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Population Dynamics of Adults and Immature Stages of Mosquitoes (Diptera:Culicidae) in Gölbaşı District, Ankara*

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Abstract: In studies carried out from January 2001 to December 2002 in Ankara-Gölbaşı district, 9 mosquito species (*Anopheles sacharovi*, *An. maculipennis*, *An. claviger*, *Culex mimeticus*, *Cx. pipiens*, *Cx. theileri*, *Culiseta annulata*, *Cs. longiareolata* and *Ochlerotatus caspius*) were determined. The population estimations of immature stages were performed in 15 breeding habitats such as lake edge, swamp, wet pasture, canal and pond. The species that had the most sampled immature stages was *Cx. pipiens* (29.30%); *An. sacharovi* (18.93%) and *An. maculipennis* (17.47%) followed it. The samplings of adult mosquitoes were performed in 5 stables and 5 light traps. The most abundant species collected from the stables were *An. maculipennis* (24.67%), followed by *An. sacharovi* (24.17%) and *Cx. pipiens* (18.78%). On the other hand, the most abundant species trapped in the light traps were *Cx. pipiens* (29.05%) and *Cs. annulata* (18.46%). Generally, an increase was observed in the population dynamics of the all mosquito species in the July- September period.

Key Words: Lake Mogan, mosquito, breeding habitats, population dynamics, abundance

Ankara-Gölbaşı'nda Sivrisineklerin (Diptera:Culicidae) Ergin ve Ergin Öncesi Populasyon Dinamizmi

Özet: Gölbaşı ilçesinde Ocak 2001 - Aralık 2002 süresince yapılan araştırmalarda dokuz sivrisinek türü (*Anopheles sacharovi*, *An. maculipennis*, *An. claviger*, *Culex mimeticus*, *Cx. pipiens*, *Cx. theileri*, *Culiseta annulata*, *Cs. longiareolata* and *Ochlerotatus caspius*) belirlenmiştir. Ergin öncesi populasyon sayımları göl kenarı, bataklık, mera, kanal ve havuz olmak üzere on beş habitatta yapılmıştır. Larva/pupası en fazla örneklenen tür *Culex pipiens* (%29,30) olup, bunu *An. sacharovi* (%18,93) ve *An. maculipennis* (%17,47) izlemektedir. Sivrisinek erginlerinin örneklenmesi beş ahır ve beş ışık tuzağında yapılmıştır. Ahırlarda en yoğun toplanan tür, *An. maculipennis* (%24,67) olup, bunu *An. sacharovi* (%24,17) ve *Cx. pipiens* (%18,78) izlemektedir. Işık tuzaklarında ise en fazla yakalanan türler *Cx. pipiens* (%29,05) ve *Cs. annulata* (%18,46)'dır. Genellikle, Temmuz-Eylül döneminde bütün sivrisinek türlerinin populasyon dinamizminde artış görülmüştür.

Anahtar Sözcükler: Mogan Gölü, sivrisinek, üreme habitatları, populasyon dinamizmi, bolluk

Introduction

Mosquitoes are very important vectors and extoparasites for humans and animals. Insect-borne diseases, such as malaria, lymphatic filariasis, yellow fever, dengue, Saint Louis encephalomyelitis, western equine encephalomyelitis, eastern equine encephalomyelitis and Japanese encephalitis are transmitted by mosquitoes. Among these diseases, the death rate caused by malaria is quite high. Currently, an estimated 2,073 million people living in 103 countries are at risk of malaria (Service, 1992).

Like many other countries, Turkey has also faced many epidemic cases due to mosquitoes. According to WHO (2001), a rather large proportion of the total population (nearly 44%) lives in areas where the risk of the explosive resumption of malaria transmission, leading to an outbreak, remains high in Turkey. Turkey is divided into 4 regions in terms of malaria risk and the study area belongs to Stratum III, which consists of Central Anatolia provinces. When parasites are brought from outside into Stratum III, malaria transmission occurs, and even local epidemics can be seen (Akdur, 1997).

* This study is a part of the doctoral dissertation by A. Aldemir.

Although there was no malaria transmission, according to public surveys mosquitoes were the major nuisance in the area (Aker and Uzan, 1999; Aldemir, 2003). Prior to our study, some other studies were performed in the area on mosquitoes (Kasap, 1979; Koçak et al., 1995; Aldemir, 1997; Şimşek, 1997). By considering those data, our study established the breeding habitats, population size, seasonal occurrence and abundance of all the mosquito species that were necessary for integrated mosquito control activities in the study area. Furthermore, due to the similar climatic conditions of the study area, these data can be used in many regions of Central Anatolia for the purpose of mosquito control.

Materials and Methods

Study area

The study area consists of Gölbaşı District, Mogan Lake vicinity, Çökek Swamp and Gölbaşı Swamp (Figure 1). The area is within the Gölbaşı Specially Protected Area and it is a very vulnerable ecosystem where biodiversity and especially bird species are concerned (Yerli, 2002). The population of the area and its vicinity was 63,281 in 2000. The building of new settlements in the area has occurred quite densely. This is expected to lead to a rapid population increase in the following years. Moreover, the area is frequently visited by the inhabitants of Ankara for recreational purposes (Aldemir, 2003).

There are many factories and recreational areas that considerably contribute to the town's economy in the Mogan Lake vicinity. Domestic wastewater and various industrial wastes have increased the pollution level in the lake. Lake Mogan is eutrophic and the swamping level has been increasing year by year. In addition, sedimentation transfer from drainage area to the lake causes an increase in the swamping level (Yerli, 2002). This situation creates more favorable conditions for mosquito development in the area that potentially contains various breeding habitats.

The study area has typical Central Anatolian continental climatic conditions. According to the average climatic data of the 18 years between 1985 and 2002 (D.M.İ., 2003), the annual average temperature was 10.0 °C; the highest temperatures were measured in July (21.5 °C) and August (21.3 °C) and the lowest temperatures were measured in January (-1.8 °C) and February (-0.1 °C). The annual rainfall is 411.4 mm. The lowest rainfall was measured in July (15.7 mm) and August (14.8 mm). The annual average of relative humidity is 74%. The lowest relative humidity rates were measured in July (64%) and August (63%), when the temperature was high and the rainfall was low.

Selection of sampling stations

Some early studies were referred to for the selection of the sampling stations (Boşgelmez et al., 1994; Boşgelmez et al., 1995). Both immature and adult population estimations were carried out in habitats that had different characteristics and that were located within different sub-units of the study area. A total of 15 sampling sites were selected for immature population estimation, whereas 5 stable stations (animal barns) were determined and 5 New Jersey Light Traps (NJLTs) were placed in the study area for adult population estimation (Figure 1).

Sampling of immature stages

Immature and adult mosquitoes were sampled in the study area between January 2001 and December 2002. All the immature samplings were performed by dipping with a standard 400 ml dipper (WHO, 1975). At least 5 dipper samples were taken from each larval breeding habitat and the average value of these samples was calculated. These samples were labeled, placed into different pots and later transported to the laboratory. The third and fourth instars larvae were immediately identified while the first and second instars were rearing to the third and fourth. Sampling was performed twice a month. Data from the 15 breeding habitats were calculated and evaluated afterwards.

Sampling of adults

a. Stables (Animal barns): Five stable stations were selected in different locations of the study area so as to determine particularly the endophilic species and their seasonal population fluctuations. Glass tubing aspirators were used in the sampling process (WHO, 1975). The samplings carried out in each stable were performed on the basis of 2 persons/10 min/twice a month.

b. Light Traps: Five New Jersey Light Traps (NJLTs) were used to catch outdoor flying mosquitoes in different

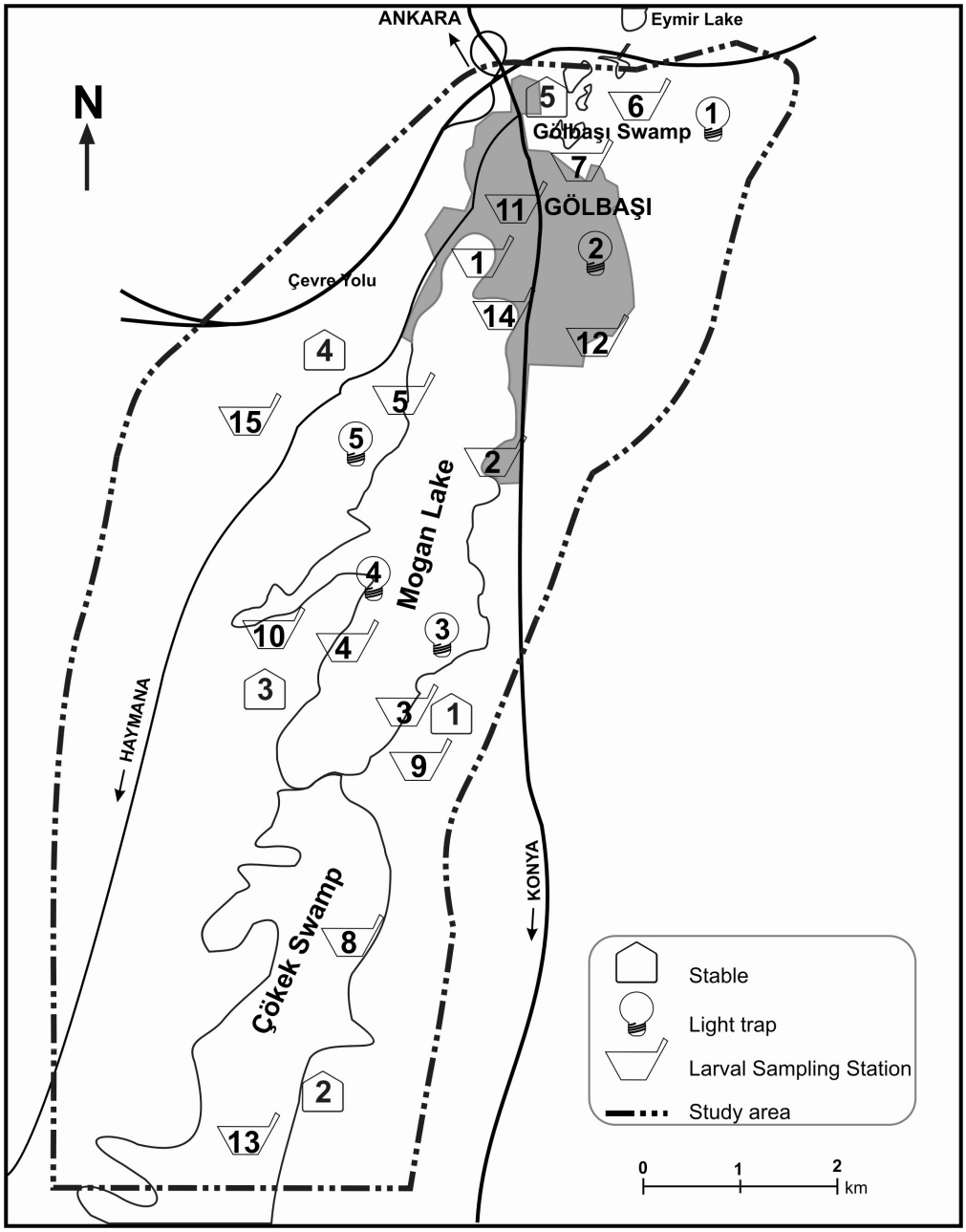


Figure 1. Sampling stations of immature stages (1-5 lake edge, 6-8 swamp, 9-10 wet pasture, 11-13 canal, 14-15 pond) and adults (Stables-Light traps) in the study area.

sites of the study area (WHO, 1975; Ramos et al., 1992). The traps were placed 1.5 m above the ground and were operated between 18^{00} and 06^{00} twice a month.

Adult and immature stages of mosquitoes were identified to species level with the use of previously reported keys (DuBose and Curtin, 1965; Kahraman and Savaş, 1978; Merdivenci, 1984; Şahin, 1984; Harbach, 1985, 1988; Snow, 1990).

The relative abundance of the adult and immature stages of mosquito species in the study area was calculated according to the results of the population estimation (Margalit et al., 1987).

Results

Mosquito species

Nine mosquito species were detected in the study area. Both immature stages and adults of these species were identified. Three of these species belong to *Anopheles* (*Anopheles sacharovi*, *Anopheles maculipennis*, *Anopheles claviger*), whereas 3 of them belong to *Culex* (*Culex mimeticus*, *Culex pipiens*, *Culex theileri*), 2 to *Culiseta* (*Culiseta annulata*, *Culiseta longiareolata*) and 1 to *Ochlerotatus* (*Ochlerotatus caspius*).

Population dynamics of immature stages

The larvae of *An. claviger*, *Cs. annulata* and *Cs. longiareolata* were sampled throughout the year, whereas the larvae of other species were sampled during the April-October period. The immature stages of *Cx. pipiens* were the most sampled species in the study area and the population reached its peak in the July-August period. Immature populations of all species increased in summer (Table 1).

In study area, 15 breeding habitats were characterized in 5 different categories. These categories are namely lake edge, swamp, wet pasture, canal and pond. The immature specimen numbers sampled in these breeding habitats were 8833, 3493, 1936, 1893 and 1102, respectively. Six species were sampled in the habitats of lake edge, swamp and canal; 5 species in the wet pasture; and 4 species in pond. The most abundant species in the habitats of lake edge and swamp is *Cx. pipiens*, *An. maculipennis* in wet pasture, *An. sacharovi* in canal, and *Cs. annulata* in pond (Table 2).

Population dynamics of adults

Stables

Cs. longiareolata was sampled in only 1 stable station, whereas *An. claviger*, *Cx. mimeticus, Cx. theileri*, *Cs. annulata* and *Oc. caspius* were sampled in 2 stable stations, *An. maculipennis* and *Cx. pipiens* in 3, and *An. sacharovi* in 4.

Population sizes of mosquitoes collected in the stables were *An. maculipennis* (1720), *An. sacharovi* (1685), *Cx. pipiens* (1309), *Cx. theileri* (870), *An. claviger* (516), *Cs. annulata* (365), *Cx. mimeticus* (253), *Cs. longiareolata* (188) and *Oc. caspius* (64). The population size of all species sampled in the stable stations increased in summer. *An. claviger* was sampled in the April-October period, Oc. caspius in the May-October period and the other species throughout the year (Table 3).

Light Traps

An. maculipennis, *Cx. mimeticus* and *Cs. longiareolata* were sampled in 1 light trap; *An. claviger*, *An. sacharovi,*

Table 1. Monthly average population fluctuations of immature stages of mosquitoes in the study area during the study period.

Species	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
An. claviger	23	16	11	30	74	198	322	210	253	75	19	18	1249
An. maculipennis	0	0	0	26	229	580	660	621	718	180	0	0	3014
An. sacharovi	0	0	0	57	301	512	680	714	773	230	0	0	3267
Cx. mimeticus	0	0	0	24	50	106	292	265	155	44	0	0	936
Cx. pipiens	0	0	0	46	358	654	1,408	1,529	754	308	0	0	5057
Cx. theileri	0	0	0	21	104	310	565	753	308	97	0	0	2158
Cs. annulata	5	0	2	4	86	150	174	124	140	48	13	10	756
Cs .longiareolata	8	3	0	4	11	23	19	14	7	8	0	5	102
Oc. caspius	0	0	0	47	71	160	202	129	85	24	0	0	718

Table 2. Mosquito species and their relative abundance (%) in types of 5 habitats in the study area.

Species	Types of habitats				
	Lake edge	Swamp	Wet pasture	Canal	Pond
An. claviger	10.14*			18.65	
	896**			353	
An. maculipennis	21.57	9.73	32.39	7.5	
	1,905	340	627	142	
An. sacharovi	16.44	15.75	29.18	21.24	27.04
	1,452	550	565	402	298
Cx. mimeticus	3.59	13.17	8.21		
	317	460	159		
Cx. pipiens	35.68	37.13		16.8	26.32
	3,152	1,297		318	290
Cx. theileri	12.58	12.02	15.13	17.64	
	1,111	420	293	334	
Cs. annulata				18.17	37.39
				344	412
Cs. longiareolata					9.26
					102
Oc. caspius		12.2	15.08		
		426	292		

* Relative abundance (%)
** Number of specimens

Cx. theileri and *Oc. caspius* in 2; and *Cx. pipiens* and *Cs. annulata* in 4.

Population sizes of mosquito species caught in light traps were *Cx. pipiens* (823), *Cs. annulata* (523), *Cx. theileri* (407), *An. sacharovi* (309), *An. claviger* (292), *Oc. caspius* (237), *An. maculipennis* (98), *Cs. longiareolata* (73) and *Cx. mimeticus* (71). In the light traps, *Cx. mimeticus* was sampled in the June-October period while other species were sampled in the May-October period (Table 4).

Relative abundance of immature stages and adults

In breeding habitats, the total quantity of immature stages belonging to the 9 sampled species was 17,257.

Table 3. Monthly population fluctuations of adult mosquitoes collected from stables during the study period.

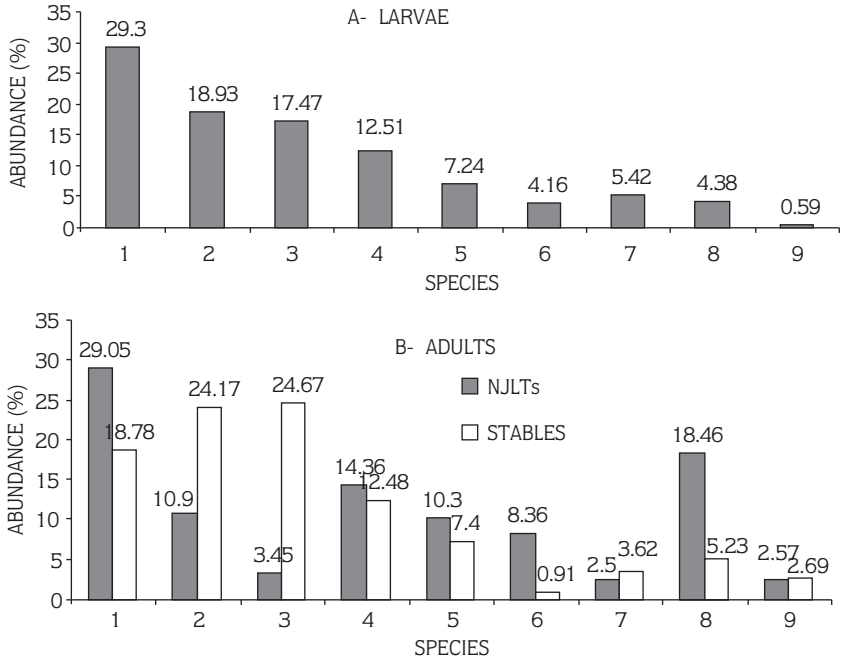
Species	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
An. claviger	0	0	0	12	50	99	109	120	106	20	0	0	516
An. maculipennis	45	29	20	15	74	165	221	312	403	220	147	69	1720
An. sacharovi	56	36	23	18	78	105	254	260	336	247	181	91	1685
Cx. mimeticus	13	9	5	1	23	34	23	20	28	39	36	22	253
Cx. pipiens	34	21	17	8	82	153	184	275	261	141	84	49	1309
Cx. theileri	9	12	14	7	52	99	137	178	169	115	45	33	870
Cs. annulata	6	10	6	8	36	66	62	42	72	33	12	12	365
Cs. longiareolata	10	2	1	2	3	32	30	52	26	10	9	11	188
Oc. caspius	0	0	0	0	6	11	10	15	14	8	0	0	64

Table 4. Monthly population fluctuations of adult mosquitoes caught by NJLTs during the study period.

Species	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
An. claviger	0	0	0	0	29	46	78	65	46	28	0	0	292
An. maculipennis	0	0	0	0	7	10	18	34	20	9	0	0	98
An. sacharovi	0	0	0	0	28	50	56	83	74	18	0	0	309
Cx. mimeticus	0	0	0	0	0	6	11	26	16	12	0	0	71
Cx. pipiens	0	0	0	0	44	95	156	232	225	71	0	0	823
Cx. theileri	0	0	0	0	20	47	78	120	109	33	0	0	407
Cs. annulata	0	0	0	0	56	120	100	113	103	31	0	0	523
Cs. longiareolata	0	0	0	0	5	5	13	19	26	5	0	0	73
Oc. caspius	0	0	0	0	22	38	45	62	50	20	0	0	237

The most sampled species of larvae/pupae was *Cx. pipiens* (29.30%), followed by *An. sacharovi* (18.93%) and *An. maculipennis* (17.47%). The least sampled species was *Cs. longiareolata* (0.59%) (Figure 2-A).

A total of 6,970 mosquito specimens were collected from the stables. The species having the highest relative abundance were *An. maculipennis* (24.67%), *An. sacharovi* (24.17%), and *Cx. pipiens* (18.78%), with *Oc. caspius* having the lowest relative abundance (0.91%) in the stables (Figure 2-B). A total of 2,833 mosquito specimens were caught in the light traps. The most abundant species was *Cx. pipiens* (29.05%); the scarcest species was *Cx. mimeticus* (2.50%) (Figure 2-B).



Code species: 1. *Cx. pipiens*, 2. *An. sacharovi*, 3. *An. maculipennis*, 4. *Cx. theileri*, 5. *An. claviger*, 6. *Oc. caspius*, 7. *Cx. mimeticus*, 8. *Cs. annulata*, 9. *Cs. longiareolata*

Figure 2. Relative abundance of immature stages (A) and adult (B) mosquito species sampled in the study area from January 2001 to December 2002.

Discussion

The larvae of *An. claviger*, *Cs. annulata* and *Cs. longiareolata* were sampled throughout the year and the larvae of other species in the April-October period. Immature populations of all species increased in summer. *An. claviger* spends the winter in the larval stage (Marshall, 1938; Postiglione et al., 1973; Kasap, 1979; Merdivenci, 1984). Aldemir (1997) reported that *An. claviger* larvae were sampled throughout the year and the population growth reached its peak in June and September. In the same study, *An. maculipennis*, *An. sacharovi* and *Oc. caspius* larvae/pupae were found in the May-October period and the population growth of these species reached its peak in August and September. According to Şimşek (1997), *Cx. pipiens* and *Cx. theileri* larvae in Gölbaşı and vicinity were sampled in the May-November period, *Cx. mimeticus* larvae in the May-October period, and *Cs. annulata* and *Cs. longiareolata* larvae throughout the year. Because *Oc. caspius* spends the winter in the egg stage (Snow, 1990), it was not possible in our study to sample the larvae and adults of this species in winter.

In this study, essential differences were established among types of habitats whose immature stages were sampled. For instance, although *An. sacharovi* larvae were sampled in all types of habitats (lake edge, swamp, wet pasture, canal and pond), *Cs. longiareolata* was only sampled in pond (Table 2). Intensive field studies have shown that mosquitoes are quite discriminating in selecting sites for egg deposition. Although species overlap in habitat preference, oviposition site selectivity is considerably species dependent (Bentley and Day, 1989). In the study carried out in the Belek-Antalya district in the Mediterranean region, *An. claviger*, *An. sacharovi*, *Cx. pipiens*, *Cs. longiareolata* and *Cs. annulata* larvae were sampled in great abundance in pasture, well, and canal; and *Oc. caspius* in pasture, swamp, and well; (Boşgelmez et al., 1995). In another study, carried out in the Tarsus district in the Mediterranean region, different types of ponds were reported as the habitats, where *An.*

sacharovi, *Cx. pipiens* and *Oc. caspius* larvae were sampled in large numbers (Alptekin and Kasap, 1997). The difference between our results and the previous results can be explained in terms of numerous factors such as the climatic and topographical differences, the adaptation of species to different habitats, and probable differences in the same habitat types.

The adults of *An. maculipennis*, *An. sacharovi*, *Cx. mimeticus*, *Cx. pipiens*, *Cx. theileri*, *Cs. annulata* and *Cs. longiareolata* were sampled throughout the year; *An. claviger* in the April-October period; and *Oc. caspius* in the May-October period from the stables. In the light traps, *Cx. mimeticus* was sampled in the June-October period and other species in the May-October period. According to Aldemir et al. (2002), in the study area *An. maculipennis*, *An. sacharovi* and species of *Culex* overwinter as adult females, *An. claviger* at the larval stage, species of *Culiseta* as adult females and at the larval stage, and *Oc. caspius* at the egg stage. When the reports by Aldemir et al. (2002) are taken into consideration, the sampling periods of mosquito species in stables and light traps in the study area yielded expected results.

The endophilic or exophilic behavior of mosquito species resulted in discrepancies in the relative abundance of the mosquitoes collected from the stables and trapped in light traps. *An. maculipennis* and *An. sacharovi* were sampled in the stables in large numbers; and *Cx. pipiens*, *Oc. caspius* and *Cs. annulata* were sampled in the NJLTs abundantly. For *Cx. theileri* (12.48:14.36), *An. claviger* (7.4:10.3), *Cx. mimeticus* (3.62:2.5), and *Cs. longiareolata* (2.69:2.57) the ratio of the sampled mosquitoes in stables is close to that sampled in the light traps (Figure 2 B).

An. sacharovi was sampled in stables in 90% in Muğla-Sarıgerme-Dalaman (Boşgelmez et al., 1994), and in Antalya-Belek *An. sacharovi* is the most intensely collected species from stables (Boşgelmez et al., 1995). *An. sacharovi* and *An. maculipennis*, which are antropophilic and endophilic species, were sampled more intensely in stables than in light traps (Aldemir, 1997). The adults of *Cx. pipiens* are zoo-antropophilic (Merdivenci, 1984; Snow, 1990) and they have endophilic behavior and were sampled in great abundance in houses and stables (Alten, 1993). *Cs. annulata* is zoo-antropophilic, although it has endophilic behavior and it can suck blood in rural areas (Dahl, 1975; Boşgelmez et al., 1994). In a study carried out by NJLTs and CO_2 traps in Belek area-Antalya province (Alten et al., 2000), *Cx. pipiens* was the most abundant species (26.77%); *Oc. caspius* was also trapped abundantly (23.44%), but *Cs. annulata* was the least trapped species (6.25%).

Oc. caspius was found more intensely indoors than outdoors (Rıfaat et al., 1970; Ramos et al., 1992; Boşgelmez et al., 1994; Boşgelmez et al., 1995; Aldemir et al., 2002). A study performed in southern Israel showed that the most abundant species was *Cx. pipiens* (79.7%), followed by *Oc. caspius* (10.0%) (Margalit et al., 1987). In some studies, *An. claviger* was sampled more abundantly in stables than in light traps (Boşgelmez et al., 1994; Boşgelmez et al., 1995), and sometimes in low abundance in light traps (Margalit et al., 1987). These differences among the reported results can be explained by various parameters such as geographic position of the study area, habitat diversity and climatic factors.

The high relative abundance of *An. sacharovi*, which is a malaria vector in Turkey, (Figure 2 A-B) and sampling of it in all habitat types (Table 2) are important issues that should to be taken into consideration in mosquito control activities.

Consequently, control activities of immature stages and adults in outdoor areas should be started in late April-early May and should be continued until late September-early October, taking into consideration the changes in the climatic parameters. Furthermore, control activities should also be carried out in indoor areas, especially in stables. Indoor control activities are very important during November and early April, because mosquito adults in the area do not leave their indoor areas and they do not lay eggs in November. The adult females leave their indoor areas and begin to lay eggs in breeding habitats in April (Tables 1, 4). Control activities in indoor areas during November and early April can significantly prevent the establishment of large new mosquito populations in the study area.

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