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Prevalence and intensity of parasitic helminths of thicklip grey mullet *Chelon labrosus* in hosts in Beymelek Lagoon Lake in Antalya, Turkey, according to season, host size, age, and sex of the host

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Abstract: In this study, helminth parasites of the thicklip grey mullet (*Chelon labrosus*) in Beymelek Lagoon, Antalya (Turkey) were studied to determine the effect of seasonal changes and host size, age, and sex on the incidence of parasitic helminth infection. Three helminth species were identified: *Ligophorus angustus* Euzet & Suriano 1977 (Monogenea) on the gills, and *Saccocoelium obesum* Looss, 1902 (Digenea) and *Neoechinorhynchus agilis* (Rudolphi, 1819) (Acanthocephala) in the intestine. Among these species, *S. obesum* was the most common species, with an overall prevalence and mean intensity of 42.7% and 13.6 ± 12.5 parasites/fish, respectively. *L. angustus* was the second most prevalent parasite, with an overall prevalence of 21.3%. The third most prevalent parasite was *N. agilis*, with an overall prevalence and mean intensity of 12.6% and 3.6 ± 2.1 parasites/fish, respectively. Regarding the effect of seasonal changes, the prevalence and mean intensity of *S. obesum* was highest in the summer and spring, respectively. For *L. angustus*, while the highest prevalence was observed in winter (40.6%), this species was not recorded in summer. The prevalence of *N. agilis* was rather low (41.6%) in spring, and this species was also not detected in summer. With regard to host size-related incidence, the differences in the abundance of the 3 species among 4 size classes were not significant ($P > 0.05$). In contrast, there were significant differences in the abundance of *N. agilis* among the age groups ($P = 0.33$). As for the infrapopulations of the parasite species depending on the host's sex, significant differences were found in the infrapopulations of *L. angustus* and *S. obesum* between the sexes ($P < 0.001$ and $P = 0. 007$, respectively).

Key words: *Chelon labrosus*, helminth parasites, seasonal effects, host size, sex and age effects

1. Introduction

Thicklip grey mullets, *Chelon labrosus* (family Mugilidae), are commonly found from the coastal regions of the eastern Atlantic, Scandinavia, and Iceland to southern Senegal and the Mediterranean Sea and southwestern Black Sea. They live inshore, in brackish lagoons and fresh water, and they tend to move northward in the summer as the temperature rises. Little is known about the parasitic fauna of *C. labrosus*. To our knowledge, *Dicrogaster perpusilla*, *Haploporus benedenii*, and *Saccocoelium tensum* from southern Sardinia, Italy (Culurgioni et al., 2013); *Saturnius* sp. and *Capillaria* sp. from Sardinia (Meralla and Garippa, 2001); *Ergenstrema mugilis*, *Ligophorus* spp., *Dicragaster contractus*, *Haploporus benedeni*, *Lecithaster confusus*, *Saccocoelium tensum*, and *Neoechinorhynchus agilis* from Greece (Ragias et al., 2005); and *Gyrodactylus* sp., *Ligophorus angustus*, *E. mugilis*, *Microcotyle mugilis*, *Haploporus benedeni*, *D. contractus*, *Saccocoelium obesum*, *S. tensum*, *Haplosplanchnus pachysomus*, *Schikhobalotrema sparisomoe*, and *Schikhobalotrema* sp. from Turkey (Altunel, 1983) have been recorded in several locations.

Although there are some studies on the parasitic fauna of this species, no work has been done in relation to seasonal population dynamics, host size, and the age and sex of the host. In addition, the study area, Beymelek Lagoon, Turkey, is a very important fisheries ecosystem with at least 23 fish species. The most common species are *Mugil cephalus*, *Chelon labrosus*, *Liza ramada*, *Liza saliens*, *Liza aurata*, *Sparus aurata*, *Dicentrarchus labrax*, *Anguilla anguilla*, *Lithognathus mormyrus*, and *Diplodus sargus* (Emre and Balık, 2009). Therefore, the aims of this study were to determine the helminth parasite fauna of the host fish in Beymelek Lagoon and to present the prevalence and mean intensity of parasite species in relation to different seasons, host sizes, ages, and sexes.

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2. Materials and methods

The study was conducted in Beymelek Lagoon (36°16′N, 30°03′E) in the western part of the Mediterranean region. This lagoon has a surface area of 225 ha and is approximately 2.5 km long and 2.1 km wide, with a maximum depth of 3 m (Figure). Fish specimens were collected by a variety of methods, including the use of a fishing net, from the Beymelek Lagoon at seasonal intervals from May 2008 to April 2009. Random samples were taken representing the different fish lengths in the lagoon, and a total of 103 fish specimens were examined. Fish were immediately transferred to the research laboratory in lagoon water. They were kept in aquaria until examined and euthanized within 24 h. Fish were killed by vertebral dislocation, and the total length, age, and sex of each fish were determined. Fish were classed into 4 length classes: 25.1–30 cm, 30.1–35 cm, 35.1–40 cm, and >40 cm. Age calculations were carried out using fish scales. Six ages were classified for the host fish using the keys given by Lagler (1966) and Begenal (1978).

During the dissection, the viscera, gills, gastrointestinal tract, liver, kidney, heart, swim bladder, gall bladder, eyes, fins, and body surfaces were examined separately for helminths with a dissecting microscope. All helminths found in each individual fish were identified and counted. Monogeneans were permanently mounted using the ammonium picrate glycerin procedure according to Malmberg (1970) and Fernando et al. (1972). The other helminths were killed in hot saline solution; digeneans and acanthocephalans were fixed in 70% ethanol, stained with iron–acetocarmine (Georgiev et al., 1986), cleared, and mounted in Entellan. All parasites were identified using selected identification keys (Yamaguti, 1985a, 1985b, 1985c). The prevalence, mean intensity, and mean abundance levels of the parasite species were calculated according to Bush et al. (1997). Standard statistical computation (standard deviation) was carried out using Microsoft Excel (Office 2000). A Kruskal–Wallis (K–W) test was applied to find significant differences in the mean intensity of the parasite species for host fish size and seasons. The Mann–Whitney (M–W) U test was used to measure the correlation between the intensity of each helminth species and the host's sex.

3. Results

3.1. Seasonality and the distribution of helminth species

Three helminth species were recorded during the sampling period from *C. labrosus*. These were the monogenean gill parasite *L. angustus* (overall prevalence 21.3%) and 2 intestinal helminths, *S. obesum* (Digenea) and *N. agilis* (Acanthocephala) (overall prevalence 42.7% and 12.6%, respectively).

A definite seasonal effect was noted for all 3 helminth species under investigation. In the case of *L. angustus*, the prevalence of infection ranged from 16.6% in spring to 40.6% in winter throughout the seasons, with the exception of summer when this species was not observed (Table 1). The mean intensity levels recorded throughout the sampling period showed that the minimum level of mean intensity was observed in autumn (2.2 parasites/fish) and the maximum level in winter (5 parasites/fish) (Table 1). The abundance of *L. angustus* varied significantly among seasons (K–W χ^2 = 15.31, P = 0.002). Significantly higher abundance was observed in winter than in spring (M–W Z = –2.18, P = 0.029). However, there was no significant relationship between spring and autumn (M–W Z = –0.448, P = 0.33).

Seasonal changes in the prevalence and mean intensity of *S. obesum* also showed variation. The prevalence of infection was highest in summer (72%), followed by spring (50%), winter (31.2%), and then autumn (18.1%). The maximum intensity level was recorded in spring as 17.9

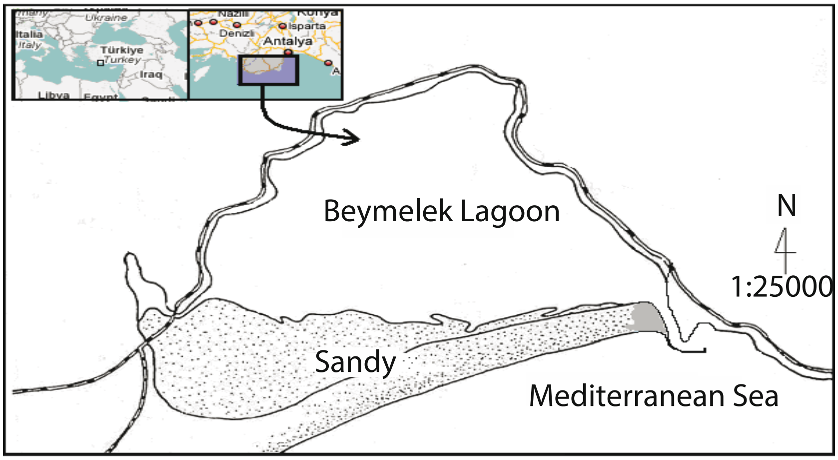

Figure. Location of Beymelek Lagoon in southern Turkey.

Table 1. Seasonal changes of some parameters regarding helminths from *C. labrosus* from Beymelek Lagoon.

Seasons	Spring (n: 24)				Summer (n: 25)				Autumn (n: 22)				Winter (n: 32)			
Helminth species	P	MA ± SD	MI ± SD	Range	P	MA ± SD	MI ± SD	Range	P	MA ± SD	MI ± SD	Range	P	MA ± SD	MI ± SD	Range
Ligophorus angustus	16.6	0.4 ± 1.2	2.5 ± 2.3	1–6	-	-	-	-	22.7	0.5 ± 1.1	2.2 ± 1.6	1–4	40.6	2.3 ± 3.3	5 ± 3.6	1–13
Saccocoelium obesum	50	8.9 ± 16.02	17.9 ± 19.01	2–50	72	12.3 ± 10.4	17.1 ± 8.1	5–38	18.1	1.8 ± 4.5	10 ± 5.7	5–18	31.2	1.1 ± 2.6	3.7 ± 3.6	1–12
Neoechinorhynchus agilis	41.6	0.6 ± 2.4	3.8 ± 2.5	1–8	-	-	-	-	9.09	0.2 ± 0.9	3 ± 1.4	2–4	3.1	0.1 ± 0.7	4 ± 2.8	4

P: prevalence (%); MA: mean abundance; MI: mean intensity.

parasites/fish (range: 2–50), decreasing gradually to 17.1 parasites/fish (range: 5–38) in summer, and 10 parasites/fish (range: 5–18) in autumn; the lowest mean intensity was detected in winter at 3.7 parasites/fish (range: 1–12). As for *N. agilis*, the prevalence levels of infection were highest in spring (41.6%), followed by autumn (9.1%) and winter (3.1%), but this helminth was not found in summer. There were significant differences in the abundance of *S. obesum* between seasons (K–W χ^2 = 24. 48, P < 0.001). A significantly higher abundance of *S. obesum* was observed in summer than in spring (M–W Z = –2, P = 0.045). A significant difference was also found between spring and autumn (M–W Z = –2.16, P = 0.031), spring and winter (M–W Z = –2.05, P = 0.04), and summer and autumn (M–W Z = –3.88, P < 0.001). However, there were no significant differences in the abundance of. *S. obesum* between autumn and winter (M–W Z = –72, P = 0.472).

There seemed to be no seasonal difference in the mean intensity of *N. agilis*. The mean intensity of *N. agilis* was higher in winter (4 parasites/fish), followed by spring (3.8 parasites/fish), and autumn (3 parasites/fish) (Table 1). This observation was confirmed statistically, as there were significant differences between seasons (K–W χ^2 = 24. 27, P < 0.001). Significantly higher mean intensity was observed in spring compared with summer (M–W Z = –3.55, P < 0.01), in spring compared with autumn (M–W Z = –2.49, P = 0.013), and in spring compared with winter (M–W Z = –3.47, P = 0.001). Seasonal changes in the prevalence and abundance of the 3 helminth species from *C. labrosus* in Beymelek Lagoon are given in Table 1.

3.2. The distribution of helminth species with respect to length classes of the host fish

Both the prevalence and mean intensity levels of the parasite species varied in different size classes (Table 2). Higher prevalence was observed for *L. angustus* (24%) in fish of 35.1–40 cm and for *S. obesum* (52.1%) and *N. agilis* (21.7%) in fish of 25.1–30 cm when compared with other size classes. The prevalence level of *L. angustus* was similar at 21.7%, 22.4%, and 24% in 3 of the size classes of host fish (25.1–30 cm, 30–35 cm, and 35.1–40 cm, respectively), but there was no infection in the size class of fish >40 cm. The mean intensity of *L. angustus* was higher in fish of 25.1–30 cm (5.6 parasites/fish), followed by fish of 30–35 cm (4.3 parasites/fish) and 35.1–40 cm (3.3 parasites/fish). *S. obesum* was found in all sizes of host fish, with slight changes in prevalence rates. Higher prevalence was observed in the 25.1–30 cm (52.1%) size class, followed by 30–35 cm (44.8%) and >40 cm (33.3%), and was lowest in fish between 35.1–40 cm (32%). Its mean intensity reached the maximum level (26 parasites/fish) in fish of >40 cm. Similarly, the highest prevalence of *N. agilis* was found in fish of 25.1–30 cm (21.7%) compared with the other size classes of 30–35 cm, 35.1–40 cm, and >40 cm (8.1%, 12%, and 2.5%, respectively). Its mean intensity reached the maximum level (5.6 parasites/fish) in fish of 25.1–30 cm. However, the differences in the abundance of the 3 species among the 4 size classes were not significant (P > 0.05).

Table 2. Prevalence and mean intensity of helminth infection of *C. labrosus* in relation to host fish size.

Size classes	I (n: 23)	II (n: 49)	III (n: 25)	IV (n: 6)
Length (cm)	25.1–30	30.1–35	35.1–40	>40
Ligophorus angustus				
Prevalence (%)	21.7	22.4	24	0
Mean intensity ± SD	5.6 ± 2.3	4.3 ± 4	3.3 ± 2.1	0
Total parasite no.	11	53	22	
Saccocoelium obesum				
Prevalence (%)	52.1	44.8	32	33.3
Mean intensity ± SD	13.9 ± 15.4	11.8 ± 10.1	14.2 ± 9.4	26 ± 28.2
Total parasite no.	195	260	114	60
Neoechinorhynchus agilis				
Prevalence (%)	21.7	8.1	12	2.5
Mean intensity ± SD	5.6 ± 1.8	2.7 ± 2.1	2.3 ± 1.5	2
Total parasite no.	28	11	7	0

3.3. The distributions of helminth species on fish hosts of different fish ages

Prevalence and mean intensity of parasitic helminth infection varied in fish of different ages (Table 3). *L. angustus* was found in fish of all ages, with a varying prevalence from 9.1% in age group VI to 50% in age group V, and the mean intensity varied from 2.6 parasites/fish in age group II to 4.7 parasites/fish in age group III; however, there was no infection in fish of age group VII. *S. obesum* was found in fish of all ages with a varying prevalence from 12.5% in age group V to 100% in age group VII, and the mean intensity varied from 2 parasites/fish in age group V to 23 parasites/fish in age group VI (Table 4). *N. agilis* occurred in all host fish ages except age group VII, with varying prevalence from 8.8% in age group III to 30.7% in age group II, and the mean intensity ranged from 2 parasites/fish in age groups V and VI to 5.5 parasites/fish in age group II. There was a significant difference in the abundance of *N. agilis* between the age groups ($r = -0.211$, $P = 0.33$). In contrast, there were no significant differences in the abundance of *S. obesum* and *L. angustus* between age groups ($P = 0.949$ and $P = 0.948$, respectively).

3.4. The distributions of helminth species on fish hosts in relation to host sex

A total of 103 thicklip grey mullet (58 females, 25 males, and 20 juveniles) were examined for helminth parasites. The prevalence of infection was higher in females than in males. Of the females, 40 were found to be infected by 1 or more parasite species. Overall prevalence of parasitic infection was found to be 68.9%, 64%, and 15% in females, males, and juveniles, respectively. With respect to the season, the highest prevalence of infection was observed in the summer for females (81.8%), while it was detected in the spring for males (71.4%) (Table 4).

L. angustus occurred only in male and juvenile fish in spring. This species was recorded in 3 out of 7 males (42.5%), while it was found on only 1 juvenile fish (50%) in spring. The mean intensity of *L. angustus* also showed similar results, with higher intensity in males (3 parasites/fish) and juveniles (1 parasite/fish) than in females in spring. The prevalence and mean intensity levels of *S. obesum* were higher in females (53%, 21.2 parasites/fish) than in males (42.8%, 14.3 parasites/fish) and juveniles (50%, 2 parasites/fish) in spring. In the case of *N. agilis*, the prevalence of infection was found to be 50%, 43%, and 40% in juvenile, male, and female fish, respectively, in spring.

In summer, *S. obesum* was found in 18 of 24 female fish examined, with a prevalence of 81.8%, while the other species were not detected in this season. In autumn, the prevalence of *L. angustus* was higher in males (50%) than in females (25%), while its mean intensity was higher in females (3 parasites/fish) than in males (1 parasite/fish). The prevalence and mean intensity levels of *S. obesum* were both higher in juvenile fish (33.3%, 11.5 parasites/fish) than in females (16.6%, 8.5 parasites/fish). This species was

Table 3. Prevalence and mean intensity of helminth infections of *C. labrosus* from Beymelek Lagoon in relation to host age.

Age cohort	II	III	IV	V	VI	VII
Sample size	13	45	25	8	11	1
Infected fish	9	25	14	5	6	1
L. angustus						
Prevalence (%)	33.3	17.7	24	50	9.09	0
Mean intensity ± SD	2.6 ± 2.8	4.7 ± 3.1	3.3 ± 4.8	4 ± 2.1	4	0
Total parasite no.	8	38	20	16	4	0
S. obesum						
Prevalence (%)	53.8	44.4	36	12.5	45.4	100
Mean intensity ± SD	20.8 ± 19.8	11.5 ± 9.4	10.8 ± 10.6	2	23 ± 15.9	10
Total parasite no.	146	230	98	2	115	10
N. agilis						
Prevalence (%)	30.7	8.8	12	12.5	9.1	0
Mean intensity ±SD	5.5 ± 2.1	3.2 ± 2.3	3 ± 1.7	2	2	0
Total parasite no.	22	13	9	2	2	0

Table 4. Prevalence and mean intensity of helminth infections of *C. labrosus* from Beymelek Lagoon in relation to host sex.

Season	*L. angustus*			*S. obesum*			*N. agilis*		
Fish sex	Juvenile	Female	Male	Juvenile	Female	Male	Juvenile	Female	Male
Spring	(n: 2)	(n: 15)	(n: 7)	(n: 2)	(n: 15)	(n: 7)	(n: 2)	(n: 15)	(n: 7)
Prevalence (%)	50	0	42.8	50	53	42.8	50	40	42.8
Mean intensity ± SD	1	0	3 ± 2.6	2	21.2 ± 21.4	14.3 ± 13.6	8	2.8 ± 2.2	4.3 ± 2.1
Total parasite no.	1	0	9	2	170	43	8	17	13
Summer	(n: 3)	(n: 22)	(n: 0)	(n: 3)	(n: 22)	(n: 0)	(n: 3)	(n: 22)	(n: 0)
Prevalence (%)	0	0	0	66.6	81.8	0	0	0	0
Mean intensity ± SD	0	0	0	16.5 ± 2.12	17.1 ± 8.7	0	0	0	0
Total parasite no.	0	0	0	0	309	0	0	0	0
Autumn	(n: 6)	(n: 12)	(n: 4)	(n: 6)	(n: 12)	(n: 4)	(n: 6)	(n: 12)	(n: 4)
Prevalence (%)	0	25	50	33.3	16.6	0	0	8.3	25
Mean intensity ± SD	0	3 ± 1.7	1	11.5 ± 9.2	8.5 ± 2.1	0	0	4	2
Total parasite no.	0	9	2	23	17	0	0	4	2
Winter	(n: 9)	(n: 9)	(n: 14)	(n: 9)	(n: 9)	(n: 14)	(n: 9)	(n: 9)	(n: 14)
Prevalence (%)	0	44.4	64.2	0	66.6	28.5	0	22.2	0
Mean intensity ± SD	0	3 ± 2.7	5.8 ± 3.7	0	4.6 ± 4.3	2.25 ± 1.8	0	4	0
Total parasite no.	0	12	56	0	28	9	0	8	0

Values with the same superscript letter are not significantly different (P < 0.05).

not detected in male fish in this season. As for *N. agilis*, it was found in both females and males but not in juvenile fish. The prevalence of *N. agilis* was higher in males (25%) than in females (8.3%), while its mean intensity was higher in females (4 parasites/fish) than in males (2 parasites/fish). This species was recorded in 1 of 12 female fish (45 parasites), while it was recorded in 1 of 4 male fish (2 parasites). In winter, a total of 7 female fish were found to be infected by 1 or more parasite species (77.7%). The prevalence and mean intensity of *L. angustus* were both higher in males (64.2%, 6.2 parasites/fish) than in females (44.4%, 3 parasites/fish). In contrast to *L. angustus*, the prevalence and mean intensity of *S. obesum* was higher in females (66.6%, 4.6 parasites/fish) than in males (28.6%, 2.25 parasites/fish) in this season (Table 4). In contrast, *N. agilis* was only found in female fish (44.4%, 11.1 parasites/fish) in winter and was not detected in juvenile and male fish (Table 4). Significant differences were found in the infrapopulations of *L. angustus* among different sexes (K–W χ^2 = 25.10, P < 0.001). However, a comparison of male and female fish infected with *L. angustus* showed significant differences (M–W Z = –4.28, P < 0.001). There was no significant difference for *L. angustus* infection between juvenile and female fish. There was also evidence for sex-related differences in the infrapopulation of *S. obesum* (K–W χ^2 = 10.05, P = 0.007). Female fish showed significantly higher mean abundance than males (M–W Z = –2.73, P = 0.006). There was also significantly higher infestation of *S. obesum* in females than in juveniles (M–W Z = –2.17, P = 0.003). However, there was no significant sex-related difference in the distributions of infrapopulations of *N. agilis* (K–W χ^2 = 1.22, P = 0.054).

4. Discussion

The thicklip grey mullet, *C. labrosus*, represents an important part of fish assemblages in Mediterranean coastal lagoons. In the present study, parasitic fauna of *C. labrosus* in Beymelek Lagoon, Turkey, were investigated. Three parasitic helminth species were recorded from *C. labrosus*. These were *L. angustus* (Monogenea, Ancyrocephalidae), *S. obesum* (Digenea: Haploporidae), and *N. agilis* (Acanthocephala: Eoacanthocephala). To our knowledge, this is the first study showing the prevalence and mean intensity of parasitic infection with regards to the seasonal population dynamics and the size, age, and sex of the host.

Previously, *E. mugilis*, *L. angustus*, *M. mugilis*, *Gyrodactylus* spp. (Monogenea), *D. contractus*, *H. benedeni*, *L. confusus*, *S. tensum*, *S. obesum*, *H. pachysomus*, *S. sparisomoe*, *Saturnius* sp. (Digenea), *N. agilis* (Acanthocephala), *C. irritans* (Protozoa), and *Capillaria* sp. (Nematoda) from the Mediterranean Sea have been reported in *C. labrosus* (Radujković, 1982; Altunel, 1983; Meralla and Garippa, 2001; Mariniello et al., 2004; Ragias et al., 2005).

In the present study, *L. angustus*, *S. obesum*, and *N. agilis* showed a definite seasonal cycle in their prevalence of infection. The highest prevalence and significantly higher mean abundance of infection were observed in winter for *L. angustus*, in summer for *S. obesum*, and in spring for *N. agilis* compared with other seasons. It should be kept in mind that the seasonal abundance of helminth parasites is influenced by various factors such as host hibernation, spawning of the host fish, changes in the immune response of fish at different temperatures, and the feeding habits of the host fish (Bauer, 1957; Lom, 1970; Chubb, 1977; Hanzelova and Zitnan, 1985). According to Hanzelova and Zitnan (1985), the fish are exposed to increased monogenean infection during the spawning period. The spawning of *C. labrosus* takes place in the winter months in Beymelek Lagoon, where the study took place (Ben-Tuvra, 1986). This concurs with the present study in that the highest prevalence and mean abundance of infection of *L. angustus* were observed in the winter months. Mladineo (2005) assumed that the diverse and wide feeding characteristics of marine fish were the prime parameters determining the structure of their parasite communities. Similarly, Hegazy (1979) claimed that the type of food is the influencing factor for infection by helminth parasites. In this study, infection with *S. obesum* and *N. agilis* was high in summer and spring, respectively. Accordingly, the choice and composition of food and the presence or absence of intermediate hosts are very important for the presence of the intestinal helminth parasitic fauna of *C. labrosus* in this locality. We suggest that the choice and composition of the host fish's food contributes substantially to the observed differences in infection levels of intestinal parasitic helminths (*S. obesum* and *N. agilis*) between seasons because *C. labrosus* is a pelagic species and feeds on benthic diatoms, copepods, and amphipods, which are intermediate hosts for acanthocephalans.

In general, there is a positive relationship between the level of parasitic infection and the size and age of the host fish (Dogiel, 1970; McKeown and Irwin, 1997; Zelmer and Arai, 1998; Aydogdu et al., 2003). In the present study, the infection prevalence and mean intensity values changed as the size and age of the fish varied. The highest prevalence and mean intensity of *L. angustus* was observed in a larger size group, 35.1–40 cm, and a smaller group, 25.1–30 cm, respectively, compared with the other groups. It can be concluded that larger fish are more heavily parasitized than smaller ones. As for *S. obesum*, the highest prevalence and mean intensity were in a smaller group, 25.1–30 cm, and in the largest group, >40 cm. *N. agilis* infection showed the highest prevalence and mean intensity in smaller fish, the 25.1–30 cm group. This observation agrees with the finding of Tekin-Özan et al. (2008), who reported that the infection of *Caryophyllaeus laticeps* (Cestoda) was high in smaller size classes and in the largest size classes. Moravec and Scholz (1991) studied the occurrence of endohelminths in *Leuciscus cephalus* and found that the prevalence and mean intensity of *Pseudopcapillaria tomentosa*, *Rhabdochona denudata* (Nematoda), and *Allocreadium isoporum* (Digenea) decreased with the growth of *L. cephalus*, and they also found that this was associated with changes in the food composition of different size groups of *L. cephalus*. In contrast, they found that prevalence and mean intensity of helminth parasites increased with increasing fish lengths. Dogiel (1970) reported that the intensity and prevalence of parasitic infection increased with the length of the fish host. Similarly, Zdzitowiecki (1988) studied the occurrence of digenetic trematodes in fishes and found that *Macvicaria pennelli* infections were dependent on the body size of their fish host. The most heavily infected fish by this trematode were the medium-sized fish, and these authors noted that other trematode species occurred most frequently in fish with body length of ≥31 cm. Furthermore, the prevalence and mean intensity of the digenean *Lecithochirium* sp. was reported to be positively correlated with host size, increasing as host size increased (Al-Zubaidy, 2010). Additionally, Sasal et al. (2000) reported that the prevalence and intensity of acanthocephalan infection was not correlated with fish size. Finally, our findings are in agreement with the results of Tekin-Özan et al. (2008) and Moravec and Scholz (1991). These results were parallel to the infection rate in relation to host age results. The prevalence and mean intensity of infection also varied in relation to the size of the fish, with the highest prevalence and mean intensity of *L. angustus* in fish of age group II and age group III, respectively, compared with the other groups. As for *S. obesum*, the highest prevalence and mean intensity were in younger fish (age group II) and in older fish (age group VI), respectively, compared to other groups. Infection by *N. agilis* showed the highest prevalence and mean intensity in younger fish (age group II). The influence of the host's age on metazoan parasites was studied by Öztürk and Altunel (2006), who found *D. extensus* on all host fish, but they found no definite differences in the prevalence of *C. laticeps* with respect to host age. Similarly, Koskivaara et al. (1991) found no monogenean parasites on the roach *Rutilus rutilus* when under 3 years of age. However, they found that *Dactylogyrus* infection increased with the age of the roach. They concluded that this was due to the fact that older fish have a larger gill surface area with no permanent immunity against these parasites. Öztürk and Altunel (2006) studied the occurrence of *Dactylogyrus* infection in 4 cyprinid fishes and found a relationship between infection by the parasite and host age. Other instances where the parasitic infection increased with the age of the host can be found in the studies of Dogiel (1970), Meyer and Vik (1968), and Khalil (1981).

There are biological differences between host sexes, which could lead to one sex being more parasitized than the other. In this study, the overall prevalence of *L. angustus* and *N. agilis* was higher in male than in female and juvenile fish, whereas *S. obesum* showed a higher prevalence in female than male and juvenile fish. Balling and Pfeiffer (1997) reported higher *Proteocephalus percae* infection in female perch than in males during the spawning period. They also explained that this might be the result of the higher food consumption of females; thus, females are more likely to become infected by copepods. Kim et al. (2001) also reported that the period of peak abundances of *Prosomicrocotyla gotoi* and *Opecoelus sphaericus* infections corresponded well to the spawning season (from October to January) of the greenling *Hexagrammos atakii*. Moharram (1980) studied the parasitic fauna of *Merluccius merluccius* from Alexandria and found that female fish were more susceptible to infections with cestode, nematode, and copepod parasites than males. In a similar study, Mhaisen et al. (1988) reported higher *N. agilis* infection in female *Liza abu* than males. Pickering and Christie (1980) determined higher prevalence in females than in males. Özer et al. (2004) found definitive differences in the prevalence of infection of *Gyrodactylus aculeatus* between males and females.

In conclusion, changes in the prevalence and mean intensity of parasitic infection might be influenced by various factors such as water temperature, water pollution, parasite biology, host hormonal status, host immunological response, host migration, changes in the feeding habits of the host, and the availability of infected intermediate hosts (Chubb, 1963; Kennedy, 1969; Pennycuick, 1971; Hanzelova and Zitnan, 1985; Simkova et al., 2005). However, the influence of these factors is difficult to distinguish because they are most likely interrelated and influence each other.

In this study, *S. obesum*, a digenean found in the intestine, had the highest prevalence among the 3 parasite families and is the most important in terms of pathological potential for fishes. As for *L. angustus*, a monogenean, this parasite has a direct life cycle and easily causes parasitic infection in fish farms. The presence of these parasites might be a potential problem for cultured fish.

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