Monitoring the Lion’s Weir Fishway
Hotham River, Western Australia

Report to the
Department of Environment
Government of Western Australia

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Centre for Fish & Fisheries Research

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This report has two major components:

PART I  Fish fauna of the Hotham River (including the impact of the Lion’s Weir on fish migration)

Part I of the study was conducted prior to the construction of the Lion’s Weir Fishway and reports on the fish fauna of 22 sites in the Hotham and Williams River catchments and the impact of the Lion’s Weir on fish migrations. Salinisation of the catchment and species salinity tolerances were found to be the main determinant of fish distributions.

PART II  Fish utilisation of the Lion’s Weir Fishway

Part II provides data on fish utilisation of the Lion’s Weir Fishway between late July and November 2003.

Acknowledgements

Thanks to the help provided by Antonietta Torre of the Department of Environment Western Australia, Boddington Rivers Action Group, the Natural Heritage Trust, Fishcare WA, Boddington Gold Mine, Boddington Earthmoving, members of the Hotham Catchment (Boddington-Cuballing-Wandering), Shire of Boddington and the members of the community. Thanks also to Simon Visser for help with sampling and for some of the photographs (frontispiece).
PART I

Fish fauna of the Hotham River
(including the impact of the Lion’s Weir on fish migration)
Background

This part of the study was completed prior to the construction of the Lion’s Weir Fishway that was built in autumn 2003.

In order to enhance the migration of fish species that are currently impeded by the Lion’s Weir on the Hotham River, the Boddington Rivers Action Group is due to construct a rock ramp fishway in the summer of 2003. Prior to the construction of the fishway, the Centre for Fish and Fisheries Research was invited by the Water and Rivers Commission and the Boddington Rivers Action Group to determine the extent to which the Lion’s Weir and the downstream William St crossing affected fish migration.

Aims of Part I of the study

* The first aim of this study was to determine the distribution of fish in the Hotham and Williams Rivers (late spring/early summer 2002).

* The second aim was to determine which species of freshwater fish are currently restricted by the Lion’s Weir (and William St crossing) and whether the weir acts as a barrier to their migration. This was achieved by sampling in the different spawning periods for the different fishes, as upstream migrations occur prior to spawning periods, for example, western minnows (Galaxias occidentalis) spawn in late winter/early spring and thus any barrier may impede their upstream migration at this time.
Methods

Fish were captured using seine nets (5, 10 and 15 m lengths all comprised of 3 mm woven mesh) and an electrofisher (Smith-Root 12 A POW) in sites with lower salinities. On capture, all fish were identified and released immediately. Longitude, latitude and salinity were recorded at each site. Fish species maps were created using MapInfo. Lion’s Weir and William St crossing were each sampled in late winter and early summer to encompass the spawning periods of the endemic species known to occur in the catchment and thus to determine whether these structures impeded the migration of native species.

Results and Discussion

Distribution of fishes in the Hotham River catchment

A total of 22 sites in the Hotham and Williams River catchments were sampled for fish (Figure 1). The salinity of sites sampled ranged from 3 to 66 parts per thousand (ppt) (Table 1). N.B. Seawater = 35 ppt. Five species of fish were captured in the sites sampled, one of which was an introduced species, and the other four were native fishes. A synopsis of the species follows:
Table 1: The sites sampled in the Hotham and Williams Rivers, their salinity and the species captured.
N.B. Gh = *Gambusia holbrooki* (mosquitofish), Go = *Galaxias occidentalis* (western minnow),
Ev = *Edelia vittata* (western pygmy perch), Bp = *Bostokia porosa* (Nightfish) and Po =
*Pseudogobius olorum* (Swan River goby).

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Site Name</th>
<th>Salinity (ppt)</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Gh</th>
<th>Go</th>
<th>Ev</th>
<th>Bp</th>
<th>Po</th>
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<td>9</td>
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<td>33.0332</td>
<td></td>
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<td>32.9908</td>
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Mosquitofish (*Gambusia holbrooki*)

The mosquitofish, which was introduced from central America into W.A. in the 1930’s, was the most abundant species and was captured at 19 of the 22 sites sampled (Table 1, Figure 2). The fact that this species was found in salinities ranging from 3 to 58.2 ppt demonstrates its ability to tolerate extremely saline waters. This is a pest species that is aggressive and has a deleterious impact on native fishes in the form of fin-nipping (Gill *et al*. 1999).

Figure 2: The sites in the Hotham and Williams Rivers where the introduced mosquitofish were captured.
Western minnow (*Galaxias occidentalis*)
The western minnow, which is endemic to south-western Australia, was found in 11 of the 22 sites sampled in salinities up to 24.1 ppt (Table 1, Figure 3). This salinity is likely to represent the upper limit of their tolerance to saline water. They were often extremely abundant and thousands of individuals were captured directly below the Lion’s Weir in both late winter and early summer. It is therefore likely that when the river is flowing, the Lion’s Weir acts as a barrier to the upstream migration of western minnows.
Western pygmy perch (*Edelia vittata*)

The western pygmy perch, which is endemic to south-western Australia, was captured at only four of the 22 sites sampled (Table 1, Figure 4). They were restricted to sites with salinities of less than 8 ppt. Elsewhere in south-western Australia they are usually associated with low salinity waters. They are often predated (fin-nipped) on by mosquitofish (Gill *et al.* 1999). No western pygmy perch were captured below the Lion’s Weir.

![Image of a fish](image)

*Figure 4.* The sites in the Hotham and Williams Rivers where the western pygmy perch was captured.
Nightfish (*Bostockia porosa*)

Nightfish, which are endemic to south-western Australia, were captured at five sites during the study (Table 1, Figure 5). They are generally not abundant when captured and are restricted to lower salinity waters. During this study they were captured in salinities up to 7.8 ppt. One individual in both late winter and early summer was captured below the Lion’s Weir. This species is fin-nipped by mosquitofish in areas where the degree of instream habitat is low (Morgan unpublished data).
Swan River goby (*Pseudogobius olorum*)

The Swan River goby typically occurs in the estuaries of south-western Australia however, salinisation of the region has facilitated their movement considerable distances up the main channels of salt-affected rivers (Morgan *et al.* 1998, in press). This situation is evident in the Hotham and Williams Rivers where they were caught in five sites in the main channel of these rivers (Table 1, Figure 6).

![Swan River goby](image)

**Figure 6:** The sites in the Hotham and Williams Rivers where the Swan River goby was captured.
Salinities of the Hotham and Williams Rivers

The salinities of the water in the sites sampled in the Hotham and Williams Rivers demonstrate that the region is salt-affected (Table 1, Figure 7). Thus, the salinity of sites ranged from 3 ppt in one of the smaller tributaries (i.e. Minniging Brook) to 66 ppt in the upper Hotham River. The salinities in many parts of the catchment are higher than those tolerable to the endemic freshwater fishes of south-western Australia. Thus, while the western minnow was found in salinities up to 24.1 ppt, the western pygmy perch and nightfish are more sensitive to salt and were not found in sites with salinities over 8 ppt. The increasing salinities in these rivers have also aided in the upstream migration of the primarily estuarine Swan River goby and have allowed the extremely salt tolerant introduced mosquitofish to become the dominant species.

Figure 7: The salinity of the sites sampled in the Hotham and Williams Rivers.
Impact of the Lion’s Weir on fish migration

The three endemic species captured during the study (i.e. western minnow, western pygmy perch and nightfish) are each known to undertake upstream pre-spawning migrations (Pen and Potter 1990, 1991a, 1991b). Their movement upstream and into smaller tributary sites provides their larvae and juveniles with relatively safe feeding grounds and offsets any downstream flushing of their small, less mobile offspring. Large numbers (1000’s) of western minnows were captured or observed below the Lion’s Weir (and only 40 immediately above the weir) on each sampling occasion, suggesting that it does seriously impede the upstream migration of this species. Large numbers stranded below the fishway as the water recedes would also perish. Of the other endemic freshwater species only the nightfish was captured below the weir. However, as only two individuals were captured, it is likely that this nocturnal cryptic species utilises the rocks below the weir as a place to hide during the day. The western pygmy perch was not captured below the weir. As the salinity of the main channel of the Hotham River is generally above the upper salinity tolerance of the western pygmy perch and nightfish, it is unlikely that they would inhabit the main channel in large numbers, and thus will not be impeded by the Lion’s Weir. As fish were not found to congregate below the William St crossing it does not appear to impede the migration of fish.

Conclusions

Although the results of the above study suggest that while the Lion’s Weir severely impedes the upstream migration of the western minnow, it is the prevailing high salinities in the Hotham River that govern the distribution of fish in the system. For example, the endemic western pygmy perch and nightfish were not found in salinities >8 ppt and this salinity may be close to the upper limit of their tolerance. Furthermore, the high salinity of the system has also enabled the primarily estuarine Swan River goby to migrate up the main channel of the system. The introduced mosquitofish, which is extremely tolerant of salt, has become the dominant species of the system. Their have also been reports of fish kills from upstream of the Lion’s Weir, with deaths of the introduced redfin perch (Perca fluviatilis) reported (Morrissy 1978, Ray Farmer pers. comm.). This species was not captured in the sample sites and it is likely that both the fish kills and its absence from the upper reaches of the Hotham and Williams River is a result of their inability to survive in salinities above 10 ppt (Privolnev 1970). Sudden lethal increases in salinity may occur during inflows after summer rains or after the first major flood events of winter. The salinities encountered in the sample sites are also often above the lethal tolerance (17 ppt) of the recreationally important marron (Cherax tenuimanus).
Simple fishway designs are provided in the Water and Rivers Commission and Department of Fisheries Water notes WN26 ‘Simple fishways’ by Beatty and Morgan (2002).

References


PART II

Fish utilisation of the Lion’s Weir Fishway
Background

Part I of the study demonstrated that large numbers of the endemic western minnow were impeded by Lion’s Weir, presumably during and immediately after their upstream spawning migration. As a result of this barrier to movements, a rock ramp fishway was constructed at the Lion’s Weir in late summer and early autumn 2003. The fishway construction was implemented by the Boddington Rivers Action Group and supported by the Water and Rivers Commission of Western Australia, the Natural Heritage Trust, Boddington Gold Mine, Boddington Earthmoving, Hotham Catchment (Boddington-Cuballing-Wandering), Shire of Boddington and members of the community.

Aims of Part II of the study

* The first aim of this study was to determine the extent to which the different species of fish found in the Hotham River utilise the newly-constructed Lion’s Weir Fishway.

* The second aim was to make recommendations related to enhancing the fishways function.

Introduction

Although the Lion’s Weir severely impedes the upstream migration of the western minnow, it is the prevailing high salinities in the Hotham River that govern fish distributions in the river and its tributaries. For example, the endemic western pygmy perch and nightfish were not found in salinities >8 ppt (parts per thousand) and this salinity may be close to the upper limit of their tolerance. The river at the Lion’s Weir often attains salinities greater than 8 ppt. This high salinity, which is found throughout the upper catchment (see Part I - Figure 7); has allowed the primarily estuarine Swan River goby to migrate up the main channel. High salinities and the exclusion of native fishes have also led to the introduced mosquitofish becoming the dominant species of the catchment’s waterways. Notwithstanding the results of Part I of the study, the Lion’s Weir acts as an impediment to fish migrations and creates a reservoir habitat that is conducive to the introduced mosquitofish, a species that plagues much of the Hotham River and indeed many systems of southwestern Western Australia.
Methods

Fishway Design

A rock ramp fishway was considered the most appropriate design for the Lion’s Weir for both aesthetic reasons and for the fact that the weir is supported by rocks. The fishway was built at a gradient of approximately 1:20, is 32 m long, approximately 5 m wide and there are 16 ridges forming 0.1 m high step pools to climb the weir (i.e. the weir is 1.6 m high). A geotech liner was placed on the substructure and was covered with small granite rocks and gravel. A series of larger granite rocks were placed at intervals on the fishway to create resting pools throughout. Construction was implemented by the Boddington Rivers Action Grouped and supported by Antonietta Torre of the Department of Environment, the Natural Heritage Trust, Boddington Gold Mine, Boddington Earthmoving, Hotham Catchment (Boddington-Cuballing-Wandering), Shire of Boddington and members of the community. The Boddington Gold Mine donated the rock and its haulage. The design for the fishway was developed Antonietta Torre (Department of Environment) in conjunction with Tim Marsden (Fish Passage Consultant, Queensland).

Fishway monitoring

Fishway monitoring techniques vary according to design. For example, vertical-slot fishways can be readily monitored using a combination of unidirectional cone traps (funnels) at various slots, with mesh screens blocking the exits; thereby allowing fish to reach the top of the fishway but not being able to exit or retreat back down the fishway (see Close et al. 2001). This method allows fishway utilisation to be effectively measured and limits the number of individuals leaving the fishway as they become caught above the cone (funnel) traps. Assessing the effectiveness of rock ramp fishways, however, requires either determining the number of fish exiting the fishway – by setting a trap at the top of the fishway and/or by counting the number of fish utilising the fishway at any particular time.

The Lion’s Weir Fishway was monitored during late July/early August, September, October and November 2003. In November flow on the fishway had ceased and the fishway wasn’t functioning. These monitoring times were chosen to coincide with peak spawning periods of the fishes of the river (see Part I of this study, Pen and Potter 1990, 1991a, 1991b, Morgan et al. 1998). Due to the deep drop off at the top of the fishway a trap could not be set to determine the number of fish exiting the fishway. A trap however does not prevent fish moving back down the fishway after
reaching the trap. Instead, observations were made at the top of the fishway to determine whether fish were leaving the fishway.

Sampling was achieved by setting a 10m seine net across the bottom of the fishway and electrofishing the width of the fishway in a downstream direction. In each month the number of fish from each species on the fishway was recorded. The first sampling occurred at the end of July and early August and the fishway was sampled twice at dusk. In September the fishway was sampled three times at dusk and at dawn on two occasions. In October it was sampled twice at both dusk and dawn. The majority of fish caught in the net were released immediately with a subsample measured for total length (mm) and gonad stage estimated by macroscopic observations through the ventral surface in the case of females, and the larger males were gently squeezed so to determine if sperm was exuded and thus maturity had been attained.

During October, a night sample was achieved by setting a 5 m seine across the top of the fishway, thereby capturing fish moving downstream at night, to determine whether fish were moving down the fishway from the pool above the weir.

Results and Discussion

Rainfall, flow rates and fishway function

Rainfall for Boddington is highly seasonal, with the majority of precipitation occurring between June and October. As a consequence of this highly seasonal rainfall, flows peak in the river in late winter/early spring and during 2003 flow ceased in late spring (November) (Figure 1, Plates 1 and 2). The fishway functioned in October but had ceased in early November, however, this time period could be lengthened by removing a section of concrete (5-10 cm deep) in the weir wall the length of the fishway exit. A notch of approximately 5-10 cm would also allow easier fish movement over the fishway exit as it is the greatest vertical drop on the fishway and therefore probably represents the most difficult part for fish to negotiate.

Mean water temperatures and salinity increased during the study period (Figure 2). Thus, mean water temperature increased from a low of 12.7°C in July/August to 23.2°C in November, and mean salinity rose from 5.1 and 4.6 in July/August and September, respectively to 5.9 in October and 8.1 in November (Figure 2)

Fish and freshwater crayfish utilisation of the Lion’s Weir Fishway

Endemic freshwater fishes
A total of 769 endemic freshwater fish were captured on the fishway between July/August and November 2003 (Table 1). Of these, 758 (or 98.6%) were western minnows (G. occidentalis) and 11 (or 1.4%) were nightfish (B. porosa) (see Table 1). Western minnows were the most abundant endemic fish captured below the Lion’s Weir during the earlier study (see Part I).

Figure 1: Mean daily discharge per month of the Hotham River, between 1970-2001. (Western Australian Department of Environment).
Plate 1 The Lion’s Weir Fishway in September 2003, (A) fishway exit and (B) looking upstream.
Plate 2  The Lion’s Weir Fishway in November 2003 (A) looking downstream and (B) looking upstream.
Figure 2: A) Water temperature and B) salinity on the Hotham River Fishway.
Table 1: Total number and mean number per sample (in parenthesis) of each species captured on the Hotham River Fishway at dawn and dusk in the different months. The number of samples (on different days) is given. N.B. Go = western minnow, Po = Swan River goby, Bp = nightfish, Gh = mosquitofish (feral).

<table>
<thead>
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<th>Month</th>
<th>Time (# samples)</th>
<th>Native</th>
<th>Feral</th>
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<tr>
<td></td>
<td></td>
<td>Go</td>
<td>Po</td>
</tr>
<tr>
<td>August</td>
<td>Dusk (1)</td>
<td>2 (2)</td>
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<td></td>
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<tr>
<td></td>
<td>Dusk (3)</td>
<td>279 (93)</td>
<td>1 (0.3)</td>
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<tr>
<td></td>
<td>Dawn (1)</td>
<td>17 (17)</td>
<td>14 (14)</td>
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<tr>
<td>September</td>
<td>Dusk (2)</td>
<td>211 (105.5)</td>
<td>23 (11.5)</td>
</tr>
<tr>
<td></td>
<td>Dawn (2)</td>
<td>249 (124.5)</td>
<td>8 (4)</td>
</tr>
<tr>
<td>TOTAL (fish on fishway)</td>
<td>758</td>
<td>46</td>
<td>11</td>
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There was a pronounced increase in western minnows utilising the fishway between July/August and September, which continued into October (Figures 3 and 4, Table 1). Analysis of variance (ANOVA) of log-transformed data revealed that this increase in fishway utilisation in September by western minnows was significant i.e. \( p<0.01 \) between August and September. This increase in abundance is undoubtedly in response to an upstream spawning migration, with many of the female fish in September having clearly discernable mature ovaries and the males were running ripe (i.e., when the male body cavity is squeezed slightly, sperm is exuded). Furthermore, in the nearby Collie River (see Figure 4 in Pen and Potter (1991a)), the only population of western minnows to be subjected to a spawning period study, there was a major decrease in gonadosomatic index between August and September, indicating peak spawning had occurred during this period.

Between September and October there were considerable differences in size classes of the fish utilising the fishway (swimming upstream) (Figure 4). Thus, those in September were dominated by larger, mature fish (50-84 mm TL) moving upstream to spawn with a few 0+ (new recruits) fish, which contrasted with the October fish that were dominated by young fish < 50 mm TL. During October there were considerable differences between the sizes of western minnows moving downstream on the fishway compared to those moving upstream (Figure 4). For example, those moving upstream were comprised solely of 0+ (2003 cohort) fish (25-39 mm TL) while the fish moving downstream were comprised of the 0+ age class and also older and larger fish (25-104 mm TL) (Figure 4). The larger fish in this latter group may be adults returning to their origin after moving upstream to spawn.

Thus, the above data suggests that the western minnow utilised the Lion’s Weir Fishway for: (1) an upstream spawning migration, (2) a downstream post spawning migration and (3) upstream and downstream movement of juvenile fish.

Similarly, but on a much smaller scale, nightfish were captured on the fishway in higher numbers in September than in any other month and was more common at dusk when it is expected that this nocturnal species would be more active (Figure 3, Table 1). The peak spawning period (evidenced by a decline in gonadosomatic index (Pen and Potter 1990)) for this species is also between August and September. The presence of nightfish however, may also be a response to their requirement of complex habitat. Being a nocturnal species, nightfish seek refuge during the day under logs and rocks, such as those provided by the fishway. It is also worth noting that more were captured after construction of the fishway, further suggesting that the increase in habitat (rocks) may have contributed to the increase in numbers.

The absence of western pygmy perch on the fishway may be a result of their low numbers in this section of the river (see Part I), which may be in part due to both the higher salinities recorded in this part of the river or may reflect the high numbers of the feral, aggressive mosquitofish (G.
western pygmy perch have previously been shown to be susceptible to mosquitofish attack and such attacks often result in death (Gill et al. 1999).
Western minnow (*Galaxias occidentalis*)

Figure 4: The monthly length-frequency distributions of the western minnow (*Galaxias occidentalis*) captured on the Lion's Weir Fishway during September and October, and those captured in October moving downstream (day) and upstream (night). N.B. *n* = number measured and total number captured is given in parenthesis.
Swan River goby (*Pseudogobius olorum*)

A total of 46 Swan River gobies were captured on the fishway and the majority were captured at the bottom of the structure (Table 1, Figure 5). The steady increase in abundance between August and October may suggest that the species undertakes spawning migrations (Figure 2). Many of the larger females captured on the fishway had clearly discernable eggs in October, a month that is known as a peak spawning period for the species in the Swan River (Gill *et al*. 1996).

An upstream migration to spawn has not previously been reported for this species and there are no data on the biology and ecology of riverine populations of this estuarine species.

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**Figure 5**: The monthly length-frequency distributions of the Swan River goby (*Pseudogobius olorum*) captured on the Lion's Weir Fishway during the sampling period. N.B. $n =$ number measured and total number captured is given in parenthesis.
Feral fishes (mosquitofish *Gambusia holbrooki*)

Although introduced mosquitofish (*G. holbrooki*) plague the Hotham River both upstream and downstream of the Lion’s Weir (see Part I), only 83 were found on the fishway (Table 1). Their low abundance on the fishway is undoubtedly influenced by their preference for slow moving or still waters, such as those created above dams (Morgan *et al.* 1998, 2002, Gill *et al.* 1999). Many of the mosquitofish captured may have been on the bottom of the fishway where flow becomes reduced and this is reflected in the fact that most were caught in October when flows had reduced substantially. The absence of this feral species from the fishway is important in that it will not be interfering with native species attempting to negotiate the fishway.

Freshwater crayfish and shrimp

During each sampling occasion gilgies (*Cherax quinquecarinatus*) and the freshwater shrimp (*Palaemonetes australis*) were captured on the fishway. There may have been some upstream and downstream movement by freshwater crayfish and freshwater shrimp via the fishway, however it is likely that their presence was due to the high degree of suitable habitat offered by the rocks used to construct the fishway.

**Conclusions**

The Lion’s Weir Fishway, on the Hotham River, has allowed the upstream and downstream movement of fishes past this barrier for the first time since the weir was built. Peak movements of the endemic freshwater fish, the western minnow, occurred in September and October. Movement in September was comprised mainly of western minnows on their upstream spawning migration, while those in October were new recruits moving both upstream and downstream and also adults that had spawning and were moving (back) downstream, possibly to their original habitat in the river. Similarly, the nightfish, another endemic freshwater fish, also showed peak movement during September, their known peak spawning period. The upstream movement of these species offsets the downstream movement of eggs and larvae during periods of high flows. Furthermore, the estuarine Swan River goby was found on the fishway in the highest numbers in October, a known peak spawning period in the Swan River (Gill *et al.* 1996). Many of the larger fishes of these species had clearly discernable eggs, indicating maturity, and the males were seen to exude sperm when gently squeezed. The low numbers of the feral mosquitofish that utilise the fishway, even though they are easily the most abundant fish in the Hotham River, is a likely response of their ‘preference’ for still waters and thus they rarely inhabit flowing waters. The absence of western pygmy perch from the fishway (and from this part of the Hotham River) is probably a consequence of their inability to tolerate the high salinities of this part of the river.
References


