

## Seasonal dynamics and nocturnal activities of mosquitoes (Diptera: Culicidae) in the Aras Valley, Turkey\*

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**Abstract:** Species composition, nocturnal activity and population dynamics of mosquitoes in the Aras Valley of Turkey are studied. Seven New Jersey light traps were activated two nights per month at different sampling sites showing various habitats such as riverside, orchard, roadside, village, wooded area, agricultural area and pasture in 30 km<sup>2</sup> area. The night was divided into 6 equal nocturnal periods (18<sup>00</sup>-20<sup>00</sup> h, 20<sup>00</sup>-22<sup>00</sup> h, 22<sup>00</sup>-24<sup>00</sup> h, 24<sup>00</sup>-02<sup>00</sup> h, 02<sup>00</sup>-04<sup>00</sup> h, 04<sup>00</sup>-06<sup>00</sup> h), and the specimens were collected in consecutive 2 hours. From June to September 2006, 2415 specimens representing 6 species were collected. The most dominant species was *Oc. dorsalis* (72.13% of total specimens) followed by *Cx. pipiens* (12.05%) and *Cx. theileri* (9.44%).

**Key Words:** *Ochlerotatus dorsalis*, mosquitoes, population fluctuations, light traps, Aras Valley

### Aras Vadisi'ndeki (Türkiye) sivrisineklerin (Diptera: Culicidae) mevsimsel dinamikleri ve nokturnal aktiviteleri

**Özet:** Türkiye'nin Aras Vadisi'ndeki sivrisineklerin tür kompozisyonu, nokturnal aktiviteleri ve popülasyon dinamikleri araştırıldı. Yedi ışık tuzağı, her ay iki gece, yaklaşık 30 km<sup>2</sup> alandaki nehir kenarı, meyva bahçesi, yol kenarı, köy, ağaçlık alan, tarım alanı ve mera gibi değişik habitatlarda çalıştırıldı. Gece, altı eşit zaman dilimine bölünerek (18<sup>00</sup>-20<sup>00</sup> s, 20<sup>00</sup>-22<sup>00</sup> s, 22<sup>00</sup>-24<sup>00</sup> s, 24<sup>00</sup>-02<sup>00</sup> s, 02<sup>00</sup>-04<sup>00</sup> s, 04<sup>00</sup>-06<sup>00</sup> s), her iki saat sonunda tuzaklardaki örnekler toplandı. Haziran-Eylül 2006 periyodunda, altı türe ait 2.415 birey toplandı. En dominant türün *Oc. dorsalis* (toplam örneklerin %72,13'ü) olduğu ve bu türü, *Cx. pipiens* (%12,05) ile *Cx. theileri*'nin (%9,44) takip ettiği belirlendi.

**Anahtar Sözcükler:** *Ochlerotatus dorsalis*, sivrisinekler, popülasyon dalgalanmaları, ışık tuzakları, Aras Vadisi

#### Introduction

It is essential to have knowledge about the abundance and species composition of mosquitoes in the given area so as to perform and evaluate an influential mosquito control program (Reinert, 1989).

The study area in the Aras Valley is about several hundred meters from the Armenian border and about 50-60 km from the Nakhichevan (Azerbaijan) and the Iranian border. The area is an important ecological corridor where desert fauna come into Anatolia

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(Demirsoy, 2002). Because of its appropriate climatic conditions and some artificial features such as irrigation systems and agricultural areas, the study area is a suitable environment for breeding mosquitoes. In recent studies, *Anopheles sacharovi*, a proven malaria vector, was rediscovered in the Ararat Valley (the Aras Valley) (Romi et al., 2002; Aldemir et al., 2009). Malaria is an important human health problem for the Caucasian Region including the study area, the Aras Valley (WHO, 2001; 2007). In addition, as a result of global warming, the possibility of emergence of other diseases transmitted by mosquitoes may increase in the area.

Detailed information on the biology and ecology of the mosquito fauna of the region is necessary for the development of ecologically sensitive and efficient mosquito control strategies. The present work is a part of a larger study on the bio-ecology of mosquitoes in the Aras Valley between 2004 and 2007, and provides data on three important aspects of mosquito biology in the Aras Valley: species composition, seasonal population dynamics and nocturnal activity patterns of the species.

**Materials and methods**

**Study area and sampling method**

The study was performed in the Iğdır Plain located in the Aras Valley. In the north of the plain, the Aras

River forms the Turkish-Armenian border, and Ararat Mountain, the highest mountain in Turkey (5182 m), is situated in the south. The plain has salty soil because of alluvium carried by the Aras River and materials from volcanic Ararat Mountain. It is 850 meters above sea level. About 70,000 hectare of the plain is cultivated. Cotton was the main agricultural product in this area previously but at present fruit, sugar beet, wheat, barley, leguminous seeds and various vegetable are cultivated. Together with permanent drainage canals and ponds in the plain, drainage water and temporary standing water from flooding is favorable mosquito breeding sites (Demirci, 2006).

7 New Jersey light traps (NJLTs) containing 40 watt light bulbs were installed in nearly 30 km<sup>2</sup> of area for mosquitoes sampling. While installing these traps, the habitats were chosen according to their different ecological characteristics, and to be as far as possible from one another (Alten et al., 2000; Çağlar et al., 2003). Because of the temporary mosquito breeding sites in the area, the distances of sampling habitats from the breeding sites were not fixed. 7 stations in the area and their characteristics are shown in Figure 1.

NJLTs were placed 1.5 m above ground, and they were activated for 2 nights per month from June to September 2006. The traps were operated between 18<sup>00</sup> and 06<sup>00</sup> h, and they were emptied at regular



Figure 1. The study area and location of light traps (Mba: the nearest mosquito breeding area from habitat, Ls: various light sources 30-40 m from habitat).

intervals so as to divide the night into six 2-hour periods (18<sup>00</sup>-20<sup>00</sup> h, 20<sup>00</sup>-22<sup>00</sup> h, 22<sup>00</sup>-24<sup>00</sup> h, 24<sup>00</sup>-02<sup>00</sup> h, 02<sup>00</sup>-04<sup>00</sup> h, 04<sup>00</sup>-06<sup>00</sup> h) (Çağlar et al., 2003).

Specimens were transferred into the previously prepared tubes from the traps at the end of each 2-hour period and stored in dry-ice boxes. The specimens were brought to the laboratory in the following morning in order to identify the species, and to record the sex (Harbach, 1985; Schaffner et al., 2001) and stages of gonotrophic development in females (Christophers, 1911).

No precipitation was recorded when the traps were activated. Wind speed measured at sampling stations was negligible (1-2 m/s); some light breezes of 3 m/s were recorded during the study period.

All data were tested for significance by one-way analysis of variance (ANOVA) with equal sample size.

## Results

### Mosquito species and their relative density

A total of 2415 mosquitoes of the six species present were collected during the study (Table 1). Of these, *Ochlerotatus dorsalis* (72.15% of the total), *Culex pipiens* (12.05%), *Culex theileri* (9.44%) were found to be dominant species (relative abundance > 5%); while *Aedes vexans* (3.35%) and *Ochlerotatus caspius* (2.32%) were subdominant species (1% < relative abundance < 5%), and *Anopheles hyrcanus* (0.7%) were satellite species (relative abundance < 1%) (Table 1). We also sampled some mosquito species such as *Culex territans* (n=5), *Culex modestus* (n=5),

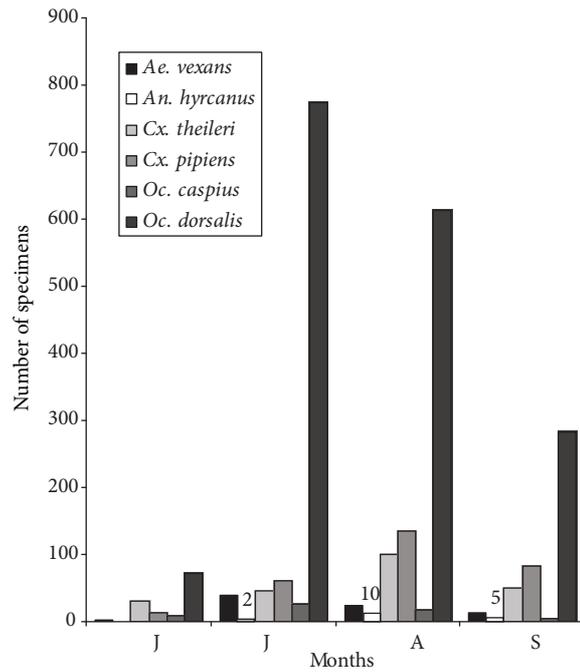


Figure 2. Monthly population fluctuations of 6 mosquito species in the study area.

*Culex tritaeniorhynchus* (n=1) and *Culiseta longiareolata* (n=4), however, these locally uncommon species accounted for a negligible amount of the total catch and were therefore not considered in this paper.

### Monthly changes in population fluctuations

The fluctuations that occurred between June and September in the population of the 6 common species are shown in Figure 2 and Table 1.

Table 1. Numbers of each species trapped expressed as percentages of the monthly mosquito catches.

Months	Total no of sampled mosquito		<i>Ae. vexans</i>		<i>An. hyrcanus</i>		<i>Cx. theileri</i>		<i>Cx. pipiens</i>		<i>Oc. caspius</i>		<i>Oc. dorsalis</i>	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
June	5.26	(127)	2.36	(3)	-	(0)	24.41	(31)	11.02	(14)	6.3	(8)	55.91	(71)
July	39.21	(947)	4.12	(39)	0.21	(2)	4.75	(45)	6.33	(60)	2.74	(26)	81.84	(775)
August	37.30	(901)	2.77	(25)	1.11	(10)	11.21	(101)	14.87	(134)	1.89	(17)	68.15	(614)
Sept	18.22	(440)	3.19	(14)	1.14	(5)	11.59	(51)	18.86	(83)	1.14	(5)	64.09	(282)
Total	100	(2415)	3.35	(81)	0.7	(17)	9.44	(228)	12.05	(291)	2.32	(56)	72.13	(1742)

In the study area, the dominant species throughout most of the study period was *Oc. dorsalis* ( $P < 0.05$ ). The number of the individuals increased from June to August. The largest peak of *Oc. dorsalis* was in July ( $n=775$ ,  $P < 0.05$ ). The second largest peak in the number of adults was recorded in August ( $n=614$ ) under optimal climatic conditions in an assortment of breeding sites, after which the total number of adults trapped decreased until October when this species was almost completely absent from mosquito fauna. In July and August, there were highly significant differences ( $P < 0.05$ ) in population density between *Oc. dorsalis* and the other species.

*Cx. pipiens*, the second most common species in the study area, was found from June to September. The population density of this species increased in July ( $n=60$ ), reaching its largest peak in August ( $n=134$ ). The lowest number of this species was found in June ( $n=14$ ).

*Cx. thileri* was also trapped from June to September, with a major peak in August ( $n=101$ ). This species had a pattern similar to that of *Cx. pipiens*. After the spring rainy season, the population density of this species began to increase in the middle of July, reaching its biggest peak in August ( $P < 0.05$ ), and began to decrease in September until it disappeared from the study area in late October.

*Ae. vexans* was found during 4 months in the study area. The highest number of adults sampled was in July ( $n=39$ ). It disappeared from mosquito fauna in October. Other species showed restricted seasonal occurrence. *Oc. caspius* occurred in June to September. The highest number of adults being collected in July ( $n=26$ ). *An. hyrcanus* was the satellite species throughout the study period and its highest peak was found in also August ( $n=10$ ).

The number of the total samples increased from July to September. The first peak occurred in July ( $n=947$ ) after the rainy season. The second largest peak in the number of adults was recorded in August ( $n=901$ ) under optimal climatic conditions in an assortment of breeding sites. The relative abundance of the general mosquito population was found to be almost the same ( $P=0.57$ ) in July and August (39% and 37%, respectively). The greatest part of the total relative abundance during the study period (76%) was

obtained in these 2 months. Other months had very low mosquito abundances: 5% in June and 18% in September (Table 1).

The number of mosquitoes sampled in the traps (Figure 3) differed significantly between nocturnal periods ( $P < 0.001$ ). The results indicated that nocturnal activity in the aggregate mosquito population increased from the 18<sup>00</sup>-20<sup>00</sup> h to the 20<sup>00</sup>-22<sup>00</sup> h period. The highest activity was found at the 20<sup>00</sup>-22<sup>00</sup> h period ( $P < 0.05$ ). This was followed by reduced activity during the 22<sup>00</sup>-24<sup>00</sup> h period and activity sharply reduced until the dusk period. Crepuscular activity was more pronounced during the dusk than the dawn period. While the most specimens were sampled in the 20<sup>00</sup>-22<sup>00</sup> h period (41.53% of total), the least were sampled at the 04<sup>00</sup>-06<sup>00</sup> h period (2.44%). The results showed that while 82.36% of the total specimens were caught at the first half of the night (from 18<sup>00</sup> to 24<sup>00</sup> h), 17.63% were sampled at the second half.

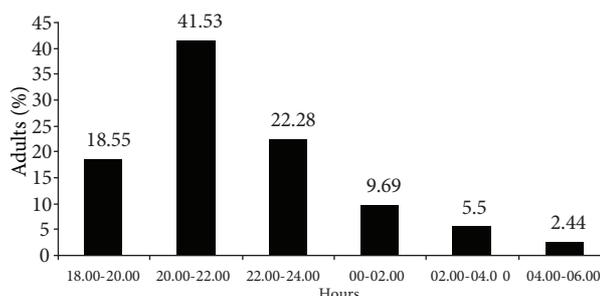


Figure 3. Percentage of the aggregate mosquito population trapped during different nocturnal periods.

When the captures of individual taxa during each nocturnal period are plotted as percentages of the total samples (Figure 4), it can be seen that the changes in the levels of activity between nocturnal periods slightly varied between species, though ANOVA analysis indicated the differences were not statistically significant. Nevertheless, with more pronounced fluctuations between numbers captured at different periods of the night, nocturnal activity profiles of *Oc. caspius* clearly differed from those of the other species, in which activity levels during all nocturnal periods were even more.

The highest level of *Oc. caspius* activity occurred during the 22<sup>00</sup>-24<sup>00</sup> h period (when 32.14% of this

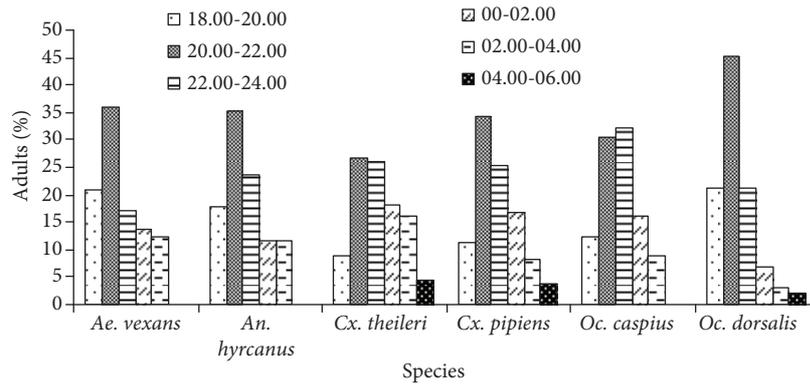


Figure 4. Range of activity during different nocturnal periods as measured by trap catches.

species were trapped). Lower catches during the 24<sup>00</sup>-02<sup>00</sup> h period were then followed by the 02<sup>00</sup>-04<sup>00</sup> h period of the lowest activity (8.93%). There were low trap densities of *Cx. pipiens* during the 18<sup>00</sup>-20<sup>00</sup> h (11.34%), the 24<sup>00</sup>-02<sup>00</sup> h (16.84%), the 02<sup>00</sup>-04<sup>00</sup> h (8.25 %) and 04<sup>00</sup>-06<sup>00</sup> (3.78 %) nocturnal periods, i.e. before and after peaks of high activity during the 20<sup>00</sup>-22<sup>00</sup> h (34.36%) and 22<sup>00</sup>-24<sup>00</sup> h (25.43%) periods. A long peak of *Cx. theileri* activity covering the 20<sup>00</sup>-22<sup>00</sup> h and 22<sup>00</sup>-24<sup>00</sup> h periods was followed by another, smaller peak during the 24<sup>00</sup>-02<sup>00</sup> h and 02<sup>00</sup>-04<sup>00</sup> h nocturnal periods.

*Ae. vexans*, *Oc. dorsalis* and *An. hyrcanus* were more active during the dusk (18<sup>00</sup>-20<sup>00</sup> h) period than the other species, when the respective catches amounted to 21%, 22% and 17% of the totals of these species. On the other hand, neither *Ae. vexans* nor *An.*

*hyrcanus* was active at dawn. The highest activity peak of *An. hyrcanus* was found at the 20<sup>00</sup>-22<sup>00</sup> h period. In contrast to the dusk period, activity levels of all the species were lowest during the dawn period.

The distribution pattern of mosquito species in the study area was found to be very regular in general. All the data showed that the resting and feeding behavior in the species and differences of breeding habitats between the sites affect the distribution of species. No significant differences were found in the relative abundance of the aggregate mosquito populations at all sites in the study area (P=0.05). Thus, the mosquito population showed widespread dispersion in the region during 4-month study period.

On the other hand, as can be seen in Table 2, significant differences in the relative abundance of species were found between sampling stations. For

Table 2. Total abundance of the 6 mosquito species at different sampling sites.

Habitat	<i>Ae. vexans</i>	<i>An. hyrcanus</i>	<i>Cx. pipiens</i>	<i>Cx. theileri</i>	<i>Oc. caspius</i>	<i>Oc. dorsalis</i>	Total
Riverside	4 (4.93%)	2 (11.76%)	49 (16.84%)	21 (9.21)	9 (16.07%)	46 (2.64%)	131 (5.43%)
Orchard		3 (17.64%)	28 (9.62%)	77 (33.77)	15 (26.78%)	316 (18.14%)	439 (18.17%)
Roadside	3 (3.70%)	4 (23.53%)	34 (11.69%)	38 (16.67)		85 (4.89%)	164 (6.79%)
Village	3 (3.70%)		11 (3.78%)	13 (5.71)	6 (10.71%)	53 (3.05%)	86 (3.57%)
Wooded area	8 (9.87%)	1 (5.88%)	15 (5.15%)	42 (18.42)	4 (7.15%)	106 (6.08%)	176 (7.28%)
Agriculture area	14 (17.31%)	2 (11.76%)	46 (15.81%)	16 (7.01)	4 (7.15%)	257 (14.75%)	339 (14.04%)
Pasture	49 (60.49%)	5 (29.43%)	108 (37.11%)	21 (9.21%)	18 (32.14%)	879 (50.45%)	1080 (44.72%)
Total	81 (100%)	17 (100%)	291 (100%)	228 (100%)	56 (100%)	1742 (100%)	2415 (100%)

instance, *Ae. vexans* (60.49%) and *Oc. dorsalis* (50.45%) were sampled mostly in pasture habitats, and the numbers of these species were significantly different among sites ( $P < 0.05$ ). Although there was no significant difference ( $P > 0.05$ ), *Cx. pipiens* was also mostly sampled in pastures (37.11%).

Some species were not sampled in some habitats, for instance, *Ae. vexans* at orchards, *Oc. caspius* at roadsides and potential malaria species *An. hyrcanus* at settlements.

## Discussion

In a previous study performed in the temporarily breeding sites, the dominant species was found to be *Oc. dorsalis* in part of the study area (Aldemir et al., 2009). Relative abundance of *Cx. theileri* larvae (27.1%) in the Aras Valley was higher than that of *Cx. pipiens* larvae (3.54%) (Demirci, 2006). Similar to this finding, the results of human bait collections performed in the Iğdır Plain showed that the relative abundance of *Cx. theileri* (9.25%) was also higher than that of *Cx. pipiens* (1.49%) (Aldemir et al., 2007). However, in this study, *Cx. pipiens* (12.05%) were sampled more frequently than *Cx. theileri* (9.44%) by light traps. This result indicates that light sources are more attractive for *Cx. pipiens* than *Cx. theileri*. In a similar study performed by light traps in Ankara (Aldemir and Boşgelmez, 2006), the authors sampled more *Cx. pipiens* adults (29.3%) than *Cx. theileri* (12.51%) by light traps. 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 (Reinert, 1989).

7 mosquito species were sampled by light traps in Belek area, in the Mediterranean region of Turkey presenting *Oc. caspius* (29.48%), *Cx. tritaeniorhynchus* (29.03%), *Cx. pipiens* (19.61%), *Oc. dorsalis* (9.52%), *Ae. cretinus* (6.4%), *Cs. annulata* (5.81%), and *Ae. vexans* (0.2%) (Alten et al., 2000). In contrast to this study, a higher amount of *Oc. dorsalis* adults (72.15%) was sampled in this work than *Oc. caspius* (2.32%) by light traps in our study area. That may be explained by adaptation of *Oc. dorsalis* to higher altitude than lower. Although the relative abundance of *Ae. vexans* (3.35%) was not found to be high, the adaptation of this species to higher elevations might be also better than to sea level near the Mediterranean.

The only species from the Anopheline subfamily, *An. hyrcanus* was found with low relative abundance (0.7%) in the area. According to Demirci (2006), larval relative abundance of *An. hyrcanus* was quite low (0.16%) in the Aras Valley. Similar to our result, *An. hyrcanus* was found to be an uncommon species (1.54% of total samples) in the study carried out in Belek and Titreyen Lake, Antalya (Boşgelmez et al., 1995). On the other hand, in the northwest of Iran (East-Azerbaijan province), only 150-200 km far from our study area, Vatandoost et al. (2005) found that 73.07% of *Anopheles* species ( $n=26$ , female) collected by light traps in houses and stables was *An. hyrcanus*. We collected most of the *An. hyrcanus* adults in August. It was reported that the dominant species of *Anopheles* sampled by various methods in the southeast of France (in Camargue) was *An. hyrcanus* and that this species had high level of antropophily and it reached its peak in August (Ponçon et al., 2007).

*Ae. vexans* reached its highest peak at the 20<sup>00</sup>-22<sup>00</sup> h period after dusk and it reached its second and third peaks at the 18<sup>00</sup>-20<sup>00</sup> h and 22<sup>00</sup>-24<sup>00</sup> h periods. *Ae. vexans* will feed in shady places during the day; however, they are very active at dusk and vigorously seek blood meals at this time. Peak activity appears to be thirty to forty minutes after sunset (Thompson and Dicke, 1965). Çağlar et al. (2003) determined that *Oc. dorsalis* were collected by light traps (72%) rather than CO<sub>2</sub> traps (28%), and this species reached its the highest activity at the 20<sup>00</sup>-22<sup>00</sup> h nocturnal period and the lowest was found at the 04<sup>00</sup>-06<sup>00</sup> h period in Antalya. Sampling rate of *Oc. dorsalis* in Antalya at different nocturnal periods was similar to our results. In the same study performed in Antalya, it was also determined that the period in which *Oc. caspius* and *Cx. pipiens* had lowest number was the 04<sup>00</sup>-06<sup>00</sup> h period. According to Çağlar et al. (2003), *Oc. caspius*, *Oc. dorsalis* and *Cx. pipiens* were very active during the dusk (18<sup>00</sup>-20<sup>00</sup> h); the dusk period (twilight) is also more favorable for *Cx. pipiens*.

Placement variations refer to the variability of light trap collection due to the location of the trap. The variables between locations include the proximity to a mosquito source, the degree of protection from wind in the preferred activity and resting areas, and the proximity to artificial background light (Reinert, 1989). A big part of aggregate mosquito populations was collected by light traps installed in pasture,

orchard and agricultural area (44.72%, 18.17% and 14.04% of total samples, respectively). These 3 sampling sites were closer to the mosquito breeding areas and farther from other light sources compared with other sites. Collecting low number of specimens in riverside (5.43%) can be explained with its being far from mosquito breeding areas. Wooded area was about 100 m away from the village and 50-60 m away from mosquito breeding sites. The rate of the mosquito adults collected from sampling station in wooded area was not high (7.28%), as expected. In our opinion, the result can be explained by obstruction of the trap light due to high tree density in a 20-30 m radius around the station.

Both physical control activities against mosquito larvae and informing local people about control activities are of great importance. Although nuisance caused by mosquitoes are quite high in the study area, local people does not apply any control and individual protection methods against mosquito biting, so they indirectly contribute to increasing mosquito populations. Physical control activities and informing

local people about mosquito control activities will also contribute to Roll Back Malaria in The Trans-Caucasian Countries and Turkey (WHO, 2001). The Roll Back Malaria Project advises strengthening cross-border collaboration for solving malaria-related problems. In addition, basic scientific knowledge contributes to integrated control activities. This study reveals, for the first time, certain aspects of the spatial and temporal patterns, seasonal abundance, and species composition of mosquitoes in the Aras Valley. However, a better understanding of these distribution patterns can be achieved only by further research concentrating on the ecology of breeding sites and on the migration and dispersal patterns of adult mosquitoes.

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