Ecological parameters of *Lamproglena hoi* (Copepoda: Lernaeidae) infection on the Bushveld smallscale yellowfish, *Labeobarbus polylepis* (Boulenger, 1907)

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ABSTRACT

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This study describes the distribution and aspects of the ecology of *Lamproglena hoi*. Bushveld smallscale yellowfish, *Labeobarbus polylepis* (Boulenger, 1907) were collected during June 2006 from the Phongolo and Assegaai rivers, March 2005 and October 2006 from the Elands River, and January 2007 and June 2008 from the Komati River in Mpumalanga, South Africa and examined for the presence of parasites. *Lamproglena hoi* specimens were collected from the gill filaments of the host. Specimens were fixed with warm AFA (alcohol-formaldehyde-acetic acid) and preserved in 70 % ethanol. The identification of parasites took place in the laboratories of the University of Johannesburg.

Twenty-five copepods (prevalence 21 %, mean intensity = 4.17, abundance = 0.86) were collected on 29 fish in the Phongolo River and 46 copepods (prevalence 40 %, mean intensity = 3.83, abundance = 1.53) were collected on 30 fish in the Assegaai River. One hundred and sixty eight copepods (prevalence 52 %, mean intensity = 12.92, abundance = 6.72) were collected on 25 fish in 2005, and 527 copepods (prevalence 95 %, mean intensity = 27.74, abundance = 26.35) were collected on 20 fish in the Elands River. One hundred and sixteen copepods (prevalence 75 %, mean intensity = 7.73, abundance = 5.80) were collected on 20 fish in 2007, and 273 copepods (prevalence 63 %, mean intensity = 16.06, abundance = 10.11) were collected on 27 fish in 2008 in the Komati River. *Labeobarbus polylepis* from these four rivers was found to have a relatively high *L. hoi* infection.

Inseminated *L. hoi* females (immature) attach to the host in winter and their ovaries become conspicuous (mature). In spring fertilized eggs are stored in egg sacs hanging from the body (gravid), indicating that fertilized eggs start to hatch in spring and continued hatching into summer. Parasites prefer the median part of the second gill arch for attachment. No correlation exists between the number of parasites recorded on the gills and the sizes (total lengths) of yellowfish sampled.

Keywords: Copepoda, Crustacea, ecology, *Labeobarbus polylepis*, *Lamproglena hoi*, yellowfish

INTRODUCTION

In the genus *Lamproglena* Von Nordmann, 1832 only the adult females are gill parasites of fishes. The majority of species occur in freshwater and the only exception, *Lamproglena lichiae* Von Nordmann, 1832 was collected from the Red Sea (Fryer 1968) on the doublespotted queenfish, *Scomberoides lysan*. Six of the 39 species of this genus recorded are from southern Africa (Moll & Avenant-Oldewage 2008) and include *Lamproglena monodi* Capart, 1944; *Lamproglena clariae* Fryer, 1956; *Lamproglena barbicola* Fryer, 1961; *Lamproglena cornuta* Fryer, 1964; *Lamproglena hoi* Dippenaar, Luus-

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Powell & Roux, 2001; *Lamproglena hepsetii* Van As & Van As, 2006.

Lamproglena hoi was described from specimens collected in the Spekboom River, Mpumalanga (Dippenaar, Luus-Powell & Roux 2001). It is an ectoparasite on the gills of the Lowveld largescale yellowfish, *Labeobarbus marequensis* and the Bushveld smallscale yellowfish, *Labeobarbus polylepis*. *Labeobarbus polylepis* is an indigenous species endemic in the southern tributaries of the Limpopo River System, as well as the Inkomati and Phongolo system, above altitudes of 600 m and prefers permanent rivers with deep pools, riffles and runs (Skelton 2001).

The only publication that exists on *L. hoi* was by Dippenaar *et al.* (2001) and described the morphological features of this species by means of scanning electron micrographs and drawings. The aim of this study is to contribute to the understanding of the ecology of this parasite on *L. polylepis*.

MATERIALS AND METHODS

Sampling sites and hosts

Specimens of four *Labeobarbus polylepis* (Boulenger, 1907) populations were collected from Inkomati and Phongolo River systems within the natural geographical distribution range of the species. Twenty nine specimens were collected from the Phongolo River (27°22'17.93" S, 30°35'24.50" E) and 30 specimens from the Assegaai River (27°4'48.22" S, 30°49'15.09" E) during June 2006. In the Inkomati system, 25 specimens were sampled from the Elands River (25°36'56.09" S, 30°30'55.29" E) in March 2005 and 20 in October 2006. Twenty specimens were collected from the Komati River (25°53'40.94" S, 30°17'1.19" E) in January 2007 and 27 in June 2008 (Fig. 1).

Collection of fish and parasites

Fish specimens were captured by means of gill nets and killed by severing the spinal cord behind the head. They were weighed and their sizes were determined in the field by measuring their total length. The fish were dissected by cutting from the anus towards the head and the sex was determined. The gills were removed, dissected apart, placed in water and examined for parasites with the aid of a dissecting microscope. The gill arches were divided into three areas: anterior, median and posterior, and the positions of the parasites on each gill arch were noted. Females of *L. hoi* were collected and fixed in warm alcohol-formaldehyde-acetic acid (AFA) and preserved in 70 % ethanol.

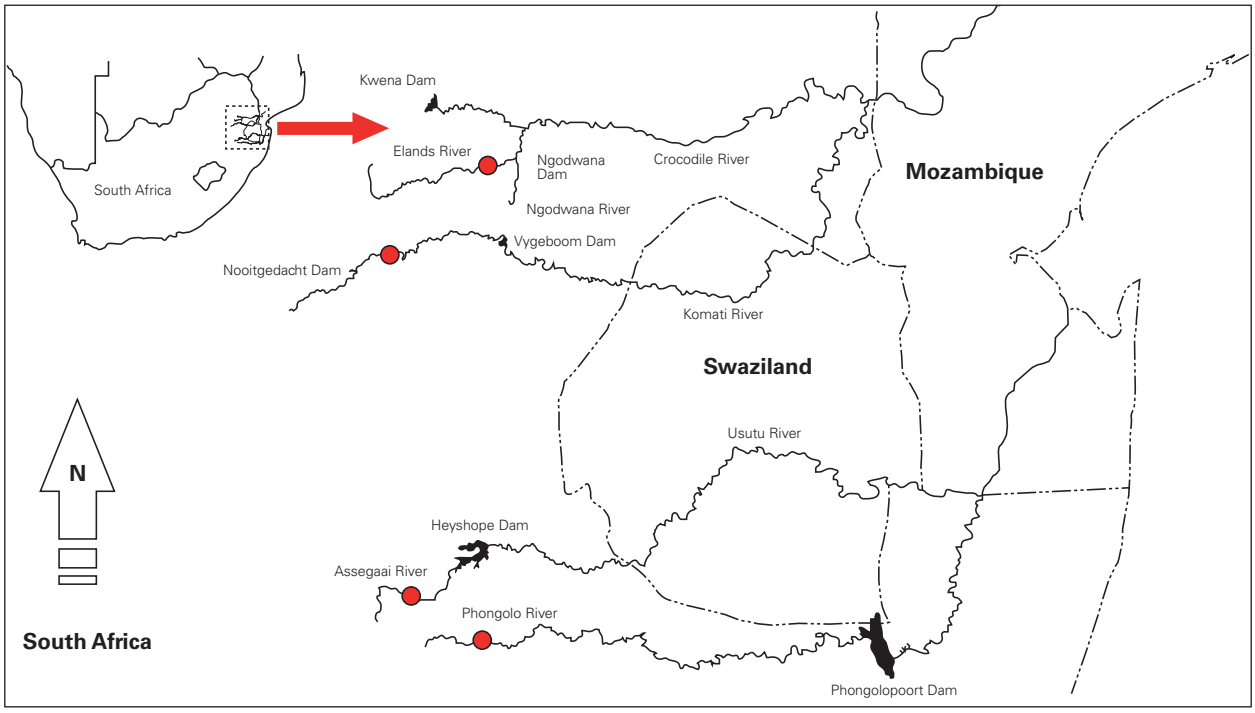

FIG. 1 Map indicating the geographic distribution of *Labeobarbus polylepis* sampled in four rivers (Elands, Phongolo, Assegaai and Komati rivers) in Mpumalanga, South Africa. Dots indicate the position of the sampling sites

Identification of parasites

The identification of the parasites took place in the laboratory of the University of Johannesburg. Parasites were identified as *L. hoi* based on their morphology (Dippenaar *et al*. 2001). Three developmental stages were observed in *L. hoi* females. Inseminated females were categorized as immature when attaching to the gill arches of the host. When the ovaries became conspicuous the females were considered mature. Subsequently, fertilized eggs are stored in egg sacs hanging from the body and females were classified as gravid.

Data presentation

Lamproglena hoi specimens were counted and the data obtained were graphically represented. A comparison between the infections in the four *L. polylepis* populations was done. Geographical locality, seasonality and gender specificity of *L. hoi* were determined. The location of the parasites on the gills was recorded. The correlations between the total length of the host and the number of parasites were determined. Infection levels were expressed as prevalence, mean intensity and abundance according to the definitions of Bush, Lafferty, Lotz & Shostak (1997).

RESULTS

The combined surface area of the second and third gills of *L. polylepis* is larger than that of the first and fourth gills (Fig. 2) and the fact that the former two gills are situated centrally in the gill chamber allows for maximum water flow over this area.

Lamproglena hoi congregates on the outside of the gill filaments and attaches close to the gill arches with the posterior end facing away from gill arches (Fig. 3A and 3B). In young females the gut content appears green (Fig. 3B) and no proliferation of gill tissue is apparent. In mature females the gut is filled with a red substance that appears to be blood (Fig. 3A) and proliferation of gill tissue is observed (Fig. 3B).

Infection statistics of *Lamproglena hoi*

Prevalence, abundance (relative density) and mean intensity

Sampling in the Phongolo and Assegaai rivers was done in winter, while the specimens in the Elands River were collected in autumn and spring and in the Komati River in summer and winter. The prevalence, mean intensity and abundance of the four rivers show seasonal variance (Fig. 7). The prevalence of *L. hoi* on the gills of *L. polylepis* varied between the different rivers. The prevalence in *L.*

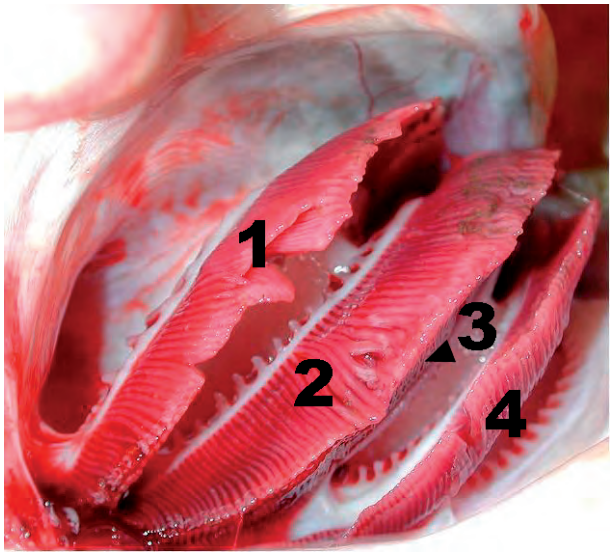

FIG. 2 Gill arches of *Labeobarbus polylepis* in the gill chamber. Numbers indicate the gills' position in succession from anterior to posterior

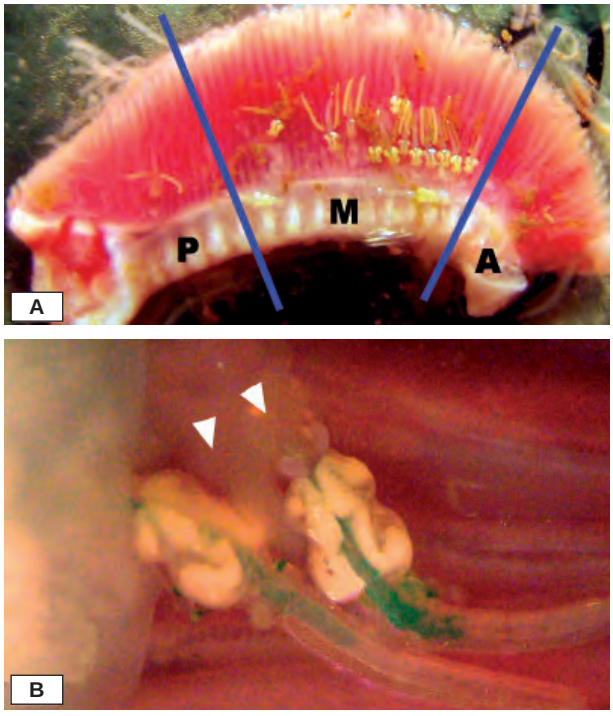

FIG. 3 (A) Photograph of a gill arch of *Labeobarbus polylepis* to indicate attachment sites of *Lamproglena hoi* parasites. Gill is divided into three sites (anterior (A), median (M) and posterior (P)), and (B) an enlargement to show attachment and proliferation at attachment site. Arrows indicate proliferation

polylepis in the Phongolo River (21 %) and Assegaai River (40 %) were relatively low, compared to the considerable higher prevalence in the Elands River (52 % and 95 %) and Komati River (63 % and 75 %). The highest mean intensity value recorded for *L. hoi* was in the Elands River and increased from 12.92 in autumn to 27.74 in spring (Fig. 4). The lowest values noted were 3.83 in the Assegaai River and 4.17

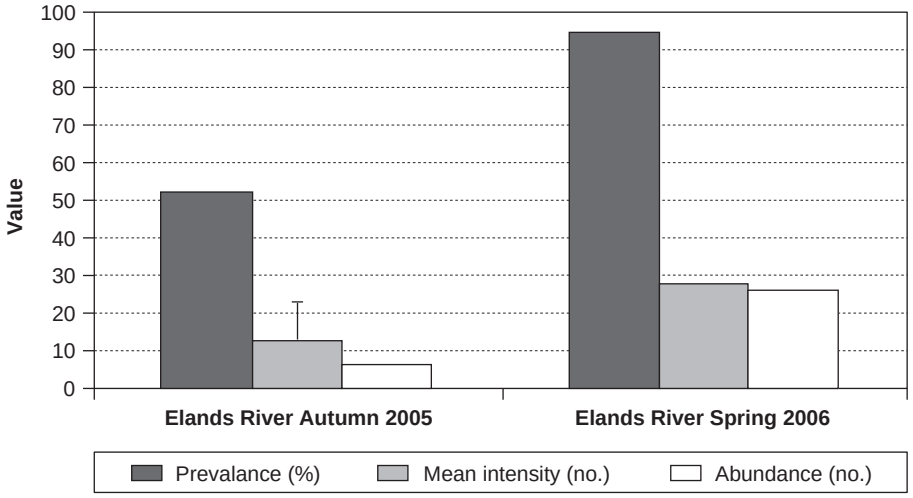

FIG. 4

Graph depicting the prevalence, mean intensity and abundance of *Lamproglena hoi* on the gills of *Labeobarbus polylepis* in autumn 2005 and spring 2006 in the Elands River in Mpumalanga, South Africa

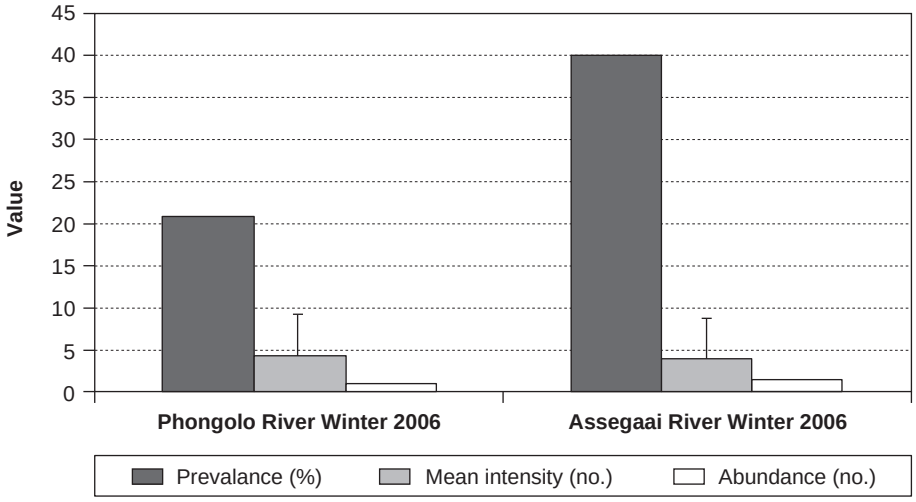

FIG. 5

Graph depicting the prevalence, mean intensity and abundance of *Lamproglena hoi* on the gills of *Labeobarbus polylepis* in winter 2006 in the Phongolo and Assegaai rivers in Mpumalanga, South Africa

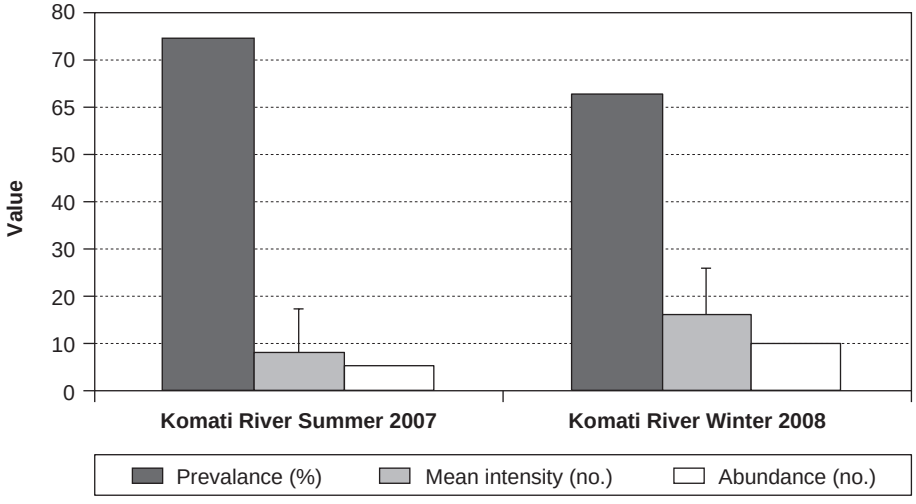

FIG. 6

Graph depicting the prevalence, mean intensity and abundance of *Lamproglena hoi* on the gills of *Labeobarbus polylepis* in summer 2007 and winter 2008 in the Komati River in Mpumalanga, South Africa

in the Phongolo River during winter (Fig. 5). The rest of the values ranged between 7.73 (summer) and 10.11 (winter) in the Komati River (Fig. 6).

For this fish species, the abundance values of *L. hoi* ranged from 6.72–26.35 (autumn and spring) in the Elands River to 0.86–1.53 (winter) in the Phongolo and Assegaai rivers and then increased to 5.80–16.06 (summer and winter) in the Komati River (Fig. 4, 5 and 6).

Ecological parameters

Seasonality

When the data sets from the various surveys are combined a pattern becomes apparent. The highest number of *L. hoi* was collected in spring. The highest prevalence, mean intensity and abundance of *L. hoi* were also recorded in spring. All parameters decreased toward summer and the lowest numbers were observed during winter surveys (Fig. 7).

In autumn 58 % of females were mature; this percentage increased in winter to 95 % and 96 %, respectively with 4 % and 5 % immature, indicating that eggs are not released during winter and that young females are present in this season.

In spring 84 % of females were gravid and egg sacs were hanging from the body.

In summer 55 % females were gravid, indicating that fertilized eggs start to hatch in spring and continued hatching into the summer season, as gravid females decreased in number from spring to summer (Fig. 8) and non parasitic nauplii were observed in close proximity to the egg sacks.

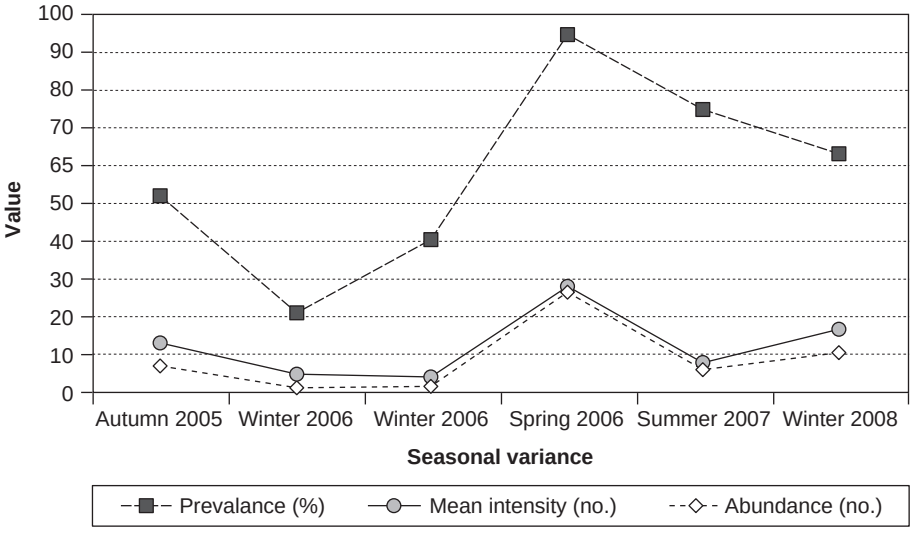

FIG. 7

Graph illustrating the seasonal variance of prevalence, mean intensity and abundance of *Lamproglena hoi* on the gills of *Labeobarbus polylepis* found in four rivers in Mpumalanga, South Africa

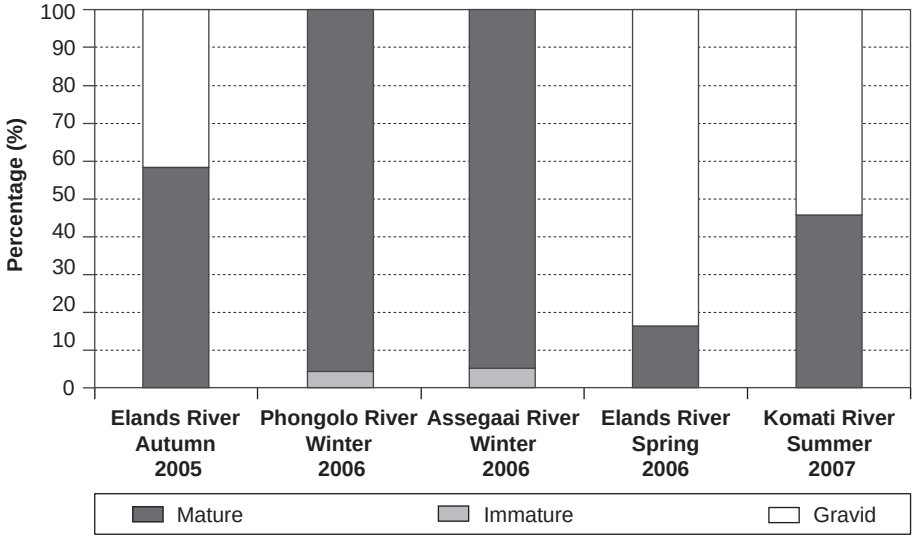

FIG. 8

Graph showing composition of immature, mature and gravid *Lamproglena hoi* females percentages in autumn, winter, spring and summer

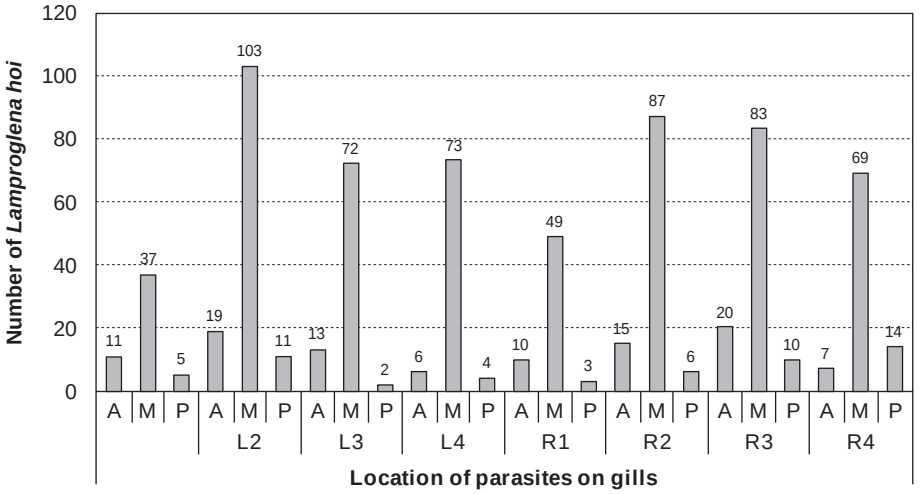

FIG. 9

Graph showing the position (anterior (A), median (M) or posterior (P)) of the *Lamproglena hoi* on the left (L) and right gill (R) arches of *Labeobarbus polylepis*

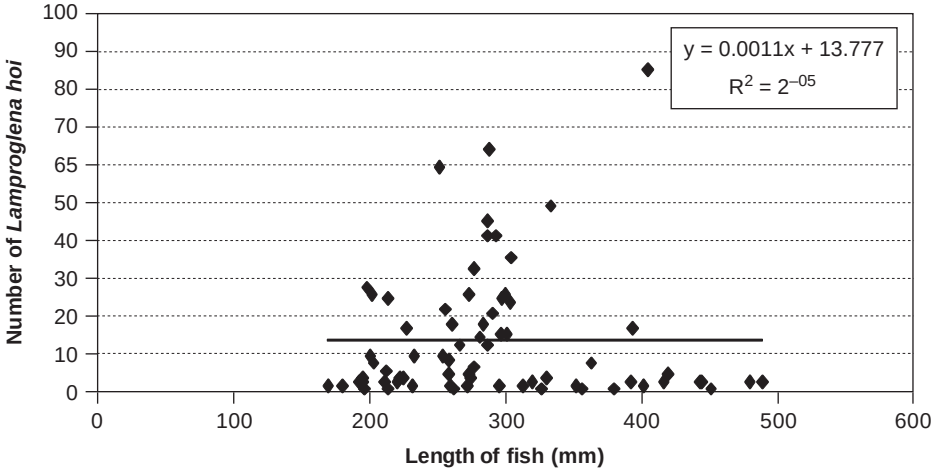

FIG. 10

Graph showing the number of *Lamproglena hoi* compared to the total size of *Labeobarbus polylepis* hosts

Location of parasites on the gills

The gill arches were divided into three areas: anterior, median and posterior and the positions of the parasites on each gill arch were noted. From a sub sample, a total of 729 parasites were collected on the gills of *L. polylepis*, 49 % were found on the left gills and 51 % on the right gills. On both the left and right side, 79 % of the parasites were attached to the median part of the gill arch. The gill arch's anterior gill area had 14 % of parasites and the posterior gill area 8 %. The second gill on both the left and right sides had the highest numbers of parasites (Fig. 9). The position of *L. hoi* on the hosts collected from the Elands River in autumn 2005 was excluded from the sub sample.

Gender specificity

In the sub sample (excluding Eland River data 2005) of 126 infected fish, the number of infected males (*n* = 56 or 81 % of infected fish) was much higher than that of the females (*n* = 13 or 19 %). However, mainly male fish were collected in the Komati River, hence the large infection on male hosts (*n* = 31).

Host size preference

No correlation existed between the number of parasites and the size of the host (Fig. 10).

DISCUSSION

The highest number of *L. hoi* females was observed during spring and it decreased from summer to autumn. The lowest number of parasites occurred in winter. Abundance and mean intensity values differ, the numbers in both cases were lower in spring time (Komati River) than in autumn (Elands River). *Labeobarbus polylepis* in the Elands River demonstrated extremely high numbers of *L. hoi* infections during autumn and spring. The hosts in the Komati

River showed exceptionally high numbers of parasites in winter compared to those in the Phongolo and Assegaai rivers. Khan & Thulin (1991) suggested that since ectoparasites are directly exposed to the river water, they are in contact with pollutants in it, which could reduce continued occurrence or reproductive tempo. According to Marx & Avenant-Oldewage (1996) and Avenant-Oldewage (2003) higher numbers of ectoparasites occur in less contaminated waters, while more polluted water has the reverse effect.

The Elands River is geographically isolated from the Komati River by two waterfalls, but the sampling localities in both rivers are not highly impacted (Ferreira, Wepener & Van Vuren 2008). The Komati River drainage area is mainly covered by forests and the river is therefore not impacted by anthropogenic activities. The less polluted Elands and Komati rivers have higher numbers of copepod ectoparasites than those fish in the Phongolo and Assegaai rivers. This finding corroborates the results of Avenant-Oldewage (2003) for *L. clariae* in the Olifants River and that of Tsotetsi, Avenant-Oldewage & Mashego (2004) on *L. clariae* in the Vaal River.

Only three developmental stages of the life cycle of *L. hoi* females were observed. The immature stage occurred in winter and the highest percentage of mature females was also observed during this season. In spring, gravid females dominated in numbers on the gills, and this phenomenon continues into summer. It appears that fertilized eggs hatch in spring and summer. The females die after egg production as is evident from the decline in the number of gravid females as spring goes into summer (84 % compared to 55 %).

There were no significant differences in the parasite load between the left and right gill, which indicates that *L. hoi* do not have a gill side preference. Rhode (1993) speculated that the preference for a particular gill side is due to the asymmetrical body shape of many parasites. *Lamproglena hoi* is bilaterally symmetrical which may possibly explain why there is no gill side preference. Rhode (1993) furthermore suggested that the distribution of parasites on different gills differs because of the preference or size of the gills. Marx & Avenant-Oldewage (1996) found that *L. clariae* concentrated near the ends of the gill arches which are completely different from *L. hoi* which congregates all over the gill surface. Furthermore, Tsotetsi *et al*. (2004) reported that *L. clariae* specimens attach midway along the gill filament so that the genital segment is in line with the apex of the filament. In *L. hoi*, the parasite attaches close to the bony part of the gill arch as well as along the length of the filament towards the tip.

Seventy-nine percent of the *L. hoi* were attached to the median part of the gill arch. This differs from the findings of Tsotetsi *et al*. (2004), who determined that 52 % *L. clariae* parasites attach to the median part of gill arch. According to Tsotetsi *et al*. (2004) the anterior part of the *Clarias gariepinus* gill arch also harboured 14 % of parasites, similar to the finding in this study. The posterior gill arches of *L. polylepis* harboured fewer *L. hoi* parasites (8 %) compared to *L. clariae* (34 %) were situated on the posterior gill arches of *C. gariepinus* (Tsotetsi *et al.* 2004).

More *L. hoi* parasites preferred the median position on the gill arches. The second gill arch on both sides had more *L. hoi* parasites than any other gills. The increased gill surface and water flow through the gill chamber might explain why there are more *L. hoi* parasites in these positions. It is suggested that water flow in these areas provides the ideal opportunity for attachment. This will furthermore provide an advantage for distribution of offspring. On the other hand, Tsotetsi *et al.* (2004) found a higher occurrence of *L. clariae* on the fourth gill on both sides. The fourth gill arch of *C. gariepinus* is shorter than the others and consists of fewer, thinner gill filaments. Tsotetsi *et al.* (2004) suggested that the protection or diminished turbulence in the part of the gill chamber may offer an explanation for attachment location.

In 2004 Tsotetsi *et al.* found that *L. clariae* had no preference regarding the sex of the host. Mainly male fish were collected during this study in the Komati River which makes this sample survey biased and a conclusion could not be made on gender preference.

Data of the present study showed no correlation between the number of parasites and the host size. This is in agreement with the results of Tsotetsi *et al.* (2004) on *L. clariae* on *C. gariepinus* and those of Sproston, Yin & Hu (1950) on *Ophiocephalus argus* and number of *Lamproglena chinensis*. Similar results for other copepod studies have been reported by Marcogliese (1991) for *Caligus* Műller, 1758 and Lo, Morand & Galzin (1998) for *Lernaea cyprinacea* Linnaeus, 1758. The increase in the size of the host will lead to an increase in gill surface and volume water flow through the gill chamber. However, these advantages have no affect on the number of parasites.

CONCLUSION

The numbers of *L. hoi* specimens on the gills of *L. polylepis* from the four rivers indicate a relatively high prevalence, mean intensity and abundance, and the occurrence of a seasonal variance. These observations corroborate those of Tsotetsi *et al.* (2004) for *L. clariae*. The median part of the gill arch on the second gill on both the left and right sides was the preferred attachment site. No correlation was found between the number of parasites and the host size or sex.

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