Detection of Ectoparasite *Lernaea cyprinacea* (Copepoda: Lernaeidae) on some Cypriniformes Fish from the Mediterranean Region of Turkey

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**Keywords:** Endemism, non-indigenous species, ectoparasite, freshwater.

**Abstract:** *Lernaea cyprinacea* L., 1758 is a lernaeid copepod species usually known as anchor worm. It is usually reported as having a wide range of host susceptibility. Parasites belonging to the genus *Lernaea* can have serious deleterious effects on their freshwater fish hosts. Parasites belonging to the genus *Lernaea*, it has been reported from several host fish species to date in Turkey. Mediterranean region of Turkey supports a rich diversity of Cypriniformes fish fauna, with a high percentage of endemic species. This study reports the infection of *L. cyprinacea* on some native and alien Cypriniformes fish in the Mediterranean region of Turkey. *Barbus xanthis, Alburnus baliki, Pseudophoxinus zekayi* and *Pseudorasbora parva* were found as new host records for *L. cyprinacea*.

**1. Introduction**

The order Cypriniformes is the most diverse order of freshwater fish. In the inland waters of Turkey, this order is represented by 278 species according to Çiçek, Sungur, and Fricke (2020). Ecology of parasites of the order Cypriniformes has been the center of an increasing attention for two decades (Dorovskikh & Stepanov, 2009; Gabagambi & Soylu, 2018; Czerniejewski, Rybczyk, Linowska, & Soylu, Uzmanoğlu, Çolak, 2019).

Copepod parasites have recently been highlighted as serious pathogenic problems in order Cypriniformes (Unal et al., 2017). Among the Copepod parasites, *L. cyprinacea* was mostly described from the gills, skin or fins of wild and cultured Cypriniformes fish (Boane, Cruz, & Saraiva, 2018; Çiçek, Sungur, & Fricke, 2020). Ecology of parasites of the order Cypriniformes has been the center of an increasing attention for two decades (Dorovskikh & Stepanov, 2009; Gabagambi & Soylu, 2018; Czerniejewski, Rybczyk, Linowska, & Soylu, Uzmanoğlu, Çolak, 2019).

There have been numerous reports of *L. cyprinacea* from Turkey and adjacent regions: Iraq (Mhaisen, 1982), Iran (Barzegar, Raesi, Bozorgnia, & Jalali, 2008; Raissy & Ansari, 2012; Raissy, Sohrabi, Rashedi, & Ansari, 2013; Daghigh Roohi, Sattari, Nezamabadi, & Ghorbanpour, 2014) as well as Mediterranean countries (Nofal, Zaki, & El-Shebly, 2016; Ahnelt et al., 2018).

After the first report of *L. cyprinacea* in Turkey, several studies have demonstrated that the parasite is widespread in this country and identified as a possible threat to the endemic and economic fish stocks. *L. cyprinacea* has been found infesting Cypriniformes host species in Turkey, as follows, *Carassius carassius* in Kovada Lake (Geldiay & Balık, 1974); *Cyprinus carpio* (Burgu, Oguz, Korting, & Guralp, 1988), *Chondrostoma nasus* in Tahtalı Dam Lake, İzmir (Demir, 2008); *Cyprinus carpio* in Tahtalı Dam Lake, İzmir (Karakisi & Demir, 2012); *Carassius gibelio* in Karacaoğan II Dam Lake, Burdur (Kırmızı & Samancı, 2012); *Tinca tinca* in Seyhan Dam Lake, Adana (Ince, 2013); *Cyprioidea macrostomus* in Murat River, Bingöl (Koyun, Ulupınar, & Mart, 2015); *Pseudophoxinus burduricus* and *Oxyromochelus analiticus* in Düğü Creek, Burdur (İnнал et al., 2017); *Pseudophoxinus egridi* in Eğirdir Lake, İsparta (Akcimen et al., 2018); *Chondrostoma beysi* and *Squalius cephalus* from the Üzümli pond, Konya (Erbaş, Yağcı, Öktener, & Akcimen, 2018).

Mediterranean region of Turkey supports a rich diversity of Cypriniformes fish fauna with a high percentage of endemic species. Although a large number of endoparasite species has been reported in this order, studies on ectoparasite species are very limited. The present study was conducted to identify the parasitic infections of *L. cyprinacea* on some native and alien Cypriniformes species in the Mediterranean region of Turkey.

**Anahtar kelimeler:** Endemizm, yabancı türler, ektoparazit, tatlısu.

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2. Material and Methods

Overall, 679 individuals belonging to seven fish species (Table 1) were analyzed: *Pseudophoxinus burduricus* Küçük, Gülle, Güçlü, Çiftçi, & Erdoğan, 2013 (Burdur spring minnow); *Pseudophoxinus zekayi* Bogutskaya, Küçük & Atalay, 2006 (Ceyhan spring minnow); *Barbus xanthos* (Güçlü, Kalaycı, Küçük, Turan 2020); *Tinca tinca* (Linnaeus, 1758) (Tench); *Pseudorasbora parva* (Temminck & Schlegel, 1846) (Stone moroko); *Carassius gibelio* Bloch, 1782 (Prussian carp); *Alburnus baliki* Bogutskaya, Küçük & Ünlü, 2000 (Antalya bleak).

The investigation was carried out from May 2013 to July 2020. Fish were collected using beach seine nets, longline nets, and electroshock methods in ten aquatic systems (Fig. 1) (on the map; 1: Lake Gölhisar; 2: Dalaman River; 3: Değirmendere Creek; 4: Lake Karataş; 5: Soğanlı Pond; 6: Çanaklı Pond; 7: Onaç Reservoir; 8: Lake Beyşehir; 9: Karpuzçay Creek; 10: Ceyhan River).

Fish were transported immediately to the Burdur Mehmet Akif Ersoy University Ichthyology Laboratory in plastic bags. Each fish was measured (total length in cm) and weighed (g) before observation. Fish species were examined for the presence of *L. cyprinacea*. Areas around the fins, nostril, opercular cavity, and skin were examined with a dissecting microscope. *L. cyprinacea* was identified using a dissecting microscope and according to Bauer (1987). Prevalence and intensity of infection were recorded (Bush, Lafferty, Lotz, & Shostak, 1997).

3. Results

Among the seven species examined for infestation with *L. cyprinacea*, the highest prevalence of infection was reached in *Pseudophoxinus burduricus*, a native fish from Değirmendere Creek, followed by Çanaklı Pond population of *C. gibelio* and Onaç Reservoir population of *C. gibelio* (48%; 15.38%; 11.02%, respectively) (Fig. 2). With respect to mean intensity, the highest values were recorded in Gölhisar Lake population of *Tinca tinca*, Beyşehir Lake population of *Carassius gibelio*, Karataş Lake Population of *Carassius gibelio* (3.7; 3.5; 3 parasites/fish, respectively).

4. Discussion

*Lernaea* is a copepod, which is parasitic on many species of freshwater fish and is extremely common among the Cypriniformes fish. In Turkey, previous records of the genus *Lernaea* on order Cypriniformes are provided by Geldiy and Balık (1974); Burgu et al. (1988); Demir (2008); Karakızi and Demir (2012); Kir and Samancı (2012); Ince (2013); Koyun et al. (2015); Innal et al. (2017); Akcimen et al. (2018); Erbatur et al. (2018). To date, 11 Cypriniformes species have been reported as host of *L. cyprinacea* in Turkey. This study documents the expanded geographical and host distribution of *L. cyprinacea* in Turkey. The present findings of *L. cyprinacea* from *Barbus xanthos*, *Alburnus baliki*, *Pseudophoxinus zekayi*, and *Pseudorasbora parva* represent the first records of the copepod from these fish in Turkey. This copepod is characterized with a wide host and geographic distribution and adapted to a large variety of habitat in Turkey.

In this study, *Lernaea* parasites were collected from the skin, gills, opercular cavity, and fins of *Pseudophoxinus* systems (Fig. 1) (on the map; 1: Lake Gölhisar; 2: Dalaman River; 3: Değirmendere Creek; 4: Lake Karataş; 5: Soğanlı Pond; 6: Çanaklı Pond; 7: Onaç Reservoir; 8: Lake Beyşehir; 9: Karpuzçay Creek; 10: Ceyhan River).

Table 1. Systematic overview of host fish species

| No | Host                        | Common name       | Order           | Family                |
|----|-----------------------------|-------------------|-----------------|-----------------------|
| 1  | *Pseudophoxinus burduricus* | Burdur spring minnow | Cypriniformes | Leuciscidae            |
| 2  | *Alburnus baliki*           | Antalya bleak      | Cypriniformes   | Leuciscidae            |
| 3  | *Pseudophoxinus zekayi*     | Ceyhan spring minnow | Cypriniformes   | Leuciscidae            |
| 4  | *Barbus xanthos*            | Eşen barbel        | Cypriniformes   | Cyprinidae             |
| 5  | *Tinca tinca*               | Tench              | Cypriniformes   | Tincidae               |
| 6  | *Pseudorasbora parva*       | Stone moroko       | Cypriniformes   | Gobionidae             |
| 7  | *Carassius gibelio*         | Prussian carp      | Cypriniformes   | Cyprinidae             |

Figure 1. Sampling localities [1. Lake Gölhisar (37°07’16.27”N 29°35’35.31”E); 2. Dalaman River (37°13’35.33”N 29°32’57.54”E); 3. Değirmendere Creek (37°25’29.85”N 29°49’19.34”E); 4. Lake Karataş (37°23’42.37”N 29°58’40.75”E); 5. Soğanlı Pond (37°38’29.60”N 30°3’14.68”E); 6. Çanaklı Pond (37°36’15.21”N 30°32’25.25”E); 7. Onaç Reservoir (37°29’37.12”N 30°34’3.42”E); 8. Lake Beyşehir (37°41’4.83”N 31°40’39.57”E); 9. Karpuzçay Creek (36°42’57.03”N 31°33’1.22”E); 10. Ceyhan River (36°39’2.28”N 35°33’46.79”E)].
burduricus, Pseudophoxinus zekayi, Barbus xanthos, Tinca tinca, Pseudorasbora parva, Carassius gibelio and Alburnus baliki in different water bodies. The highest infection prevalence value was found in Pseudophoxinus burduricus from Değirmendere Creek (48%) and the lowest in Carassius gibelio from Beyşehir Lake (3%). The mean intensity varied from 1 parasite in Alburnus baliki in Karpuzçay Creek and Carassius gibelio in Soğanlı Reservoir to 3.7 in Tinca tinca from Gölhisar Lake.

Different prevalence and intensity values in L. cyprinacea infections between the localities and hosts may depend on the changing habitat conditions such as temperature, pH, salinity and dissolved oxygen, and biotic parameters. For some populations, the data of infections were not representative for four seasons. In addition to seasonality and habitat conditions, the observed difference in infection parameters could be due to the sample size, sampling differences, feeding habits of fish species, sex ratio, length range, and host resistance.

A number of studies have investigated the differences in parasitism levels of L. cyprinacea on host Cypriniformes species (Gutiérrez-Galindo & Lacasa-Millán, 2005; Barson et al., 2008; Pérez-Bote, 2010; Stavrescu-Bedivan, Popa, Aioanei, & Popa, 2011). In some cases, they can be very abundant: in Chondrostoma orientale Bianco & Banarescu, 1982 from the Kor River Basin, southwestern Iran the prevalence of L. cyprinacea infections reached 100%, with a mean intensity of 10.3 parasites per fish (Savyadzadeh & Roudbar, 2015), and in Hypophthalmichthys molitrix from Manzala area 64% of the specimens were infected (Nofal et al., 2016).

In this study, it was determined that L. cyprinacea affected native and introduced Cypriniformes fish in Turkey. The results of this study encourage further investigations in different aquatic systems of the Mediterranean region of Turkey in order to identify prevalence and intensity of L. cyprinacea infestation for other Cypriniformes fish species. Moreover, the differences in morphological structure of the parasite individuals (L. cyprinacea) between regions and hosts should be investigated by molecular genetic methods.

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Figure 2. Prevalence and intensity values of host fish species
Table 2. Occurrence of Lernaea cyprinacea infestation in host fish species (N=total number of hosts examined; N’=number of infected fishes)

| No | Host                                      | Location                     | Status         | N  | N’  | Total length (cm) | Weight (g) Range (Min-Max) |
|----|------------------------------------------|------------------------------|----------------|----|-----|--------------------|-----------------------------|
| 1  | Pseudophonusinus budirucinus              | Degirmendere Creek           | Endemic        | 25 | 12  | 4.9-10.7           | 1.4-16                      |
| 2  | Alburnus balili                         | Karapınar Creek              | Endemic        | 60 | 2   | 4.2-10.8           | 0.6-15.7                    |
| 3  | Pseudophonusinus zoharii                | Ceyhan River                 | Endemic        | 4  | 1   | 9.5-12.8           | 9.1-30.4                    |
| 4  | Barbus xanthon                         | Dalaman Stream               | Native         | 60 | 3   | 3.5-20            | 0.5-80                      |
| 5  | Timca timca                            | Göllhiçar Lake               | Alien          | 50 | 3   | 16.2-39.3         | 78.5-1056                   |
| 6  | Pseudorasbora parra                    | Onal Reservoir               | Alien          | 217| 10  | 2.8-6.7           | 0.143-2.9                  |
| 7  | Carassius gibelio                      | Onal Reservoir               | Alien          | 127| 14  | 3.4-27.9          | 0.547-0.4                  |
| 8  | Carassius gibelio                      | Çanaklı Reservoir           | Alien          | 13 | 2   | 4.4-12.6          | 1.2-35.7                    |
| 9  | Carassius gibelio                      | Soğanlı Reservoir           | Alien          | 18 | 1   | 8.4-14.1         | 10.1-48                     |
| 10 | Carassius gibelio                      | Karatay Lake                | Alien          | 38 | 3   | 20.3-56.3        | 153-560                     |
| 11 | Carassius gibelio                      | Beyşehir Lake               | Alien          | 67 | 2   | 18.1-24.2        | 46.263                     |

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