The occurrence and dynamics of *Ligula intestinalis* in its cyprinid fish host, tench, *Tinca tinca*, in Mogan Lake (Ankara, Turkey)

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ABSTRACT: Although *Ligula intestinalis* (L., 1758) has been recorded in several fish hosts, available data on the parasitization parameters of *Ligula intestinalis* plerocercoids such as prevalence, mean intensity and parasitic index in tench (*Tinca tinca* L., 1758) is limited. In this study, totally 272 fishes were investigated for the presence of *L. intestinalis* plerocercoids. The prevalence value was 40.01% of the whole fish sample and the mean intensity was 2.48. The lower *IP* values and mean intensity levels may provide some evidence of the strategy of *Ligula* in order to complete its life cycle. None of the parasitization parameters showed significant differences between the sexes.

Keywords: *Ligula intestinalis*; Cestoda; prevalence; parasitic index; Mogan Lake

Tench (*Tinca tinca* L., 1758) is one of the economically most important fish species in Central Europe (Lukowicz and Proske, 1979) and in the former Czechoslovakia (Moravec, 1985). In several European countries, tench is reared in farm ponds, either in monoculture or along with common carp (*Cyprinus carpio*) (Svobodova and Kolarova, 2004). It also has a big population in Turkey and more than 80% is sold to EU countries (Unlusayin et al., 2002). Compared to the other fish species, the occurrence of diseases in tench is lower, and prevalence and intensity of infections tend to be also relatively low (Svobodova and Kolarova, 2004).

Ligula intestinalis (L., 1758) is a pseudophyllidean cestode which in its plerocercoid stage infests a range of freshwater fish species, particularly members of the Cyprinidae, as its second intermediate host and it has a widespread distribution throughout the northern hemisphere (Dubinina, 1980). The plerocercoid stage is infective to a wide range of fish-eating birds, which serve as the final host. *Ligula* has been the subject of a number of studies, mainly those aimed at differences in pathogenicity and parasite-host relationships (Arme, 1968; Arme and Owen, 1968; see review by Arme et al., 1983). Although the parasite-host relation parameters were studied in many fish species including *Abramis brama* (Barus and Prokes, 2002), *Blicca bjoerkna* (Barus and Prokes, 1994, 2002), *Gobio gobio* (Arme and Owen, 1968), *Rutilus rutilus* (Arme and Owen, 1968; Kennedy and Burrough, 1981; Kennedy et al., 2001), there is only one study dealing with these parameters in the system of *Ligula intestinalis* – *Tinca tinca* (Yavuzcan et al., 2003). According to our literature review, tench is an unusual host for *Ligula* in European countries, but in Turkey tench is the most common host for *Ligula* (Oktener, 2003). The objective of the present study was to determine the parameters of the parasite-host relation in *Ligula* in relation to age classes, months sampled and genders of tench in Mogan Lake.

MATERIAL AND METHODS

The study was carried out in Mogan Lake (39.47' N, 32.47' E), which is known to be eutrophic (Manav and Yerli, 2005). It is a shallow (mean depth 2.1 m, max. depth 3.5 m) large (5.4–6 km^2), non-stratifying lake with total drainage area of 925 km^2. In 1990, the lake was declared as a "specially protected area" by the Ministry of Environment, and due to its rich and diverse waterfowl, the lake acquired the status of "important bird area" (IBA) (Akbulut, 2004).

A total of 272 fish samples were collected with gill nets and fyke nets from Mogan Lake, Ankara, Turkey between 2002 July and 2003 June. During the study, the lake froze between mid-January and February. For each fish collected, the fork length (nearest to 0.1 cm) and total weight (nearest to 0.1 g) were recorded and the sex was determined by the macroscopic examination of gonads. Age of fish was determined from scales by a microfiche reader. The body cavity was examined for the presence of plerocercoids, if present, the number plerocercoids was counted and the total weight was recorded nearest to 0.1 g. Parasitic index (*IP*%) was calculated according to Kennedy and Burrough (1981). Prevalence and mean intensity were calculated according to Bush et al. (1997). Kruskal-Wallis or Mann-Whitney *U*-test was performed to test the differences in the mean intensity, parasitic index and total plerocercoid weight between age classes and between genders. Results were considered to be significant where $P < 0.05$.

RESULTS

A total of 272 fish specimens were investigated. Fork length ranged between 7.8 and 30.2 cm for non-infected fish and from 6.9 to 29.6 cm for infected counterparts. Total weight ranged between 9.4 and 454.1 g for non-infected fish and from 7.3 to 370.7 g for infected counterparts (somatic weight not including parasite weight for infected fish). Fish aged I–VII years were present in the samples. Infected specimens ($n = 109$) consisted of 55 males and 54 females, uninfected specimens ($n = 163$) consisted of 80 males and 83 females. It was found that being infected was independent of gender in the studied population ($\chi^2_{0.05,\,1}$; $P = 0.921$).

Out of the investigated 272 specimens of tench, 109 were found to be infected with *L. intestinalis* and the prevalence was 40.01% (95% CI; 34.2–46.1%) of the whole sample, the highest in July (75.94%) and the lowest in May (8.32%) (Table 1). The values of prevalence, mean intensity and parasitic index for the age classes are given in Table 2. A sharp decrease in prevalence was recorded in age class II.

The frequency of distribution of fish in the intensity classes and months sampled is shown in Figure 1. Multiple infections (intensity class: 3–9) were the most common in July, and single infections were observed throughout the study. The mean intensity was 2.48 (95% CI; 2.11–2.84), the highest in July (3.20) and the lowest in May (1.00) (Table 1). Its range was 1 to 9 plerocercoids per infected fish in the whole sample. The mean intensity fluctuated between 1.00 and 3.08 in relation to age classes, the highest in age class VI and the lowest in age class I and II (Table 2).

The *IP*% values for the months sampled and age classes are given in Table 1 and 2, respectively. The

Table 1. Prevalence (%), mean intensity and parasitic index (*IP*%) values for the months sampled

Months	N	N'	Prevalence (95% CI)	Mean intensity (min–max; ± SD)	Mean *IP* (min–max; ±SD)
July	60	19	75.94 (65.0–84.0)	3.20 (1–9; ± 2.30)	2.08 (0.10–7.60; ± 1.65)
August	8	22	26.66 (12.0–45.0)	1.63 (1–4; ± 1.19)	1.25 (0.30–3.80; ± 1.08)
September	12	23	48.00 (27.0–68.0)	2.00 (1–7; ± 1.71)	1.88 (0.10–6.40; ± 1.84)
December	7	10	41.17 (18.0–67.0)	1.43 (1–3; ± 0.79)	0.97 (0.10–2.80; ± 1.18)
January	9	14	39.13 (19.0–61.0)	1.33 (1–2; ± 0.50)	1.26 (0.10–3.20; ± 1.14)
April	5	13	27.77 (9.0–53.0)	1.80 (1–3; ± 0.84)	1.96 (0.40–3.60; ± 1.21)
May	3	33	8.33 (1.70–22.0)	1.00	0.40 (0.10–1.00; ± 0.52)
June	5	29	14.70 (4.00–31.0)	1.40 (1–3; ± 0.89)	0.60 (0.20–1.60; ± 0.57)
Total	109	163	40.01 (34.2–46.1)	2.48 (1–9; ± 2.02)	1.74 (0.10–7.60; ± 1.55)

N – number of infected fish, N' – number of non-infected fish

Table 2. Prevalence (%), mean intensity and parasitic index (*IP*%) values for the age classes

Age classes	N	N'	Prevalence (95% CI)	Mean intensity (min–max; ± SD)	Mean *IP* (min–max; ±SD)
I	3	4	42.85 (9.00–81.0)	1.00	2.10 (1.10–3.80; ± 1.48)
II	2	19	9.52 (1.10–30.0)	1.00	0.95 (0.30–1.60; ± 0.91)
III	4	11	26.66 (7.00–55.0)	1.75 (1–3; ± 0.96)	1.97 (0.50–3.20; ± 1.25)
IV	24	38	38.71 (26.0–51.0)	1.83 (1–7; ± 1.46)	1.27 (0.10–3.40; ± 1.04)
V	57	61	48.30 (39.0–57.0)	2.82 (1–9; ± 2.26)	2.04 (0.10–7.60; ± 1.86)
VI	12	21	36.36 (20.0–54.0)	3.08 (1–7; ± 1.88)	1.62 (0.20–2.90; ± 1.03)
VII	7	9	43.75 (19.0–.70.0)	2.29 (1–7; ± 2.14)	1.02 (0.10–2.70; ± 0.84)
Total	109	163	40.01 (34.2–46.1)	2.48 (1–9; ± 2.02)	1.74 (0.10–7.60; ± 1.55)

N – number of infected fish, N' – number of non-infected fish

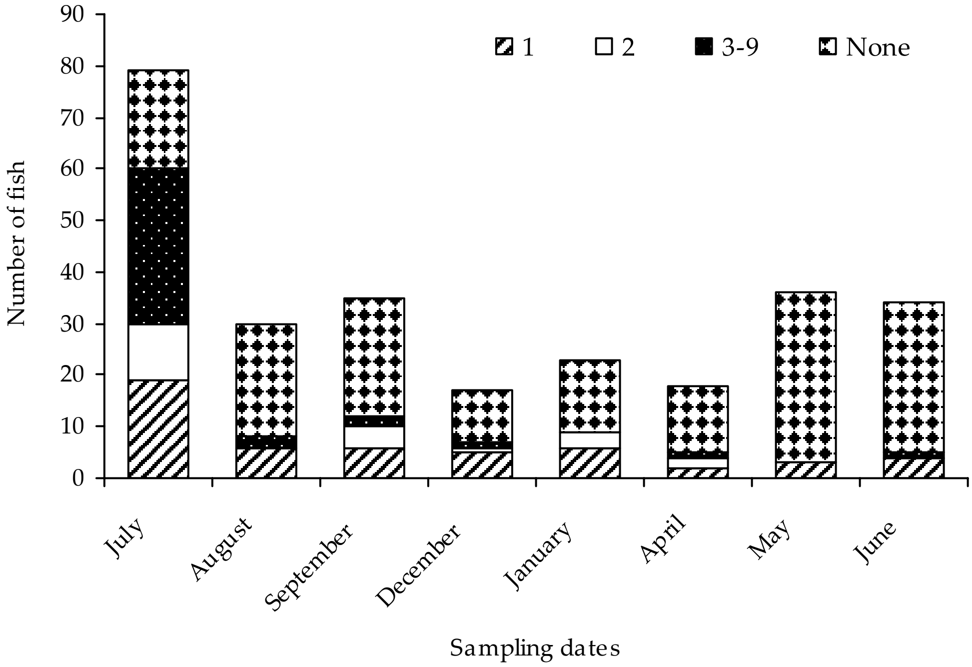

Figure 1. The number of fish in the intensity classes (n = 1, 2 and 3–9 plerocercoids per fish) and months sampled

IP% fluctuated between 0.1 and 7.60%, the highest in July (2.08%) and the lowest in May (0.40%) (Table 1). The highest *IP*% was calculated for the fish in age class I (2.10%) and the lowest in age class II (0.95%) (Table 2). A significant difference in the number of infected fish was found between age classes (I to VII) ($\chi^2_{0.05,6}$ = 12.963, P = 0.044). When age class II was excluded from the case and the data was re-analysed, no significant differences between age classes (I, III, IV, V, VI and VII) were found ($\chi^2_{0.05,5}$ = 4.045, P = 0.543). Mean intensity levels and parasitic index values showed no differences between the age classes (Kruskal-Wallis test; $\chi^2_{0.05,6}$ = 12.012, P = 0.062 and $\chi^2_{0.05,6}$ = 5.935, P = 0.430, respectively). It was found that none of the parasitization parameters, including parasite weight, mean intensity and parasitic index, showed significant differences between the genders (Mann-Whitney *U*-test; U = 1 344.5, P = 0.366, U = 1 368.0, P = 0.478 and U = 1 329.5, P = 0.345, respectively).

DISCUSSION

Ligula intestinalis is known to infest many freshwater fishes including tench in Turkey (see the checklist by Oktener, 2003) although it is not a common host for *Ligula* in European countries. Only Yavuzcan et al. (2003) investigated the parasitization parameters of *Ligula* infection such as mean intensity, prevalence and parasitic index in tench. The presence of *L. intestinalis* plerocercoids was shown by many researchers to be associated with certain pathological effects in the fish host (Arme, 1968; Arme and Owen, 1968; Arme et al., 1983). These pathological effects mainly include the inhibition of gonadal development in the fish host (Arme et al., 1983). Thus, *Ligula* plerocercoids may play a role in the regulation of their fish hosts' population dynamics, via the inhibition of gonadal development.

According to Kennedy et al. (2001), *Ligula* typically exhibits epizootic cycles over a period of 4–5 years and it has excellent powers of dispersal and is brought into a lake by migratory birds. Following its arrival in a lake, if the conditions are suitable, its population increases rapidly which in turn results in mortality of fish hosts because of parasite-induced host mortality (PIHM) (Loot et al., 2001a). Since the whole fish population may be infected in the course of time (Kennedy et al., 2001), there would be a decrease in the fish population because of PIHM. This will also decrease the *Ligula* population because of not being able to complete its life cycle. The pattern that observed in this study resembled an epizootic cycle; prevalence was 75.94% at the beginning of the study and it declined to 14.70% at the end of the study. Except for August, there was a gradual decrease through July to May, and a slight increase in June (Table 1). Most probably this was so because the study was carried out in the last period of an epizootic cycle. But several authors stated that to give an imprecise measure of *Ligula* infection levels, long-term data sets are needed (Burrough and Kennedy, 1979; Kennedy and Burrough, 1981). The pattern observed in this study may also simply be attributed to a seasonal fluctuation which may result from the feeding behaviour of tench and the seasonal dynamics of appropriate copepod hosts.

No significant differences in prevalence between age classes, except for age class II, were found out. The sharp decrease in prevalence in age class II may be due to the higher mortality rate of younger tench during winterkill. The lake froze between mid-January and February; which might have caused the winterkill. Because of the scarcity of the fish in age class I it is not possible to interpret whether mortality – due to winterkill or PIHM or both – also occurred in age class I or not. Harris and Wheeler (1974) found that *Ligula*-induced host mortality occurred primarily in colder months. The prevalence values were similar in all age classes, except for age class II, which may indicate that, contrary to other studies (Arme and Owen, 1968; Wyatt and Kennedy, 1989), tench continue to pick up infections in their whole life, not only in their early life stages.

The *IP* values for months sampled and age classes were not found to show a marked pattern, being only lower compared to other studies. Arme and Owen (1968) found that plerocercoids weighed up to 50% of the roach weight. Barus and Prokes (1994) reported that *IP*% values fluctuated between 0.4 and 17.7% in silver bream and they also observed that *IP*% value did not exceed 20% in roach, silver bream and bream (Barus and Prokes, 2002). Yavuzcan et al. (2003) found that IP values fluctuated between 2.72 and 5.55% in tench. In this study, *IP*% values fluctuated between 0.1 and 7.60%, being similar to those reported by Yavuzcan et al. (2003). The lower *IP*% values observed in this study may simply result from the resistance of tench to infections; Svobodova and Kolarova (2004) mentioned that the occurrence of diseases was lower and the intensity of infections also tended to be relatively low in tench. However, it is assumed that causing less harm to the host will benefit the parasite in order to complete its life cycle (see the review by Barber et al., 2000).

The mean intensity in the particular months sampled did not exhibit a marked pattern. Multiple infections (3–9 plerocercoids per fish) were the most common in July, which may indicate that the acquisition of plerocercoids was highest in mid-summer; it may result from the density of the copepod population. Although not statistically significant, the mean intensity showed a gradual but slight increase in age classes, except for age class VII. This may be due to the accumulation of plerocercoids in fish as they grow; it is generally accepted that the plerocercoids may survive in fish for several years (Arme, 2002).

There was not any significant difference between the sexes of tench in any aspects of parasitization, including total parasite weight, parasitic index, mean intensity and prevalence. Thus it is clear from these results that *Ligula* has no preference to male or female tench in Mogan Lake.

Grozev et al. (2000) studied the natural feeding of tench in a polyculture rearing pond and found that zooplankton was predominant in one- and two-summer old tench, but in three-summer old tench no zooplankton was found; the stomach contents of tench consisted of benthic organisms at this age. Similar findings were reported by Kennedy and Fitzmaurice (1970). Thus, tench seems to pick up infections mainly in the early stages of its life. However, in our study newly acquired plerocercoids were found even in older tench. It is unclear whether the newly acquired worms in older fish were the result of accidental copepod ingestion during foraging for benthic prey or were alternatively selected actively by fish as a source of food.

Mogan Lake is an Important Bird Area (IBA) and approximately 170 bird species were recorded in Mogan Lake (Kirac, 1995). Since the worms acquire maturity in 3–5 days in the bird host, infected piscivorous birds are scarcely observed in natural conditions (Loot et al., 2001b). Thus it is difficult to determine which the bird species play a key role in the transmission of *L. intestinalis* in Mogan Lake.

REFERENCES

Akbulut N. (2004): Limnology in Turkey. In: Gopal, B., Wetzel R.W. (eds.): Limnology in Developing Countries. SIL, 4, 171–218.

Arme C. (1968): Effects of the plerocercoid larva of pseudophyllidean cestode, *Ligula intestinalis*, on the pituitary gland and gonads of its host. Biological Bulletin, 134, 15–25.

Arme C. (2002): *Ligula intestinalis*, a tapeworm contraceptive. Biologist, 49, 265–269.

Arme C., Owen R.W. (1968): Occurrence and pathology of *Ligula intestinalis* infection in British fishes. Journal of Parasitology, 54, 272–280.

Arme C., Bridges J.F., Hoole D. (1983): Pathology of cestode infections in the vertebrate host. In: Arme C. & Pappas P.W. (eds.): Biology of the Eucestoda. Academic Press, London. 499–538.

Barber I., Hoare D., Krause J. (2000): Effects of parasites on fish behaviour: a review and evolutionary perspective. Reviews in Fish Biology and Fisheries, 10, 131–165.

Barus V., Prokes M. (1994): Parasite load of *Ligula intestinalis* plerocercoids in adult silver bream, *Blicca bjoerkna*. Helminthologia, 31, 91–94.

Barus V., Prokes M. (2002): Length and weight of *Ligula intestinalis* plerocercoids (Cestoda) parasitizing adult cyprinid fishes (Cyprinidae): a comparative analysis. Helminthologia, 39, 29–34.

Burrough R.J., Kennedy C.R. (1979): The occurrence and natural alleviation of stunting in a population of roach, *Rutilus rutilus* (L.). Journal of Fish Biology, 15, 93–109.

Bush A.O., Lafferty K.D., Lotz J.M., Shostak A.W. (1997): Parasitology meets ecology on its own terms: Margolis et. al., revisited. Journal of Parasitology, 83, 575–583.

Dubinina M.N. (1980): Tapeworms (Cestoda, Ligulidae) of the Fauna of the U.S.S.R. Amerind Publishing Co., New Delhi.

Grozev G.K., Hubenova-Siderova T., Paskaleva E. (2000): Natural feeding of tench at polyculture rearing in carp ponds. Bulgarian Journal of Agricultural Science, 6, 209–214.

Harris M.T., Wheeler A. (1974): *Ligula* infestation of bleak *Alburnus alburnus* (L.) in the tidal Thames. Journal of Fish Biology, 6, 181–188.

Kennedy C.R., Burrough R. J. (1981): The establishment and subsequent history of a population of *Ligula intestinalis* in roach *Rutilus rutilus* (L.). Journal of Fish Biology, 19, 105–126.

Kennedy C.R., Shears P.C., Shears J.A. (2001): Long-term dynamics of *Ligula intestinalis* and *Rutilus rutilus*: a study of three epizootic cycles over 31 years. Parasitology, 123, 257–269.

Kennedy M., Fitzmaurice P. (1970): The biology of the tench in Irish waters. Proceedings of the Royal Irish Academy B, 69, 31–82.

Kirac S.K. (1995): The importance of Mogan Lake in terms of bird life. In: First Environmental Congress on Lake Mogan and Eymir. 18–20 January, Golbasi, Ankara, 196–200.

Loot G., Lek S., Dejean D., Guegan J.F. (2001a): Parasite-induced mortality in three host populations of the roach, *Rutilus rutilus* by the tapeworm *Ligula intestinalis*. Annales de Limnologie, 37, 151–159.

Loot G., Francisco P., Santoul F., Lek S., Guegan J.F. (2001b): The three hosts of the *Ligula intestinalis* (Cestoda) life cycle in Lavernose-Lacasse gravel pit, France. Archiv fur Hydrobiologie, 152, 511–525.

Lukowicz M.V., Proske C.H.R. (1979): Production and reproduction of tench. Rivista Italiana di Pisciocultura e Ittiopatologia A, 14, 109–112.

Manav E., Yerli S.V. (2005): The determination of the trophic status of Lake Mogan (Ankara, Turkey). Fresenius Environmental Bulletin (in press).

Moravec F. (1985): Occurrence of the endoparasitic helminths in tench (*Tinca tinca*) from the Macha Lake fishpond system. Vestnik Ceskoslovenske Spolecnosti Zoologicke, 49, 32–50.

Oktener A. (2003): A checklist of metazoan parasites recorded in freshwater fish from Turkey. Zootaxa, 394, 1– 28.

Svobodova Z., Kolarova J. (2004): A review of the diseases and contaminant related mortalities of tench. Veterinarni medicina, 49, 19–34. http://www.vri.cz/docs/vetmed/49-1-19.pdf

Unlusayin M., Bilgin S., Izci L., Gulyavuz H. (2002): The preparation of fish ball from pike perch (*Sander lucioperca*) and tench (*Tinca tinca*) filet cracks and determination of shelf life. S.D.U. Fen Bilimleri Enstitusu Dergisi, 6, 34–43.

Wyatt R.J., Kennedy C.R. (1989): Host-constrained epidemiology of the fish tapeworm *Ligula intestinalis*. Journal of Fish Biology, 35, 215–227.

Yavuzcan H., Korkmaz A.S., Zencir O. (2003): The infection of tench (*Tinca tinca*) with *Ligula intestinalis* plerocercoids in Lake Beysehir (Turkey). Bulletin of the European Association of Fish Pathologists, 23, 223–227.

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