *Cx. tritaeniorhynchus*, *Cs. longiareolata* and *Ur. unguiculata* (Zaim *et al.*, 1985, 1986), were found in the present study. Also, *Cx. mimeticus*, *Cx. pipiens* and *Oc. caspius* s.l., which have wide distributions in Iran and were recorded in the former Khorasan Province (Zaim, 1987) and *Culex modestus* and *Cx. perexiguus*, which were not recorded previously, were collected for the first time in the province. *Culex arbieeni*, *Cx. laticinctus*, *Cx. territans* and *Culiseta subochrea* recorded in the former Khorasan Province by Zaim (1987) were not found in the present study.

Ochlerotatus caspius s.l., which is widely distributed in Iran, was found in this study, but none of the other aedine species are known to occur in northeastern Iran (Zaim, 1987). There is, in general, less information for aedine mosquitoes in the country than for other culicine mosquitoes. A species of *Aedimorphus*, i.e. *Am. vexans* (Meigen), a species of *Fredwardsius* Reinert, i.e., *Fr. vittatus* (Bigot), six species of *Ochlerotatus* and two species of *Dahlia* are documented in Iran. *Ochlerotatus berlandi* (Seguy), *Oc. chelli* (Edwards), *Oc. dorsalis* (Meigen) and *Stegomyia aegypti* (Linnaeus) are listed in old Iranian records, but they are not currently known to occur in the country (Azari-Hamidian, 2007). *Aedimorphus vexans*, *Ae. cinereus* Meigen, *Ae. esoensis* Yamada, *Da. geniculata* (Olivier) and 21 species of *Ochlerotatus*, *Oc. campestris* (Dyar and Knab), *Oc. caspius* s.l., *Oc. cataphylla* (Dyar), *Oc. communis* (De Geer), *Oc. cyprius* (Ludlow), *Oc. detritus* (Haliday), *Oc. dorsalis*, *Oc. euedes* (Howard, Dyar and Knab), *Oc. exerucians* (Walker), *Oc. flavescens* (Mueller), *Oc. gutzevichi* (Dubitsky and Deshevych), *Oc. kasachstanicus* (Gutsevich), *Oc. leucomelas* (Meigen), *Oc. montchadskyi* (Dubitsky), *Oc. pulcritarsis* (Rondani), *Oc. pullatus* (Coquillett), *Oc. punctor* (Kirby), *Oc. rempeli* (Vockeroth), *Oc. simanini* (Gutsevich), *Oc. stramineus* (Dubitzky) and *Oc. subdiversus* (Martini), are recorded in Middle Asia (Gutsevich *et al.*, 1974; Gutsevich and Dubitskiy, 1987; Mamednyasov, 1995; Tarbinsky, 1996). Mamednyasov (1995) listed *Ae. cinereus*, *Am. vexans* (as *Ae. vexans*), *Da. geniculata* (as *Ae. geniculatus*) and eight species of *Ochlerotatus*, including *Oc. simanini* [as *Oc. niphadopsis* (Dyar and Knab)], in Turkmenistan. Tarbinskiy (1996) mentioned the presence of *Am. vexans*, two species of *Aedes*, *Da. geniculata* (as *Ae. geniculatus*) and nine species of *Ochlerotatus* in Kyrgyzstan. Gutsevich *et al.* (1974) recorded *Oc. caspius* s.l. and *Oc. pulcritarsis* in Tajikistan and *Oc. pulcritarsis* and *Oc. simanini* in Uzbekistan (Kokand in the Fergana Valley of Uzbekistan is the type locality of *Oc. simanini*). Gutsevich *et al.* (1974) and Gutsevich and Dubitskiy (1987) listed *Am. vexans*, two species of *Aedes* and 18 species of *Ochlerotatus* in Kazakhstan. Gutsevich *et al.* (1974) indicated that *Oc. caspius* s.l. is widespread in Middle Asia. Of the species of the tribe Aedini that occur in Middle Asia, only seven (28%) are found in Iran. Three Iranian species, *Fr. vittatus*, *Oc. caballus* (Theobald) and *Da. echinus* (Edwards), are not found in Middle Asia (Azari-Hamidian, 2007). *Aedimorphus vexans* occurs principally in the Holarctic and Oriental Regions with extensions into the Australasian Region (not Australia) and Central America and populations in South Africa, *Ae. cinereus* is a northern Holarctic species and *Ae. esoensis* occurs in the Palaearctic Region, including far eastern Russia, Korea and Japan (Knight and Stone, 1977). *Dahlia geniculata* and nine species of

Ochlerotatus, *Oc. leucomelas*, *Oc. detritus*, *Oc. simanini*, *Oc. montchadskyi*, *Oc. stramineus*, *Oc. gutzevichi*, *Oc. kasachstanicus*, *Oc. cyprius* and *Oc. subdiversus*, are only found in the Palaearctic Region and five species of the genus, *Oc. dorsalis*, *Oc. communis*, *Oc. rempeli*, *Oc. cataphylla* and *Oc. euedes*, are Holarctic. Four species, *Oc. pullatus*, *Oc. flavescens*, *Oc. excrucians* and *Oc. punctor*, occur mainly in northern areas of the Holarctic Region (Knight and Stone, 1977). *Ochlerotatus pullatus* also occurs in the Oriental Region (India and Pakistan) (Aslamkhan, 1971; Kaur, 2003). *Ochlerotatus caspius* s.l. and *Oc. pulcritarsis* have distributions in the Palaearctic and Oriental Regions: *Oc. caspius* s.l. is found in Pakistan (Aslamkhan, 1971) and *Oc. pulcritarsis* in Pakistan and Thailand (Knight and Stone, 1977). Of the Middle Asian aedine fauna, 10 species of *Ochlerotatus* (*Oc. communis*, *Oc. montchadskyi*, *Oc. rempeli*, *Oc. gutzevichi*, *Oc. euedes*, *Oc. kasachstanicus*, *Oc. excrucians*, *Oc. subdiversus*, *Oc. cyprius* and *Oc. punctor*) are only recorded from Kazakhstan (Gutsevich *et al.*, 1974; Gutsevich and Dubitskiy, 1987) [*Oc. kasachstanicus*, *Oc. montchadskyi*, *Oc. stramineus* and *Oc. gutzevichi* were originally described from localities in Kazakhstan]. Mamednyasov (1995) and Gutsevich and Dubitskiy (1987) noted the presence of *Oc. campestris*, a Nearctic species, in Turkmenistan and Kazakhstan, respectively and Gornostayeva (2000) listed it among the Russian mosquito fauna. Gutsevich and Dubitskiy (1987) noted some differences in the male genitalia and larva of specimens from Kazakhstan and the Western Hemisphere; hence, the occurrence of *Oc. campestris* in Middle Asia and Russia requires further investigation.

Coquillettidia richiardii (Ficalbi) is widely distributed in Middle Asia, with occurrence records in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan (Gutsevich *et al.*, 1974; Mamednyasov, 1995; Tarbinsky, 1996). Although this species is present in northern and western provinces of Iran (Zaim, 1987; Azari-Hamidian, 2007; Azari-Hamidian and Harbach, 2009; Azari-Hamidian *et al.*, 2009), it was not found in the present study and is not known to occur in northeastern Iran. The genus includes two species in the western Palaearctic Region, *Cq. richiardii* and *Cq. buxtoni* (Edwards) (Gutsevich *et al.*, 1974; Knight and Stone, 1977).

Thirteen species of the genus *Culex* are recorded from countries in Middle Asia, including *Cx. hortensis*, *Cx. martinii* Medschid, *Cx. mimeticus*, *Cx. modestus*, *Cx. orientalis* Edwards, *Cx. perexiguus* (as *Cx. univittatus* Theobald), *Cx. pipiens*, *Cx. pusillus* Macquart, *Cx. territans*, *Cx. theileri*, *Cx. torrentium* Martini, *Cx. tritaeniorhynchus* and *Cx. vagans* Wiedemann (Gutsevich *et al.*, 1974; Mamednyasov, 1995; Tarbinsky, 1996). Seven of these species were collected during the present study, but three others that are known to occur in Iran (*Cx. pusillus*, *Cx. torrentium* and *Cx. territans*) were not encountered. *Culex martinii*, *Cx. orientalis* and *Cx. vagans* have never been found in Iran; thus, 77% of the *Culex* species that occur in Middle Asia also occur in Iran. However, nine species that occur in Iran are not found in Middle Asia (Azari-Hamidian, 2007). It should be noted that the occurrence of *Cx. orientalis* in Middle Asia is doubtful as it otherwise only occurs in eastern areas of the Palaearctic and Oriental Regions, including the Khabarovsk, Ussuri and Maritime (Perimori) territories of Russia (Gutsevich *et al.*, 1974). Among other species, *Cx. torrentium* and *Cx. martinii* are exclusively Palaearctic and *Cx. pipiens* is cosmopolitan. *Culex pusillus* is mainly Palaearctic but is also found in the Afrotropical Region (Sudan). *Culex territans* is Holarctic. *Culex modestus*, *Cx. hortensis* and *Cx. vagans* are mainly Palaearctic, however they are also found in the Oriental Region: *Cx. modestus* in India, Pakistan and China, *Cx. hortensis* in India and *Cx. vagans* in southern China and India. *Culex mimeticus* is found mainly in southern areas of the Palaearctic Region but its distribution extends across southwestern areas of the Oriental Region. *Culex theileri*, *Cx. perexiguus* and

Cx. tritaeniorhynchus are found in the Palaearctic, Afrotropical and Oriental Regions, however *Cx. theileri* and *Cx. perexiguus* are mainly Palaearctic and *Cx. tritaeniorhynchus* is mainly Oriental (Knight and Stone, 1977; Harbach, 1988). As explained by Harbach (1988), the species recorded as *Cx. univittatus* in areas outside of the Afrotropical Region, including Iran and Middle Asia, is *Cx. perexiguus*.

Five species of the genus *Culiseta*, *Cs. alaskaensis* Ludlow, *Cs. annulata* (Schrank), *Cs. longiareolata*, *Cs. morsitans* (Theobald) and *Cs. subochrea*, are recorded from countries in Middle Asia (Gutsevich *et al.*, 1974; Maslov, 1989; Mamednyasov, 1995; Tarbinsky, 1996). These five species also occur in Iran (Azari-Hamidian, 2007), however only the widespread *Cs. longiareolata* was found during the present study. *Culiseta longiareolata* occurs in the Afrotropical, Oriental (India and Pakistan) and southern Palaearctic Regions; *Cs. alaskaensis* occurs in the northern Nearctic, northern and central Palaearctic and Oriental (India and Pakistan) Regions. Both *Cs. annulata* and *Cs. subochrea* are western Palaearctic species and *Cs. morsitans* is Holarctic (Knight and Stone, 1977; Maslov, 1989).

Uranotaenia unguiculata, which was collected in the present study, is widespread in Iran (Zaim, 1987), but it does not seem to be an abundant species (Azari-Hamidian *et al.*, 2009). The species occurs in Turkmenistan and Kyrgyzstan (Mamednyasov, 1995; Tarbinsky, 1996) and in Middle Asia in general (Gutsevich *et al.*, 1974). *Uranotaenia* includes two species in the Palaearctic Region, *Ur. unguiculata* and *Ur. mashonaensis* Theobald. The latter, which is an Afrotropical species, was recently recorded from Israel (Harbach and Schnur, 2007).

Overall, the main difference between the mosquito fauna of Iran (64 species) (Azari-Hamidian, 2007) and Middle Asia (62 species) (Gutsevich *et al.*, 1974; Gutsevich and Dubitskiy, 1987; Mamednyasov, 1995; Tarbinsky, 1996; Mamednyasov and Yerokhin, 2005; Ejov, 2008) involves species in southern Iran that have their principal distributions in southwestern Asia and in the Afrotropical Region [such as *Cx. antennatus* (Becker) and *Oc. caballus*] or Oriental Region [such as *An. peditaeniatus* (Leicester), *An. subpictus* Grassi s.l. and *Cx. pseudovishnui* Colless]. The fauna of southwestern Asia includes many species that occur in two or more zoogeographical regions, such as *Cx. quinquefasciatus* Say (cosmotropical), *Cx. bitaeniorhynchus* Giles and *Cx. sitiens* Wiedemann (Palaearctic, Afrotropical, Oriental and Australasian Regions), *An. culicifacies* Giles s.l., *An. dthali* Patton, *An. fluviatilis* s.l., *An. turkhudi* Liston and *Fr. vittatus* (Palaearctic, Oriental and Afrotropical Regions), *An. moghulensis* and *An. stephensi* Liston (Palaearctic and Oriental Regions), *Cx. arbieeni*, *Cx. deserticola* Kirkpatrick, *Cx. laticinctus* and *Cx. sinaiticus* Kirkpatrick (Palaearctic and Afrotropical Regions). Among these species, *An. culicifacies* s.l. and *An. fluviatilis* s.l. are mainly Oriental, with populations in southwestern Asia that extend into the Afrotropical Region (Yemen and Ethiopia). *Dahlia echinus*, which occurs in Iran but not in Middle Asia, is exclusively Palaearctic (Knight and Stone, 1977). Two species originally discovered in Iran, *An. apoci* Marsh and *An. persiensis* Linton, Sedaghat and Harbach, have limited distributions. In addition to Iran, *An. apoci* also occurs in Iraq (Knight and Stone, 1977) and *An. persiensis* occurs in the Azerbaijan Republic (Ejov, 2008). Among the exclusively Palaearctic species, *An. beklemishevi* and 10 species of the genus *Ochlerotatus* have only been found in one country (Kazakhstan) of Middle Asia and three species, *Oc. gutzevichi*, *Oc. montchadskyi* and *Oc. kasachstanicus*, are endemic to the country.

Among the species of Culicinae that were found in the present study, *Cx. perexiguus*, *Cx. pipiens*, *Cx. theileri*, *Cx. tritaeniorhynchus* and *Oc. caspius* s.l. are potential or proven vectors of pathogens that cause diseases in humans and domesticated animals in various areas of the world

(Gutsevich *et al.*, 1974; Harbach, 1988). *Culex theileri* is a known vector of canine heartworm in northwestern Iran (Azari-Hamidian *et al.*, 2009). Many questions about the ecology of medically important species and the taxonomy of species complexes in Iran remain to be answered, especially in areas of northeastern Iran that have yet to be investigated.

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REFERENCES

- Amangeldiev, K.A., 2001. Current malaria situation in Turkmenistan. *Med. Parasitol. Parasitic Dis.*, 1: 37-39.
- Aslamkhan, M., 1971. The mosquitoes of Pakistan I. A checklist. *Mosq. Syst. Newslett.*, 3: 147-159.
- Azari-Hamidian, S., M.R. Abai, H. Ladonni, H. Vatandoost and K. Akbarzadeh, 2006. *Anopheles peditaeniatus* (Leicester) new to the Iranian mosquito fauna with notes on *Anopheles hyrcanus* group in Iran. *J. Am. Mosq. Control Assoc.*, 22: 144-146.
- Azari-Hamidian, S., 2007. Checklist of Iranian mosquitoes (Diptera: Culicidae). *J Vector Ecol.*, 32: 235-242.
- Azari-Hamidian, S., M.R. Yaghoobi-Ershadi, E. Javadian, I. Mobedi and M.R. Abai, 2007. Review of dirofilariasis in Iran. *J. Med. Fac. Guilan Univ. Med. Sci.*, 15: 102-113.
- Azari-Hamidian, S. and R.E. Harbach, 2009. Keys to the adult females and fourth-instar larvae of the mosquitoes of Iran (Diptera: Culicidae). *Zootaxa*, 2078: 1-33.
- Azari-Hamidian, S., M.R. Yaghoobi-Ershadi, E. Javadian, M.R. Abai, I. Mobedi, Y.M. Linton and R.E. Harbach, 2009. Distribution and ecology of mosquitoes in a focus of dirofilariasis in Northwestern Iran, with the first finding of filarial larvae in naturally infected local mosquitoes. *Med. Vet. Entomol.*, 23: 111-121.
- Collins, F.H. and S.M. Paskewitz, 1996. A review of the use of ribosomal DNA (rDNA) to differentiate among cryptic *Anopheles* species. *Insect. Mol. Biol.*, 5: 1-9.
- Djadid, N.D., S. Gholizadeh, E. Tafhiri, R. Romi, M. Gordeev and S. Zakeri, 2007. Molecular identification of Palaearctic members of *Anopheles maculipennis* in northern Iran. *Malaria J.*, 6: 6-6.
- Djadid, N.D., H. Jazayeri, S. Gholizadeh, Sh.P. Rad and S. Zakeri, 2009. First record of a new member of *Anopheles Hyrcanus* Group from Iran: Molecular identification, diagnosis, phylogeny, status of kdr resistance and *Plasmodium* infection. *J. Med. Entomol.*, 46: 1084-1093.

- Edrissian, Gh.H., 2006. Malaria in Iran: Past and present situation. *Iran. J. Parasitol.*, 1: 1-14.
- Ejov, M., 2005. Scaling up the Response to Malaria in the WHO European Region. Progress Towards Curbing an Epidemic 2000–2004. WHO Regional Office for Europe, Copenhagen, Denmark, pp: 59.
- Ejov, M., 2008. Mosquitoes of the Genus *Anopheles* in Countries of the WHO European Region Having Faced a Recent Resurgence of Malaria. Regional Research Project, 2003–2007. WHO Regional Office for Europe, Copenhagen, Denmark, pp: 26.
- Eshghy, N., 1977. *Anopheles multicolor* Cambouliu and its role in the transmission of malaria in Iran. *J. Entomol. Soc. Iran*, 4: 87-88.
- Eslami, A., 1997. Veterinary Helminthology. Nematoda and Acanthocephala. Vol. 3. Tehran University Publications, Tehran, pp: 892.
- Foote, R.H. and D.R. Cook, 1959. Mosquitoes of Medical Importance. ARS, US Department of Agriculture, Washington, DC., pp: 158.
- Gaffary, E.N., 1954. Tentative distributional data on the anophelines of Iran. Proceedings of the Annual Meeting of the American Mosquito Control Association and the New Jersey Mosquito Extermination Association, (AMAMCANJMEA'54), Atlantic City, New Jersey, USA., pp: 4-4.
- Gornostayeva, R.M., 2000. Checklist of mosquitoes (Culicidae) from the Asian part of Russia. *Parazitologia*, 34: 477-485.
- Gutsevich, A.V. and A.M. Dubitskiy, 1987. New species of mosquitoes in the fauna of the USSR. *Mosq. Syst.*, 19: 1-92.
- Gutsevich, A.V., A.S. Monchadskii and A.A. Shtakelberg, 1974. Fauna of the U.S.S.R. Diptera. Vol. 3. Keter Publishing House Jerusalem Ltd., Jerusalem, pp: iii + 408.
- Harbach, R.E., 1988. The mosquitoes of the subgenus *Culex* in Southwestern Asia and Egypt (Diptera: Culicidae). *Contribut. Am. Entomol. Inst.*, 24: 1-240.
- Harbach, R.E. and H.J. Schnur, 2007. *Uranotaenia (Pseudoficalbia) mashonaensis*, an Afrotropical species found in Northern Israel. *J. Am. Mosq. Control Assoc.*, 23: 224-225.
- Institute of Malariology and Parasitology, 1953. Distribution of *Anopheles* spp in Iran. Institute of Malariology and Parasitology, Tehran, pp: 4.
- Kaur, R., 2003. An update on the distribution of mosquitoes of the tribe Aedini in India (Diptera: Culicidae). *Orient. Insects*, 37: 439-455.
- Knight, K.L. and A. Stone, 1977. A Catalog of the Mosquitoes of the World (Diptera: Culicidae). 2nd Edn., Thomas Say Foundation, Maryland, College Park, pp: 611.
- Linton, Y.M., R.E. Harbach, M.S. Chang, T.G. Anthony and A. Matusop, 2001. Morphological and molecular identity of *Anopheles (Cellia) sundaicus* (Diptera: Culicidae), the nominotypical member of a malaria vector species complex in Southeast Asia. *Syst. Entomol.*, 26: 357-366.
- Mamednyasov, O., 1995. Blood-Sucking Mosquitoes (Diptera, Culicidae) in Turkmenistan and an Integrated System of their Control. Ylym Publishing House, Ashgabat, pp: 374.
- Mamednyazov, O. and P. Yerokhin, 2005. Illustrated Key of Malaria Mosquitoes (Culicidae, Anophelinae) in Middle Asia. Ylym Publishing House, Ashgabat, pp: 68.
- Maslov, A.V., 1989. Blood-sucking Mosquitoes of the Subtribe Culisetina [sic] (Diptera, Culicidae) in World Fauna. Smithsonian Institution Libraries and the National Science Foundation, Washington, DC., pp: 248.
- Naficy, K. and S. Saidi, 1970. Serological survey on viral antibodies in Iran. *Trop Geogr. Med.*, 2: 183-188.

- Nicolescu, G., Y.M. Linton, A. Vladimirescu, T.M. Howard and R.E. Harbach, 2004. Mosquitoes of the *Anopheles maculipennis* group (Diptera: Culicidae) in Romania, with the discovery and formal recognition of a new species based on molecular and morphological evidence. *Bull. Entomol. Res.*, 94: 525-535.
- Oshaghi, M.A., M.R. Yaghoobi-Ershadi, Kh. Shemshad, M. Pedram and H. Amani, 2008. The *Anopheles superpictus* complex: Introduction of a new malaria vector complex in Iran. *Bull. Soc. Pathol. Exot.*, 101: 429-434.
- Patsoula, E., A. Samanidou-Voyadjoglou, G. Spanakos, J. Kremastinou, G. Nasioulas and N.C. Vakalis, 2007. Molecular characterization of the *Anopheles maculipennis* complex during surveillance for the 2004 Olympic Games in Athens. *Med. Vet. Entomol.*, 21: 36-43.
- Ponçon, N., C. Toty, P. Kengne, B. Alten and D. Fontenille, 2008. Molecular evidence for similarity between *Anopheles hyrcanus* (Diptera: Culicidae) and *Anopheles pseudopictus* (Diptera: Culicidae), sympatric potential vectors of malaria in France. *J. Med. Entomol.*, 45: 576-580.
- Reinert, J.F., 2009. List of abbreviations for currently valid generic-level taxa in family Culicidae (Diptera). *Eur. Mosq. Bull.*, 27: 68-76.
- Saebi, M.E., 1987. Morphological study on anopheline larvae and their distribution in Iran. Ph.D. Thesis, Tehran University of Medical Sciences, Tehran, pp: 201.
- Saidi, S., R. Tesh, E. Javadian and A. Nadim, 1976. The prevalence of human infection of West Nile in Iran. *Iran. J. Publ. Health*, 5: 8-14.
- School of Public Health, 1970. Geographical Pathology of Iran. Scientific Publication of School of Public Health and Institute of Public Health Research No. 1802, Tehran, pp: 120.
- Sharifi, Z., M. Mahmoodian Shooshtari and A. Talebian, 2010. A study of West Nile virus infection in Iranian blood donors. *Arch. Iran. Med.*, 13: 1-4.
- Tarbinsky, Y.S., 1996. Superclassis Hexapoda (Entognatha and Insecta). In: Genetical Fund Cadastre of Kyrghyzstan, Tarbinsky, Y.S. (Ed.). Vol. 3, Institute for Biology and Pedology, National Academy of Sciences, Bishkek, ISBN: 5-8355-0907-3, pp: 406.
- Ward, R.A., 1987. Nomenclatural status and some additions to the species listed in the publication, New Species of Mosquitoes in the Fauna of the USSR by A.V. Gutsevich and A.M. Dubitskiy (1981) (Diptera: Culicidae). *Mosq. Syst.*, 19: 93-99.
- WHO, 2004. Integrated Vector Management. WHO Regional Officer for Eastern Mediterranean, Cairo, pp: 27.
- Zaim, M., A.V. Manouchehri and M.R.Y. Ershadi, 1985. Mosquito fauna of Iran. 2- *Culex* (Diptera: Culicidae). *Iran. J. Publ. Health*, 14: 1-12.
- Zaim, M., A.V. Manouchehri and M.R.Y. Ershadi, 1986. Mosquito fauna of Iran (Diptera: Culicidae) 3-*Culiseta*, *Coquillettidia*, *Uranotaenia*. *Iran. J. Publ. Health*, 15: 1-9.
- Zaim, M., 1987. The distribution and larval habitat characteristics of Iranian Culicinae. *J. Am. Mosq. Control Assoc.*, 3: 568-573.