

Invertebrate infestation in green turtle (*Chelonia mydas* (Linnaeus, 1758)) and loggerhead turtle (*Caretta caretta* (Linnaeus, 1758)) nests on Alata Beach, Mersin, Turkey

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Abstract: Invertebrate infestation in sea turtle nests (*Caretta caretta* and *Chelonia mydas*) was recorded for the first time for Alata beach, Mersin, Turkey. A total of 121 green and 32 loggerhead nests were recorded and 34 (22.22%) of these were examined in terms of the invertebrate faunal composition. The specimens found in the nests were identified to order, family, or genus levels and they were represented as 5 orders. These invertebrate groups are *Pimelia* sp. larvae (Tenebrionidae; Coleoptera), *Elater* sp. larvae (Elateridae; Coleoptera), Scarabaeidae larvae (Coleoptera), Muscidae (Diptera), Enchytraeidae (Oligochaeta), Myrmeleontidae (Neuroptera), and Cyrptostigmata (Acari).

Key words: *Chelonia mydas*, *Caretta caretta*, nest, invertebrate infestation, *Pimelia* sp., Alata beach, Turkey

Among the marine turtle species around the world, *Chelonia mydas* and *Caretta caretta* nest in the Mediterranean (Baran and Kasperek, 1989; Groombridge, 1990; Türkozan et al., 2003; Canbolat, 2004; Türkozan and Kaska, 2010). Alata beach in Mersin was added to the nesting areas of these two turtles in the eastern Mediterranean (Oruç et al., 2003; Aymak, 2004; Aymak et al., 2005; Ergene et al., 2006, 2009; Türkozan and Kaska, 2010). Consequently, 21 important nesting areas have been identified in studies conducted on the beaches of Turkey (Türkozan and Kaska, 2010).

The presence of larvae in marine turtle nests has been previously reported and they have been identified as belonging to the Sarcophagidae (Lopes, 1982; Andrade et al., 1992; Broderick and Hancock, 1997; McGowan et al., 2001a; Hall, 2005; Phillott, 2005) and the Phoridae (Fowler, 1979; Bjørndal et al., 1985; Broderick and Hancock, 1997; McGowan et al., 2001a). Larvae of the dipteran family Phoridae (specifically *Megaselia scalaris*) have been determined in the nests of the green turtle (Fowler, 1979) and hawksbill turtle (*Eretmochelys imbricata*) (Bjørndal et al., 1985) in studies performed in Costa Rica. On the Pacific coast of Mexico, *Eumacronychia sternalis* (Sarcophagidae, Diptera) was determined in green turtle eggs (Lopes, 1982). In nests of the leatherback turtle (*Dermochelys coriacea*) and olive ridley turtle (*Lepidochelys olivacea*) in Mexico,

Sarcophagids of the genera *Phorosinella* and *Eusenotainia* were reported (Andrade et al., 1992). In Australia, two species of Platystomatidae from green and loggerhead turtle nests were recorded (Hall and Parmenter, 2006).

In the Mediterranean, Türkozan and Baran (1996) are the first researchers to report the presence of coleopteran larvae infestation (infesting eggs of the loggerhead turtle). Broderick and Hancock (1997) reported different kinds of insect groups infesting marine turtle eggs in Northern Cyprus. In another study in Northern Cyprus, eleven dipteran species were recorded in turtle nests. Among these, *Sarcotachina aegyptica* was dominant (McGowan et al., 2001a). Similar types of infestations were also recorded on Kızılot (Türkozan, 2000) and Fethiye beaches (Baran et al., 2001).

Özdemir et al. (2004) investigated the physical nest parameters of loggerhead turtle nests, e.g., grain size and distance to low vegetation, and they reported that both factors were negatively correlated with the presence of invertebrates and also smaller nest diameters attracted more invertebrates on Fethiye beach in 2001.

Özdemir et al. (2006) researched the impact of the invertebrate group on hatchlings and eggs of loggerhead turtle on Fethiye beach between the 1999 and 2003 nesting seasons and found that Tenebrionidae larvae caused destruction of nests and caused greater damage to eggs.

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They also gave information about protective measures against infestation by the invertebrate group.

Pimelia sp. (Tenebrionidae) and Muscidae larvae were found in loggerhead turtle nests on Dalaman beach (Katılmış et al., 2006). The depth of the egg chamber was found to be the most significant factor for Dipteran infestation on loggerhead turtle eggs (McGowan et al., 2001b; Katılmış and Urhan, 2007a). Similarly, Muscidae and Tenebrionidae larvae were also observed in Nile soft-shelled turtle (*Trionyx triunguis*) nests at Kükürtlü Lake, Dalaman (Katılmış and Urhan, 2007b).

Urhan et al. (2010) investigated loggerhead turtle nests infested by *Pimelia* sp. (Tenebrionidae: Coleoptera), Muscidae (Diptera), *Rhodacarellus* sp. (Mesostigmata: Acari), Cryptostigmata (Acari), and Oligochaeta on Dalyan İztuzu beach, Turkey, during the breeding season of 2008. Their study gave the infestation level and effects of those invertebrates in loggerhead sea turtle nests for the first time at this beach.

The aim of the present study was to identify the invertebrates found in sea turtle nests on Alata beach, Mersin, Turkey.

Alata Beach is 30 km from the center of Mersin (Figure 1) and is located within the borders of Alata Horticultural Research Institute, which is a 1st degree natural site. It extends over 3 km from the marine resorts in the east of the Research Institute (N 36°37'930" E 34°21'187") to the Topraksu camping site, which belongs to the Research Institute (N 36°36'868" E 34°19'711"), at the western end of the beach. For sea turtle monitoring purposes, Alata beach was divided into four sectors according to its ecological characteristics, such as its natural structure and sand properties, and human effects as described in the studies conducted in the area before (Aymak et al., 2005; Ergene et al., 2006) (Figure 1).

Sector A1: From the holiday sites to the east of the Research Institute to the beginning of the officials' club. Total length: 500 m. It consists of fine sand suitable for turtle nesting.

Sector A2: The beach in front of the officials' club and social club. Total length: 250 m. It consists of fine sand with a few pebbles. There are artificial light sources in the clubs.

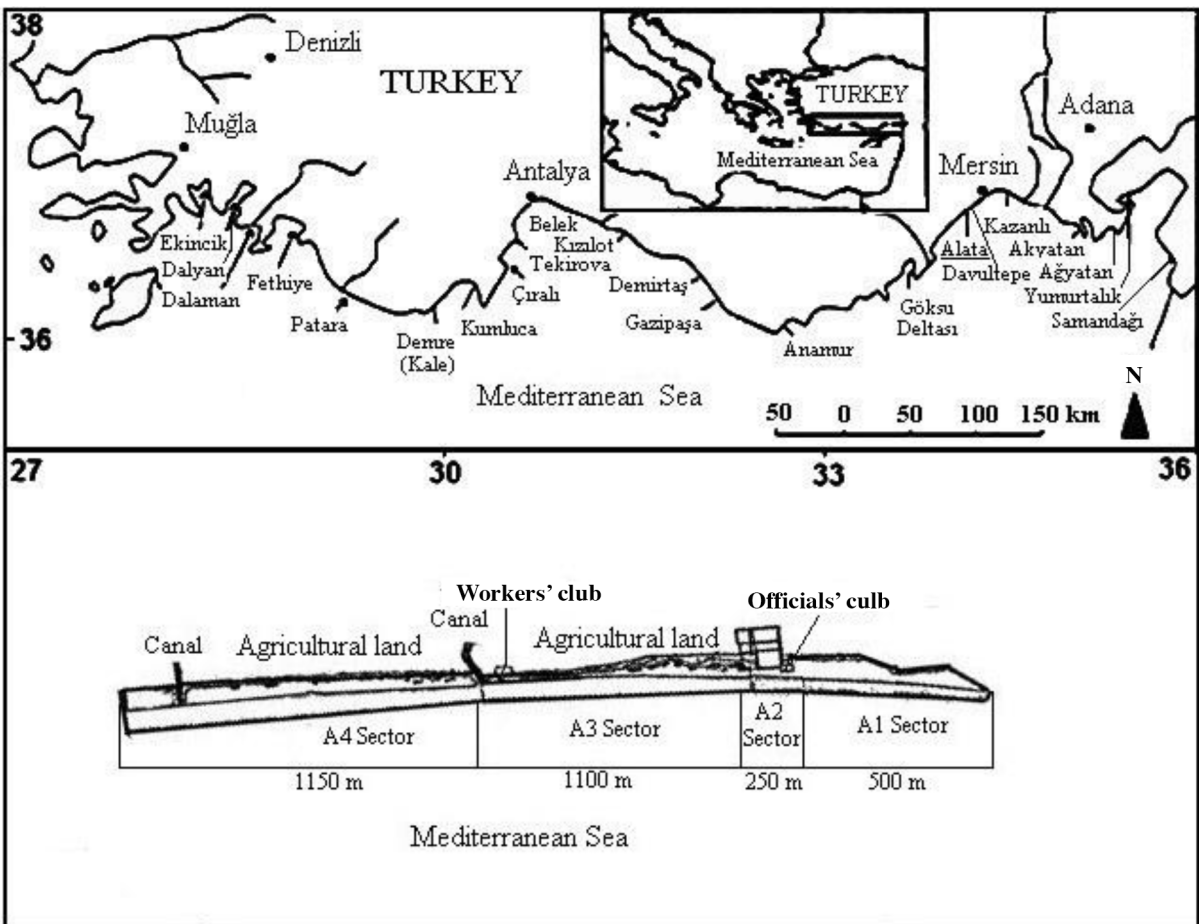


Figure 1. The important sea turtle nesting beaches in Turkey and a general view of Alata beach showing the back structure.

Sector A3: From the dry canal to the west of the social club to the big canal at the end of the officials' club. Total length: 1100 m. It consists of natural sand dunes to the palms and stones from palms to the end of the officials' club. There is no artificial light source in this sector. There is agricultural activity just behind the A3 sector. Sea daffodils (*Pancratium maritimum* L.) are found growing on the natural sand dunes and the dense vegetation structure behind these sand dunes provides a shield against possible lights from the highway passing to the north of the area.

Sector A4: From the big canal to the end of the beach. Total length: 1150 m. There is agricultural activity just behind the A4 sector and there is no artificial light source. The structure of the beach in this sector has been changed due to the pebbles piled up by waves.

In this study, all data were collected from July to September in 2003. The invertebrates and co-existence of invertebrate groups in infested sea turtle nests were described. Considering the sectors of Alata beach, the spatial distribution of infested sea turtle nests was examined according to distances of nests from the sea.

After 5–9 days had elapsed from the first emergence of hatchlings, the nests were excavated by hand for examination. When the nests were opened for examination, in each nest the empty egg shells, the infested eggs and hatchlings, dead hatchlings and embryos, and surviving hatchlings were counted and checked for infestation. The locations of larvae and other invertebrates within the nests were noted and the specimens were identified at the level of genus and family or order according to literature sources (Krantz, 1978; Hockett and Vockeroth, 1987; Booth et al., 1990; Karg, 1993; Lodos, 1995; Elzinga, 2000) and were kept in 70% alcohol and labeled.

The distances of nests from the sea were measured in meters. The beach was divided into 5-m-wide transects according to the distances of nests from the sea and the spatial distributions of infested nests of marine turtles in these four sectors of Alata beach were examined.

During the study a total of 153 nests were recorded with 121 belonging to *C. mydas* and the remainder (32) to *C. caretta*. All nests were excavated to examine their contents and in 34 (22.22%) of these 153 nests invertebrate faunal composition was detected. Of these 34 infested nests, 31 were intact nests that had not been subjected to predation. Two nests had been partly scratched by dogs 2 days before they were excavated but the eggs and hatchlings were not damaged. The invertebrates found in these 2 nests were the same: *Elater* sp. larvae. One nest was disturbed by a dog and 36 eggs were damaged. Five days after predation the nest was excavated. Myrmeleontidae were found in this nest.

Specimens representing 5 orders were determined as infesting invertebrates in the nests: *Pimelia* sp. larvae

(Tenebrioniade; Coleoptera) (Figure 2), *Elater* sp. larvae (Elateridae; Coleoptera) (Figures 3 and 4), Scarabaeidae larvae (Coleoptera), Muscidae (Diptera) (Figure 5), Enchytraeidae (Oligochaeta) (Figure 6), Myrmeleontidae (Neuroptera) (Figure 7), Cryptostigmata (Acari).

The percentages of both invertebrates and co-existence of the invertebrate groups in the loggerhead and green turtle nests and number of nests are given in Table 1. The proportion of infested nests is 19.83% (24 nests) and 31.25% (10 nests) for green and loggerhead turtles, respectively.

Pimelia sp. was the most common invertebrate group in the green turtle (13 nests; 10.74%) and loggerhead turtle (4 nests; 12.5%) nests. For *C. mydas*, the other notable species observed in the nests were Oligochaeta, Acari, and Scarabaeidae larvae (0.83%, for all) while there were Myrmeleontidae (3.13%) and Muscidae (3.13%) for *C. caretta* (Table 1). No Muscidae in the nests of *C. mydas* and no Scarabaeidae in the nests of *C. caretta* were recorded. Invertebrates were recorded in the eggs for 12 turtle nests (4 *C. mydas* nests and 8 *C. caretta* nests). The other invertebrates were found outside the eggs in the remaining 22 nests. The number of infested green turtle eggs represented 0.07% (9 eggs) of the total 13,606 green turtle eggs in a total of 121 nests, while this proportion was 1.25% (33 eggs) for 2649 *C. caretta* eggs in a total of 32 nests. Moreover, 0.31% (8 eggs) of the total 2616 *C. mydas* eggs in 24 infested nests of a total of 121 nests and 2.94% (24 eggs) of the total 816 *C. caretta* eggs in 10 infested nests of a total of 32 nests were infested by *Pimelia* sp. larvae; 0.54% (8 eggs) of the total 1492 *C. mydas* eggs in 13 nests and 7.1% (24 eggs) of the total 338 *C. caretta* eggs in 4 nests



Figure 2. *Pimelia* sp. larva.



Figure 3. *Elater* sp. larva in the egg.



Figure 4. *Elater* sp. larva.



Figure 5. Muscidae pupae.



Figure 6. Enchytraeidae (Oligochaeta) sample.



Figure 7. Myrmeleontidae.

were infested by *Pimelia* sp. larvae. *Pimelia* sp. larvae and *Elater* sp. larvae were found both in the eggs and in the sand of nests. Three Muscidae pupae were found in empty egg shells. Members of Enchytraeidae (Oligochaeta) were found in empty egg shells and in the sand of nests. Members of Cryptostigmata and Myrmeleontidae were recorded in the eggs. Members of Scarabaeidae larvae were found only in the sand inside the nests.

Pimelia sp. larvae and other invertebrates were not observed in the infested nests between 0 and 5 m on Alata beach. In the A2 sector, which was smaller in length and had fewer nests than the other sectors, no infested nests were found. In addition, the beach in the A2 sector was not natural due to human use because of the officials' club and

Table 1. The diversity of both invertebrates and co-existence of invertebrate groups found in the green turtle and loggerhead turtle nests on Alata beach [p: *Pimelia* sp. larvae (Tenebrionidae; Coleoptera); o: Enchytraeidae (Oligochaeta); e: *Elater* sp. larvae (Elateridae; Coleoptera); c: Cryptostigmata (Acari); s: Scarabaeidae larvae (Coleoptera); m: Myrmeleontidae (Neuroptera); mus: Muscidae (Diptera)].

	Invertebrates and co-existence of invertebrate groups		<i>Chelonia mydas</i>			<i>Caretta caretta</i>		
			No. of nests observed	Percentage in the total nests (%)	No. of individuals observed	No. of nests observed	Percentage in the total nests (%)	No. of individuals observed
Single invertebrate	Coleoptera	<i>Pimelia</i> sp. larvae (Tenebrionidae), (p.)	12	9.92	14	3	9.38	3
		<i>Elater</i> sp. larvae (Elateridae), (e.)	5	4.13	5	1	3.13	1
		Scarabaeidae larvae, (s.)	1	0.83	1	-	-	-
	Myrmeleontidae (Neuroptera), (m.)	4	3.31	4	-	-	-	
	Enchytraeidae (Oligochaeta), (o.)	-	-	-	2	6.25	2	
	Cryptostigmata (Acari), (c.)	-	-	-	1	3.13	1	
	Muscidae (Diptera), (mus.)	-	-	-	-	-	-	
Co-existence of invertebrates	Mixposition of (e.; o. and c.)		1	0.83	(2+1+1)	-	-	-
	Mixposition of (p. and e.)		1	0.83	(1+3)	-	-	-
	Mixposition of (m. and c.)		-	-	-	1	3.13	(1+1)
	Mixposition of (o. and c.)		-	-	-	1	3.13	(1+1)
	Mixposition of (p.; e. and mus.)		-	-	-	1	3.13	(1+1+3)
Total infested nests			24	19.83	32	10	31.25	16
Total noninfested nests			97	80.17	-	22	68.75	-
Total nests			121	-	-	32	-	-

it was cleaned regularly and had no intense vegetation in contrast to the other sectors. The diversity of invertebrates found in sea turtles' infested nests and their spatial distribution are given in Table 2.

Researchers recorded some invertebrate infestation in loggerhead turtle nests in Turkey. Nematoda, Enchytraeidae (Oligochaeta), Oniscidae (Isopoda), Mesostigmat (Acari), Cryptostigmata (Acari), Araneidae (Arenea), Sphecidae (Hymenoptera), Elateridae larvae (Coleoptera), Scarabeidae larvae (Coleoptera), Muscidae larvae (Diptera), Myrmeleontidae larvae (Neuroptera), and Tenebrionidae larvae (Coleoptera) individuals were recorded infesting loggerhead turtle nests on Fethiye, Kızılot, Dalaman, and Dalyan İztuzu beaches in Turkey (Türkozan and Baran, 1996; Türkozan, 2000; Baran et al., 2001; Özdemir et al., 2004, 2006; Katılmış et al., 2006; Urhan et al., 2010). In Northern Cyprus, Broderick and Hancock (1997) reported that nests of both species of turtles were infested by Sarcophagidae (Diptera) and Phoridae (Diptera) was reared from a *C. caretta* nest. They found an antlion larva (Neuroptera: Myrmeleonidae) in one of the *C. caretta* nests, enchytraeid worms (Annelida)

in eggs of *C. caretta* in many nests, and one larvae of a beetle (Coleoptera: Scarabaeidae) in a *C. mydas* nest. McGowan et al. (2001a) found that the invertebrates that infested nests in Northern Cyprus were Diptera [Sarcophagidae; Milichiidae; Muscidae (*Atherigona orientalis*); Chloropidae; Ephydriidae; Phoridae] and Coleoptera (Elateridae; *Cardiophorine* sp., *Agriotine* sp.). However, on Alata beach, Muscidae (Diptera) was found in only *C. caretta* nests. Scarabaeidae larvae (Coleoptera) were found only in *C. mydas* nests. *Pimelia* sp. larvae (Tenebrionidae; Coleoptera), *Elater* sp. larvae (Elateridae; Coleoptera), Enchytraeidae (Oligochaeta), Myrmeleontidae (Neuroptera), and Cryptostigmata (Acari) were found in both species of sea turtle nests. In addition, only loggerhead turtle nests could be compared in terms of the invertebrate groups on Alata beach and other beaches in Turkey, because Fethiye, Kızılot, Dalaman, and Dalyan İztuzu beaches are loggerhead turtle nesting areas. Alata beach did not have any invertebrate groups different from those on other beaches.

Researchers recorded the ratio of infested loggerhead turtle nests in Turkey. On Fethiye beach, the rate of

Table 2. Spatial distribution of infested nests of green turtle and loggerhead turtle according to distances of nests from the sea in the sectors of Alata beach [p: *Pimelia* sp. larvae (Tenebrionidae; Coleoptera); o: Enchytraeidae (Oligochaeta); e: *Elater* sp. larvae (Elateridae; Coleoptera); c: Cryptostigmata (Acari); s: Scarabaeidae larvae (Coleoptera); m: Myrmeleontidae (Neuroptera); mus: Muscidae (Diptera)].

Species	Sector	Distances of nests from the sea	Invertebrates	Nest	Percentage in the total infested nests (%)
<i>Chelonia mydas</i>	A1	5–10 m	p.	1	4.17
		15–20 m	p.	1	4.17
		20–25 m	p.	1	4.17
	A3	10–15 m	m.	2	8.33
			e.	2	8.33
		15–20 m	e.; o.; c.	1	4.17
			p.; e.	1	4.17
		20–25 m	p.	1	4.17
			m.	1	4.17
	e.		2	8.33	
	A4	10–15 m	p.	5	20.83
			m.	1	4.17
			e.	1	4.17
		15–20 m	p.	3	12.5
			s.	1	4.17
Total infested nests				24	100
<i>Caretta caretta</i>	A1	5–10 m	o.	1	10
	A3	10–15 m	e.	1	10
			m.; c.	1	10
		15–20 m	p.	1	10
	A4	5–10 m	p.; e.; mus.	1	10
			p.	1	10
			o.	1	10
		10–15 m	c.	1	10
		15–20 m	p.	1	10
	Total infested nests				10

nests infested was determined as 50% by Tenebrionidae larvae and 41.5% by Muscidae larvae (Baran et al., 2001). The invertebrate groups were found as 66.25% in 2002 and 76.04% in 2003 and Tenebrionidae larvae caused destruction in 265 (56.98 %) of the 465 nests between the 1999 and 2003 (Özdemir et al., 2006). On Dalaman beach, 36.3% were infested by *Pimelia* sp. larvae (Tenebrionidae; Coleoptera) and 39.3% by Muscidae (Diptera) in 2002 and 33.9% by *Pimelia* sp. larvae and 33.9% by Muscidae in 2003 (Katılmış, 2004; Katılmış et al., 2006). On Dalyan İztuzu beach, Urhan et al. (2010) stated that 18.3% of nests were infested by Muscidae larvae and 13.3% by *Pimelia*

larvae. When the percentages of infested *C. caretta* nests on Alata beach (31.25%) and the other beaches in Turkey were compared, the percentages of Alata beach were lower than those of Fethiye and Dalaman beaches but higher than those of Dalyan İztuzu beach in Turkey. In addition, the rate of infested *C. caretta* nests on Alata beach (12.5%) by *Pimelia* sp. was lower than that of Fethiye, Dalaman, and Dalyan İztuzu beaches.

In Northern Cyprus, the percentages of infested *C. caretta* (31.25%) and *C. mydas* (19.83%) nests on Alata beach were higher than those on Alagadi beach in 1995 (9% *C. mydas* and 23% *C. caretta*) reported by Broderick

and Hancock (1997). The percentage of infested *C. caretta* nests on Alata beach (31.25%) was higher than those in Northern Cyprus in 1996 (13.4%) and 1997 (17.4%) reported by McGowan et al. (2001a). The percentage of infested *C. mydas* nests on Alata beach (19.83%) was higher than that in Northern Cyprus in 1996 (3.3%) but close to that in 1997 (20.7%) reported by McGowan et al. (2001a).

The rate of eggs infested by invertebrates to total eggs in *C. caretta* nests on Alata beach (1.25%) was lower than the percentage on Fethiye beach (4.2%) (Baran et al., 2001).

When the rate of 24 eggs infested by Tenebrionid larvae (*Pimelia* sp.) to 2649 eggs in 32 *C. caretta* nests on Alata beach (0.9%) and the other beaches in Turkey were compared, the percentage of Alata beach was lower than the 2.64% (destroyed by coleopter larvae) on Fethiye beach reported by Türkozan and Baran (1996), the 1.39% (destroyed by coleopter larvae) on Kızılot beach reported by Türkozan (2000), and the 3.9% (damaged by *Pimelia* sp. larvae) on Dalaman beach reported by Katılmış et al. (2006).

When the rate of 24 eggs infested by Tenebrionid larvae (*Pimelia* sp.) to 816 eggs in 10 infested nests of *C. caretta* on Alata beach (2.94%) and the other beaches in Turkey were compared, the percentage of Alata beach was lower than the 8.1% (destroyed by Tenebrionid larvae) on Fethiye beach reported by Baran et al. (2001) and the 8.22% (damaged by Tenebrionidae larvae) on Fethiye beach reported by Özdemir et al. (2006).

When the rate of 24 eggs infested by Tenebrionid larvae (*Pimelia* sp.) to 338 eggs in 4 infested nests of *C. caretta* on Alata beach (7.1%) and the other beaches in Turkey were compared, the percentage of Alata beach was lower than the 11.01% (damaged by *Pimelia* sp.) on Dalyan İztuzu beach reported by Urhan et al. (2010), the 10.6% (damage by *Pimelia* sp.) on Dalaman beach reported by Katılmış et al. (2006), and the 11.01% (damaged by *Pimelia* sp. larvae) on Dalyan İztuzu beach reported by Urhan et al. (2010).

During the 1995 season at Alagadi in Northern Cyprus, infestation was observed in 4.6% of *C. mydas* eggs and 10.6% of *C. caretta* eggs by Broderick and Hancock (1997). For both species, the rate of eggs infested by invertebrates to total eggs of turtles was lower on Alata beach (*C. mydas* 0.07% and *C. caretta* 1.25%) than at Alagadi in Northern

Cyprus. McGowan et al. (2001a) estimated the rate of infested loggerhead and green turtle eggs in Northern Cyprus in 1996 by using the data of Godley and Kelly (1996) and in 1997 by using the data of Broderick et al. (1997). The rate of eggs infested by invertebrates to total eggs in *C. caretta* nests on Alata beach (1.25%) was higher than in 1996 (0.5%) and in 1997 (0.8%), and in *C. mydas* nests on Alata beach (0.07%) it was higher than in 1996 (0.01%) but lower than in 1997 (0.2%) in Northern Cyprus in the study by McGowan et al. (2001a).

When the nests were opened for examination after 5–9 days from the first emergence of hatchlings, each nest was excavated by hand and checked for infestation. However, the results of this study were confounded in time because of the excessive time span of 5–9 days. It remains uncertain whether fly larvae (Özdemir et al., 2004), dipterans, and coleopteran larvae (Katılmış et al., 2006) have a detrimental effect on sea turtle populations. Therefore, in this study the role of these invertebrates in the sea turtle nests was not determined and no effort was made to minimize the effect of insect infestation on sea turtle nests on Alata beach.

This study is the first on invertebrate infestation in marine turtle nests at the east Mediterranean coast of Turkey and the invertebrate groups were found in sea turtle nests and their frequencies were determined primarily. Being the first invertebrate infestation study on Alata beach, this study can provide a base for further studies on invertebrate groups especially determining dipterans and coleopterans at the level of species and focusing on the detrimental effects on sea turtle populations. In further studies, the factors that have impact on invertebrate infestation on Alata beach and on other east Mediterranean beaches will be analyzed in detail.

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