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Influence of the host sex, size, and season on *Ergasilus lizae* infestation of Thicklip Grey Mullet (*Chelon labrosus*, L., 1758) in Beymelek Lagoon Lake (Antalya, Türkiye)

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ABSTRACT

The aim of the study was investigation of the changes in infestation levels of *Ergasilus lizae* on economically important fish species, thicklip grey mullet (*Chelon labrossus*) from Beymelek Lagoon Lake located on the western Mediterranean coast (Antalya, Türkiye). In this context, the infestation levels of *E. lizae* with respect to fish sexes, fish sizes and season were evaluated statistically. The research was conducted seasonally between May 2008 to April 2009, and the gills which belong to 103 fish samples were examined. The overall infection prevalence and mean intensity values were 60.2% and 15.95, respectively. The prevalence and mean intensity of *E. lizae* for thicklip grey mullet male and sexually unidentified fish samples were higher than that for females. Prevalence and mean intensity were determined the highest in size class I with 69.6% and 26.3, and almost the same values in size groups II and III. *E. lizae* on host fish were observed in every season. The highest prevalence and mean intensity of *E. lizae* was recorded in spring with 100%, 24.88. The lowest prevalence of *E. lizae* was recorded in summer at 12% and the lowest mean intensity of *E. lizae* was in the summer and the winter with 9, 8.67 respectively. The infestation level of *E. lizae* was statistically significant with host sex and season, but there was no effect on the fish size groups.

Keywords: *Ergasilus lizae*, *Chelon labrosus*, Infestation, Beymelek Lagoon, Türkiye

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Beymelek Lagün Gölü'ndeki (Antalya, Türkiye) Kalın Dudaklı Kefal (*Chelon labrosus*, L., 1758)'de *Ergasilus lizae* Kroyer, 1863 (Copepoda: Ergasilidae) Enfestasyonu Üzerine Konak Cinsiyeti, Büyüklüğü Ve Mevsimin Etkisi

Öz: Bu çalışmada, Batı Akdeniz kıyısında (Antalya, Türkiye) yer alan Beymelek Lagün Gölü'nde yaşayan ekonomik öneme sahip bir balık türü olan kalın dudaklı kefal (*Chelon labrossus*) üzerindeki *Ergasilus lizae* enfestasyon seviyesindeki değişimler araştırılmıştır. Konak balık cinsiyeti, konak balık büyüklüğü ve mevsime göre *E. lizae*'nin enfestasyon seviyesi istatistiksel olarak değerlendirilmiştir. Çalışma mevsimsel olarak Mayıs 2008 ile Nisan 2009 tarihleri arasında yürütülmüş ve 103 balık örneğine ait solungaç incelenmiştir. Toplam yaygınlık ve ortalama yoğunluk değerleri sırasıyla % 60,2 ve 15,95 olarak bulunmuştur. Erkek ve cinsiyeti belirlenemeyen balık örneklerinde *E. lizae* yaygınlığı ve ortalama yoğunluğu dişilerden daha yüksek bulunmuştur. Boy gruplarına göre, yaygınlık ve ortalama yoğunluk % 69,6 ve 26,3 ile I. boy sınıfında en yüksek, II. ve III. boy gruplarında ise hemen hemen aynı değerlerde tespit edilmiştir. Konak balık üzerindeki *E. lizae* her mevsimde gözlenmiştir. En yüksek *E. lizae* yaygınlığı ve ortalama yoğunluğu %100 ve 24,88 ile ilkbaharda kaydedilmiştir. En düşük *E. lizae* yaygınlığı %12 ile yaz mevsiminde, en düşük ortalama *E. lizae* yoğunluğu sırasıyla 9 ve 8,67 ile yaz ve kış mevsimlerinde kaydedilmiştir. *E. lizae*'nin enfestasyon seviyesi konakçı cinsiyeti ve mevsim ile istatistiksel olarak önemli bulunurken, balık büyüklük gruplarının etkisi görülmemiştir.

Anahtar Kelimeler: *Ergasilus lizae*, *Chelon labrosus*, Enfestasyon, Beymelek Lagoon, Türkiye

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Introduction

Ergasilidae von Nordmann, 1832 is one of the major families within the parasitic cyclopoid copepods and of the 13 valid genera of the family

Ergasilidae. The genus *Ergasilus* von Nordmann, 1832 contains 66 valid species (Walter and Boxshall 2023a). To date, four genera and nine species belonging to the family were recorded from Türkiye; *Ergasilus, Nipergasilus* Yamaguti, 1939 and *Paraergasilus* Markewitsch, 1937, *Neoergasilus* Yin 1965 comprising marine, brackishwater and freshwater species (Altunel 1983,1990; Öztürk 2002; Öktener and Trilles 2004; Oğuz and Öktener 2007; Öktener et al. 2007; Koyun et al. 2007; Akbeniz and Soylu 2008; Öktener et al. 2008; Soylu and Soylu 2012; Özer and Kırca 2013; Öztürk 2013; Soylu et al 2013, Alaş et al. 2015; Özer and Acar 2022).

E. lizae Kroyer, 1863 and *E. gibbus* belong to the genus *Ergasilus* the type genus of the family was recorded on Turkish marine fish, mullets, and European Eel (Altunel 1983, 1990; Öktener & Trilles 2004; Oğuz and Öktener 2007; Öztürk 2013; Soylu et al 2013, Özer and Acar 2022). *E. lizae* Kroyer, 1863 reported as *E. nanus* Beneden, 1870 by Altunel (1983) and Öktener and Trilles (2004) who recorded on mullets. *E. nanus*, is invalid species and should be accepted as *E. lizae* (Ben Hassine and Raibaut 1980; Kabata 1992; Walter and Boxshall 2023b).

Pathogens like fish parasites can cause significant diseases in wild and cultured fish populations but the effect of diseases on wild fish is less known than that of cultured fish populations (Hedrick 1998; Kır 2007; Özbek and Öztürk 2010). High levels of *Ergasilus* spp. infestation on cultured and wild fish can cause serious health problems, mortalities, and significant economic loss (Paperna and Overseet 1981; Johnson et al. 2004; Jithendran et al. 2008; Özer and Kırca 2013).

Although there are a few parasitological studies on thicklip grey mullet *Chelon labrosus* L., 1758 in marine and inland waters of Türkiye (Alaş et al. 2015; Koç et al. 2018) only one study on helminth parasites of thicklip grey mullet was conducted by Aydoğdu et al. (2015) in Beymelek Lagoon Lake. In addition, the helminth and parasitic copepod fauna of sea bass fish except thick-lipped mullet, were studied in our study area (Emre and Kubilay 2014; Yalım et al. 2014).

Beymelek Lagoon (30° 03' E, 36° 16' N), located on the southwest coast of Türkiye, is connected to a brackish water spring in the northwest by a small channel and to the Mediterranean Sea in the southeast by an inlet. The lagoon is a shallow lake with a mean depth of about 1.6 m and a surface area of 250 ha (Anonymous, 1984). It is one of the most productive and important lagoon lakes of Türkiye in which is identified 51 fish and crustacean species and 41 of these species are of commercial importance (Aydın et al. 2023). In the lagoon lake, the most common species are *Mugil cephalus, C. labrosus, Liza ramada, L. saliens, L. aurata, Sparus aurata, Dicentrarchus labrax, Lithognathus mormyrus* and *Diplodus sargus* (Emre et al. 2011).

Identifying parasite fauna in wild fish and monitoring studies are important to avoid spreading parasite infections from wild fish to cultured fish. In context, the infestation level of E. lizae in economically an important fish species thicklip grey mullet (*C. labrosus* L., 1758) in Beymelek Lagoon Lake was evaluated in relation to host sexes, host size, and season.

Materials and Methods

For the determining copepod parasites, the thicklip grey mullet samples were used from the research conducted by Aydoğdu et al. (2015). In this context, specimens of thicklip grey mullet were collected seasonally between May 2008 to April 2009 by fishing nets in Beymelek Lagoon Lake (30^0 04' E, 36^0 16' N). The fish samples were measured in total body length. Their sexes were determined with the examination of gonads. All fish samples were examined for the presence of gill lice under the Olympus SZ61 stereo microscopy. The copepod parasite samples were removed from the gill filaments and then dissected under the stereo microscope and eventually examined under the Olympus BX53 light microscope. The copepod parasites were identified according to Kabata (1979, 1992). The number of parasite samples and infected fish samples were counted. The prevalence and mean intensity levels of parasite infestation for host fish species were calculated according to Bush et al. (1997). Significant differences were detected using Fisher's exact tests for prevalence, the Kruskal-Wallis test (more than two groups), and the bootstrap t-test for mean intensity. Significance for all the statistical analyses was established with 95% confidence intervals. A statistical package the Jamovi program (Jamovi, 2019) for Windows and Quantitative Parasitology 3.0 (Rózsa et al., 2000; Reiczigel and Rózsa, 2005) were used for these statistical analyses.

Results

A total of 103 fish samples belonging to the thicklip grey mullet were examined. One copepod, *Ergasilus lizae* Kroyer, 1863 was determined on the gill flaments of the fish samples during the study period. Total lengths ranged from 25.8 to 50.8 cm for the host fish.

62 of 103 the thicklip grey mullet were infected by *E. lizae*. The prevalence and mean intensity of *E. lizae* were 60.2% and 15.95, respectively (Table 1). The intensity of *E. lizae* ranged from 1 to 99 parasites per fish sample and A total of 998 parasites were counted (Table 1).

The levels of infestation in thicklip grey mullet

male, female and sexually unidentified showed differences. The variation of infestation observed in host sexes was presented in Table 1. In general, the prevalence and mean intensity of *E. lizae* for thicklip grey mullet male and sexually unidentified fish samples (92%, 16.78; 55%, 21) were higher than that for female (48.3%, 13.61) respectively (Table 1). It is clearly indicated that the parasite on host male and sexually unidentified are highly aggregated than that for females (Table 1). Although the prevalence of *E. lizae* was significantly different between the sexes by Fisher exacts test ($P < 0.001$), the mean intensity was not Kruskal-Wallis test (P=0.84).

Table 1. Variations in infestations of *E. lizae* according to fish sexes

Host Sexes	No of host	No of infected host	Prevalence (%)	Mean intensity	Intensity range
Female	58	28	48.3	13.61	381 (1-41)
Male	25	23	92	16.78	386 (1-92)
Undetermined gender	20	11	55	21	231 (1-99)
Total	103	62	60.2	15.95	998 (1-99)

The thicklip grey mullet samples were infested with *E. lizae* in all size classes. The occurrence of infestation in different size classes was presented in Table 3. Prevalence was highest (69.6%) in size class I, followed by size class III (58.1%) and size class II (57.1%). Intensity was highest (26.31) in size class I, followed by size class III (13), and size class II (11.93) class (Table 2). The parasite is highly aggregated size class I of the host than other size classes (Table 2) but there were no significant differences in the prevalence and mean intensity of the parasite among the size class by Fisher exact's test and Kruskal-Wallis test (P=0.61, P= 0.37, respectively).

E. lizae on the gills of examined fish samples were observed in every season during the study period and the occurrence of the parasite showed a pronounced seasonal variation. The highest prevalence of *E. lizae* was recorded in spring with 100%, it was followed by winter with 75%, autumn with 50%, then finally dropped minimum in the summer with 12% (Table 3). Fisher's exact test showed seasonally significant differences in the prevalence of *E. lizae* on the thicklip grey mullet ($P < 0.001$). The highest mean intensity of *E. lizae* was recorded in the spring with 24.88, it was followed by 14.27, 9, and 8.67 during the autumn, the summer, and the winter respectively (Table 3). Comparing seasonal variations in the mean intensity of *E. lizae*, the Kruskal-Wallis test showed significant differences for the thicklip grey mullet (P=0.031).

Table 2. Variations in infestations of *E. lizae* according to fish length

Size Class	No of host	No of infected host	Prevalence (%)	Mean intensity	Intensity range
I	23	16	69.6	26.31	421 (3-99)
II	49	28	57.1	11.93	334 (1-28)
III	31	18	58.1	13	150 (4-38)

Table 3. Seasonal variations in infestation of *E. lizae* on host fish

Season	No of host	No of infected host	Prevalence (%)	Mean intensity	Intensity range
Spring	24	24	100	24.88	597 (4-99)
Summer	25	3	12	9	27 (4-14)
Autumn	22	11	50	14.27	157 (3-28)
Winter	32	24	75	8.67	208 (1-21)

Discussion

All parasite specimens, attributed as belonging to the genus *Ergasilus* based (a) two-branched leg IV with a 2-segmented exopod and 3-segmented endopod, (b) 6-segmented antennule, (c) well developed antenna with a single claw (Kabata 1979; Boxshall and Montú 1997). *E. lizae* was identified based on the violin body shape and narrower posteriorly, the grasping organ, antenna elongated and slender; basal segment short and small, the inner margin of the second segment with small outgrowth, subchelate with one small proximal and one distal setule, slightly curved claw. 2-segmented of leg 5; basal segment with one small seta, distal segment with two terminal setae, and one subterminal seta.

The present study is the report on the infestation of *E. lizae* in relation to season, host sexes, and length classes of thicklip grey mullet inhabited in Beymelek Lagoon Lake which is located in the West Mediterranean Sea coast of Türkiye. Gill lice, ectoparasite *E. lizae,* is widespread on host fish living in marine and brackish waters and also commonly reported on mullets (Kabata 1979, 1992; Knoff et al. 1994; El-Rashidy and Boxshall 1999; Marcogliese et al. 2001; Norris et al. 2002; Johnson et al. 2004).

The findings of the study were generally found to be higher compared to infestation levels of *E. lizae* observed on other hosts. Norris et al. (2002) recorded four ergasilid copepod species on *Acanthopagrus butcheri*. The prevalence and relative density of *E. lizae* ranged from 10 to 80% and 0.15 to 12.4, respectively. Marcoglise et al. 2001 determined the potential impacts of clear-cutting on parasites of the northern redbelly dace in four boreal lakes and the prevalence *E. lizae* was recorded between 7 and 23% in two lakes. Altunel (1983) determined that the infestation level of *E. lizae* (reported as *E. nanus*) was recorded on five species of mullets. These are *Mugil cephalus, Liza ramada, L. saliens, Chelon labrosus, Oedalechilus labeo,* and their parasite prevalences were 56%, 43%, 36.73%, 16.45%, 37.5%, respectively. Özer and Kırca (2013) investigated the natural parasite fauna of *Liza aurata* captured from Kızılırmak Delta. The prevalence of *E. lizae* was 50%. Öztürk (2013) determined the parasitic fauna of Juvenile golden grey mullet, *L. aurata* collected from Sarıkum Lagoon Lake (Sinop, Turkey) and evaluated diversity and the occurrence of parasites in relation to season and size classes of host fish. The prevalence was 14.2%. The occurrence of crustacean ectoparasites on white mullet, *Mugil curema* captured from the littoral waters of Rio Grande do Norte State, Brazil (Cavalcanti et.al., 2011). *E. lizae* occurred 8.33%, 3.23% during the rainy and the drought seasons, respectively. Aladetohun et al. (2013) carried out copepod parasites in the gills of *M. cephalus* and *L. falcipinnis* in Ganvie, Djdje and Zogbo regions of Lac Nokoue Lagoon. Three species of parasitic copepod were identified *Nipergasilus bora, E. latus* and *E. lizae*. *E. lizae* was 2.33%, 7.09%, 0.39% and 3.15% during the drought and rainy seasons in the Ganvie and Djdje respectively. The metazoan parasite fauna and infestation levels of 19 fish species caught from Mert Lake located in Igneada Wetland Ecosystem were examined between June 2015 and May 2017, seasonally (Kırcalar, 2018). *E. lizae* was determined in seven fish species, *A Alburnus chalcoides M. cephalus, C. ramada, Alosa sp., Lepomis gibbosus, C. saliens, Barbus* sp. The prevalence of *E. lizae* parasite was determined in *A.chalcoides* with 6.11 %, in *Alosa* sp. with %27, in *Barbus* sp. with 100 %, *Lepomis gibbosus* with %1.96 *C. ramada* with 34.33%, in *C. saliens* with 54.90 % and in *M. cephalus* with 53 %. Gueretz et. al. (2022) investigated the parasitic fauna of *M. curunema* in Parati River on the northern coast of the Santa Catarina State, Brazil. The prevalence of *E. lizae* was 77.66%. Özer and Acar (2022) investigated metazoan parasites in leaping mullets caught from Sinop coasts (Black Sea) and it was notified that the prevalence of *E. lizae* parasite was 4.2%.

In this study, the infestation level of *E. lizae* was affected by the host sex. Infestation of *E. lizae* for the thicklip grey mullet male and undetermined gender were higher than that for females. It was observed that *E. lizae* preferred thicklip grey mullet male over female of thicklip grey mullet. Twice the number of parasites found in only one host male and undetermined gender than that in females. We can say that the male and undetermined genders can be precise to parasitic infestation. Host sex is one important factor in interactions between the host and parasite (Lizama et al. 2005). The differences in parasitic load are related to physiological differences between the male and female hosts (Aloo et al. 2004; Lizama et al. 2005) and they notified that it might be related to the feeding habits and reproduction migrations of the fish hosts.

The parasite infestation levels were changed in relation to the size of the thicklip grey mullet. In general, a positive correlation was expected between parasite infestation (prevalence and intensity) and host fish size (Lo et al. 1998; Poulin 1999, 2000; Öztürk 2013) but, our findings showed a negative relation between host fish size and aggregation. The highest parasite accumulations were not found on the largest fish specimens, the parasitize loads decreased with the increase in fish length. The parasite is highly aggregated size class I of the host than other size classes. These results are consistent with the findings of several metazoan parasites studies (Bortone et. al. 1978; Meeûs et al. 1995; Öztürk 2002; Öztürk and Aydoğdu 2003; Kutlu and Özturk 2006; Ekanem

2011; Aydoğdu et al. 2015; Eyo and Effanga 2018; Özer and Acar 2022).

Differences in the prevalence and mean intensity of *E. lizae* were found significant seasonally. Seasonal occurrence of some species of the genus *Ergasilus* was reported to be higher in the spring, summer, and autumn compared to the winter by numerous authors (Altunel, 1983, Öztürk and Aydoğdu 2003; Öztürk 2013; Aladetohun et al. 2013; Garcia and Williams 1985). Öztürk and Aydoğdu (2003) reported that the infestation level of *E. sieboldi* on grey mullet in Karacabey Lagoon was higher during the summer and autumn than in the winter and early spring. Altunel (1983) notified that the highest infestation levels of *E. lizae* (reported as *E. nanus*) recorded on five species of mullets were determined in periods of increasing water temperature. Öztürk (2013) reported that the highest prevalence and mean intensity of *E. lizae* in juvenile the golden grey mullet was in autumn with 47.37%, 3.78, respectively and the lowest values were recorded in the winter with 2.72%, 3 for the prevalence and mean intensity, respectively. Aladetohun et al., (2013) researched the prevalence of parasitic copepods on *Mugil cephalus* and *Liza falcipinnis* captured from Lac Nokoue Lagoon during the dry (December-March, 2011) and the rainy season (April-July, 2012). They determined that the prevalence of *E. lizae* was higher in the rainy season than in the dry season. Garcia and Williams (1985) reported that the highest prevalence of *E. lizae* on the white mullet was recorded in winter and disappeared between April and September in Joyuda Lagoon. But the water temperature and salinity values of the lagoon were recorded at 24.8 ^{0}C, 19.9 ppt, respectively. They notified that the high prevalence of *E. lizae* was related to the migratory pattern of the adult fish than to seasonal hydrological conditions (Garcia and Williams, 1985). Obtained data for *C. labrosus* showed similarity to the above studies. *C. labrosus* the highest prevalence and intensity of *E. lizae* was recorded in spring. It was followed during winter and autumn and then finally dropped minimum in summer. The mean intensity of *E. lizae* was higher in the spring and autumn than in the summer and winter.

As reported in the studies above, the host size, host age, host sex, fish migration periods, spawning periods, and environmental conditions (temperature, rainfall, salinity, etc.) are the most important biotic and abiotic factors affecting the infestation levels of parasite species.

The fishes are also more susceptible to parasite infestations during the spawning period (Šimková et al. 2005; Lizama et al. 2006). The spawning period was from December to February for thicklip grey mullet in Beymelek Lagoon (Emre et al. 2011). As seen in Table 3, the heavily infestation of parasites was observed in the spawning period of fish (in winter), and spring period with increased water temperature. The present study showed that the infestation level of *E. lizae* was significantly changed with host sex and especially season, but there was no effect of fish size groups. It is important to carry out such studies continuously in the natural environment as well as in aquaculture conditions in order to prevent epizootic outbreaks. In conclusion, It is thought that parasitic copepod studies on wild fish could be useful determined, understood, and prevented in their effects on cultured fish.

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