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Invasive potential of a South-American fish species, *Geophagus brasiliensis*, in the Swan River, Western Australia: based on tolerance to instantaneous and gradual changes in salinity

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Abstract

The south-west of Western Australia is a biodiversity hotspot and has a high proportion of endemic freshwater fishes. None of the native fish species are primary piscivores and with the exception of the freshwater cobbler (*Tandanus bostocki*) all species are small (< 200 mm total length (TL)).

The introduction of non-native freshwater fish species is considered one of the most damaging threats to this region's native fish diversity. Recently a new, large (maximum size 300 mm total length) feral fish species, the South American Pearl Cichlid (*Geophagus brasiliensis)*, was found in Bennett Brook, a small tributary of the Swan River.

The aim of this study was to determine the salinity tolerance of the feral Pearl Cichlid in order to predict it's invasive potential in watercourses of the Swan River catchment. *Geophagus brasiliensis* tolerated direct transfer from fresh water to 18–27 PPT with no mortality but more importantly, *G. brasiliensis* was able to resist gradual transference from freshwater to salt water (36 PPT) with very low mortalities. Therefore, ongoing control efforts are required in order to limit/prevent the invasion of this feral species into the Swan and other catchments in the southwest of Western Australia.

Keywords: aquatic biodiversity, freshwater fish, introduced species

Introduction

Biodiversity 'hotspots' are areas of exceptional concentrations of endemic species undergoing exceptional loss of habitat (Myers *et al.* 2000). Of the 34 currently recognized biodiversity hotspots in the world only one is situated in Australia; the south-west corner of Western Australia. The south-west of Western Australia has the highest proportion of endemic freshwater fishes (80%) of all of the major Australian Drainage Divisions. Ten species of native freshwater fish occur in south-western Australia, eight of which are endemic to the region (Morgan *et al.* 1998; Allen *et al.* 2002). None of the native fish species are large piscivorous predators; only the Freshwater Cobbler (*Tandanus bostocki*) typically attains a maximum size greater than 200 mm total length (TL) (Morgan *et al.* 1998; Allen *et al.* 2002).

Invasions of non-native species are increasingly recognised as one of the most damaging threats to biodiversity, especially the introduction of freshwater fish species (Kolar & Lodge 2002). At present nine species of non-native fish (Rainbow Trout, *Oncorhynchus mykiss*; Brown Trout, *Salmo trutta*; Redfin Perch, *Perca fluviatilus*; Silver Perch, *Bidyanus bidyanus*; Eastern Mosquitofish, *Gambusia holbrooki*; One-spot Livebearer, *Phalloceros caudimaculatus*; Goldfish *Carassius auratus*; Carp, *Cyprinus carpio*; Rosy Barb, *Puntius conchonius*) are found in the south-west of Western Australia (Morgan *et al.* 2004; Maddern 2008; DL Morgan and SJ Beatty personal communications). Human-mediated translocation [*e.g.* ongoing stocking of trout species for recreational fishing; biological control (Eastern Mosquitofish); aquaculture escapees (Silver Perch); ornamental escapes (Goldfish, Koi Carp, Rosy Barb)], either deliberate or accidental, is the major vector of introduction (Morgan *et al.* 2004).

Recently a new feral species (ornamental escape), the South American Pearl Cichlid (*Geophagus brasiliensis)* (Figure 1), was recorded in Bennett Brook (Figure 2), a tributary of the Swan River. The coastal drainages of Uruguay (Rio da Prata) and south-eastern Brazil (Amazon Basin) are the natural habitat of *G. brasiliensis,* a secondary-division freshwater fish (Axelrod & Schultz 1955; Lowe-McConnell 1991). Primary-division freshwater families are strictly confined to freshwater, whereas secondary-division freshwater families are generally restricted to freshwater but may occasionally enter salt water. *Geophagus brasiliensis* is known to occur in brackish water (14 PPT; Mazzoni & Iglesias-Rios 2002)

Figure 1. Pearl Cichlid, *Geophagus brasiliensis*, captured in Bennet Brook.

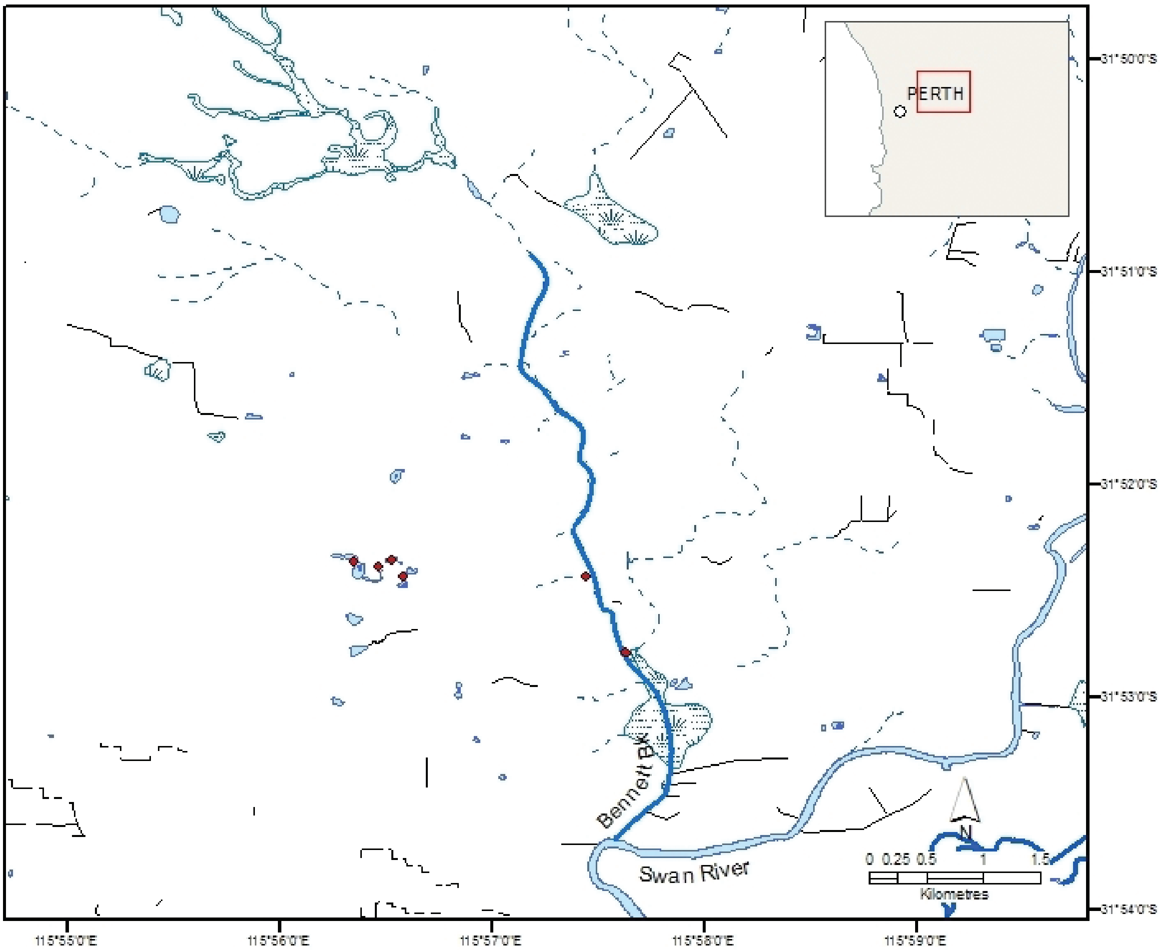

Figure 2. Location of Bennet brook in the Swan River Catchment. Red diamond markers indicate locations where *G. brasiliensis* has been found.

and it may be expected that this species would tolerate elevated levels of salinity.

The Swan River at the confluence with Bennett Brook is brackish for most of the year (Figure 2). Therefore, this species may be able to tolerate salinities that occur in the Swan River. The aim of this study was to determine the salinity tolerance of this population of Pearl Cichlid in order to predict its invasive potential in watercourses of the Swan River catchment.

Methods

Instantaneous Salinity Increase Tolerance Tests

Experimental 72 L aquaria (0.3 x 0.4 x 0.6 m) were partitioned in five equal sections using perforated plastic sheets. Pearl cichlids were captured from Bennett Brook using seine nets and placed individually in a section within experimental aquaria. Each aquarium was aerated and 25% of its volume replaced three times per week. Fish were fed commercial fish pellets twice a week. Fish were acclimatised for two weeks in the experimental aquaria prior to being subjected to salinity tolerance trials.

The first trial was conducted at a water temperature of ~15 °C (avg. 14.8 °C, 0.62 95% CI) using 60 fish (avg. 67.6 mm Standard Length [SL], 4.3 95% CI) divided over 12 experimental tanks. Treatments for the first trial consisted of 0 (control), 4.5, 9, 18 and 36 PPT. Aquaria were randomly assigned to each treatment and mortality was recorded daily.

The second trial was conducted at a water temperature of ~21°C (20.7 °C, 0.16 95% CI) using 64 fish (86.5 mm SL, 2.7 95% CI) divided over 13 experimental aquaria. Treatments for the second trial consisted of 0 (control), 4.5, 9, 18, 27 and 36 PPT. Aquaria were randomly assigned to each treatment and mortality was recorded daily.

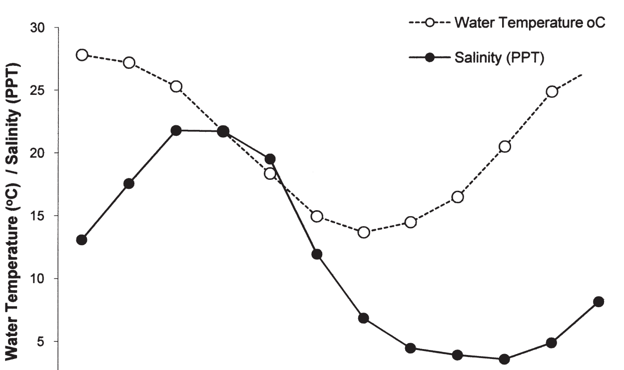

Figure 3. Monthly changes in salinity (PPT) and water temperature (°C) of the Swan River near the mouth of Bennett Brook between 1995–2007 (data source Swan River Trust).

Progressive Salinity Increase Tolerance Test

Fish were captured in the wild using seine nets and acclimatized to laboratory conditions in the 72 L tanks described above. After two weeks, 18 fish (avg. 92.6 mm SL, 5.5 95% CI) were individually placed in 7 L containers. Six containers were randomly assigned as controls (0 PPT), while salinity in the remaining 12 containers was gradually increased from 0 to 36 PPT over a nine-day period (4.5 PPT per day). After the initial nine day period, salinity levels were retained at 36 PPT for an additional 15 days. Water in all 18 containers was replaced daily and fish were fed commercial pellets twice a week. The surviving fish in 36 PPT were all transferred to one large tank (0.5 x 0. 5 x 1.2 m) for a further 26 days before the experiment was concluded.

Results

In both instantaneous salinity increase experiments (Figures 4A,B), no mortality was observed up to 27 PPT. A direct transfer to 36 PPT caused mortality of all fish within 24 hours at 14°C and within six days at 21°C. In contrast, low mortality (< 10%) among specimens of *G. brasiliensis* was observed when salinity was gradually increased over a nine day period (Figure 4C). The majority of fish survived at 36 PPT for a period of 41 days.

Discussion

Geophagus brasiliensis from Bennett Brook tolerated direct transfer from fresh water to 18–27 PPT with no mortality (Figures 4A,B). Fish transfer directly to seawater (36 PPT) did not survive in both instantaneous trials but when conducted at 15°C most fish died within 24 hours while in water of 21°C several individuals survived for six days. Compared to temperate fish species the neotropical *G. brasiliensis* has a low thermal tolerance (Tantin & Petersen 1985) and at 15°C the fish most likely suffer from both salinity and temperature stress.

More importantly, this study clearly demonstrated that *G. brasiliensis* from Bennet Brook is able to resist gradual transference from fresh water to sea water and survive in sea water for a long period of time, *i.e.* up to at least 40 days) with very low mortalities (Figure 4C).

Based on the results of this study it is highly unlikely that without effective management action, the feral *G. brasiliensis* will be confined to Bennett Brook. *Geophagus brasiliensis* is likely to spread throughout the interconnected watercourses of the upper Swan catchment. It is, however, unclear whether *G. brasiliensis* would be able leave the Swan system and to migrate along the coast and invade other river systems in south-western WA. The spread of *G. brasiliensis* may pose a threat to aquatic biodiversity for several reasons. In the first place, the relatively large *G. brasiliensis* is territorial and aggressive towards conspecifics and other fish species especially during the breeding season. Secondly, *G. brasiliensis* is an omnivore (de Moraes *et al*. 2004; Figure 5, de Graaf unpublished data) and will compete with most native fish species for the same food resources (Morgan *et al*. 1998). Furthermore, introductions of *G.*

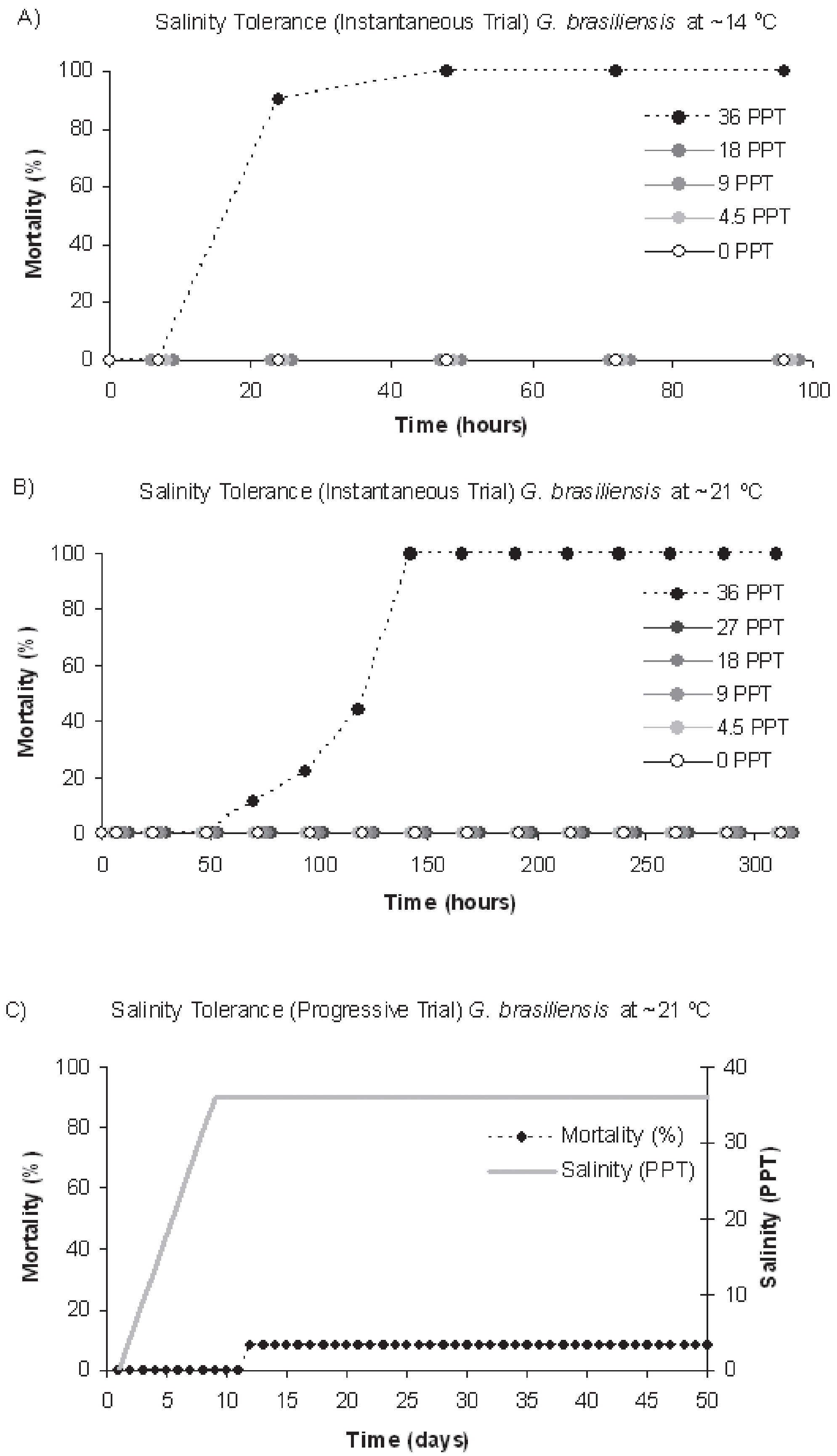

Figure 4. Percentage mortality of *Geophagus brasiliensis* in the different salinity treatments in the instantaneous salinity increase tolerance trails at (A) 14 °C, and (B) 21°C and (C) the percentage mortality of *Geophagus brasiliensis* recorded during the progressive salinity increase tolerance trial.

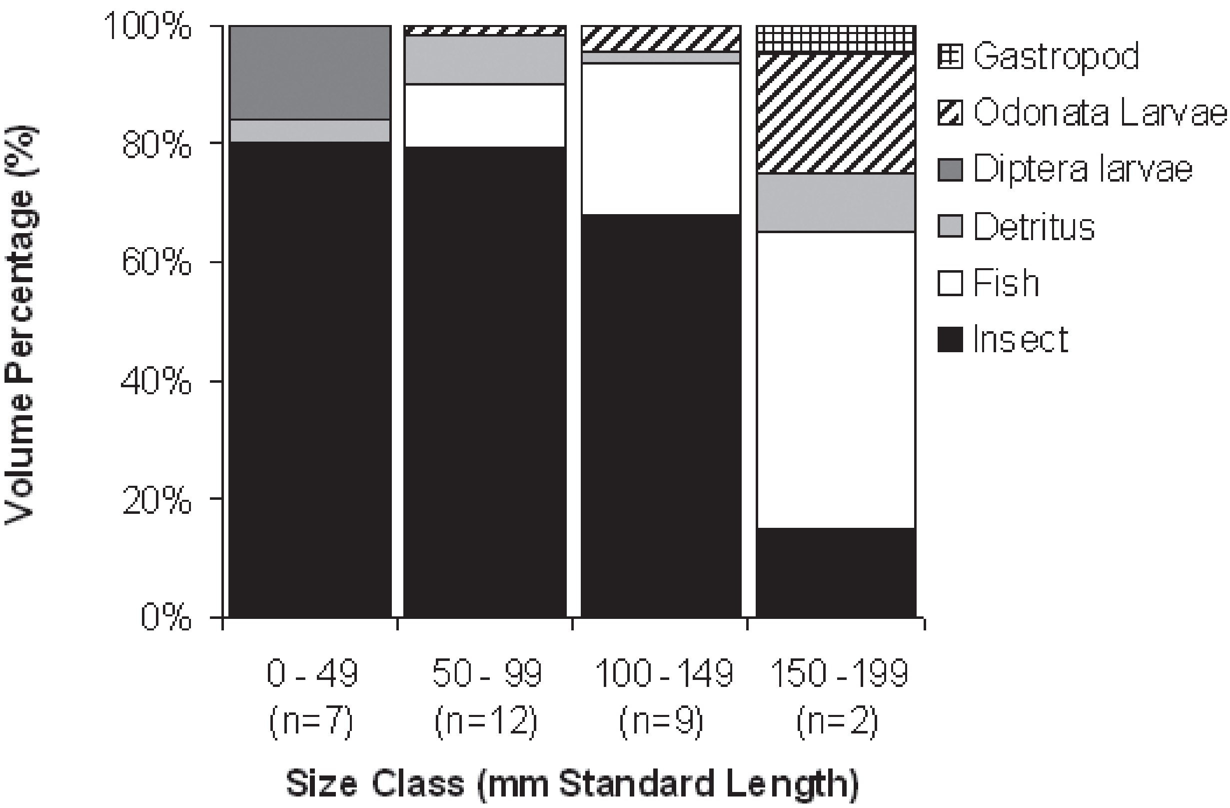

Figure 5. Ontogenetic changes in the diet of *Geophagus brasiliensis* at Bennet Brook (May 2006).

brasiliensis have been reported in Taiwan, USA, Philippines (www.fishbase.org) and the Tweed River, New South Wales, Australia.

Future research should focus on a) the reproductive biology to determine size-at-maturity, breeding period and its potential ability to reproduce in the Swan River, and b) the diet of *G. brasiliensis* to determine the potential impact on native fish through competition and/or predation. The results of this preliminary study clearly suggest that ongoing control efforts are required in order to limit/prevent the invasion of the species into the Swan catchment.

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