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RESEARCH ARTICLE

Seasonal Dynamics of Mosquitoes (Diptera: Culicidae) in Animal Barns and Houses in Aras Valley, Turkey [1] [2]

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Summary

A total of 8,923 mosquitoes of the twelve species present were collected from animal barns and houses in Aras Valley during June-October 2007 period. The most dominant species was *Ae. dorsalis* (42.2% of total catch) followed by *Cx. theileri* (26.54%), *Ae. vexans* (17.86%) and *An. maculipennis* s.l. (5.74%). More specimens (1630.5 specimens/habitat) in rural habitats were caught than the ones (184,7 specimens/habitat) in suburban habitats. While 4% of samples were caught from houses (71 specimens/house), 96% were caught from animal barns (714 specimens/animal barn). The highest samples were collected in June (n= 5.621) and the lowest in October (n= 129). The population density of *Ae. dorsalis*, *Cx. theileri* and *Ae. vexans* reached their peaks in June, *An. maculipennis* s.l. and *Cx. pipiens* in August.

Keywords: *Mosquitoes, Light traps, Animal barns, Aras Valley, Turkey*

Aras Vadisi'ndeki (Türkiye) Hayvan Ahırları ve Evlerdeki Sivrisineklerin (Diptera: Culicidae) Mevsimsel Dinamizmleri

Özet

Haziran-Ekim 2007 döneminde Aras Vadisi'ndeki hayvan ahırları ve evlerden ışık tuzakları ile on iki sivrisinek türüne ait toplam 8.923 birey toplandı. En dominant türün *Ae. dorsalis* (toplam yakalananların %42.2'si) olduğu, bu türü *Cx. theileri* (%26.54), *Ae. vexans* (%17.86) ve *An. maculipennis* s.l.'nin (%5.74) takip ettiği belirlendi. Kırsal alanlardaki habitatlarda yakalanan birey sayısı (1630,5 birey/habitat) kentsel alanlardaki birey sayısından (184.7 birey/habitat) daha fazlaydı. Örneklerin %4'ü evlerden (71 birey/ev), %96'sı ahırlardan (714 birey/ahır) toplandı. En fazla örnek Haziran (n= 5.621), en az örnek ise Ekim ayında (n= 129) toplandı. *Ae. dorsalis*, *Cx. theileri* ve *Ae. vexans* populasyon büyüklüğü Haziranda, *An. maculipennis* s.l. ve *Cx. pipiens*'in ise Ağustos ayında en yüksek noktaya ulaştı.

Anahtar sözcükler: *Sivrisinekler, Işık tuzakları, Ahırlar, Aras Vadisi, Türkiye*

INTRODUCTION

Mosquitoes are potential vectors of some important diseases for humans and animals [1,2]. Apart from mosquito borne diseases, mosquitoes cause nuisances for both humans and animals when they are abundant. Nuisances caused by mosquitoes decrease milk production and reduce weight of domestic animals [3,4]. Animal barns and houses are very suitable feeding habitats for endophagic (indoor feeding) mosquitoes. Animal barns are also very suitable habitats for endophilic (indoor resting) mosquitoes [5]. The presence of cattle in homesteads tends to increase the man biting rate of *Anopheles arabiensis*, malaria vector, in Ethiopia [6]. The effect of pyrethroids applied on cattle, especially deltamethrin killing mosquitoes landing on the cattle, decreased the density of vector mosquitoes [7].

Malaria is an important human health problem for the Caucasian Region also covering the study area, Aras Valley [8]. After malaria outbreaks in the Aras Valley in 1990s, in addition to some studies performed in the Aras Valley, Romi et al.[9] in Armenia , Temel in Azerbaijan [10], and Yaghoobi-Ershadi et al.[11], Lak et al.[12], Vatandoost et

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al.[13] and Djadid et al.[14] in Northern Iran studied malaria vectors. In Iğdır Plain, located in Turkish side of the Aras Valley, some studies were performed related to bio-ecology of mosquitoes. The studies were the larvae of mosquito species [15], adult mosquito species outdoors [16], the biting activity of mosquitoes [17] and the control of mosquito larvae [18].

In this study, our objectives were to determine composition and seasonal dynamics of mosquito species in indoor habitats (animal barns and houses) in Iğdır Plain. We hope this study will contribute to mosquito control activities and acquiring more information about bio-ecology of mosquito species in the area.

MATERIAL and METHODS

Study Area and Sampling Method

The study was performed in Iğdır Plain of Aras Valley. Aras River forms the Turkey-Armenia border in the north of the plain, and Ararat Mountain (Ağrı Dağı), the highest mountain in Turkey (5.137 m.), is situated in the south. There are tens of villages in study area where agriculture and stockbreeding are common. Because of appropriate climatic factors, bad drainage system, high underground water level and high salinity, the density of mosquitoes is high in Aras Valley [15,16]. There are numerous large and small drainage canals built by DSI (Public Waterworks Administration) in the plain. These permanent drainage canals and temporary standing water are quite suitable for mosquito breeding [15].

A total seventeen indoor habitats (five houses, twelve animal barns) were selected for collecting adult mosquitoes in four different residential areas in Aras Valley. Sürmeli (Pirli) Village was considered as rural area, and Küllük, Akyumak Villages and Iğdır 7 Kasım Street were considered as suburban areas *(Fig. 1)*. Stockbreeding was common in all of the residential areas selected as sampling sites. In Sürmeli Villages larval sites were more limited than other residential areas.

A New Jersey light trap (NJLT), containing 40 watt light bulbs, was installed in each indoor habitat for mosquitoes sampling. NJLTs were activated for one night per month from June to October 2007. The traps were operated between 18.^{00} h and 06.^{00} h. Specimens were transferred into previously prepared tubes from the traps and stored into dry-ice boxes. The specimens were brought to the laboratory to identify the species and the recording of sex [19,20].

Determining the Density and Distribution of Mosquito Species

The density (relative abundance) and distribution of mosquito species in the area was calculated according to the following formulas [21].

1. Density was expressed as percent of specimens of the species in the whole sample, according to the formula:

D=l/L x 100%

where: D-density, l-number of specimens of each mosquito species, L-number of all specimens.

Dominant species (D>5%),

Subdominat species (1<D<5%),

Satellite species (D<1%).

2. Distribution was determined as the percent of sampling sites in which a species was noted, according to the formula:

C= n/N x 100%

Fig 1. Location of indoor habitats where mosquito sampled in Aras Valley

Şekil 1. Aras Vadisi'nde sivri-sineklerin örneklendiği kapalı habitatların lokasyonu

where: C- distribution, n- number of sites of the species, N- number of all sites.

C1 - sporadic appearance (constancy 0 - 20%)

C2 - infrequent (20.1 - 40%)

C3 - moderate (40.1 - 60%)

C4 - frequent (60.1 - 80%)

C5 - constant (80.1 - 100%)

RESULTS

Mosquito Species and Their Relative Density

A total of 8.923 mosquitoes of the twelve species present were collected during the study. The most dominant species was *Aedes dorsalis* (42.2% of total catch) followed by *Culex theileri* (26.54%), *Aedes vexans* (17.86%) and *Anopheles maculipennis* s.l. (5.74%) *(Table 1). Ae. vexans,* one of the dominant species, had moderate distribution, the others dominant species had constant distribution. Although *Culex pipiens* was a sub-dominant species, it had constant distribution. From collected satellite species, while *Culiseta annulata* had only moderate distribution, the others had sporadic distribution *(Table 1).*

Male/female ratio of all collected mosquito specimens was 1.26% (111/8.812). While this ratio was high for *Cs. longiareolata* (1/1), *Cx. pipiens* (75/296) and *An. maculipennis* s.l. (8/505), the male of some species could not be caught *(Cx. territans, Cs. annulata An. hyrcanus, An. superpictus* and *Cq. richiardii).*

Unfed females/total females ratio of the caught samples was 21.14% (1.863/ 8.812). While this ratio was quite high for *Cx. pipiens* (67.23%), it was 26.6, 11.5, 9.2, 31.7, 26.5% for *Ae. dorsalis, Cx. theileri, Ae. vexans, An. maculipennis* s.l., and *Ae. caspius,* respectively. The number of fed female (5.671) was more than sub gravid (311), half gravid (396) and gravid females (571).

Monthly Changes in Population Fluctuations

The population fluctuations of six common species during June - October period are shown in *Fig. 2.*

Six mosquito species could be sampled continiously during the study period *(Fig. 2). Ae. dorsalis,* the most dominant species in the field, reached its peak in June (n=3.216). After June the population density of *Ae. dorsalis* decreased rapidly, this decrease continued in July (n=265) and the lowest population density was measured in October (n=18). The population fluctuation of *Ae. vexans,* the third dominant species in the field, was quite similar to that of *Ae. dorsalis.* The largest peak of *Ae. vexans* was in June (n=1.206). Since June, the population density of *Ae. vexans* continued to decrease in July (n=325) and August (n=58) dramatically. The number of the specimens was very low in September (n=3) and October (n=2). *Ae. caspius* reached its peak in June (n=137). The population density of *Ae. caspius* decreased greatly in July (n=7). The second largest peak in the number of adults was recorded in August (n=53). Like other *Aedes* species, the population density of *Ae. caspius* was very low in September (n=14) and October (n= 5).

The most *Cx. theileri,* the second dominant species, was caught in June (n=934) like *Aedes* species. The population density of *Cx. theileri* decreased during July (n=610) and August (n=384) period. The number of *Cx. theileri* increased in September (n=435), and a dramatic decrease was observed again in October (n=6). The lowest number of *Cx. pipiens* was in June (n=16). *Cx. pipiens* reached its peak in August (n=144), and slight fluctuations were observed during September (n=62) and October (n=68) periods. All of *Cx. territans* were caught in June (n=35).

Anopheles maculipennis s.l. reached its peak in August (n=238). During September (n=94) and October (n=27) periods the density of the species continued to decrease *(Fig 2).* The population fluctuation of *An.*

Table 1. *The density (%) and distribution (%) of mosquito species collected in animal barns and houses in Iğdır Plain*

Tablo 1. *Iğdır Ovası'nda hayvan ahırları ve evlerden toplanan sivrisinek türlerinin dağılımı (%) ve yoğunluğu (%)*

Mosquito species	No of specimens	Density (%)	Density criteria	Distribution (%)	Distribution criteria
Aedes dorsalis (Meigen)	3.766	42.2	Dominant	82.4	Constant
Culex theileri Theobald	2.369	26.54	Dominant	94.1	Constant
Aedes vexans (Meigen)	1.594	17.86	Dominant	52.9	Moderate
Anopheles maculipennis s.l. Meigen	513	5.74	Dominant	82.4	Constant
Culex pipiens L.	371	4.16	Subdominant	94.1	Constant
Aedes caspius (Pallas)	216	2.42	Subdominant	52.9	Moderate
Culex territans Walker	35	0.39	Satellite	11.8	Sporadic
Culiseta annulata (Schrank)	27	0.3	Satellite	41.2	Moderate
Anopheles hyrcanus (Pallas)	19	0.21	Satellite	17.6	Sporadic
Anopheles superpictus Grassi	10	0.11	Satellite	17.6	Sporadic
Culiseta longiareolata (Macquart)	2	0.02	Satellite	5.9	Sporadic
Coquillettidia richiardii (Ficalbi)	1	0.01	Satellite	5.9	Sporadic

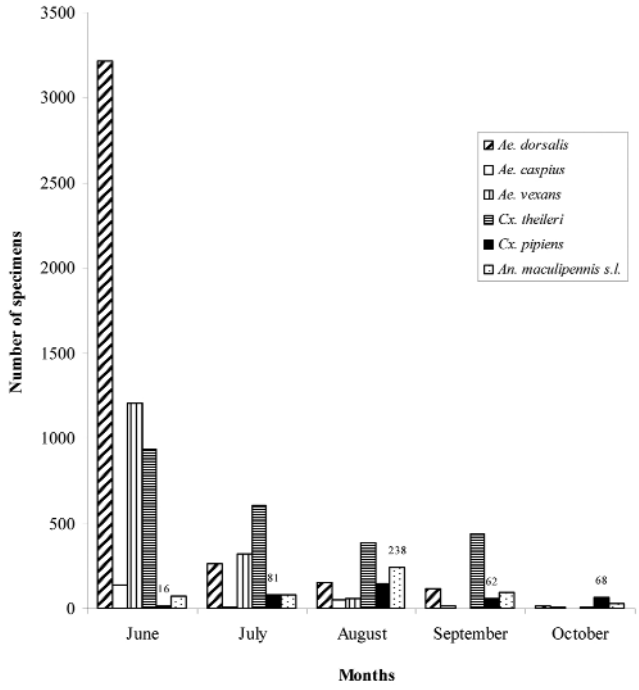

Fig 2. Monthly population fluctuations of six adult mosquito species in the study area

Şekil 2. Çalışma alanında altı ergin sivrisinek türünün aylık populasyon dalgalanmaları

Table 2. *The number (n) and relative abundance (%) of mosquito species caught in indoor habitats of rural and suburban areas of Iğdır Plain*

Tablo 2. *Iğdır Ovası'nın kırsal ve yarı kentsel alanlarındaki kapalı habitatlarda yakalanan sivrisinek türlerinin bolluk (%) ve sayıları (n)*

Mosquito species	Rural area		Suburban area	
	n	%	n	%
Ae. dorsalis	3.024	46.37	742	30.9
Cx. theileri	1.623	24.89	746	31.07
Ae. vexans	1.513	23.2	81	3.37
An. maculipennis s.l.	158	2.42	355	14.79
Cx. pipiens	10	0.15	361	15.04
Ae. caspius	117	1.8	99	4.12
Cx. territans	35	0.54	-	-
Cs. annulata	20	0.31	7	0.29
An. hyrcanus	10	0.15	9	0.37
An. superpictus	10	0.15	-	-
Cs. longiareolata	1	0.015	1	0.04
Cq. richiardii	1	0.015	-	-
Total	**6.522**	**100**	**2.401**	**100**

hyrcanus was similar to that of *An. maculipennis* s.l. The number of caught *An. hyrcanus* was one in June and two in July, the species reached its first peak in August (n=11) and second peak in September (n=5), and no *An. hyrcanus* could be caught in October. *An. superpictus,* found in Iğdır Plain for the first time with this study, was caught in July (n=1), September (n=8) and October (n=1) periods.

Despite the low population, *Cs. annulata,* which was sampled continuously, reached first peak in August (n=14)

Table 3. *The number (n) and relative abundance (%) of mosquito species caught in houses and animal barns of Iğdır Plain*

Tablo 3. *Iğdır Ovası'ndaki evler ve hayvan ahırlarında yakalanan sivrisinek türlerinin bolluk (%) ve sayıları (n)*

Mosquito species	Houses		Animal barns	
	n	%	n	%
Ae. dorsalis	211	59.44	3.555	41.49
Cx. theileri	23	6.48	2.346	27.38
Ae. vexans	76	21.41	1.518	17.72
An. maculipennis	15	4.23	498	5.81
Cx. pipiens	30	8.45	341	3.98
Ae. caspius	-	-	216	2.52
Cx. territans	-	-	35	0.41
Cs. annulata	-	-	27	0.31
An. hyrcanus	-	-	19	0.22
An. superpictus	-	-	10	0.11
Cs. longiareolata	-	-	2	0.02
Cq. richiardii	-	-	1	0.01
Total	**355**	**100**	**8.568**	**100**

and second peak in September (n=7). On the other hand, total two specimens of *Cs. longiareolata* were caught in July and September. Only one specimen of *Cq. richiardii* could be caught in July.

While *Ae. dorsalis* (57.21%) and *Ae. vexans* (21.46%) had the highest relative abundance in June, *Cx. theileri* had the highest relative abundance in July (44.36%), August (36.47%) and September (58.39%). *Cx. pipiens* was the most dominant in October (52.71%).

63% (n=5.621) of total 8.923 specimens, belonging to twelve mosquito species, was caught in June. Significant difference in the total mosquito number was found between sampling periods (P<0.05). The second largest adult peak in the number of adults was recorded in July (n=1.375, 15.41%). The number of total specimens continued to decrease in August (n=1.053, 11.8%) and September (n=745, 8.35%), and only 129 specimens (1.45%) could be caught in October.

Species Composition of the Mosquitoes in Rural and Suburban Habitats

While twelve mosquito species were sampled in rural areas (four habitats), nine species were sampled in suburban areas (thirteen habitats). The contribution of the habitats of the rural areas to total mosquito specimens was 73% (1630.5 specimens/habitat). On the other hand, this ratio was only 27% (184.7 specimens/habitat) in suburban habitats *(Table 2).*

Aedes dorsalis and *Cx. theileri* were sampled abundantly both in rural and suburban habitats. While *Ae. vexans* had high relative abundance in rural areas, *An. maculipennis* s.l., *Cx. pipiens* and *Ae. caspius* were sampled abundantly from suburban habitats. *An. superpictus, Cx. territans*

and *Cq. richiardii* could be sampled only from habitats of rural areas *(Table 2).*

Species Composition of Mosquitoes in Animal Barns and Houses

Nearly 4% of specimens were sampled from houses (71 specimens/house) and 96% were sampled from animal barns (714 specimens/animal barn) *(Table 3).* Although all of twelve mosquito species were collected from animal barns, only five species of them were collected from houses. The relative abundance of *Ae. dorsalis, Ae. vexans* and *Cx. pipiens* were more in houses than in animal barns. On the other hand, the relative abundance of *Cx. theileri* was more in animal barns than in houses *(Table 3).* There was significant difference in total mosquito number between animal barns ($P<0.05$). On the other hand, no significant difference in the total mosquito number between the houses ($P>0.05$).

DISCUSSION

In this study, *Aedes* species *(Ae. caspius, Ae. dorsalis* and *Ae. vexans), Cx. theileri* and *Cx. territans* were mostly collected in June. We detected that the population density of these species in indoor habitats decreased after June *(Fig 2).* Contrary to our findings, in the previous studies performed in the area, it had been determined that adult population density in outdoor habitats and larval density of both *Aedes* species and *Cx. theileri r*eached their peaks during July-August period [15,16]. In our opinion, climatic factors might have influenced the decrease of population density of *Aedes* species, *Cx. theileri* and *Cx. territans* in indoor habitats since June. According to recent data for seventeen years (1990-2006) obtained from Iğdır weather station, average temperature in June (23.1°C) was lower than the ones in July (26.2°C) and August (25.9°C) [22]. Besides, since June, precipitation decreases and vegetation growth as a result of agricultural activities. Increase of air temperature and vegetation growth may cause these mosquito species to have more exophilic behavior (outdoor resting behavior). It was found that an increase of air temperature at the beginning of summer caused decrease at endophilic behavior (indoor resting behavior) and an increase at exophilic behavior of these mosquito species. This finding is of great importance for future mosquito control activities in indoor habitats. According to our findings, June, in which *Aedes* species, *Cx. theileri* and *Cx. territans* have high population, is the most appropriate starting point for efficient mosquito control activities in indoor habitats.

We detected that the population density of *An. maculipennis* s.l. and *Cx. pipiens* was highest in August. The larval population density of these species was highest in July-August period in Iğdır Plain [15]. Population fluctuations of *An. maculipennis* s.l. and *Cx. pipiens* showed similar character to the population fluctuations in the studies previously performed in the area [15,16]. This similarity may be caused by the intensive endophilic behavior of these species.

We could sample three *Anopheles* species *(An. maculipennis* s.l.*, An. hyrcanus* and *An. superpictus)* in the area. The ratio of *Anopheles* specimens to other specimens was only 6.46% (542/8.381). In our opinion, in fact the ratio of *Anopheles* specimens must have been higher in indoor habitats. The reason, why *Anopheles* specimens were caught in low numbers, might result from low attraction of these species to the light traps we used for sampling. A great deal of variability is possible in the attraction of mosquitoes to light traps and the accuracy of data resulting from light trap collections [23]. The ratio of *Anopheles* larvae to other mosquito larvae was 30% in Iğdır plain [15]. On the other hand, the ratio of Anophelines to Culicines was very high in animal shelter in Armenia [9].

Anopheles sacharovi is main malaria vector in Armenia [9], Azerbaijan [10] and Northern Iran [11,12] for malaria outbreaks in Ararat Valley in 1990s. Even though we did not detect in this study, in a previous study we performed in Aras Valley, the ratio of *An. sacharovi* in *An. maculipennis* complex *(An. maculipennis* s.l.*)* was 6.5% and the other specimens in the complex were *An. maculipennis* [15]. In northwest of Iran near Armenia-Azerbaijan border, *An. sacharovi* and *An. maculipennis* may be main malaria vectors; *An. superpictus* Grassi and *An. hyrcanus* may be secondary malaria vectors [13]. On the other hand, more data are needed in order to determine the role of *Anopheles* species in malaria transmissions in Northern Iran [13,14].

The mosquito population density (1630.5 specimens /habitat) and species diversity (twelve species) in rural habitats were more than density (184.7 specimens /habitat) and diversity (nine species) in suburban habitats *(Table 2).* This phenomenon may result absence of mosquito control in rural areas and the existence of more indoor habitat for the resting of mosquitoes in suburban areas.

That the number of the collected mosquitoes in houses (71 specimens/house), was less than the ones in animal barns (714 specimens/animal barn) was an expected result *(Table 3).* This phenomenon can be resulted from the existence high relative humidity, camouflage sites and hosts for blood sucking mosquitoes in animal barns. Besides, physical and chemical control against mosquitoes in houses may be influential on our results.

Though no malaria cases have been recorded in Iğdır

Plain since 2005 [24], malaria is endemic in Aras Valley [8]. It is very important to determine the bio-ecology of *Anopheles* species, potential malaria vector, for malaria epidemic control activities in the area. In addition to Aras Valley is located on bird migration route and 190 bird species was observed in the Valley [25]. It is very important for vectoral status of *Culex* species, especially for West Nile Virus transmission in the area. In this study, total relative abundance of *Ae. dorsalis* (42.2%), *Ae. caspius* (2.4%) and *Ae. vexans* (17.9%) was found 62.5%. These three species are the most important vectors for Tahyna virus, which is present in most countries of central and southern Europe [26]. There are no data related to Tahyna virus in the study area.

Culiseta annulata (0.3%) and *An. superpictus* (0.11%), which had low density, were first record for Iğdır Plain. We detected that *Ae. dorsalis* (42.2%) was the most dominant species in the area. *Ae. dorsalis* was the most dominant species in the previous studies in the area [15-17]. This findings show that *Ae. dorsalis* has adapted well in Iğdır Plain.

According to the findings in this study, we think that mosquito control in indoor habitats can be effective for mosquito population decrease in the area. As a result of decline of mosquito-human and mosquito-animal contact, nuisance and diseases caused by mosquitoes in the area will be reduced.

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