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# Endohelminth fauna of the marsh frog *Rana ridibunda* from Lake Hazar, Turkey

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ABSTRACT: In this study, 236 marsh frogs *Rana ridibunda* collected from Lake Hazar (Elaziğ, Turkey) at 15 d intervals between March 2001 and February 2002 were examined for endohelminths; of these, 148 (62.71%) frogs were found to be infected with helminths. In total, 9 helminth species (3 trematodes, 5 nematodes and 1 acanthocephalan) were identified. We observed *Gorgoderina vitelliloba* (prevalence 2.97%) in the urinary bladder, *Haematoloechus variegatus* (4.66%) and *Rhabdias bufonis* (8.90%) in the lung, *Pleurogenoides medians* (1.69%), *Oswaldocruzia filiformis* (3.81%) and *Acanthocephalus ranae* (26.27%) in the small intestine, *Neoxysomatium brevicaudatum* (16.95%) and *Cosmocercoides* sp. (3.39%) in the large intestine, and *Eustrongylides excisus* (14.41%) in the body cavity and on the stomach. No helminth was found in the spleen, kidney, gall bladder, liver, heart or muscle. Of the 9 helminth species identified, *Acanthocephalus ranae* (26.27%) had the highest prevalence and abundance and *Oswaldocruzia filiformis* (8.33 ± 4.09) had the highest mean intensity.

KEY WORDS: *Rana ridibunda* · Endohelminths · *Gorgoderina* · *Haematoloechus* · *Rhabdias* · *Pleurogenoides* · *Oswaldocruzia* · *Acanthocephalus* · *Neoxysomatium* · *Cosmocercoides*



## INTRODUCTION

Frogs and toads have received little attention from parasitologists in Turkey. To date, 4 helminth species have been recorded in *Rana ridibunda* Palas, 1771, 6 in *Rana macrocremis*, and 9 in *Bufo viridis*; 4 nemotode species were also recorded in several species (*R. ridibunda*, *Bufo bufo*, and *Pelabotes syriacus*) (Oğuz et al. 1994, Yildirimhan et al. 1997a,b, Yildirimhan 1999). Although surveys and general taxonomic studies on the helminths of frogs and toads in Turkey are few, specific studies utilizing community measures (species richness, prevelance of infection, helminth mean intensity and abundance) to study these helminth communities were published recently.

Muzzall (1991) studied parasitic helminths of frogs (*Rana catesbeiana* and *R. clamitans*) in Turkey Marsh in Michigan, USA, and found 16 helminth species (10 trematodes, 1 cestode, and 5 nematodes). Very few helminth species were recorded in the toad *Bufo marinus* in Australia by Barton (1999). The helminth fauna of some species of the Family Ranidae were observed in Poland (Cedhagen 1988, Kuc & Sulgostowska 1988a,b) and Arizona (Goldberg et al. 1998). Helminth communities in freshwater fish have been generally characterised as depauperate, exhibiting low diversity and being isolationist in nature (Kennedy et al. 1986, Kennedy 1990). Seasonal studies of the helminth communities of amphibians are few; however, Bolek & Coggins (2000, 2001) studied the seasonal occurrence and community structure of helminth parasites of the eastern American toad *Bufo americanus americanus* and green frog *Rana clamitans melanota* in the USA.

The external parasites (Saglam & Aksoy 1996) and endohelminth species (Aksoy & Sarıeyyüpoğlu 2000) of fish in Lake Hazar were previously investigated, but thus far not those of the frog *Rana ridibunda*.

In the present study, the diversity of helminth species infecting *Rana ridibunda* from Lake Hazar, Turkey, were recorded for the first time. Additionally, we set out to characterize the parasitic fauna of *R. ridibunda* with an emphasis on weight-, length-, and sex-related changes

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in the host. Thus, our purpose was to examine the seasonality of helminth species in *R. ridibunda*, in addition to their prevalence, mean intensity, and abundance.

## MATERIALS AND METHODS

**Study area.** Lake Hazar is one of the largest lakes in Eastern Anatolia, situated 1248 m above sea level (38° 27′ N, 39°18′ E). The lake is 20 km long and 4 km wide, located in a tectonic depression between the Tauros Mountains. It has a surface area of 78 km$^2$ and its basin covers an area of 273 km$^2$ (Emiroglu et al. 1998, Şen et al. 1999). At maximum water level (1242 m), the maximum volume of the lake is 7 billion m$^3$. Reports of its maximum depth vary between 80 and 300 m; its average depth is calculated to be 93 m (Şen 1988, Şen et al. 1999).

**Frog sampling.** Frogs were collected on a monthly basis from 3 different locations on the shoreline of Lake Hazar between March 2001 and February 2002. A total of 236 frogs were examined. All individuals were caught with a scoop net and anaesthetized with ether. Total length (mm), wet weight (g) and sex of each frog was determined.

**Parasitic examination.** Dissections were conducted with the aid of a dissecting microscope at a magnification of up to 12× using standard parasitological techniques (Chubb & Powell 1966). The following tissues and organs were examined: esophagus, stomach, duodenum, intestine and rectum, gall bladder, urinary bladder, liver, lung, gonad, kidney, heart, lateral musculature and mesenteries. Helminths were picked out and counted.

In order to make permanent preparations, the trematodes and achanthocephalans were fixed in Davidson's AFA (acetic acid, formalin, alcohol) and preserved in 70% ethanol, stained in Mayer's carmine, dehydrated, cleared in xylol, and mounted on slides in Canada balsam. Nematodes were straightened in 70% heated ethanol, preserved in 70% ethanol, and cleared in glycerol (Prichard & Kruse 1982, Yasarol 1984). Helminths were identified by reference to Yamaguti (1955, 1963, 1968) and Moravec (1994). The morphological characteristics of parasites were measured, and specimens were stored in the Parasitology Laboratory of the Faculty of Fisheries, Fırat University.

**Statistical analysis.** In this study, prevalence (%) was determined to be the proportion of hosts infected with particular parasite species, abundance the number of a particular parasite species per host individual (infected and uninfected), and mean intensity the mean number of a particular parasite species among infected hosts. Parasite prevalence, abundance and mean intensity (±SE) were calculated according to Bush et al. (1997).

The variance/mean ratio was used as a measure of the nature of distribution of each helminth species within the host population (Anderson & Gordon 1982, Byrne et al. 1999). All individual parasites of each helminth species in each host were counted, and mean number of helminth parasites in samples from each host (an indicator of infrapopulation composition) was calculated (Bush et al. 1997). Chi-square analysis was used to investigate the relationship between helminth number and the sex, length, and wet weight of the host. When $\alpha < 0.05$, groups were either pooled to fulfill the requirements of the test or the Kolmogorov-Smirnov (K-S) statistical test was applied (Zar 1984, Sumbuloglu & Sumbuloglu 1994). In the case of normal distribution, ANOVA was used to compare among seasonal differences in mean intensity and abundance; for abnormal distribution, the Kruskal-Wallis statistical test using Minitab Statistical Software version 10 was used to analyze the relationship between helminth worm burden (prevalence, mean intensity, and abundance). Differences were considered to be significant when $p \leq 0.05$.

## RESULTS

A total of 236 adult marsh frogs — 122 males (spring: 20, summer: 47, autumn: 48, winter: 7) and 114 females (spring: 23, summer: 55, autumn: 28, winter: 8) — were collected between March 2001 and February 2002. Nine species of endohelminth were found in *Rana ridibunda* from Lake Hazar: 3 trematodes, 5 nematodes, and 1 acanthocephalan. The prevalence of infection by trematodes, nematodes and acanthocephala was found to be 9.32, 47.46, and 26.27%, respectively. Measurements of endohelminths are given in Table 1.

### Prevalence of infection, mean intensity and abundance of endohelminths and distribution

Prevalence, mean intensity and abundance of the 9 endohelminth species and the variance/mean ratio of each are given in Table 2. *Acanthocephalus ranae* showed the highest prevalence (26.27%) and mean abundance (0.68 ± 0.13, range 0 to 25) of any species. However, *Oswaldocruzia filiformis* was present at highest mean intensity (8.33 ± 4.09, range 1 to 37). *Gorgoderina vitelliloba* and *Haematoloechus variegatus* had the lowest mean intensity (1.43 ± 0.30, range 1 to 3; 1.45 ± 0.31, range 1 to 4) and abundance (0.04 ± 0.02, range 0 to 3; 0.07 ± 0.02, range 0 to 4). In this study, endohelminths were found in the urinary bladder, lung, small and large intestine, body cavity, and on the stomach of *Rana ridibunda* (Table 1). No helminth was

Table 1. Measurements (mm) of endohelminths of *Rana ridibunda* from Lake Hazar, Turkey. Bd: body, Pr: proboscis, H: hook, Ph: pharynx, Oc: oral caecum, Lm: lemnisci, Vc: ventral sucker, Tt: testes (A: anterior–P: posterior), Ov: ovary, Sp: spicule

| Parasite species | Bd[a] | Pr | H | Ph | Oc[a] | Lm | Vc[a] | Tt (A–P)[a] | Ov[a] | Sp | Egg[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trematoda** | | | | | | | | | | | |
| *Gorgoderina vitelliloba* | 4.35 × 0.54 | – | – | – | 0.29 × 0.28 | – | 0.49 × 0.47 | 0.54 × 0.25 – 0.55 × 0.25 | 0.24 × 0.16 | – | 0.02 × 0.02 |
| *Haematoloechus variegatus* | 4.00 × 0.50 | – | – | – | 0.30 × 0.31 | – | 0.10 × 0.15 | 0.54 × 0.25 – 0.54 × 0.25 | 0.25 × 0.17 | – | – |
| *Pleurogenoides medians* | 1.47 × 0.57 | – | – | – | 0.13 × 0.10 | – | 0.08 × 0.06 | 0.11 × 0.14 – 0.11 × 0.14 | 0.10 × 0.13 | – | – |
| **Nematoda** | | | | | | | | | | | |
| *Rhabdias bufonis* | 6.13 × 0.25 | – | – | 0.40 | – | – | – | – | – | – | 0.05 × 0.08 |
| *Oswaldocruzia filiformis* | 7.18 × 0.20 | – | – | 0.46 | – | – | – | – | – | 0.17 | 0.05 × 0.08 |
| *Neoxysomatium brevicaudatum* | 5.50 × 0.38 | – | – | 0.76 | – | – | – | – | – | 1.50 | 0.04 × 0.06 |
| *Cosmocercoides* sp. | 5.03 × 0.40 | – | – | 0.54 | – | – | – | – | – | 0.20 | 0.05 × 0.08 |
| *Eustrongylides excisus* | 26.20 × 0.11 | – | – | 3.40 | – | – | – | – | – | – | – |
| **Acanthocephala** | | | | | | | | | | | |
| *Acanthocephalus ranae* | 13.17 × 1.06 | 0.41 | 0.07 | – | – | 0.98 | – | 0.80 × 0.54 – 0.85 × 0.55 | – | – | 0.03 × 0.05 |

[a]Length × width

Table 2. No. of parasites and infected frogs (male and female), prevalence of infection (%), mean abundance, mean intensity and location of endohelminths in *Rana ridibunda*. AC: abdominal cavity, I: intestine, L: lungs, S: on the stomach, UB: urinary bladder

| Parasite species | No. of frogs infected | No. of parasites | Prevalence of infection (%) | Mean intensity ± SE | Mean abundance ± SE | Variance/mean ratio | Location |
|---|---|---|---|---|---|---|---|
| **Trematoda** | | | | | | | |
| *Gorgoderina vitelliloba* | 7 | 10 | 2.97 | 1.43 ± 0.30 (1–3) | 0.04 ± 0.02 (0–3) | 2.36 | UB |
| *Haematoloechus variegatus* | 11 | 16 | 4.66 | 1.45 ± 0.31 (1–4) | 0.07 ± 0.02 (0–4) | 1.35 | L |
| *Pleurogenoides medians* | 4 | 29 | 1.69 | 7.25 ± 3.25 (1–16) | 0.12 ± 0.08 (0–16) | 12.59 | I |
| **Nematoda** | | | | | | | |
| *Rhabdias bufonis* | 21 | 33 | 8.90 | 1.57 ± 0.18 (1–4) | 0.14 ± 0.03 (0–4) | 1.52 | L |
| *Oswaldocruzia filiformis* | 9 | 75 | 3.81 | 8.33 ± 4.09 (1–37) | 0.32 ± 0.18 (0–37) | 23.90 | I |
| *Neoxysomatium brevicaudatum* | 40 | 105 | 16.95 | 2.63 ± 0.55 (1–22) | 0.45 ± 0.11 (0–22) | 6.35 | I |
| *Cosmocercoides* sp. | 8 | 19 | 3.39 | 2.38 ± 0.62 (1–6) | 0.08 ± 0.03 (0–6) | 2.66 | I |
| *Eustrongylides excisus* | 34 | 69 | 14.41 | 2.03 ± 0.24 (1–6) | 0.29 ± 0.06 (0–6) | 2.93 | AC, S |
| **Acanthocephala** | | | | | | | |
| *Acanthocephalus ranae* | 62 | 160 | 26.27 | 2.58 ± 0.43 (1–25) | 0.68 ± 0.13 | 5.87 | I |

found in the spleen, kidney, gall bladder, liver, heart, oesophagus, duodenum, rectum, gonad, lateral musculature, or mesenteries.

### Effect of host sex and season

The relationship between sex of the frog and prevalence of infection (%), mean intensity, and mean abundance of endohelminths according to season is presented in Table 3. *Gorgoderina vitelliloba* was not found in female frogs and *Haematoloechus variegatus* was not found in male frogs; the prevalence of *G. vitelliloba* in male frogs was highest in spring. The prevalences of *Eustrongylides excisus* and *Acanthocephalus ranae* were determined to be 41.82 and 35.00%, respectively; the prevalence *E. excisus* was highest in male frogs in summer, but that of A. ranae was highest in female frogs in spring. Mean intensity of *Oswaldocruzia filiformis* (37.00) and *Neoxysomatium brevicaudatum* (4.64) in male and female frogs was highest in summer; mean abundance of *A. ranae* in male (1.02) and female (1.21) frogs was also highest in summer (Table 3).

The numbers of parasites of male and female *Rana ridibunda* were compared, and no significant differences were observed at the 5% level ($\chi^2_{obs}$ = 0.018, df = 1, p > 0.05). Furthermore, infections of trematodes, nematodes and acanthocephalans did not differ significantly between male and female *R. ridibunda* at the 5% level ($\chi^2_{obs}$ = 1.569, df = 2, p > 0.05), indicating no effect of host sex on endohelminth diversity.

Two-way ANOVA and Kruskal-Wallis tests revealed that prevalence of infections ($H$ = 3.375, df = 3, p > 0.05), mean intensity ($F$ = 0.598, df = 3 to 64, p > 0.05), and mean abundance ($F$ = 0.199, df = 3 to 64, p > 0.05) of endohelminths did not differ significantly between male and female frogs according to season.

### Effect of host length

The relationship between 3 length groups of *Rana ridibunda* (40 to 65 mm, 66 to 90 mm and 91 to 115 mm) and prevalence of infections, mean intensity and abundance endohelminths are shown in Table 4. The highest prevalence of endohelminth infections (66.67%) was found in the 40 to 65 mm length group, whereas highest mean intensity (4.64 ± 1.85, range 1 to 22) and abundance (3.64 ± 0.55, range 0 to 22) was found in the 91 to 115 mm length group (Table 4).

Kruskal-Wallis tests revealed no significant difference in the prevalence of infections ($H$ = 0.184, df = 2, p > 0.05), mean intensity ($H$ = 0.878, df = 2, p > 0.05) and abundance ($H$ = 0.240, df = 2, p > 0.05) of endohelminths among 3 length groups of *Rana ridibunda*. The number of frogs infected/not infected with endohelmiths were compared among the 3 length groups: no significant differences were observed ($\chi^2_{obs}$ = 1.832, df = 2, p > 0.05).

### Effect of host weight

The highest prevalence of infections (65.57%) and mean intensities (2.87 ± 0.50, range 1 to 25) of endohelminths were in the 46 to 85 g weight group of *Rana ridibunda*, whereas highest mean abundance (4.17 ± 3.60, range 0 to 22) was observed in the 86 to 126 g weight group. However, in the 86 to 126 g weight group, only 2 species of parasite (*Haematoloechus variegatus* and *Neoxysomatium brevicaudatum*) were found (Table 5).

No significant differences in mean intensity of infection among 3 weight groups of *Rana ridibunda* were revealed ($H$ = 5.911, df = 2, p > 0.05). However, prevalence ($H$ = 7.046, df = 2, p < 0.05) and mean abundance ($H$ = 6.215, df = 2, p < 0.05) of endohelminths among the 3 weight groups differed significantly. Numbers of infected and uninfected frogs were compared among the 3 weight groups: no significantly differences were observed ($K\text{-}S_{obs}$ = 0.55, df = 2, p > 0.05).

## DISCUSSION

The results of the present study have added significantly to knowledge of the distribution, prevalence, mean intensity, and abundance of endoparasitic helminth infections in the frog *Rana ridibunda* from Lake Hazar, Turkey. None of the species of endohelminth observed in this frog represented a new host record. The helminth faunas of Lake Hazar *R. ridibunda* were generally similar to those recorded for *Bufo viridis* (Yildirimhan 1999) and *R. ridibunda*, *Bufo bufo* and *Pelobates syriacus* (Yildirimhan et al. 1997a) from other localities in Turkey.

*Haematoloechus variegatus* was found to have higher prevalence than *Gorgoderina vitelliloba*, and but both parasite species were observed at very low mean intensities and abundance. Mean intensity (7.25 ± 3.25) of *Pleurogenoides medians* was found to be higher than prevalence of infection (1.69%) and mean abundance (0.12 ± 0.08) (Table 2). *Gorgoderina vitelliloba* and *H. variegatus* were only found in male and female frogs, respectively (Table 3); hormonal differences between male and female hosts may account for this.

Abramoff & Thomson (1991) found *Gorgodera* and *Gorgoderina* spp. in the urinary bladder of various frog species; we also found *Gorgoderina vitelliloba* in

Table 3. Prevalence of infection (%), mean intensity and mean abundance of endohelminths with season in relation to sex of *Rana ridibunda*

| Parasite species | No. of frogs infected | No. of parasites | Prevalence of infection (%) | | | | Mean intensity | | | | Mean abundance | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | spring (n = 43) | summer (n = 102) | autumn (n = 76) | winter (n = 15) | spring (n = 43) | summer (n = 102) | autumn (n = 76) | winter (n = 15) | spring (n = 43) | summer (n = 102) | autumn (n = 76) | winter (n = 15) |
| **Male (n = 114)** | | | | | | | | | | | | | | |
| **Trematoda** | **9** | **30** | | | | | | | | | | | | |
| *Gorgoderina vitelliloba* | 7 | 10 | 13.04 | 7.27 | 0 | 0 | 1.00 | 1.75 | 0 | 0 | 0.13 | 0.13 | 0 | 0 |
| *Haematoloechus variegatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleurogenoides medians* | 2 | 20 | 8.70 | 0 | 0 | 0 | 10.00 | 0 | 0 | 0 | 0.87 | 0 | 0 | 0 |
| **Nematoda** | **52** | **160** | | | | | | | | | | | | |
| *Rhabdias bufonis* | 3 | 9 | 4.35 | 9.09 | 0 | 0 | 2.00 | 1.40 | 0 | 0 | 0.09 | 0.13 | 0 | 0 |
| *Oswaldocruzia filiformis* | 7 | 69 | 0 | 1.82 | 17.86 | 12.50 | 0 | 37.00 | 5.60 | 4.00 | 0 | 0.67 | 1.00 | 0.50 |
| *Neoxysomatium brevicaudatum* | 11 | 20 | 17.39 | 3.64 | 17.86 | 0 | 2.00 | 3.50 | 1.00 | 0 | 0.35 | 0.13 | 0.18 | 0 |
| *Cosmocercoides* sp. | 6 | 12 | 0 | 3.64 | 10.71 | 12.50 | 0 | 2.00 | 2.00 | 2.00 | 0 | 0.07 | 0.21 | 0.25 |
| *Eustrongylides excisus* | 25 | 50 | 0 | 41.82 | 0 | 25.00 | 0 | 1.96 | 0 | 2.50 | 0 | 0.82 | 0 | 0.63 |
| **Acanthocephala** | **31** | **76** | | | | | | | | | | | | |
| *Acanthocephalus ranae* | 31 | 76 | 34.78 | 36.36 | 10.71 | 12.50 | 1.75 | 2.80 | 1.00 | 3.00 | 0.61 | 1.02 | 0.11 | 0.38 |
| **Female (n = 122)** | | | | | | | | | | | | | | |
| **Trematoda** | **13** | **25** | | | | | | | | | | | | |
| *Gorgoderina vitelliloba* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haematoloechus variegatus* | 11 | 16 | 5.00 | 8.51 | 12.50 | 0 | 1.00 | 2.25 | 1.00 | 0 | 0.05 | 0.19 | 0.13 | 0 |
| *Pleurogenoides medians* | 2 | 9 | 5.00 | 0 | 2.08 | 0 | 8.00 | 0 | 1.00 | 0 | 0.40 | 0 | 0.02 | 0 |
| **Nematoda** | **57** | **141** | | | | | | | | | | | | |
| *Rhabdias bufonis* | 15 | 24 | 10.00 | 14.89 | 8.33 | 28.57 | 2.00 | 1.43 | 2.00 | 1.00 | 0.20 | 0.21 | 0.17 | 0.29 |
| *Oswaldocruzia filiformis* | 2 | 6 | 0 | 2.13 | 2.08 | 0 | 0 | 5.00 | 1.00 | 0 | 0 | 0.11 | 0.02 | 0 |
| *Neoxysomatium brevicaudatum* | 29 | 85 | 15.00 | 23.40 | 31.25 | 0 | 2.33 | 4.64 | 1.8 | 0 | 0.35 | 1.09 | 0.56 | 0 |
| *Cosmocercoides* sp. | 3 | 7 | 0 | 2.13 | 4.17 | 0 | 0 | 1.00 | 3.00 | 0 | 0 | 0.02 | 0.13 | 0 |
| *Eustrongylides excisus* | 8 | 19 | 0 | 17.02 | 2.08 | 0 | 0 | 2.00 | 3.00 | 0 | 0 | 0.34 | 0.06 | 0 |
| **Acanthocephala** | **29** | **84** | | | | | | | | | | | | |
| *Acanthocephalus ranae* | 29 | 84 | 35.00 | 27.66 | 14.58 | 28.57 | 2.14 | 4.38 | 1.43 | 1.00 | 0.75 | 1.21 | 0.21 | 0.29 |

the urinary bladder of *Rana ridibunda*. Yildirimhan et al. (1997a) reported a similar mean intensity of *G. vitelliloba* in *Rana macrocnemis* as that observed in *R. ridibunda* in the present study.

The prevalence (1.80%) and mean intensity (0.02) of *Haematoloechus variegatus* observed by Kuc & Sulgostowska (1988a) was lower than that recorded in the present study. In contrast, the prevalence (35.60%) of this parasite reported by Kuc & Sulgostowska (1988b) for *Rana esculenta* was higher than that of our study.

Male *Rana ridibunda* were infected with *Pleurogenoides medians* in spring, whereas female *R. ridibunda* were infected with *P. medians* in spring and autumn. Male frogs had a higher prevalence of infection, mean intensity and abundance of *P. medians* than female frogs ($p < 0.05$) (Table 3). The prevalence and mean intensity of *P. medians* in *R. ridibunda* from Poland varied from 12.50 to 29.4% and from 0.70 to 3.40, respectively (Kuc & Sulgostowska 1988a); that is, prevalence of *P. medians* was higher but mean intensity lower than that observed in this study.

In this study, *Rhabdias bufonis* were found in the lungs, *Oswaldocruzia filiformis*, *Neoxysomatium brevicaudatum* and *Cosmocercoides* sp. in the small and large intestine, and *Eustrongylides excisus* in the body cavity and on the stomach of *Rana ridibunda* (Table 2). *Rhabdias bufonis* was found in male frogs in spring and summer and in female frogs in all seasons. *Oswaldocruzia filiformis*, *Cosmocercoides* sp. and *E. excisus* were found in male frogs in summer, autumn and winter, and in female frogs in summer and autumn. *Neoxysomatium brevicaudatum* had a higher prevalence and mean abundance, and was present in male and female frogs in spring, summer, and autumn (Table 3).

Table 4. Prevalence of infection (%), mean intensity and mean abundance of endohelminths in relation to length of *Rana ridibunda*

| Parasite species | 40–65 mm (n = 69) Prevalence of infection (%) | 40–65 mm (n = 69) Mean intensity ± SE | 40–65 mm (n = 69) Mean abundance ± SE | 66–90 mm (n = 118) Prevalence of infection (%) | 66–90 mm (n = 118) Mean intensity ± SE | 66–90 mm (n = 118) Mean abundance ± SE | 91–115 mm (n = 49) Prevalence of infection (%) | 91–115 mm (n = 49) Mean intensity ± SE | 91–115 mm (n = 49) Mean abundance ± SE |
|---|---|---|---|---|---|---|---|---|---|
| **Trematoda** | | | | | | | | | |
| *Gorgoderina vitelliloba* | 2.65 | 1.67 ± 0.67 (1–3) | 0.04 ± 0.03 (0–3) | 3.67 | 1.25 ± 0.25 (1–2) | 0.05 ± 0.02 (0–2) | 0 | 0 | 0 |
| *Haematoloechus variegatus* | 4.42 | 1.00 ± 0 (1) | 0.04 ± 0.02 (0–1) | 3.67 | 1.75 ± 0.75 (1–4) | 0.06 ± 0.04 (0–4) | 14.29 | 2.00 ± 1.00 (1–3) | 0.29 ± 0.08 (0–3) |
| *Pleurogenoides medians* | 0.88 | 1.00 ± 0 (1) | 0.01 ± 0.01 (0–1) | 1.83 | 10.00 ± 6.00 (4–16) | 0.18 ± 0.15 (0–16) | 7.14 | 8.00 ± 0 (8) | 0.57 ± 0.20 (0–8) |
| **Nematoda** | | | | | | | | | |
| *Rhabdias bufonis* | 8.85 | 1.60 ± 0.31 (1–4) | 0.14 ± 0.05 (0–4) | 9.17 | 1.50 ± 0.22 (1–3) | 0.14 ± 0.05 (0–3) | 7.14 | 2.00 ± 0 (2) | 0.14 ± 0.05 (0–2) |
| *Oswaldocruzia filiformis* | 5.31 | 5.33 ± 3.00 (1–20) | 0.28 ± 0.18 (0–20) | 2.75 | 14.33 ± 11.34 (1–37) | 0.39 ± 0.34 (0–37) | 0 | 0 | 0 |
| *Neoxysomatium brevicaudatum* | 20.35 | 2.17 ± 0.39 (1–7) | 0.44 ± 0.11 (0–7) | 11.93 | 1.85 ± 0.34 (1–4) | 0.22 ± 0.07 (0–4) | 28.57 | 7.75 ± 4.82 (1–22) | 2.21 ± 0.56 (0–22) |
| *Cosmocercoides sp.* | 4.42 | 2.60 ± 0.51 (1–4) | 0.12 ± 0.05 (0–4) | 1.83 | 2.00 ± 0 (2) | 0.04 ± 0.03 (0–2) | 7.14 | 2.00 ± 0 (2) | 0.14 ± 0.05 (0–2) |
| *Eustrongylides excisus* | 11.50 | 1.77 ± 0.30 (1–4) | 0.20 ± 0.06 (0–4) | 17.43 | 2.21 ± 0.37 (1–6) | 0.39 ± 0.10 (0–6) | 14.29 | 2.00 ± 1.00 (1–3) | 0.29 ± 0.79 (0–3) |
| **Acanthocephala** | | | | | | | | | |
| *Acanthocephalus ranae* | 29.20 | 2.48 ± 0.35 (1–10) | 0.73 ± 0.15 (0–10) | 26.61 | 2.69 ± 0.33 (1–25) | 0.72 ± 0.25 (0–25) | 0 | 0 | 0 |
| **Total** | 66.37 | 2.29 ± 0.25 (1–20) | 2.01 ± 0.23 (0–20) | 60.55 | 2.77 ± 0.53 (1–37) | 2.18 ± 0.43 (0–37) | 50.00 | 4.64 ± 1.85 (1–22) | 3.64 ± 0.55 (0–22) |

Table 5. Prevalence of infection (%), mean intensity and mean abundance of endohelminths in relation to weight of *Rana ridibunda*

| Parasite species | 6–45 g (n = 44) Prevalence of infection (%) | 6–45 g (n = 44) Mean intensity ± SE | 6–45 g (n = 44) Mean abundance ± SE | 46–85 g (n = 138) Prevalence of infection (%) | 46–85 g (n = 138) Mean intensity ± SE | 46–85 g (n = 138) Mean abundance ± SE | 86–126 g (n = 54) Prevalence of infection (%) | 86–126 g (n = 54) Mean intensity ± SE | 86–126 g (n = 54) Mean abundance ± SE |
|---|---|---|---|---|---|---|---|---|---|
| **Trematoda** | | | | | | | | | |
| *Gorgoderina vitelliloba* | 4.14 | 1.43 ± 0.30 (1–3) | 0.06 ± 0.02 (0–3) | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haematoloechus variegatus* | 4.73 | 1.38 ± 0.38 (1–4) | 0.07 ± 0.03 (0–4) | 3.28 | 1.00 ± 0 (1) | 0.03 ± 0.02 (0–1) | 16.67 | 3.00 ± 0 (3) | 0.50 ± 0,50 (0–3) |
| *Pleurogenoides medians* | 1.78 | 7.00 ± 4.58 (1–16) | 0.12 ± 0.10 (0–16) | 1.64 | 8.00 ± 0 (8) | 0.13 ± 0.13 (0–8) | 0 | | 0 |
| **Nematoda** | | | | | | | | | |
| *Rhabdias bufonis* | 8.88 | 1.66 ± 0.23 (1–4) | 0.15 ± 0.04 (0–4) | 9.84 | 1.33 ± 0.21 (1–2) | 0.13 ± 0.05 (0–2) | 0 | 0 | 0 |
| *Oswaldocruzia filiformis* | 4.73 | 8.88 ± 4.60 (1–37) | 0.42 ± 0.25 (0–37) | 3.28 | 4.00 ± 0 (4) | 0.07 ± 0.07 (0–4) | 0 | 0 | 0 |
| *Neoxysomatium brevicaudatum* | 20.71 | 2.09 ± 0.28 (1–7) | 0.43 ± 0.09 (0–7) | 6.56 | 2.50 ± 0.96 (1–5) | 0.16 ± 0.10 (0–5) | 16.67 | 22.00 ± 0 (22) | 3.67 ± 3.67 (0–22) |
| *Cosmocercoides* sp. | 3.55 | 2.50 ± 0.43 (1–4) | 0.09 ± 0.04 (0–4) | 3.28 | 2.00 ± 0 (2) | 0.07 ± 0.04 (0–2) | 0 | 0 | 0 |
| *Eustrongylides excisus* | 10.06 | 1.59 ± 0.21 (1–4) | 0.16 ± 0.04 (0–4) | 27.87 | 2.47 ± 0.41 (1–6) | 0.69 ± 0.18 (0–6) | 0 | 0 | 0 |
| **Acanthocephala** | | | | | | | | | |
| *Acanthocephalus ranae* | 24.85 | 2.05 ± 0.22 (1–7) | 0.51 ± 0.09 (0–7) | 32.79 | 3.70 ± 1.22 (1–25) | 1.21 ± 0.45 (0–25) | 0 | 0 | 0 |
| **Total** | 63.31 | 2.40 ± 0.32 (1–37) | 2.01 ± 0.27 (0–37) | 65.57 | 2.87 ± 0.50 (1–25) | 2.49 ± 0.45 (0–25) | 16.67 | 12.50 ± 9.50 (3–22) | 4.17 ± 3.60 (0–22) |

The prevalence of *Rhabdias bufonis* was higher in female frogs than in male frogs. In contrast, the prevalence of *Cosmocercoides* sp. and *Eustrongylides excisus* was higher in male frogs than in female frogs. The prevalence of *Oswaldocruzia filiformis* was higher in male frogs in autumn and winter and in female frogs in summer. The prevalence of *E. excisus* was higher in male frogs in spring, and in female frogs in summer and autumn. However, statistical analyses revealed no significant differences in prevalence, mean intensity and abundance of endohelminths between male and female *Rana ridibunda* according to season ($p > 0.05$).

The infection prevalance of *Rhabdias bufonis* was recorded as 17.50% in the lungs of *Rana arvalis* and 5.20% in *Rana temporaria* (Cedhagen 1988). In the present study, the infection prevalence of *Rhabdias bufonis* in *Rana ridibunda* was found to be 8.90%, i.e. intermediate between that of *Rana temporaria* and *Rana arvalis*. The prevalence and mean abundance of *Oswaldocruzia filiformis* reported by Yamaguti (1955) in *Rana ridibunda* and Yildirimhan (1999) in *Bufo viridis* was higher than that observed in the present study.

*Acanthocephalus ranae* was found in male and female frogs in all seasons. In this study, the prevalence of *A. ranae* was shown to be higher in male frogs in spring and in female frogs in other seasons. Mean intensity of *A. ranae* was recorded as 2.58 in the small intestine of *Rana ridibunda* (Kuc & Sulgostowska 1988a). Our result was similar to but slightly lower than that of Kuc & Sulgostowska (1988a).

*Rana ridibunda* has very diverse helminth fauna. This frog is large, able to leave the water to occupy aquatic and terrestrial habitats, and able to feed on a variety of aerial, terrestrial, and aquatic organisms; therefore, this diversity likely derives from transmission of helminths through various intermediate hosts. The development of helminth communities in Lake Hazar is the result of several factors such as ectothermy, host alimentary canal being gape limited and the presence of a small number of helminth species with direct life cycles. All results from the present study are similar to those of Muzzall (1991), who studied the parasitic helminths of *Rana catesbeiana* and *Rana clamitans* in Michigan, USA.

In some seasons, some species of helminth may not infect *Rana ridibunda* owing to environmental temperature, which affects the life-cycles of intermediate and definitive hosts and parasites: temperature affects the abundance of intermediate hosts, and is correlated with the population dynamics, feeding behaviour and breeding cycle of *R. ridibunda*. Maturation of some parasites was shown to be closely linked to frog spawning (Williams & Jones 1994). In addition, temperature affects the immune response of *Rana ridibunda*, which exhibits seasonal variations in resistance. Our findings showed that smaller frogs (<85 g) are more infected than larger frogs (>86 g), which may be a direct consequence of variable host behaviour and immunity with age and size.

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