An introduced parasite, *Lernaea cyprinacea* L., found on native freshwater fishes in the south west of Western Australia

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Abstract

Lernaea cyprinacea L. is a parasitic copepod found on the skin and gills of freshwater fishes. Although *L. cyprinacea* has been introduced into eastern Australia, it has, until now, never been reported in Western Australia. We found infestations of *L. cyprinacea* on four native fish species (*Galaxias occidentalis* Ogilby; *Edelia vittata* Castelnau; *Bostockia porosa* Castelnau; *Tandanus bostocki* Whitley) and three introduced fish species (*Carassius auratus* L.; *Gambusia holbrooki* (Girard); *Phalloceros caudimaculatus* (Hensel)) at two localities in the Canning River, in the south west of Western Australia. The likely source of the parasites is introduced cyprinids, such as *C. auratus* and *Cyprinus carpio* L. The parasite has the potential to have serious pathogenic effects on native fish species, although it appears to be currently localised to a small section of the Canning River.

Key words: freshwater fish, parasite, *Lernaea*, Western Australia

Introduction

The South West Coast Drainage Division (Figure 1) contains a depauparate, but highly endemic freshwater fish fauna, with eight of the 10 native species found in the region being endemic (Morgan *et al.* 1998). A number of exotic fish species have also been introduced into south west rivers, either deliberately or as escapees from aquaculture or the aquarium trade (Morgan *et al.* 2004). Morgan *et al.* (2004) documented a number of potentially deleterious impacts of introduced fishes on native species in the south west, including predation, competition and habitat alteration. Introduced fishes may also transfer exotic diseases to native species, and this has been an increasing cause of concern for the health of freshwater environments throughout the world (Bauer 1991; Kennedy 1993; Arthington & McKenzie 1997; Levy 2004)

Lernaeosis is a disease of freshwater fishes caused by parasitic copepods of the family Lernaeidae (anchor worms). About 110 species of lernaeids have been described in 14 different genera (Ho 1998). The most common species is *Lernaea cyprinacea* L., which has been widely translocated with cultured fish species and is now found throughout North America, Europe, Asia, southern Africa and eastern Australia (Hoffman 1970; Lester & Haywood 2006). *Lernaea cyprinacea* has a very wide host range and has been found on more than 45 species of cyprinids, as well as fishes belonging to many other orders and occasionally on tadpoles (Tidd & Shields 1963; Lester & Haywood 2006).

Although *L. cyprinacea* is not native to Australia, the parasite has been recorded from a number of native and cultured fish species in New South Wales and Victoria, in eastern Australia (Ashburner 1978; Hall 1983; Callinan 1988; Rowland & Ingram 1991; Dove 2000; Bond 2004). In this paper, we provide the first published report of *L. cyprinacea* in Western Australia.

Methods

As part of a larger study on the parasite fauna of freshwater fishes in Western Australia, we sampled 1429 fishes of 18 different species from 29 localities in 12 rivers, spanning the extent of the South West Coast Drainage Division (Figure 1, Table 1). After *Lernaea* infestations were found at one locality in the Canning River, we sampled a further five localities in the Swan/Canning system (Figure 1). Adult and juvenile fishes were captured during summer and autumn, 2005–2007, using a combination of seine nets (3 mm mesh), fyke nets (92 mm mesh), gill nets (25–125 mm mesh) and electrofishers. Water temperature and conductivity were recorded for each locality on each sampling occasion. Fishes were returned to the laboratory, weighed and measured for total length (TL), and the skin and gills examined externally for *Lernaea* infestation using a dissecting microscope. *Lernaea* specimens were removed and preserved in 70% ethanol. After clearing in lactophenol, they were mounted whole for identification using a compound microscope. Parasite data were expressed as prevalences (proportion of infested hosts) and intensities of infestation (number of parasites per infested host). Ninety five percent confidence intervals were calculated for prevalences, assuming a binomial

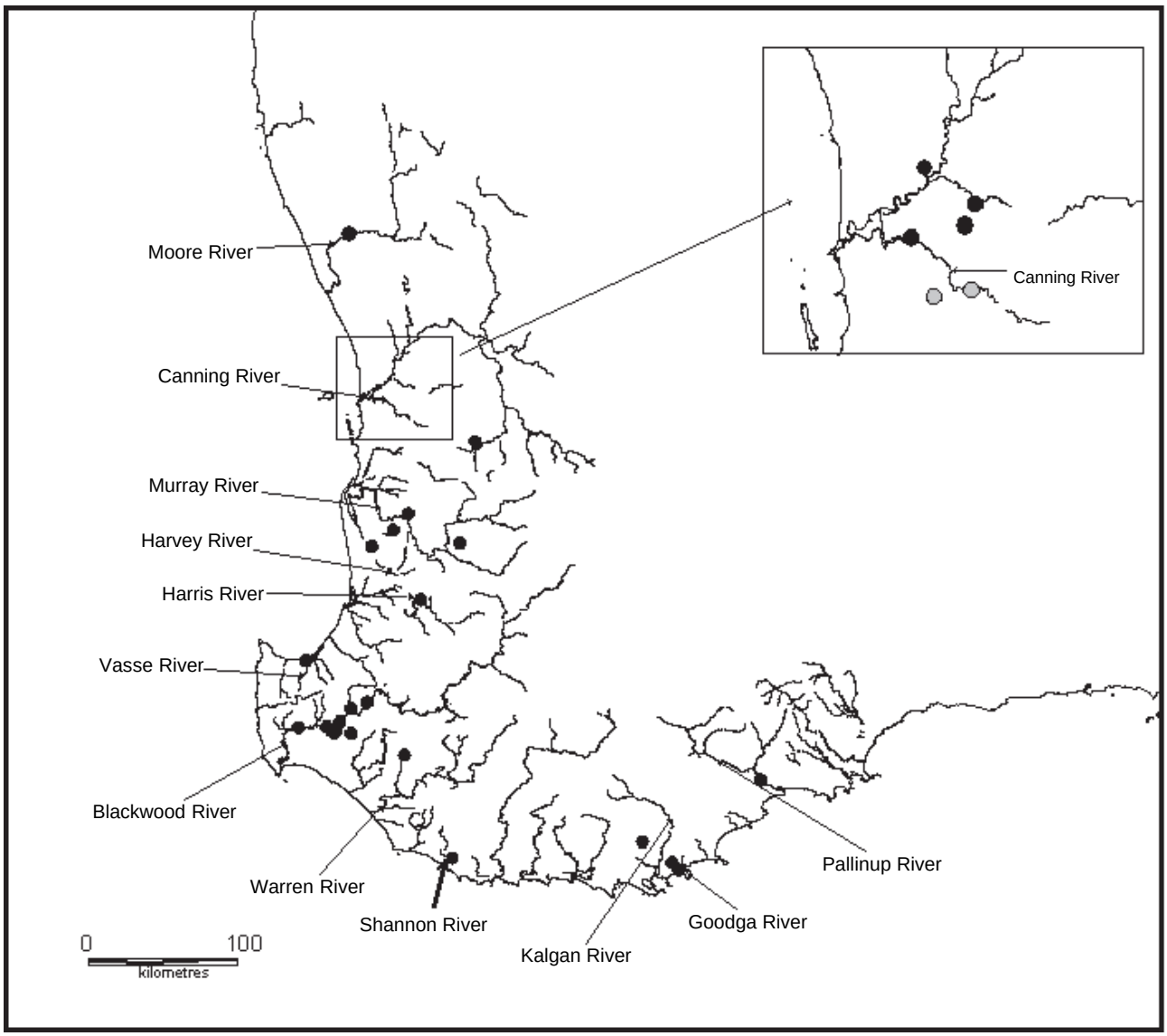

Figure 1. Southwest Coast Drainage Division, showing sampling locations. Black circles indicate that no fishes from that location were infested with *Lernaea*, grey circles indicate that *Lernaea* were found on some sampled fishes.

Table 1

Number of fishes sampled from each of 12 different river systems in the South West Coast Drainage Division of Western Australia.

River system	Number of localities sampled	Number of fishes collected
Moore River	1	59
Canning River	7	441
Murray River	2	42
Harvey River	3	113
Harris River	1	20
Vasse River	1	46
Blackwood River	8	462
Warren River	1	4
Shannon River	1	7
Kalgan River	1	139
Goodga River	2	76
Pallinup River	1	20
Total	**29**	**1429**

distribution, and intensities, from 2,000 bootstrap replications, using the software Quantitative Parasitology 3.0 (Rózsa *et al*. 2000). Differences in size between infested and non-infested hosts were tested by analysis of variance.

Results

Of the 12 different rivers sampled, anchor worms were found only on fishes from the Swan/Canning system. Infested fish were found at two of six localities in this system (Figure 1). Water temperatures at these localities over the sampling period ranged from 17–30°C and salinities from 2,000–4,000 mgL^{-1}. Overall prevalences (*i.e.*, prevalences of infestation for all fish species) at the two localities were 0.06 (n = 63 fishes) at Soldier Crossing and 0.18 (n = 231 fishes) at Southern River.

Four native fish species (western minnow, *Galaxias occidentalis* Ogilby; western pygmy perch, *Edelia vittata* Castelnau; nightfish, *Bostockia porosa* Castelnau;

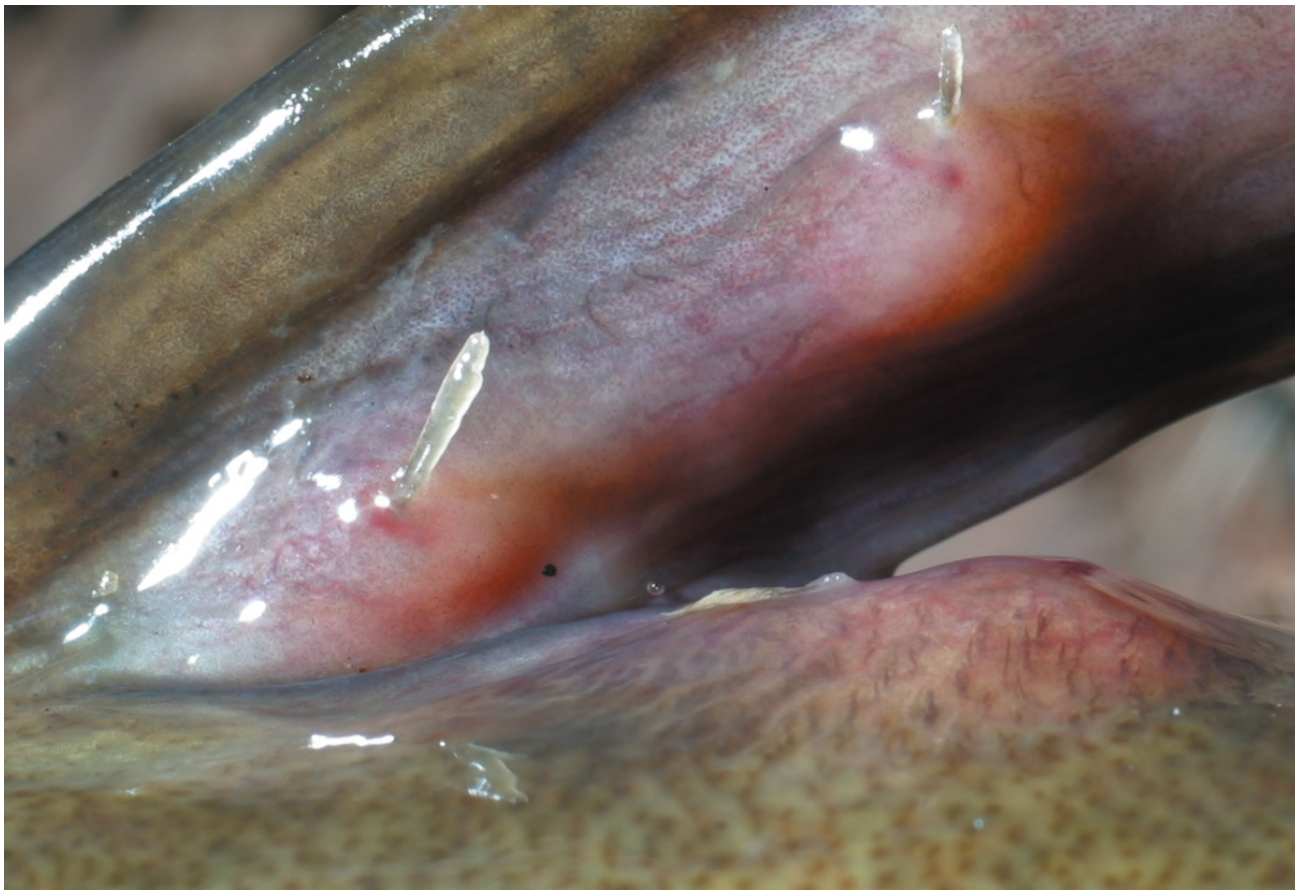

Figure 2. Ulcerated lesions at the site of attachment of female anchor worms to a freshwater cobbler (*Tandanus bostocki*) host.

freshwater cobbler, *Tandanus bostocki* Whitley) and three introduced fish species (goldfish, *Carassius auratus* L.; eastern mosquitofish, *Gambusia holbrooki* (Girard); and one-spot livebearer, *Phalloceros caudimaculatus* (Hensel)) were infested at the two localities. Prevalences differed between fish species, with the native species *G. occidentalis* and *E. vittata* being most heavily infested (Table 2). For these two species, infested fish tended to be larger, although this difference was significant only for *E. vittata* (mean TL of infested fish = 38.5 mm, mean TL of non-infested fish = 32.2 mm, $F_{1,73} = 6.28$, $P < 0.01$). For the introduced *C. auratus*, infested fish were significantly smaller, although the sample size of infested fish was small (mean TL of infested fish = 75.5 mm, mean TL of non-infested fish = 104.2 mm; $F_{1,31} = 4.04$, $P < 0.05$).

Table 2

Prevalence (with 95% confidence interval in parentheses) of *Lernaea* infestation in seven species of fish captured at two localities in the Canning River, Western Australia.

Species	Location	N	Prevalence
Galaxias occidentalis	Southern River	40	0.40 (0.25–0.60)
	Soldier Crossing	20	0.00
Edelia vittata	Southern River	76	0.20 (0.12–0.30)
	Soldier Crossing	13	0.23 (0.07–0.52)
Bostockia porosa	Southern River	10	0.10 (0.00–0.48)
	Soldier Crossing	10	0.10 (0.00–0.48)
Tandanus bostocki	Southern River	1	1.00
Carassius auratus	Southern River	39	0.10 (0.04–0.24)
Gambusia holbrooki	Southern River	39	0.02 (0.00–0.14)
	Soldier Crossing	20	0.00
Phalloceros caudimaculatus	Southern River	27	0.04 (0.00–0.18)

Most infested fishes contained a single parasite, with a mean intensity over all fish species of 1.29 (95% confidence interval = 1.12–1.45; range = 1–3). Of the 45 *Lernaea* that were found, 96% were adults and 72% were attached to the base of the dorsal fin of their host, with the remainder attached to either the base of the caudal, pectoral or pelvic fins or to the general body surface. All parasites were morphologically similar to *Lernaea cyprinacaea* as described by Kabata (1979).

We found extensive hemorrhages and ulceration at attachment sites in infested native fishes (Figure 2) and also captured several fishes without *Lernaea*, but with large scars at the base of their dorsal fins, which are likely to have been caused by previous infestations.

Discussion

As far as we are aware, this is the first account of *Lernaea* infestation on fishes in Western Australia. It appears that the species in Western Australia is most likely to be *L. cyprinacea*, although the considerable morphological plasticity of species of *Lernaea*

complicates morphological identification (Kabata 1979; Lester & Haywood 2006), and definitive confirmation of species identity will require molecular genetic studies.

Lernaea cyprinacea has been widely distributed throughout the world, presumably through the translocation of cyprinid hosts such as *C. auratus* and European carp, *Cyprinus carpio* L. This is also the likely origin of the parasite in Western Australia, possibly through the release or escape of infested aquarium fishes into natural waterways. Morgan *et al.* (2004) have reported *C. auratus* and *C. carpio* from many streams, irrigation drains and lakes in the vicinity of Perth, and also from a number of other natural waterways between the Moore and Vasse Rivers on the Swan Coastal Plain.

We found *Lernaea* infestations on seven different species of fish, with the greatest prevalence on the native species *G. occidentalis* and *E. vittata,* rather than the natural cyprinid hosts of the parasite. Differences in infestation levels among different host species have also been reported in many other studies (*e.g.*, Demaree 1967; Shariff *et al.* 1986; Marcogliese 1991; Bond 2004) and may result from different encounter frequencies between host and parasite, from differences in the rate of attachment of the parasite to different host species or from differences in the immune response of different host species to the parasite. At this stage, we have no information on the reason for the greater rate of infestation of *G. occidentalis* and *E. vittata*.

Our results suggest that *L. cyprinacea* is currently confined to a relatively small section of the Canning River, although future surveys around the Perth metropolitan area are necessary to confirm this. The spread from this population is likely to be slow, because of the life cycle of the parasite and the physical characteristics of the river, which is short and separated from other river systems by an extensive estuary. Female anchor worms, attached to the body of their host, produce eggs which hatch into free-living naupliar larvae. After about four days, the naupliar larvae moult to infective copepodid larvae, which attach, usually to the gills of a host fish. Copepodids moult to adults after a week or more, depending on the temperature, with optimal development occurring at 28–36°C and little development below 20°C (Shields & Tidd 1968; Marcogliese 1991; Lester & Haywood 2006). Adult males die within 24 hours and fertilised females either attach to the same host or swim to another host. Distribution and migration of the parasite in the south west is likely to be restricted by the direct life cycle, temperature-dependent development, low salinity tolerance and reduced survival in fast-flowing water (Bulow *et al*. 1979; Medeiros & Maltchik 1999; Lester & Haywood 2006).

Lernaea infestations can have serious pathogenic effects on their fish hosts. Copepodites may cause disruption and necrosis of gill epithelium, while attachment of adult females usually causes hemorrhages, muscle necrosis and an intense inflammatory response, sometimes associated with secondary bacterial infections (Khalifa & Post 1976; Berry *et al.* 1991; Lester & Haywood 2006). Bond (2004) demonstrated high mortality rates and reduced swimming ability, which might predispose to greater predation rates, in two species of native eastern Australian freshwater fish (*Galaxias olidus* Günther and *Nannoperca australis* Günther) infested with *Lernaea*. There is evidence that the pathological effects of *Lernaea* infestations are greater on smaller fish because the attachment organ of the parasite penetrates more deeply into the body of the fish, often causing damage to internal organs (Khalifa & Post 1976; Lester & Haywood 2006). Most native freshwater fishes in the south west of Western Australian are much smaller than typical cyprinid hosts, and the greater prevalence of infestation on larger native fishes in our study may result from an increased mortality rate of infested small native fishes, although this is speculative and remains to be tested experimentally.

Elimination of *Lernaea* from the Canning River is not likely to be achieved. Although the parasite appears to be relatively confined, it has spread to a number of different fish species, both native and introduced. A number of chemical treatments are effective against copepodids (although less effective against embedded adults or nauplii), and in a closed culture system these can be applied over a number of weeks to break the life cycle of the parasite (Lester & Haywood 2006). In an open, natural river system this is not a feasible proposition. The best prospect for containing the spread of the parasite is to prevent future releases of infected hosts into other river systems. This will require an extensive education campaign to alert the public to the threat posed by this, and other exotic diseases, which may be associated with aquarium fishes.

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