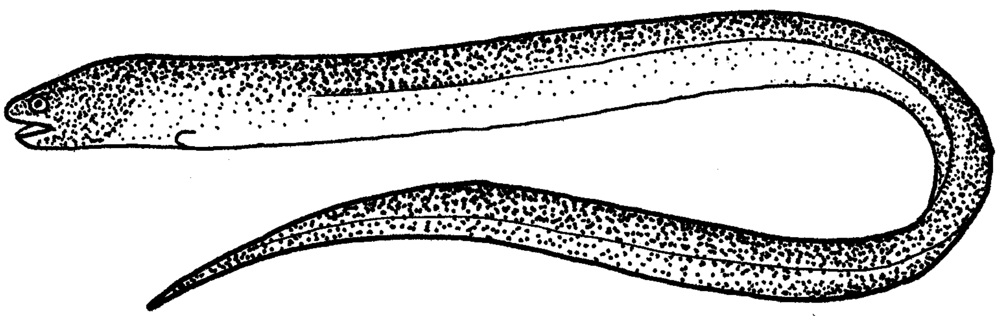
Family SYNBRANCHIDAE

3.19 *Ophisternon gutturale* (Richardson)

Ophisternon gutturale is commonly known as the one-gilled eel or swamp eel. It is found in the Timor Sea drainage system of northern Australia (see map 3). Pollard (1974) identified it as *Synbranchus bengalensis* in his collections from the Alligator Rivers Region. When Synbranchidae were revised by Rosen and Greenwood (1976), they noted the Northern Territory specimens identified as *S. bengalensis* that they examined were markedly different from more northern samples of what they referred to as *Ophisternon bengalense*. Although no Papua New Guinea samples were examined, the range of species of *Ophisternon* cannot be specified with precision,[126] the name *gutturale* was chosen to emphasise the need for more detailed analysis of the Old World genus *Ophisternon*. It seems clear, on the basis of a shared, derived maxillary character, that *bengalense* and *gutturale* are closely related.

Information on catches at each site and in each season is given in volume 2.



Ophisternon gutturale

Size composition

The two specimens captured had lengths of 84 and 111 mm TL. Both were caught in floodplain billabongs, the larger in the 1978 Late-dry season (Ja Ja Billabong) and the smaller in the Mid-wet season (at Jabiluka Billabong). Both sites had large volumes of submergent hydrophytes (mainly *Najas*), which clogged the meshes of the seine net, which aided in their capture.

Pollard (1974) noted that synbranchid eels grow to over 500 mm in length. Using a dip net, he caught only one small specimen (58 mm TL) (identified as *Synbranchus bengalensis*) — in Gulungul Creek, a small muddy creek in the lowlands of the Magela Creek catchment. Thirty-five specimens, from 60 to 282 mm TL, were caught by R. Miller in large billabongs and creeks in the Oenpelli area (Taylor 1964).

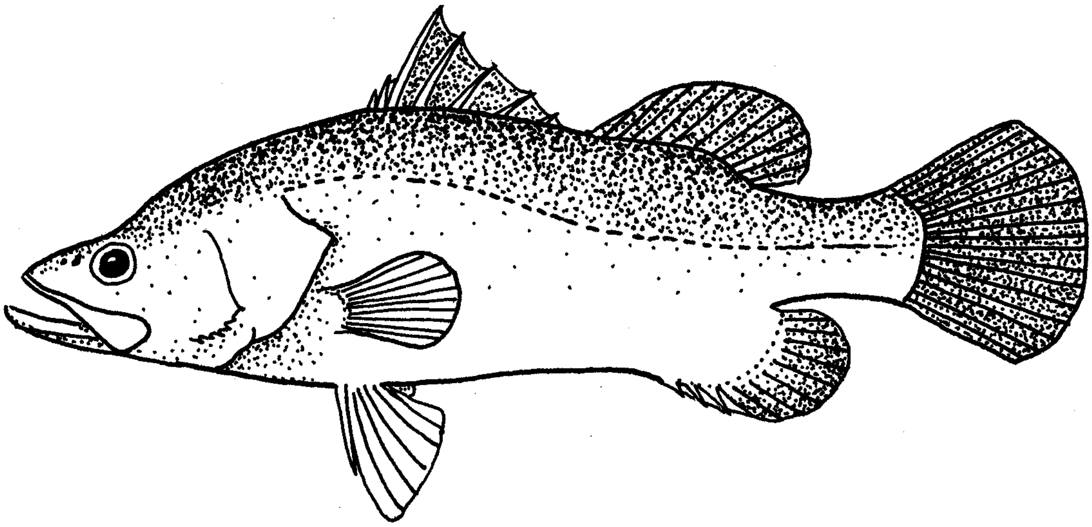
---

126 Allen (1991) indicated that *O. gutturale* is known from Papua New Guinea on the basis of one specimen collected in the Bensbach River.

Family CENTROPOMIDAE

3.20 *Lates calcarifer* (Bloch)

Lates calcarifer is commonly known as the silver barramundi or giant perch. It is found in rivers and estuaries of the north-east coast, and the drainage systems of the Gulf of Carpentaria, Timor Sea and Indian Ocean (see map 3).[127] It is also found in the tropical Indo-Pacific, from China to the Persian Gulf, including Papua New Guinea. Pollard (1974) captured many specimens in corridor and floodplain billabongs in the Magela Creek catchment, and in the mainchannel and anabranches of the East Alligator River.[128] Specimens were also captured by Miller (cited in Taylor 1964) in the Oenpelli area.



Lates calcarifer

Lates calcarifer is a catadromous species[129] and a magnificent sporting fish on account of its size, strength, and its often spectacular performance when hooked. It is also probably the finest food fish in northern Australia, and supports a commercial mesh-net fishing industry in the river mouths.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was found commonly in floodplain and corridor waterbodies and rarely in lowland backflow billabongs and sandy creekbed habitats. Some specimens were observed in escarpment mainchannel habitats in the Nourlangie Creek system.

---

127 Shaklee and Salini (1985) indicated that there were substantial genetic differences in *L. calcarifer* stocks across northern Australia, identifying at least three distinct stocks or subpopulations. Further work by Keenan (1994) identified 16 distinct populations. One population occurred from Darwin Harbour to the Mary River (no samples were taken from the South or East Alligator Rivers).

128 Herbert and Peeters (1995) indicated that *L. calcarifer* can be found in all river systems of Cape York Peninsula and far northern Queensland. They can be found throughout the entire length of a river, tolerating a wide range of habitats.

129 Based on atomic emission spectroscopy of scales, Pender and Griffin (1996) concluded that most *L. calcarifer* found in marine areas remote from freshwater parts of the Mary River system (NT), probably had no freshwater phase.

Size composition

The lengths and weights of 62 specimens were determined. Most specimens were captured by gillnets (mono- and multifilament), but many struggled free from the monofilament gillnets, which have a low breaking strain.

Length–weight relationship

The length–weight relationship for the sexes combined was described by the expression:

$W = 2.29 \times 10^{-2} L^{2.81}$ r = 0.99 (length in cm, weight in g)

Reynolds (1978) found that the length–weight relationship varied significantly between sexes and between specimens captured in salt and freshwaters.

Seasonal mean lengths, weights and condition factors are shown in table 73. Body condition was highest in the Late-wet–Early-dry season. It was lowest in the 1978–79 Early-wet, when adverse environmental conditions at times resulted in heavy mortalities.

Table 73 Mean length, mean weight and condition factor of *L. calcarifer*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	9	511.2	1494.80	1.04
Early-wet (1978–79)	20	656.0	2687.09	0.93
Mid-wet	5	602.4	2330.91	1.02
Late-wet–Early-dry 1979	1	640.1	3169.77	1.17
Mid-dry	2	466.7	1171.35	1.05
Overall	37	593.9	2194.92	1.00

Length-frequency distribution

The mean and modal lengths of specimens captured were 664 and 690 mm TL, respectively, with a secondary mode at 750 mm TL. Reynolds (1978) gives the LFM as 700 mm TL (fig 83), which suggests that more juveniles than adults were captured in the present study. Most specimens were in the size groups 550–640 mm and 670–800 mm TL, especially in the sample from the fish kill in Leichhardt Billabong. Fish of these sizes may be 3–4 years old (Reynolds 1978). Specimens less than 300 mm TL were rare in freshwaters; in Papua New Guinea, Reynolds (1978) found that juveniles of 150 mm TL leave the coastal swamps by March–April and disperse into freshwaters when they are one year old (or about 320 mm).

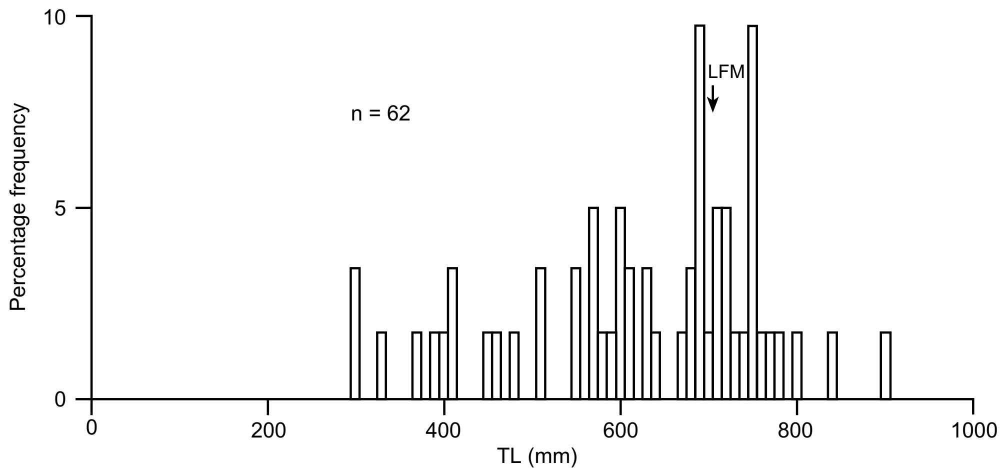


Figure 83 Length-frequency distribution of all *L. calcarifer* captured

In the Magela catchment the smallest specimen (295 mm TL) was captured in the 1978 Late-dry (fig 84), the largest (900 mm TL) in the 1978–79 Early-wet season. A 1000 mm TL specimen was caught in the East Alligator River (near Cahills Crossing) during the Mid-dry season; smaller specimens (100–150 mm TL) were caught in tidal tributaries of the East Alligator River (near Cahills Crossing) during the Late-wet–Early-dry season. *Lates calcarifer* had the greatest mean length (664 mm TL) of all the species captured in the study. Pollard (1974) reported that this species grows to 1500 mm and over 60 kg in Australian waters.[130] For Papua New Guinea specimens, Reynolds (1978) gave the L_∞ value for its von Bertalanffy growth equation as 1200 mm TL. In the Purari River, *L. calcarifer* ranged in length between 320 and 1200 mm (Haines 1979).[131]

Most specimens measured were collected after the Leichhardt Billabong fish kill in the 1978–79 Early-wet season (Bishop 1980). All other sample sizes were small.

The age–length relationship described by Davis and Kirkwood (1984) for *L. calcarifer* from the East Alligator River is superimposed on fig 84. It is apparent that specimens in the study area ranged in ages from one to seven years with most being between two and five. Reynolds (1978) stated that in Papua New Guinea most two to four years old fish are found in freshwaters, which they leave at the end of the Dry season when they are over four years old (or 700 mm TL).[132] They may return after spawning.

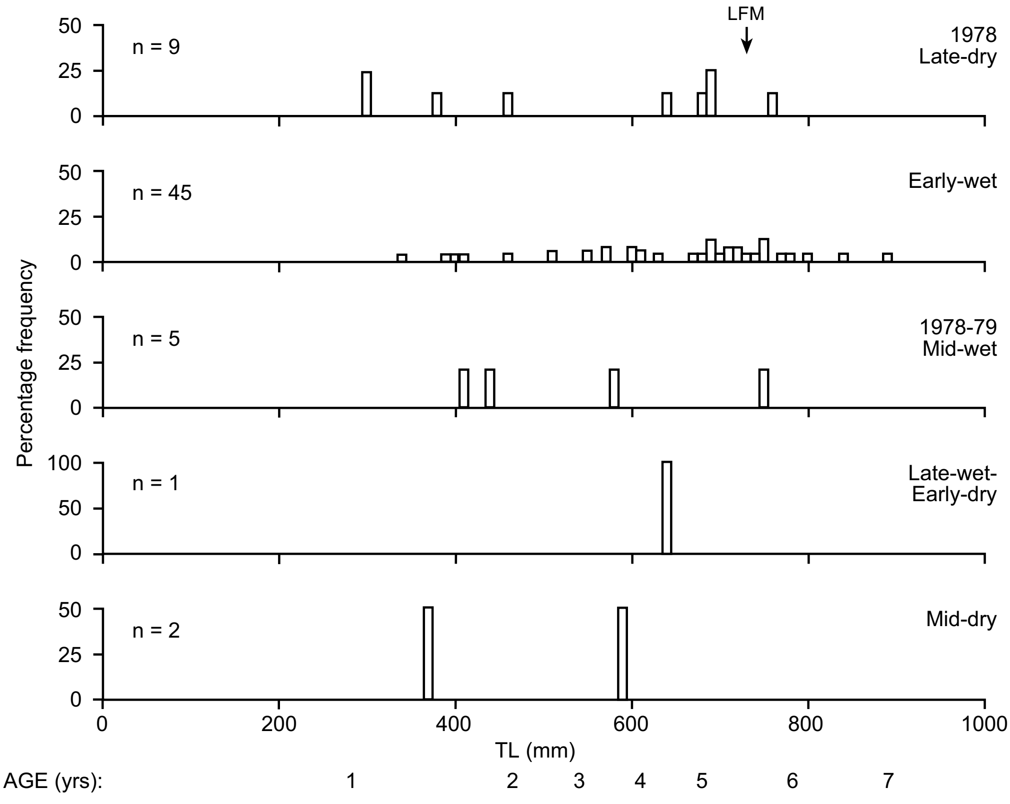


Figure 84 Seasonal length-frequency distribution of all *L. calcarifer* captured

---

130 Herbert and Peeters (1995) indicated that *L. calcarifer* grows to 1800 mm.

131 Davis and Kirkwood (1984) gave the following L_∞ values (total length) for *L. calcarifer* for rivers within the Alligator Rivers Region: Mary, 1425 mm; West Alligator, 868 mm; South Alligator, 1604 mm; East Alligator, 1775 mm. Considerable variation in growth rates between rivers was apparent.

132 This work on growth rates of *L. calcarifer* in PNG was later published by Reynolds and Moore (1982).

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *L. calcarifer* captured in regular sampling sites in the Magela Creek catchment are given in fig 85.

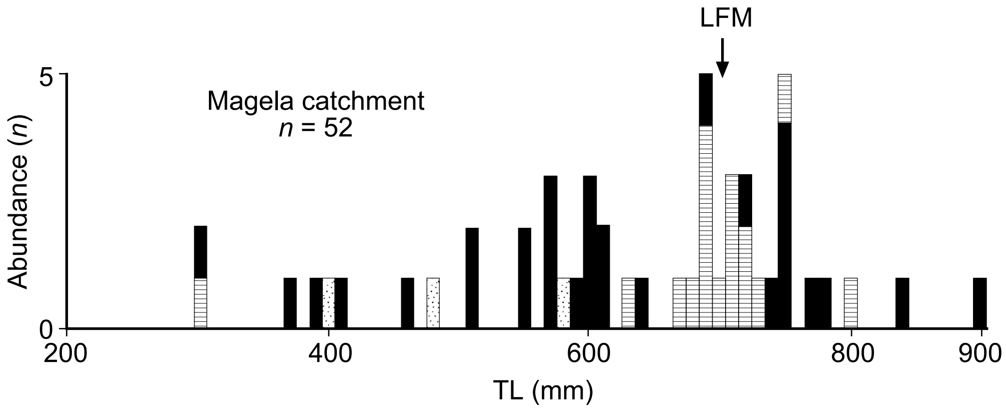


Figure 85 Length-frequency distributions and habitat preferences of *L. calcarifer* captured at regular sampling sites (see appendix 5 for key to the habitats)

The smallest juveniles were captured in floodplain and corridor anabranch billabongs. The smallest specimen captured in the Nourlangie catchment (which was close to the same size as those found in the Magela catchment) was found in a channel backflow billabong. Juveniles were occasionally observed in an escarpment mainchannel billabong in the Nourlangie catchment. Most of the juveniles captured in the Magela system were found in floodplain billabongs, with larger juveniles being found in corridor anabranch billabongs; only a few juveniles were found in lowland shallow backflow billabongs.

The smaller adults were found mainly in corridor anabranch billabongs and the larger adults mainly in floodplain billabongs. A large adult was observed in an escarpment perennial stream in the Nourlangie catchment in the Mid-wet season.

Environmental associations

Rank numbers for *L. calcarifer* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

Water temperatures ranged from 26° to 35°C (mean = 30.3°C) on the surface, and from 24° to 33°C (mean 28.2°C) on the bottom. Both these means ranked in the lower-middle quarter (see fig 170). However, *L. calcarifer* tolerates a wider range of temperatures: other workers (eg Morrissy 1971; Morrissy et al 1973) found this species living in waters at 15.5°C. Hill and Grey (1979) found that water temperature affects the timing of downstream migration. They also reported that *L. calcarifer* stops feeding when the water temperature falls below 24°C.[133] As relatively few specimens were caught in the present study, the ranges and means for environmental variables may not be fully representative of the actual ranges and means.

133 Burke (1991) found juvenile *L. calcarifer* from Queensland to have a thermal range of 10–42°C with a zone of preference from 27.5 to 36.5°C.

Dissolved oxygen

Dissolved oxygen concentrations ranged from 3.0 to 6.8 mg/L (mean = 5.0) on the surface, and from 0 to 6.8 mg/L (mean = 3.3) on the bottom (see fig 171). A tolerance of very low DO concentrations is indicated, as might be expected for a fish typically found in lentic, turbid waters (Morrissy et al 1973). *Lates calcarifer* was amongst the species recorded in the Leichhardt Billabong fish kill (Bishop 1980), when surface DO concentrations fell to 0.1 mg/L.[134]

Visibility

Secchi depth readings ranged from 3 to 120 cm (mean = 54 cm) (see fig 172). This mean ranked in the lower-middle quarter, which accords with this fish being found in turbid lowland and floodplain billabongs. Whitley (1959) attributed the mortality of large numbers of *L. calcarifer* after a flood to clogging of the fishes' gills by silt particles. However, the range of visibilities noted in the present study indicate that this species is, in fact, tolerant of very turbid waters, as Coulter (1955) observed.

pH

The pH values ranged from 4.0 to 7.2 (mean = 6.1) on the surface, and from 5.1 to 6.3 (mean = 5.9) on the bottom. Both means ranked in the lower-middle quarter (see fig 173).

Conductivity

Conductivity values ranged from 4 to 160 µS/cm on the surface, and from 4 to 110 µS/cm on the bottom. Other workers (eg Hill & Grey 1979; Pollard 1974; Morrissy et al 1973; Rao 1964) report that this species is euryhaline, tolerant of salinities of up to at least 32 ppt in estuarine waters. An increase in salinity may trigger its migration upstream to freshwaters (Morrissy et al 1973).

Habitat–structural variables

Substrate

Mud (upper quarter) and clay (upper quarter) were the most common substrates of the waters in which *L. calcarifer* was found, as might be expected for a fish typically captured in turbid lowland and floodplain billabongs. The other substrates associated with *L. calcarifer* were, in descending order of dominance, sand, leaves and boulders; no specimens were found over rock or gravel substrates (see fig 174).

Hydrophytes

Lates calcarifer was typically found in moderately vegetated waters (vegetation-occurrence index 88.9%) with emergent (43.1%), submergent (40.3%) and floating-attached (12.5%) hydrophytes.[135] Although this species is primarily a predator, it includes plant material in its diet (Chacko 1949; Whitley 1959; Morrissy et al 1973).

Reproduction

The reproductive condition of 37 specimens was examined; 34 sexually indistinguishable fish (295–800 mm TL) and 3 males (375–1000 mm TL) were identified. The three males were all immature, with GSIs of 9.12, 0.03 and 0.18; they were captured in a floodplain billabong (Leichhardt Billabong) in the Magela Creek system and in floodplain billabongs of the East Alligator River (Cahills Crossing and Cannon Hill Billabong). As no further information on

134 Wells et al (1997) stated that *L. calcarifer* was an obligate water breather with blood oxygen binding properties intermediate between the saratoga and the tarpon.

135 Herbert and Peeters (1995) indicated that in Cape York Peninsula streams their preferred habitats are aquatic plant beds, large deep-water snags and the downstream end of riffles.

the reproduction of this species was obtained from the present study, some information, mainly from research in Papua New Guinea, is summarised below.[136]

Length at first maturity

Reynolds (1978) found that males and females generally matured at 700 and 900 mm TL, respectively, although he reports that in Queensland the smallest mature female was 760 mm, while in Papua New Guinea the smallest mature fish were a 680 mm male and a 750 mm female.

Sex ratio

Lates calcarifer was found to be a protandrous hermaphrodite in Moore's 1979 study. The smaller fish were almost exclusively male; the percentage of females increased with increasing total length. The overall sex ratio was 3.8:1 in favour of males. A few primary females were found, and it is also possible that some males did not change to female. The gonads of *L. calcarifer* were strongly dimorphic, so the sex inversion requires a complete reorganisation of gonad structure as well as function. The smallest females found were 730 mm TL (five years old); few males were above 1030 mm TL. There may be a considerable variation in the size at which inversion takes place (Moore 1979).

Breeding season

The onset of the Wet season stimulates spawning behaviour but, initially, only the fish with ready access to the sea can participate. Later, as rainfall and floods allow movement of previously land-locked adult fish, there is a second spawning peak. Thus the timing, duration and intensity of the Wet season, particularly in relation to specific river systems, determines the time of spawning and, in some cases, whether some fish can spawn at all (Grey & Griffin 1979). Two main spawning seasons have been recorded: November–December and February–March (Lake 1971).

Site of spawning

The gonads begin to develop while the fish is in fresh water, and maturation is completed when the fish moves into salt water (Reynolds 1978). It spawns as the tide rises over the mudflats. Juveniles and adults migrate back into the freshwater reaches at the end of the Wet season (Pollard 1974; Reynolds 1978).

Fecundity

A very large number of small eggs are found in the ovary. Reynolds (1978) recorded 2.2–16.8 x 10^6 eggs from fish weighing 7.7–19.2 kg. The unfertilised eggs measured 0.7 x 0.8 mm and contained a single oil globule. Eggs have been reported as being demersal (Reynolds 1978) or planktonic (Lake 1978; Moore in Reynolds (1978)); according to Lake (1978) the eggs will float in water of 20–30 ppt salinity.

The larvae hatch quickly and when first hatched are about 1.5 mm long; the yolk sac is absorbed by the fifth day.

---

136 Davis (1982) examined the maturity and sexuality of *L. calcarifer* in the Northern Territory and the Gulf of Carpentaria. Davis (1985b) reported on seasonal changes in gonad maturity and the abundance of larvae and early juveniles of *Lates calcarifer* (Bloch) in Van Diemen Gulf and the Gulf of Carpentaria. Griffin (1987) examined the life history of *L. calcarifer* in the Daly River, NT. Moore (1982) described spawning and the early life history of *L. calcarifer* in Papua New Guinea.

Summary

Lates calcarifer migrates to estuaries to spawn at the onset of the Wet season. A large number of small eggs are laid as the tide rises over the mudflats. Incubation is short and tiny planktonic prolarvae emerge. Juveniles and adults move back into the freshwater reaches at the end of the Wet season.[137] No females less than about 730 mm TL have been found. Beyond this length a sex inversion occurs, and the proportion of females increases with increasing length.

Feeding habits

Overall diet

The stomachs of 35 specimens were examined; 19 contained food. The high proportion of empty stomachs may be because this species regurgitates its stomach contents as a fright response when enmeshed in gillnets (Reynolds 1978). The diet of *L. calcarifer* is summarised in fig 86; the components are listed in table 74.

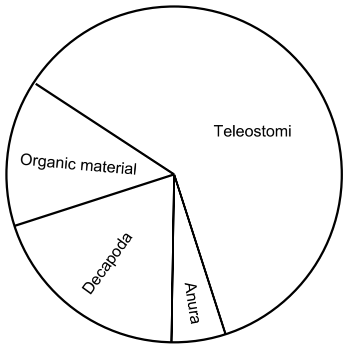


Figure 86 The main components of the diet of *L. calcarifer*

The main components were teleosts and associated unidentified organic material (65%), and macrocrustaceans (14%). The teleosts were identified as *Ambassis* spp., *Neosilurus* spp., *T. chatareus, P. rendahli, H. compressa* and *M. splendida inornata*. Anuran larvae (5%) were also found in the stomachs. *Lates calcarifer* can therefore be classified as a macrophagous piscivore/carnivore.[138] These findings are in accord with Pollard's (1974), who reported that small specimens in the Magela Creek floodplain ate *Neosilurus* and other fishes, and *Macrobrachium* and *Cherax*. Small juveniles ate some insects and occasionally some plant material in freshwaters. Larger specimens from a tidal billabong (Rock Hole) of the East Alligator River contained remains of mugilids, *Neosilurus* and other fishes.[139]

In clear water, *L. calcarifer* appears to be largely a nocturnal feeder; in turbid, estuarine waters it appears to feed during the rise and fall of the tide, following the surface movements

137 Russell (1987) reviewed juvenile *L. calcarifer* wildstocks in Australia and stressed the very important contributions wetlands make to fisheries and indirectly to local economies. Russell and Garrett (1985) examined the early life history of *L. calcarifer* in north-eastern Queensland, and Russell and Garrett (1983) investigated the use by juvenile barramundi of temporary supralittoral habitats in a tropical estuary in northern Australia.

138 Based on radio tracking studies in the Mary River, NT, Griffin (1994) concluded that *L. calcarifer* is a roving predator rather than a 'lie in wait' predator. In Van Diemen Gulf rivers, Davis (1985a) concluded that *L. calcarifer* was an opportunistic predator, with an ontogenetic progression from microcrustaceans to fish. This progression was also apparent in the Gulf of Carpentaria.

139 Herbert and Peeters (1995) indicated that in Lake Tinaroo in northern Queensland, bony bream form over 90% of the diet of the barramundi stocked there.

of small fish or crustaceans (Morrissy 1971). This fish often makes a loud noise, like a hand clap, as it chops at its prey (Whitley 1959).

Dunstan (1962) states that *L. calcarifer* is carnivorous and predacious throughout its life cycle. Generally, they will prey on any fish or crustacean smaller than themselves. In Papua New Guinea teleost remains were more common in freshwater specimens and crustacean remains in brackish-water specimens (Morrissy 1971).

Table 74 Dietary composition of *L. calcarifer*

	Season					Overall	
	1978	1978–79	1978–79	1979	1979		
Stomach contents	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Sub-mean	Main-mean
Aquatic animals							
Macrocrustacea							13.7
Macrobrachium	6.7	40.0	–	–	–	13.7	
Teleostomi							60.2
Fragmented	31.1	20.0	–	–	50.0	25.3	
Neosilurus spp.	–	–	–	100	–	5.3	
P. rendahli	–	–	–	–	37.5	4.0	
M. splendida inornata	–	–	–	–	7.5	0.8	
Ambassis spp.	–	–	20	–	5	11.1	
A. agrammus	10.0	–	80	–	–	4.7	
T. chatareus	–	20.0	–	–	–	5.3	
H. compressa	7.8	–	–	–	–	3.7	
Anura[140]							5.3
Miscellaneous (larvae)	–	20.0	–	–	–	5.3	
Parasites							
Nematoda	1.1	–	–	–	–	0.5	0.5
Organic material	43.3	–	–	–	–	20.5	20.5
Number of empty fish	–	13	3	–	–	16	16
Number of fish with food	9	5	2	1	2	19	19

Figures represent the mean percentage volume determined by the estimated volumetric method.

Seasonal changes

In sampling periods 1–5 respectively, 9 (0% empty), 18 (72% empty), 5 (60% empty), 1 (0% empty) and 2 (0% empty) stomachs of *L. calcarifer* were examined (all habitats combined). The highest proportion of empty stomachs was in the Early-wet and Mid-wet seasons.

In the 1978 Late-dry season, teleosts (the identifiable genera were *Ambassis* and *Hypseleotris*) were the main food items. The unidentified organic material in the stomachs in this season was possibly partly digested fish flesh. In the 1978–79 Early-wet season, the diet was based evenly on *Macrobrachium* and teleosts (*T. chatareus*) with a smaller component of anuran larvae. The few specimens examined in other seasons were feeding exclusively on teleosts (*Ambassis, Neosilurus, P. rendahli* and *M. splendida inornata*).

140 Lawler and Hero (1997) showed that, in comparison to native tadpoles, *Bufo marinus* tadpoles were unpalatable to *L. calcarifer*, particularly the later-stage tadpoles.

Family AMBASSIDAE

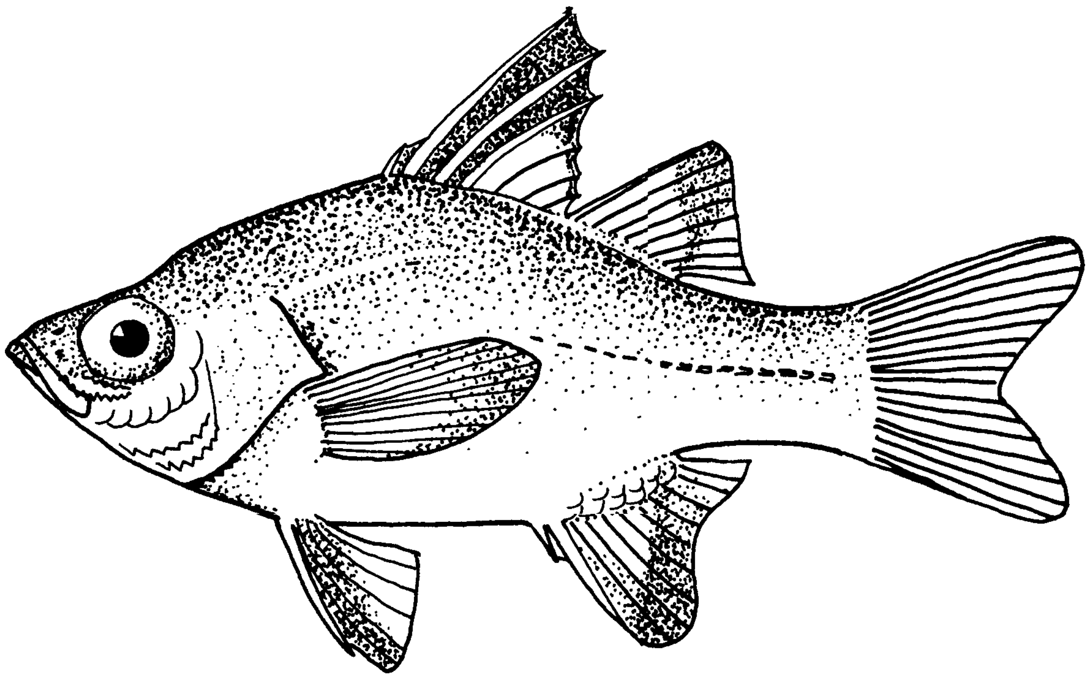
***Ambassis* spp.**

Ambassis spp. belong to a family with marine, estuarine and freshwater representatives. The taxonomic characters (mainly gill raker counts and reticulation of scales) that supposedly distinguish *Ambassis agrammus* and *A. macleayi* proved unsatisfactory with many of the specimens captured (especially the small ones), as they appeared to have intermediate or overlapping key characteristics; such specimens were recorded as *Ambassis* sp. Data on their biology for comparative use are available, though not presented in this report. Some data on *A. agrammus* and *A. macleayi* may be contaminated because of difficulties in obtaining clearcut identifications.

Family AMBASSIDAE

3.21 *Ambassis agrammus* (Gunther)

Ambassis agrammus is commonly known as the sail-fin perchlet or glassfish, or chanda perch. It is found in the drainage systems of the north-east coast, Gulf of Carpentaria and Timor Sea (map 3), and in southern rivers of Papua New Guinea. In the Magela Creek system, Pollard (1974) found it most commonly in shallow sandy and shallow vegetated areas. In the Oenpelli area, Miller (in Taylor 1964) found this species to be abundant in large billabongs.



Ambassis agrammus

Detailed information on catches at each site and in each season is given in volume 2. In summary, *A. agrammus* was found abundantly in all floodplain,[141] corridor and backflow billabongs and commonly in some lowland sandy creekbed sites and escarpment mainchannel waterbodies. It was found in the greatest number of sites in the 1978 Late-dry season (in a pattern similar to the overall distribution), and in the fewest sites in the Late-wet–Early-dry season (in some floodplain and backflow billabongs of the Magela system and in lowland sandy creekbed habitats of the Nourlangie Creek system).

Size composition

The lengths and weights of 3381 specimens were determined. Very small juveniles were captured in the 10 mm mesh seine net when hydrophytes and filamentous algae clogged the mesh; this happened most often in the Mid-wet and Late-wet–Early-dry seasons.

141 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG do not use the floodplain as a preferred habitat, even in the flood season.

Length–weight relationship

The length–weight relationship for the combined sexes was described by the expression:

$$W = 1.89 \times 10^{-2} L^{3.00} \qquad r = 0.94 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 75. The condition factor was stable (near unity) between the 1978 Late-dry and Mid-wet seasons; the near-continuous breeding of this species possibly concealed any effects of spawning on body condition.[142] Body condition fell slightly in the Late-wet–Early-dry season but rose by the Mid-dry season; the fish may have been adapting to the changing environment (Wet to Dry season). By the 1979 Late-dry season body condition was nearly equal to that recorded in the 1978 Late-dry season. The few large specimens examined in the 1978–79 Early-wet season, which was very dry, had very high body condition.

Table 75 Mean length, mean weight and condition factor of *A. agrammus*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	771	31.4	0.59	0.99
Early-wet (1978–79)	355	33.1	0.69	1.00
Mid-wet	476	29.5	0.49	0.99
Late-wet–Early-dry (1979)	301	28.8	0.44	0.96
Mid-dry	675	30.6	0.57	1.03
Late-dry	226	29.8	0.50	0.98
Early-wet (1979–80)	17	39.4	1.26	1.08
Overall	2821	30.7	0.55	1.00

Length-frequency distribution

Specimens ranged in length from 11 mm to 64 mm LCF (fig 87). Lake (1978) reported that this species grows to 70 mm. The closely related *A. macracanthus, A. nalua, A. interrupta* and *A. buruensis* were, respectively, up to 100, 90, 60 and 40 mm in length in the Purari River catchment (Haines 1979).[143]

The mean length of all specimens captured was 30.7 mm LCF and the modal length 30–31 mm LCF; the distribution was fairly symmetrical around the mean length. The LFM for males was 27 mm and for females 26 mm LCF, indicating that slightly more adults than juveniles were captured.

Seasonal changes in distribution

The smallest specimens were captured during the 1978–79 Early-wet season and the Mid-wet and Mid-dry seasons (fig 88) (as were the smallest specimens of *A. macleayi*). The largest specimens were captured in the 1978 Late-dry and the 1979 Mid-dry seasons.

Length-frequency distributions were unimodal for all seasons except the Early-wet seasons and the 1979 Mid-dry season (fig 88). Juvenile peaks were strongest in the 1978–79 Early-wet and Mid-dry seasons; in the 1979–80 Early-wet season only a few small adults were captured, but large adults were abundant (the mean length [table 75] was therefore greatest at this season).

---

142 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG had a body condition which exhibited little seasonality.

143 Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland grows to 54 mm standard length.

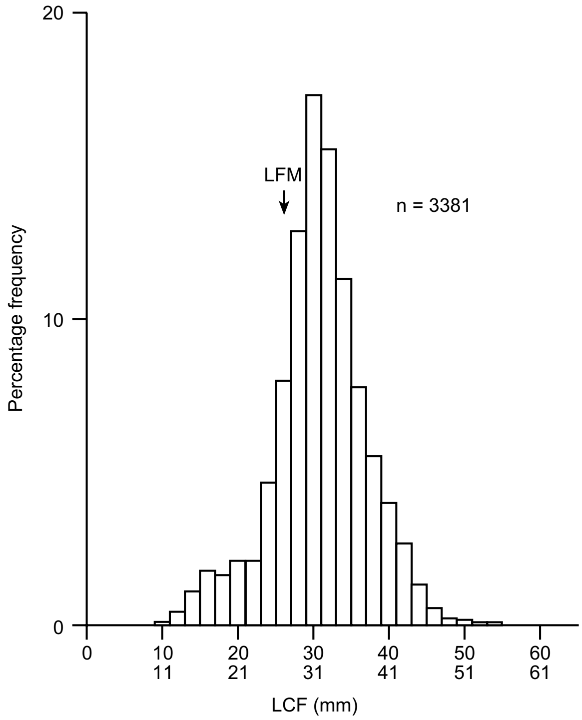


Figure 87 Length-frequency distribution of all *A. agrammus* captured

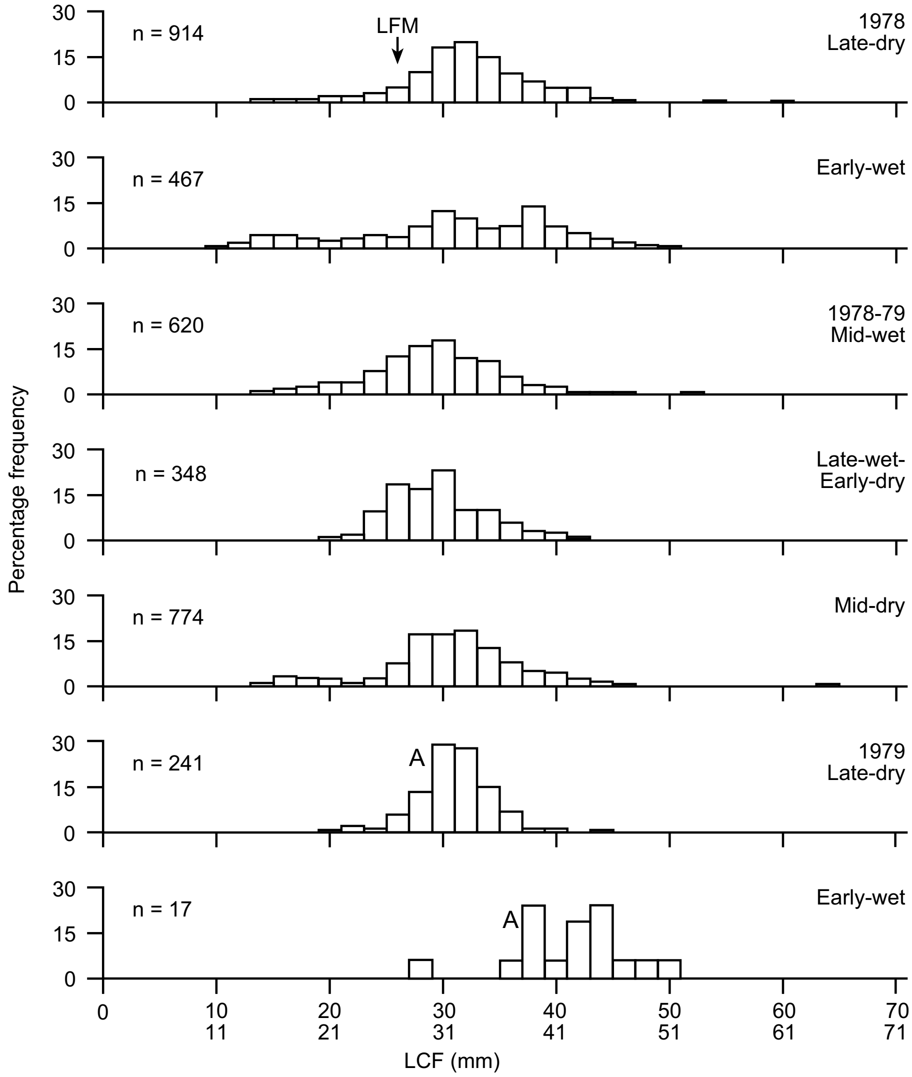


Figure 88 Seasonal length-frequency distribution of all *A. agrammus* captured

The length-frequency distributions in the two Late-dry seasons were essentially similar (with minor differences caused by sample sizes) but the 1978 mean lengths were slightly greater.

Juveniles were recruited in all seasons, except the 1979–80 Early-wet season; recruitment peaked most noticeably in the 1978–79 Early-wet and the 1979 Mid-dry season.

Growth rate

No published information on the growth of *A. agrammus* could be found. Estimation of growth rate from the seasonal length-frequency distributions is difficult due to the juveniles recruiting in most seasons and the range of habitats examined. However, between the 1979 Late-dry season and the 1979–80 Early-wet season, the length-frequency distribution shifted by approximately 10 mm (juvenile recruitment was minimal in the 1979–80 Early-wet season). If this is a true growth effect, then this species could attain its LFM within its first year of life. It is possible, therefore, that juveniles recruited in the 1979 Mid-dry season were the offspring of small adults that had been juveniles in the 1978–79 Early-wet season.[144]

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *A. agrammus* captured in regular sampling sites in the Magela and Nourlangie Creek catchments are given in figure 89.

Magela catchment

The smallest juvenile was found in a lowland sandy creekbed. Other small juveniles were found in a variety of habitats, though most frequently in floodplain and sandy corridor waterbodies and in shallow backflow billabongs. Large juveniles were found most frequently in floodplain and backflow billabongs, and to a lesser extent in corridor waterbodies. No juveniles were found in escarpment habitats.

Small adults were found in essentially the same habitats as large juveniles. Large adults were found most commonly in shallow backflow billabongs, floodplain billabongs and lowland sandy creekbeds. The largest adult specimen was captured in a channel backflow billabong. Only a few adults were found in escarpment mainchannel waterbodies and none were observed in escarpment perennial streams.

Nourlangie catchment

Juvenile *A. agrammus* were collected in a variety of habitats, from escarpment mainchannel billabongs through lowland sandy creekbed channels to backflow billabongs. The smallest specimens were found in the escarpment mainchannel billabongs.

Small adults were most frequently found in shallow backflow billabongs and to a lesser extent in channel backflow billabongs. One small adult was observed in an escarpment perennial stream during the Mid-dry season. Large adults were mainly found in lowland sandy creekbed habitats and, to a lesser extent, in backflow billabongs (as was the case for *A. macleayi*). The largest adult (54 mm LCF) was collected in a shallow backflow billabong.

Environmental associations

Rank numbers for *A. agrammus* for the physico–chemical and habitat–structural variables are shown in table 155.

---

144 Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland grows to the following standard lengths: year 1, 31 mm; year 2, 43 mm; year 3, 51 mm. This species commences to breed at 1 year old.

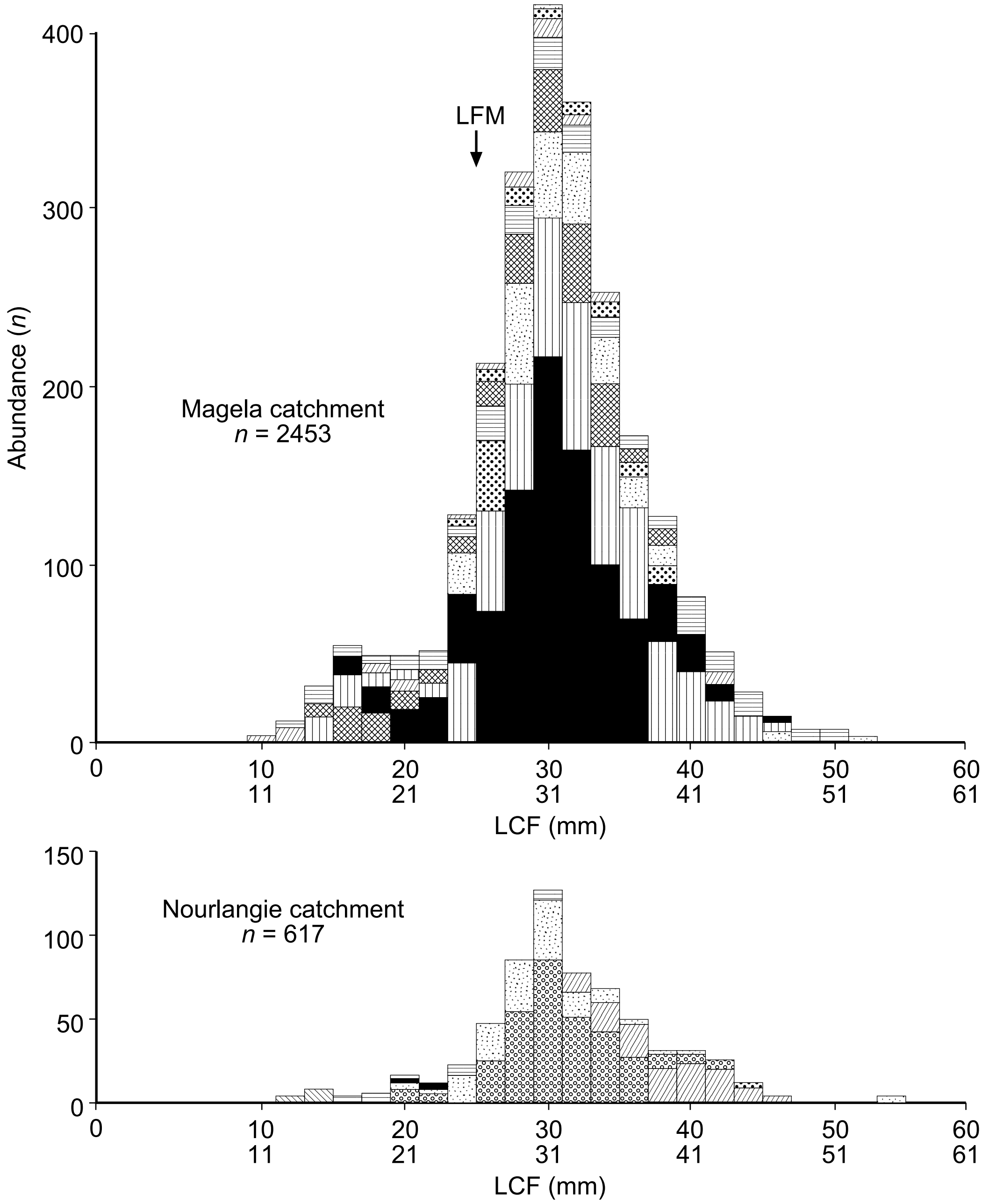


Figure 89 Length-frequency distributions and habitat preferences of *A. agrammus* captured at regular sampling sites (see appendix 5 for key to the habitats)

Physico–chemical variables

Temperature

The temperatures of waters in which *A. agrammus* was found ranged from 25° to 41°C (mean = 31.3°C) on the surface, and from 24° to 38°C (mean = 29.7°C) on the bottom. Both of these means ranked in the upper quarter (see fig 170). The tolerance of this species to a wide range of water temperatures (including some very hot surface waters) corresponds with its observed wide distribution.

Dissolved oxygen

Dissolved oxygen concentrations ranged from 1.3 to 7.8 mg/L (mean = 6.0) on the surface, and from 2.5 to 7.0 mg/L (mean = 4.4) on the bottom. Both means were placed in the lower-middle quarter (see fig 171). One hundred specimens of *A. agrammus* were found in the Leichhardt Billabong fish kill (Bishop 1980), when surface DO concentrations fell below 0.1 mg/L.

Visibility

Secchi depth readings ranged from 1 to 360 cm (mean = 32 cm). The mean depth ranked in the lower quarter (see fig 172). Specimens of *A. agrammus* were thus found in very clear to very turbid waters, but mainly in the turbid waters of the lowland and floodplain billabongs.

pH

The pH of surface waters ranged from 4.8 to 9.1 (mean = 6.4); bottom-water pH values ranged from 4.5 to 6.7 (mean = 6.0). These means ranked in the upper-middle and lower-middle quarters, respectively (see fig 173). As with other physico–chemical variables a wide tolerance is indicated.

Conductivity

Conductivity readings ranged from 4 to 220 µS/cm on the surface, and from 6 to 62 µS/cm on the bottom.

Habitat–structural variables

Substrate

As might be expected from its broad distribution, *A. agrammus* was found over the entire range of substrates defined in this study. The main one was mud (upper quarter), followed by sand (upper-middle quarter), then clay, leaf litter, gravel, boulders and rocks. Pollard (1974) commonly observed this species in shallow waters with sandy substrates.

Hydrophytes

Ambassis agrammus was usually captured in relatively heavily vegetated waters (vegetation-occurrence index 80.2%) with emergent (36.6%), submergent (35.4%) and floating-attached (24.7%) vegetation.

Reproduction

Of the 737 fish examined for reproductive condition, 153 were sexually indistinguishable, 235 were females and 349 were males. The length ranges were 18–64 mm LCF for females and 20–48 mm LCF for males.

Length at first maturity

The LFM was difficult to estimate as the percentage of mature fish in any season was between 50 and 100% (fig 90). Maturing individuals were found at 21 (female) and 27 mm LCF (male), but the LFM was estimated at 26 for females and 27 mm LCF for males.[145]

---

145 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to have a size at 50% maturity to be 70 mm for both males and females. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland to have a minimum maturity size (females) of 32 mm standard length (it commences to breed at 1 year old).

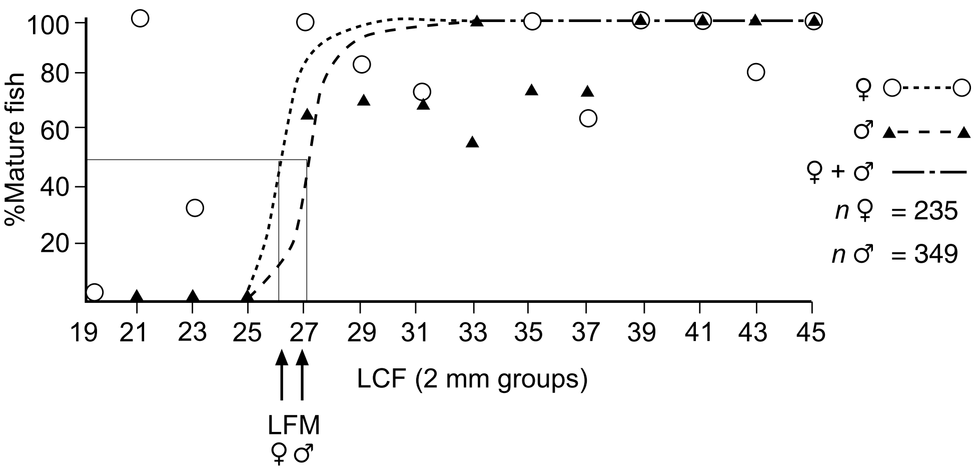


Figure 90 Estimated length at first maturity (LFM) of male and female *A. agrammus*

Sex ratio

For both juveniles + adults and adults only, the ratio of males to females was 1:1 in all seasons except the 1978 Late-dry and 1978–79 Early-wet seasons, when significantly more males were present (table 76).[146] As the unequal sex ratio occurred at the time of peak gonadal development, fish with regressed gonads are unlikely to have been misidentified as sexually indistinguishable. Localised movements within the waterbody, possibly connected with breeding behaviour, is suggested.

Breeding season

Ambassis agrammus had a well-defined breeding season: the gonads began to develop at the onset of the rains (1978 Late-dry, 1979–80 Early-wet seasons) and were fully developed in the 1978–79 Early-wet season, when the fish spawned (fig 91).[147] Rise in temperature is not thought to be a major influence on gonad development, as although the 1979 Late-dry season temperatures were higher than in the 1978 Late-dry season, the gonads were not significantly better developed. The main difference between these two seasons was that the rains were earlier and more consistent in the 1978 season, when the gonads did develop. *Ambassis agrammus* spawned at the onset of the Wet season proper; by the Mid-wet season the GSI had fallen to its lowest level.[148]

Roberts (1978) reported that *A. agrammus* in Papua New Guinea is an aseasonal breeder; however conditions are not similar to those in northern Australia.

---

146 Semple (1985) indicated that a single transient dimorphic feature was observed for gravid female *A. agrammus*. Such individuals often showed abdominal distension immediately before spawning. Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to have a sex ratio which did not differ significantly from unity during any month sampled. Similarly, Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland had an overall sex ratio which did not significantly differ from unity (some seasonal variation was apparent).

147 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to have gonadosomatic index which remained relatively constant throughout the year in both sexes, indicating that spawning was occurring throughout the year. In contrast, Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland had highly seasonal breeding. The breeding period was October–November when water temperatures exceeded 22°C, preceding summer storms and correspondingly high and variable stream flows.

148 Under laboratory conditions, Semple (1986) found that spawning occurred in water temperatures of 25–29°C. Smaller females spawned for a single night and larger females (> 40 mm SL) spawned up to four consecutive nights. Spent fish did not spawn again for 4–6 weeks.

Table 76 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *A. agrammus* over all habitats

Parameter	Sex	Statistic	Sampling period						
			Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80
Sex ratio									
Juveniles +	F	*n*	38	46	36	27	61	24	3
adults	M	*n*	134	71	39	20	55	23	7
		χ^2	53.6	5.3	0.12	1.0	0.3	0.02	1.6
		P	**	*	n.s.	n.s.	n.s.	n.s.	n.s.
Adults only	F	*n*	36	40	34	27	58	22	3
	M	*n*	128	60	38	20	52	19	7
		χ^2	51.6	4.0	0.2	1.0	0.3	0.2	1.6
		P	**	*	n.s.	n.s.	n.s.	n.s.	n.s.
GSI									
Adults only	F	mean	2.9	7.0	0.7	0.9	1.4	1.3	4.1
		s.d.	2.1	1.9	0.7	1.3	0.7	0.6	1.5
	M	mean	1.1	2.7	0.4	0.9	0.4	0.6	4.2
		s.d.	0.5	1.6	0.4	0.6	0.2	0.3	0.4
	F+M	mean	2.0	4.6	0.5	0.9	0.9	1.0	4.2
		s.d.	1.7	2.8	0.6	1.0	0.7	0.6	1.0
GMSI									
Adults only	F	mean	3.2	4.8	1.9	1.8	2.0	2.5	4.0
		s.d.	0.8	0.7	0.7	1.0	0.7	0.5	0.0
	M	mean	3.6	4.5	1.8	2.7	2.6	2.5	4.9
		s.d.	0.4	0.7	0.9	1.2	0.7	0.6	0.1
	F+M	mean	3.5	4.6	1.9	2.2	2.8	2.5	4.5
		s.d	0.7	0.7	0.8	1.1	0.7	0.5	0.5

n = number; χ^2 = Chi-squared value; P = probability; n.s. = not significant (P > 0.05); * = 0.01 < P < 0.05; ** = 0.001 < P < 0.01; s.d. = standard deviation.

Mature and ripe fish were found mainly in the 1978 Late-dry and 1978–79 Early-wet seasons, although one ripe fish was captured in the Mid-dry season, which indicated there may have been some aseasonal spawning.

Site of spawning

Ripe and spent fish were captured in backflow billabongs, floodplain billabongs and lowland sandy creekbed habitats (table 77).[149] These were also the habitats where *A. agrammus* was most abundant. Juvenile fish were found in all these habitats except the backflow billabongs. No ripe fish were captured in the corridor waterbodies, although juveniles were, and the species was very abundant.

149 Under laboratory conditions, Semple (1985) found that *A. agrammus* spawned within beds of aquatic plants. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland laid adhesive eggs attached to aquatic plants.

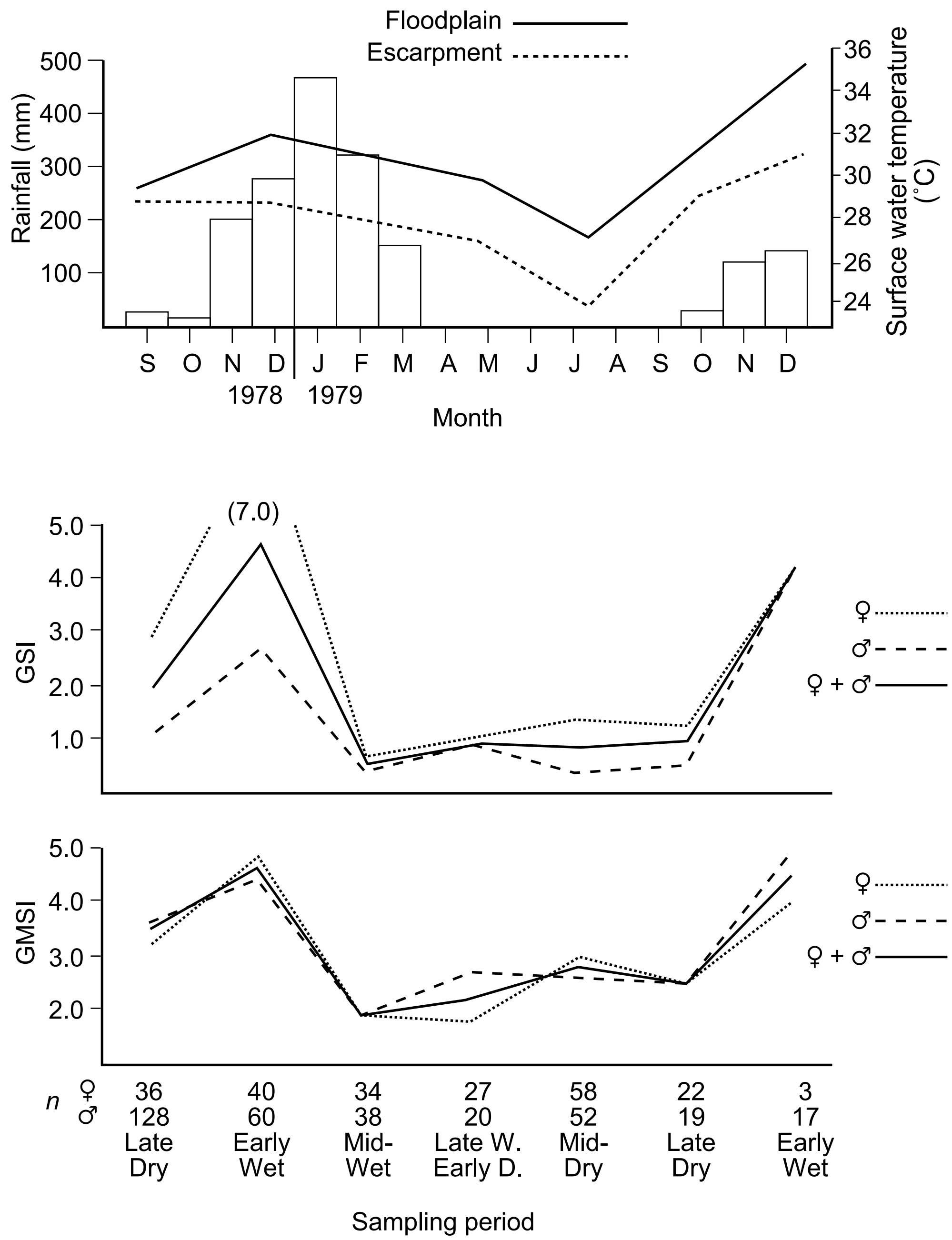


Figure 91 Seasonal fluctuations in gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *A. agrammus*

Fecundity

Sixteen ovaries were examined. The number of eggs ranged from 312 to 2905 with an average of 1614 (s.d. = 825).[150] Egg diameters were generally uniform throughout the ovary, although occasional clusters of small eggs were observed. The diameters ranged from 0.24 to 0.40 mm and were most commonly around 0.3 mm.

---

150 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to have a fecundity which varied from 29 000 to 310 000. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland had a relatively low mean fecundity of 427 eggs per individual (mean egg size was 0.6 mm).

Table 77 Possible sites of spawning of *A. agrammus* as indicated by the abundance (*n*) of mature, ripe, spent and juvenile fish

	Gonad stage						
	Mature (V)		Ripe (VI)		Spent (VII)		Juveniles
Habitat	F	M	F	M	F	M	
Escarpment							
Mainchannel waterbody	–	–	–	–	–	–	1
Seasonal feeder stream	–	–	–	–	–	–	12
Perennial stream	1	–	–	–	–	–	9
Lowlands							
Sandy creekbed	–	4	2	2	–	–	45
Backflow billabong	9	30	17	8	–	–	–
Corridor	1	1	2	–	–	1	28
Floodplain billabong							
Upper	1	11	2	4	–	1	6

Very little is known about the reproduction of any species of *Ambassis*.[151] *A. castelnaui*, the western chanda perch from warmer waters of the Murray–Darling system, Queensland and the Northern Territory, has adhesive eggs about 0.7 mm in diameter. One female (49 mm LCF) contained 2350 eggs (Llewellyn 1980).

Lake (1971) described an overseas species of *Ambassis* in which the male chased the female and displayed with zig-zag motions. Small adhesive eggs were sprayed and fertilised amongst aquatic plants. Only a few eggs were shed at a time and spawning may have been repeated several times during the day, possibly for 4–5 days. Hatching was quite rapid: 12–14 hours at an unspecified temperature and 36 hours at 28°C. Breder and Rosen (1966) also suggested that *Ambassis* lays adhesive, demersal eggs amongst aquatic plants, and while distinct pairing may take place at spawning, there is no parental care.

Summary

Ambassis agrammus had a distinct breeding season, with gonads developing in the 1978 Late-dry and 1979–80 Early-wet seasons. They apparently spawned mainly in the backflow billabongs, sandy creekbeds and floodplain billabongs.

A large number of small eggs are laid. Reports on other species suggest that the adhesive, demersal eggs are scattered amongst the aquatic plants, where they hatch in 12–36 hours.

Feeding habits

Overall diet

The stomach contents of 736 specimens were examined; 679 stomachs contained food. The diet of *A. agrammus* is summarised in figure 92; the components are listed in table 78.

151 Semple (1985) subsequently described spawning behaviour, and embryonic development of *A. agrammus*. Under laboratory conditions, Semple found that smaller females (25 mm SL) released 5–20 eggs at one spawning, while larger females (45 mm SL) produced 200–250 per spawning.

Table 78 Dietary composition of *A. agrammus*

	Habitat						Season								
	Magela system				Nourlangie system		1978	1978–79	1978–79	1979	1979	1979	1979–80	Overall	
Stomach contents	Ls	Bb	Cb	Fb	Ls	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Aquatic plants															
Algae															0.8
Miscellaneous	0.2	–	–	–	–	–	0.3	–	–	–	–	–	–	0.1	
Chlorophyceae															
Desmidaceae	–	–	0.4	–	–	–	–	–	0.3	–	–	–	–	0.1	
Dinophyceae	–	–	–	–	–	0.1	–	–	–	–	0.1	–	–	+	
Conjugatophyta															
Mougeotia	–	0.1	2.7	1.1	–	–	–	–	–	0.3	3.1	–	–	0.6	
Aquatic animals															
Protozoa	–	–	–	–	–	–	0.2	–	–	–	–	–	–	+	+
Porifera	–	–	–	–	–	–	+	–	–	–	–	–	–	+	+
Arachnida															4.5
Porohalacarida	–	0.1	–	–	–	–	–	–	–	0.5	–	–	–	+	
Hydracarina	19.4	2.1	6.5	3.1	33.8	0.2	2.6	7.0	2.7	5.1	6.7	1.9	–	4.5	
Microcrustacea															45.1
Conchostraca															
Miscellaneous	–	–	0.3	–	–	–	0.6	–	–	–	–	–	–	0.2	
Cyzicus	–	–	5.1	–	–	1.5	–	0.2	4.8	–	0.6	–	–	1.1	
Cladocera															
Miscellaneous	–	16.6	17.2	4.1	17.7	1.0	13.0	11.8	13.3	11.1	8.9	–	–	10.8	
Diaphanosoma	18.6	25.2	8.0	2.9	0.6	32.2	–	36.2	12.4	29.0	20.1	44.6	2.0	19.7	
Ostracoda	3.2	6.1	0.2	2.2	–	5.6	3.3	–	12.8	0.3	3.0	0.2	–	3.8	
Copepoda															
Miscellaneous	–	4.0	8.0	7.9	–	8.3	17.3	2.1	7.3	6.0	0.5	–	–	6.6	
Cyclops	–	3.4	–	0.1	–	1.6	–	–	–	–	7.9	0.2	98.0	2.9	
Macrocrustacea															0.9
Macrobrachium (adults)	–	–	–	0.8	–	–	0.6	–	–	–	–	–	–	0.2	
Macrobrachium (juv)	–	0.7	–	2.5	–	–	3.0	–	–	–	–	–	–	0.7	

Table 78 continued

Stomach contents	Habitat: Magela system Ls	Bb	Cb	Fb	Nourlangie system Ls	Bb	Season: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Overall Sub-mean	Main-mean
Insecta															25.4
Fragmented	–	0.7	0.6	0.8	–	1.0	0.4	–	2.1	–	0.8	–	–	0.6	
Ephemeroptera															
Baetidae	–	5.1	–	0.8	–	3.0	2.3	1.2	1.8	1.6	6.3	–	–	2.4	
Tasmanocoenis	–	–	–	–	–	1.0	–	–	–	–	0.8	–	–	0.1	
Hemiptera															
Anisops	–	–	–	–	–	–	1.3	–	–	–	–	–	–	0.3	
Corixidae	3.2	1.8	–	2.7	–	1.5	–	3.5	0.8	–	2.4	2.1	–	1.5	
Coleoptera															
Miscellaneous (adults)	–	0.2	–	–	–	–	–	–	0.3	–	–	–	–	0.1	
Miscellaneous (larvae)	1.1	–	–	–	–	–	0.1	0.1	–	–	–	–	–	0.1	
Dytiscidae (larvae)	–	–	–	–	–	0.7	–	–	–	–	–	1.5	–	0.1	
Rhantus	–	0.1	–	–	–	–	–	–	0.2	–	–	–	–	+	
Berosus							–	0.7	–	–	–	–	–	0.2	
Diptera															
Miscellaneous (larvae)	–	0.1	–	–	–	–	–	–	0.2	–	–	–	–	+	
Tipulidae	–	1.2	–	–	–	–	–	–	2.3	–	–	–	–	0.4	
Chaoborinae	–	4.1	–	–	–	–	–	6.8	–	–	–	–	–	1.5	
Chironomidae (larvae)	27.7	6.3	22.4	9.0	22.3	16.9	12.9	10.4	13.2	22.6	12.2	27.3	–	14.0	
Chironomidae (pupae)	0.3	1.3	3.3	1.7	–	0.5	4.1	0.1	0.1	0.2	1.6	–	–	1.3	
Ceratopogonidae	–	1.2	–	–	–	1.0	1.8	–	0.2	–	–	2.1	–	0.6	
Trichoptera															
Hydroptilidae	–	–	–	–	–	0.2	–	–	–	–	0.2	–	–	+	
Leptoceridae	–	1.5	1.1	1.0	1.8	9.1	–	0.7	2.9	1.9	7.3	–	–	2.2	
Teleostomi															0.7
Scales	–	–	0.2	–	–	0.1	0.1	–	0.2	–	–	–	–	+	
Miscellaneous (larvae)	–	–	–	–	–	1.3	–	0.8	–	–	–	–	–	0.2	
Craterocephalus sp.	3.1	–	–	–	–	–	0.6	–	–	–	–	–	–	0.1	
Egg material	–	0.4	–	–	–	–	–	0.7	–	–	–	–	–	0.2	
Anura															0.2
Miscellaneous (larvae)	–	–	–	–	–	1.0	–	0.7	–	–	–	–	–	0.2	

Table78 continued

Stomach contents	Habitat: Magela system Ls	Bb	Cb	Fb	Nourlangie system Ls	Bb	Season: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Overall Sub-mean	Main-mean
Terrestrial plants															
Angiospermae															0.1
Seed material	–	–	0.9	–	–	–	–	–	0.6	–	–	–	–	0.1	
Terrestrial animals															
Insecta															0.2
Trichoptera (adults)	–	0.4	–	–	–	–	0.4	–	0.8	–	–	–	–	0.2	
Parasites															
Trematoda	–	–	1.1	–	–	–	–	–	–	–	–	2.1	–	0.2	0.2
Nematoda	0.3	0.9	–	0.1	–	0.1	0.1	0.1	1.7	–	0.1	–	–	0.4	0.4
Microcrustacea															
Argulus	–	–	1.9	–	–	–	–	1.2	–	–	–	–	–	0.3	0.3
Detrital material	–	0.8	1.1	–	–	–	–	0.7	–	–	–	4.2	–	0.4	0.4
Inorganic material	–	1.3	0.2	1.0	–	–	1.4	1.5	0.2	0.2	–	–	–	0.7	0.7
Organic material	22.9	13.9	18.8	38.4	23.5	12.5	33.8	13.7	18.8	21.2	17.3	14.0	–	20.6	20.6
Number of empty fish	2	12	10	16	4	3	24	9	14	2	7	1	–	57	57
Number of fish with food	31	245	94	121	17	96	160	147	128	63	123	48	10	679	679

Figures represent the mean percentage volume determined by the estimated volumetric method.

Ls = lowland sandy creek bed; Bb = lowland backflow billabongs; Cb = corridor billabongs; Fb = floodplain billabongs

The main components were microcrustaceans (45%) (mainly cladocerans, copepods, ostracods and conchostracans) and aquatic insects (25%) (mainly chironomid, baetid and leptocerid larvae). Hydracarinids (5%) and traces of algae, macrocrustaceans, teleosts, anuran larvae, terrestrial insects and plant material were also eaten. *Ambassis agrammus* can therefore be classified as a microphagous carnivore feeding mainly in mid-waters and occasionally in benthic areas of the waterbodies.[152]

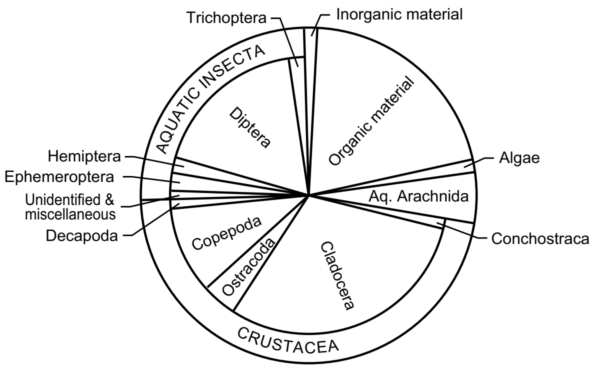


Figure 92 The main components of the diet of *A. agrammus*

Pollard (1974) suggested this species might eat small insect larvae and planktonic crustaceans. Lake (1978) noted that *A. agrammus* was similar to the inland chanda perch, *A. castelnaui*, which eats small invertebrates, particularly small crustaceans and mosquito larvae.

Sanderson (1979) noted *A. agrammus* on the Magela floodplain ate mainly small crustaceans (especially cladocerans), vegetable matter (algae and seeds) and organic detritus; in seasonal streams feeding the floodplain in the Wet season, the diet shifted to the benthic arthropod forms, especially hydracarinids, and winged terrestrial dipterans.

Seasonal changes

In sampling periods 1–7, respectively, 184 (13% empty), 156 (6% empty), 142 (10% empty), 65 (3% empty), 130 (5% empty), 49 (2% empty) and 10 (0% empty) stomachs of *A. agrammus* were examined (all habitats combined). The highest proportions of specimens with empty stomachs were found in the 1978 Late-dry and 1978–79 Mid-wet seasons.

The microcrustacean component of the diet was large throughout the study. The cladoceran component increased in importance in the 1978–79 Early-wet season, decreased during the 1979–80 Early-wet season, but remained important until the 1979 Late-dry season. The copepod component, in contrast, became markedly smaller in the 1978–79 Early-wet season, and remained relatively small, and had almost disappeared by the 1979 Late-dry season, after

152 Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland tends to feed within littoral vegetation and in the midwater. Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to consume mainly small insect larvae but also insects from terrestrial sources and on small crustaceans. Martin and Blaber (1983) found that 3 species of ambassids in a Natal estuary of South Africa feed mainly on a wide variety of zooplanktoners, with some fish and insects also occasionally consumed. All the species mainly fed on food suspended in the water column. Martin and Blaber (1984) concluded that the well-developed dentition and gut morphology (distensible stomach and a low relative gut length) of all the 3 species also suggested a predatory and carnivorous habit.

which it increased dramatically, to become effectively the sole food item that had been eaten by the few specimens examined in the 1979–80 Early-wet season.

The chironomid larvae were important in the diet throughout the study except in the 1979–80 Early-wet season; they were most important in the Late-wet–Early-dry season. Leptocerid and baetid larvae were most important in the diet during the 1979 Mid-dry season.

Habitat differences

Magela catchment

A total of 531 stomachs of *A. agrammus* were examined (all seasons combined): 33 (6% empty), from lowland sandy creekbeds; 257 (5% empty) from backflow billabongs; 104 (10% empty) from corridor billabongs; 137 (12% empty) from floodplain billabongs. The last two habitats had the highest proportions of specimens with empty stomachs.

The diet in the lowland sandy creekbeds was based primarily on chironomid larvae, cladocerans (*Diaphanosoma*) and hydracarinids. In the backflow billabongs, the hydracarinid component was smaller, while the microcrustacean component, particularly the cladocerans, copepods and ostracods, was larger; the aquatic insect component became more varied and included baetid, chironomid and chaoborid larvae.

The diet in the corridor waterbodies and floodplain was based on microcrustaceans. The aquatic insects were mainly chironomid larvae and pupae. Large volumes of unidentified organic material were also frequently found in the stomachs.

Nourlangie catchment

Totals of 21 (19% empty) and 99 (3% empty) stomachs of *A. agrammus* were examined (all seasons combined) from lowland sandy creekbeds and backflow billabongs, respectively. The highest proportions of specimens with empty stomachs were found in the sandy creekbed habitats (unlike the Magela catchment).

The diet in the lowland sandy creekbeds was very similar to that found in the equivalent Magela Creek habitat: mainly hydracarinids, chironomid larvae and cladocerans. The diet in the backflow billabongs was also similar to that in the Magela Creek system: mainly cladocerans, ostracods, copepods, and chironomid, baetid and leptocerid larvae.

Fullness

A summary of mean fullness indices of *A. agrammus* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments is shown in table 79. These data are presented on the assumption that feeding times do not vary with habitat or season.

Seasonal differences

Mean seasonal fullness indices were highest in the 1978–79 Early-wet season, fell to a low stable level, and increased again through the 1979 Mid-dry and Late-dry seasons.[153]

Habitat differences

In the Magela catchment, upstream from RUPA, mean fullness indices were highest in shallow backflow billabongs and lowest in sandy creekbeds. Downstream of RUPA, the indices, which were in the same range, were highest in backflow billabongs and lowest in corridor anabranch and floodplain billabongs.

153 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG had a stomach fullness index which exhibited little seasonality.

In the Nourlangie catchment mean fullness indices were also highest in the shallow backflow billabongs. The other habitats examined in this catchment had low indices typical of Magela Creek corridor anabranch and floodplain billabongs.

Table 79 Mean fullness indices of *A. agrammus* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments

Habitat	Sampling period						Habitat mean
	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	
Magela Creek catchment (regular sites only)							
Upstream of RUPA:							
Escarpment main-channel waterbody	2.6 (5)	n/s	3.3 (10)	n/s	n/s	n/s	3.1 (15)
Lowland sandy creekbed	n/s	n/s	1.7 (3)	n/s	n/s	n/s	1.7 (3)
Downstream of RUPA:							
Lowland sandy creekbed	3.0 (8)	2.2 (19)	n/s	n/s	1.3 (3)	n/s	2.3 (30)
Lowland channel backflow billabong	3.1 (10)	3.1 (37)	2.2 (20)	1.8 (5)	2.0 (5)	1.5 (10)	2.6 (87)
Lowland shallow backflow billabong	2.6 (24)	2.9 (28)	2.1 (49)	2.4 (10)	2.6 (35)	2.3 (9)	2.5 (155)
Corridor sandy billabong	2.1 (10)	2.2 (9)	1.5 (10)	n/s	2.1 (10)	4.4 (10)	2.1 (49)
Corridor anabranch billabong	1.6 (10)	n/s	1.1 (10)	n/s	2.6 (10)	n/s	1.8 (30)
Floodplain billabong	1.1 (41)	3.0 (30)	1.7 (20)	2.5 (24)	1.7 (37)	2.0 (10)	1.9 (162)
Nourlangie Creek catchment (regular sites only)							
Escarpment main-channel waterbody	n/s	1.8 (5)	n/s	n/s	n/s	n/s	1.8 (5)
Lowland channel backflow billabong	n/s	0 (1)	1.4 (10)	1.1 (10)	3.5 (10)	n/s	1.9 (31)
Lowland shallow backflow billabong	1.2 (6)	4.5 (17)	2.0 (10)	2.1 (10)	3.6 (10)	4.1 (10)	3.2 (63)
Lowland sandy creekbed	n/s	n/s	n/s	1.3 (6)	2.4 (10)	n/s	2.0 (16)
Seasonal mean (all sites)	2.0	2.9	2.0	2.0	2.4	2.9	

Numbers examined are given in parentheses; n/s = not sampled in the habitat.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

- corridor sandy billabong; 1979 Late-dry season
- escarpment mainchannel waterbody; 1978–79 Mid-wet season
- lowland channel backflow billabong; 1978 Late-dry season, 1978–79 Early-wet season

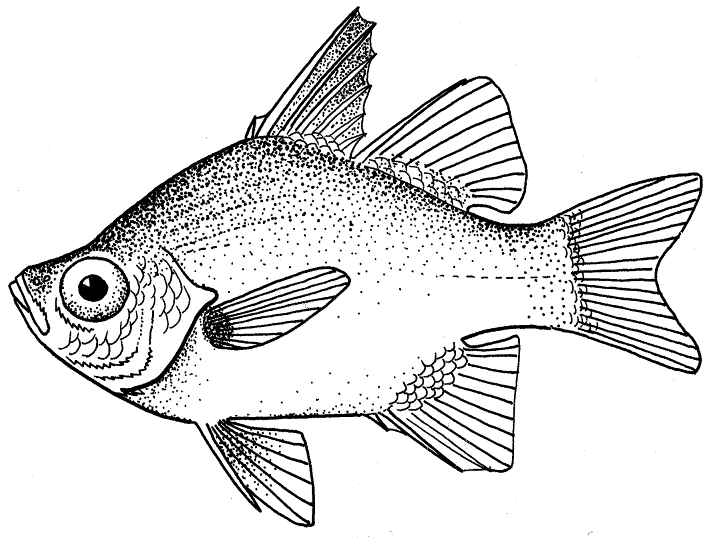
Nourlangie catchment

- lowland shallow backflow billabong; 1978–79 Early-wet season, 1979 Late-dry season.

Family AMBASSIDAE

3.22 *Ambassis macleayi* (Castelnau)

Ambassis macleayi is commonly known as the reticulated perchlet or glassfish, or chanda perch. It is distributed in the Gulf of Carpentaria and Timor Sea drainage systems (see map 3) and also occurs in rivers of southern Papua New Guinea. Pollard (1974) found it most commonly in turbid and heavily vegetated billabongs along the Magela Creek system. Miller (in Taylor 1964) reported it was abundant in large billabongs in the Oenpelli area.



Ambassis macleayi

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was moderately abundant in most corridor and backflow billabongs and common in floodplain[154] and lowland sandy creekbed sites and escarpment mainchannel waterbodies. It was found in the greatest number of sites in the Late-wet–Early-dry season and in the fewest in the 1978 Late-dry season.

Size composition

The lengths and weights of 2028 specimens were determined. The major and minor peaks in the overall length-frequency distribution correspond to the mesh selectivity of the 10 mm mesh seine net and the 26 mm mesh gillnet. Very small juveniles were captured in the seine net when hydrophytes and filamentous algae clogged the meshes.

Length–weight relationship

The length–weight relationship for the combined sexes was described by the expression:

$$W = 1.60 \times 10^{-2} L^{3.17} \qquad r = 0.98 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 80. The condition factor peaked in the 1978–79 Early-wet season, probably because of an increase in

154 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG not use the floodplain as a preferred habitat, even in the flood season.

reproductive condition; presumably environmental conditions and food availability were most favourable during this season.[155] However, by the Mid-wet and Late-wet–Early-dry seasons the condition went down to the 1978 Late-dry season level. It then improved in the Mid-dry and 1979 Late-dry seasons, but fell dramatically in the 1979–80 Early-wet (when conditions were comparable to an extreme Dry season). It seems, therefore, that conditions in the Wet and extreme Dry seasons lower the body condition of this species.

Table 80 Mean length, mean weight and condition factor of *A. macleayi*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	110	36.0	0.89	0.95
Early-wet (1978–79)	149	32.7	0.71	1.05
Mid-wet	221	40.8	1.34	0.97
Late-wet–Early-dry (1979)	340	37.0	0.99	0.98
Mid-dry	413	36.8	1.03	1.03
Late-dry	393	35.7	0.92	1.02
Early-wet (1979–80)	51	34.4	0.68	0.84
Overall	1677	36.6	0.98	1.00

Length-frequency distribution

The specimens captured ranged in length from 11 mm to 81 mm LCF (fig 93).

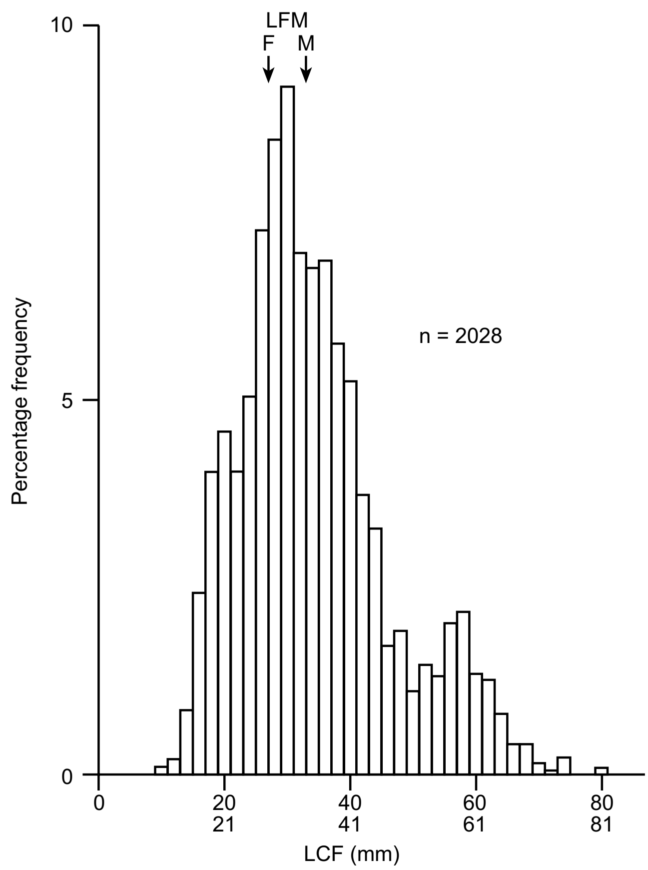


Figure 93 Length-frequency distribution of all *A. macleayi* captured

155 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG had a body condition which exhibited little seasonality.

Fishes of the genus *Ambassis* rarely exceed 80 mm in length (Lake 1971), however, *A. macleayi* is reputed to grow to 100 mm LCF (Pollard 1974).[156]

The mean and modal lengths of all specimens captured during the study were 36.6 and 30–31 mm LCF, respectively. The LFM for males was 33 mm LCF and for females 29 mm LCF, which indicates that most of the specimens were adults. There were two peaks in the length-frequency distribution: the larger peak (16–48 mm LCF) encompassed approximately 90% of the total number of specimens and the smaller peak (48–70 mm LCF) included most of the remainder.

Seasonal changes in distribution

The greatest number of small specimens was captured in the 1978–79 Early-wet season, followed closely by the 1978–79 Mid-wet and 1979 Mid-dry season. The greatest number of large specimens was captured in the 1978–79 Mid-wet season, followed closely by the 1978 Late-dry and 1979–80 Early-wet seasons (fig 94).

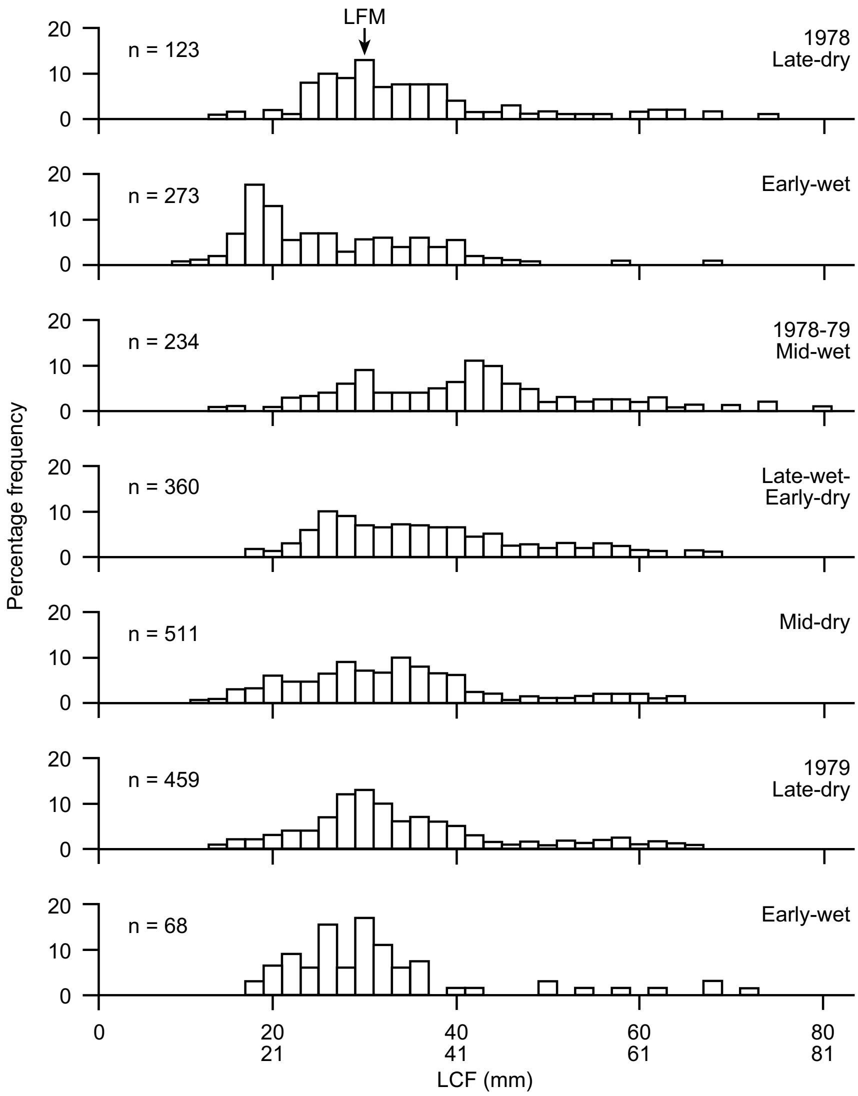


Figure 94 Seasonal length-frequency distribution of all *A. macleayi* captured

156 Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland grows to 54 mm standard length.

The length-frequency distributions in the Late-dry seasons were fairly similar, both being dominated by large juveniles and small adults, with smaller numbers of large adults. In the Early-wet seasons, samples were dominated by juveniles (especially in the 1978–79 season when there was a large juvenile peak) and to a lesser extent by small adults; few larger adults were found in these seasons (fig 94). The smallest mean lengths were recorded in the Early-wet seasons (table 80).

By the Mid-wet season adults dominated the samples, with greater numbers of larger adults and relatively few juveniles; as a consequence the mean lengths were the highest recorded for this species. The Late-wet–Early-dry and Mid-dry seasons had the same pattern (and therefore similar mean lengths) as the Late-dry seasons.

Continuous juvenile recruitment is indicated by the length-frequency distributions. There was a peak in recruitment in the 1978–79 Early-wet season.

Growth rate

No published information on the growth of *A. macleayi* was found. The growth rate was difficult to estimate from the seasonal length-frequency distributions due to mesh selectivity, continuous juvenile recruitment, and the range of habitats examined. A tentative estimate, based on specimens from channel backflow billabongs only, is that, like *D. bandata*, it may attain its LFM within one year.[157]

Habitat differences in distribution

Length-frequency distributions showing the habitats in which *A. macleayi* was captured in regular sampling sites in the Magela and Nourlangie Creek catchments are given in figure 95.

Magela catchment

The smallest juveniles were captured in corridor anabranch billabongs and backflow billabongs. Juveniles were found in a variety of habitats, though most commonly in corridor waterbodies, and backflow and floodplain billabongs; a few juveniles were captured in escarpment mainchannel waterbodies and lowland sandy creekbeds. No juveniles were found in escarpment perennial streams.

The largest adult was found in an escarpment mainchannel waterbody and other large specimens were captured in backflow billabongs. Intermediate-sized adults were found mainly in channel backflow billabongs and, to a lesser extent, in shallow backflow billabongs, floodplain and corridor anabranch billabongs and escarpment mainchannel waterbodies.

Small adults were mainly found in floodplain billabongs, shallow backflow billabongs upstream of RUPA, and in corridor anabranch billabongs. No adults were found in escarpment perennial streams.

Nourlangie catchment

Large juveniles were most commonly found in channel backflow billabongs, small adults in lowland sandy creekbeds, and intermediate-sized adults in escarpment mainchannel waterbodies. (Large schools were frequently observed near bedrock that overhung deep waters.) Adult *A. macleayi* were observed in escarpment perennial streams during the Mid-wet season.

---

157 Under laboratory conditions with a water temperature of 26°C, Ivantsoff et al (1988) indicated that *A. macleayi* can attain a total length of 30–34 mm in 80 days. By 150 days a total length of 36–40 mm was attained. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland grows to the following standard lengths: year 1, 31 mm; year 2, 43 mm; year 3, 51 mm. This species commences to breed at 1 year old.

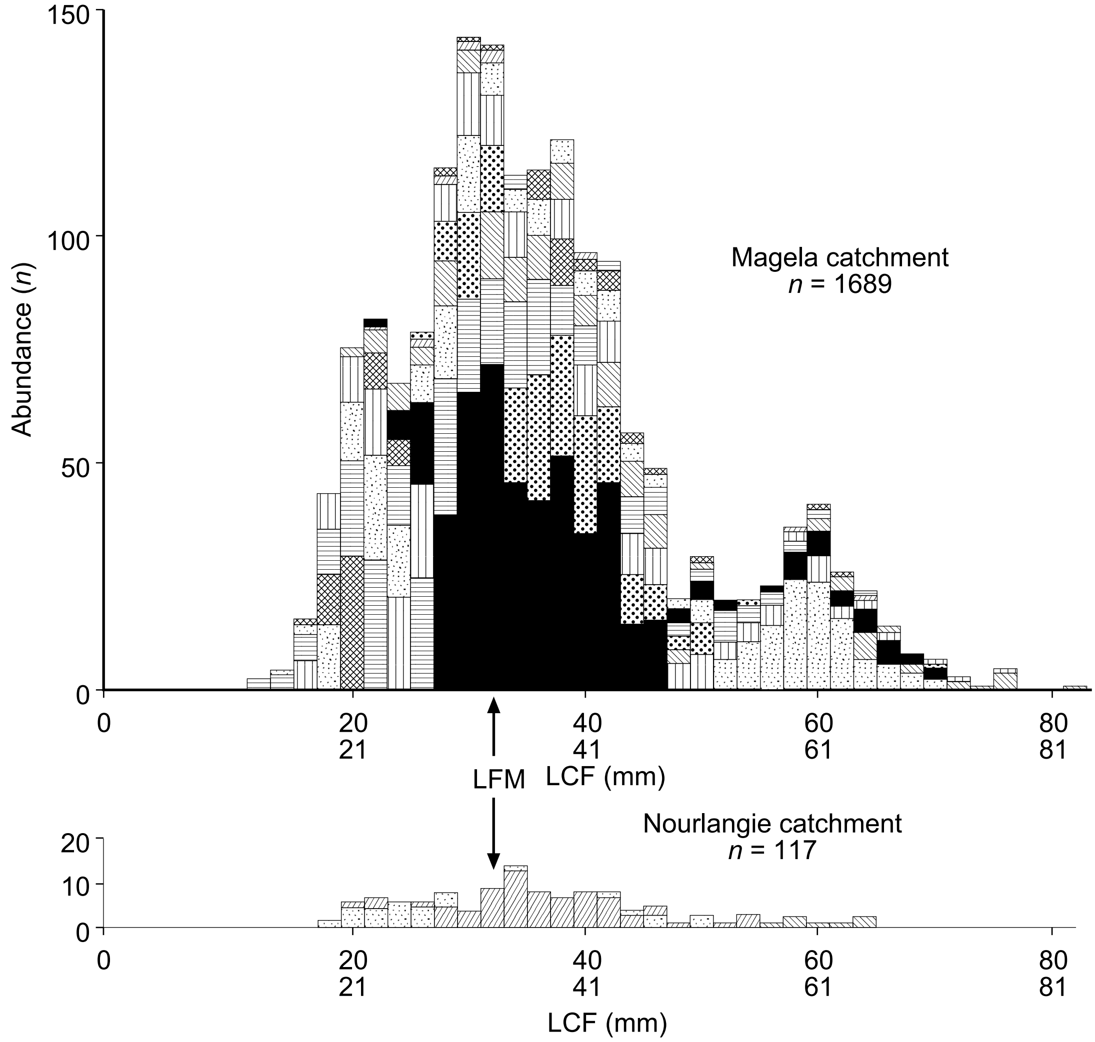


Figure 95 Length-frequency distributions and habitat preferences of *A. macleayi* captured at regular sampling sites (see appendix 5 for key to the habitats)

Environmental associations

Rank numbers for *A. macleayi* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

The water temperatures at sites where *A. macleayi* was captured ranged from 23° to 38°C (mean = 30.6°C) on the surface and from 25° to 34°C (mean = 29.3°C) on the bottom. These means ranked high in the upper and lower-middle quarters respectively (see fig 170). Apart from the lower maximum, these ranges are close to those found for *A. agrammus*.

Dissolved oxygen

Dissolved oxygen concentrations ranged from 1.0 to 9.1 mg/L (mean = 6.2) on the surface, and from 0.5 to 9.5 mg/L (mean = 4.6) on the bottom. These means both ranked in the upper-middle quarter (see fig 171). The tolerance of a wide range of DO concentrations is in accord with the distribution of *A. macleayi*. Like *A. agrammus*, it is found in habitats ranging from escarpment to floodplain.

Visibility
Secchi depth readings ranged from 1 to 150 cm (mean = 47.6 cm) (see fig 172). This mean depth was placed in the lower-middle quarter, indicating an apparent preference for less turbid waters than *A. agrammus*, although with a far narrower range.

pH
The pH values of surface waters ranged from 4.8 to 7.7 (mean = 6.2), and of bottom water from 5.3 to 7.0 (mean = 6.1). These means were placed in the lower-middle and upper-middle quarters, respectively (see fig 173). These ranges are markedly narrower than those associated with *A. agrammus*.

Conductivity
Conductivity readings ranged from 2 to 620 µS/cm on both the surface and the bottom. *A. macleayi* appears to tolerate a wider range of dissolved solids concentrations than *A. agrammus*.

Habitat–structural variables

Substrate
Like *A. agrammus, A. macleayi* was captured over the entire range of substrates, especially sand (lower-middle quarter), followed by mud (lower-middle quarter), then clay, gravel, leaves, rocks and boulders.

Hydrophytes
A. macleayi was typically captured in waters with moderate vegetation (vegetation-occurrence index 76.4%) of submergent (41.6%), emergent (34.4%) and floating-attached (19.1%) hydrophytes. *A. macleayi* was found in more sparsely vegetated waters than was *A. agrammus*, and in association with submergent rather than emergent vegetation.

Reproduction

A total of 533 fish were examined to establish reproductive condition: 53 were sexually indistinguishable, 195 were females and 285 were males. The length ranges of the male and female fish were 16–74 mm and 20–81 mm LCF, respectively.

Length at first maturity

The smallest individuals found with maturing gonads were a 31 mm LCF male and a 27 mm LCF female.[158] The estimated LFM was 33 mm LCF for males and 29 mm LCF for females (fig 96). Males of this species generally tended to be larger than the females.

Sex ratio

As with *A. agrammus*, more males than females were found in the 1978 Late-dry season; however, for *A. macleayi*, more males were also found during the 1978–79 Mid-wet (juvenile and adult fish combined) and the 1979 Mid-dry (all fish and adults only) (table 81).[159] It is unlikely that the gonads were misidentified, as females were easily recognisable and quite distinct from males.

---

158 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to have a size at 50% maturity to be 70 mm for both males and females. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland to have a minimum maturity size (females) of 32 mm standard length (it commences to breed at 1 year old).

159 Coates (1990) found *A. interrupta* in the Sepik River to have a sex ratio which did not differ significantly from unity during any month sampled. Similarly, Milton and Arthington (1985) indicated that *A. nigripinnis* from SE Queensland had an overall sex ratio that did not significantly differ from unity (some seasonal variation was apparent).

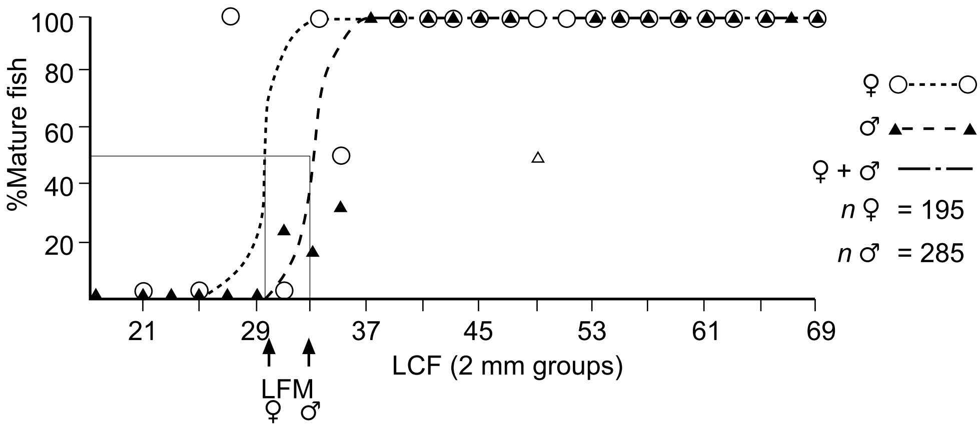


Figure 96 Estimated length at first maturity (LFM) of male and female *A. macleayi*

Table 81 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *A. macleayi* over all habitats

			Sampling period						
Parameter	Sex	Statistic	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80
Sex ratio									
Juveniles +	F	*n*	11	25	22	34	49	47	7
adults	M	*n*	28	30	39	41	80	59	8
		χ^2	7.4	0.5	4.7	0.7	7.5	1.4	0.1
		P	**	n.s.	*	n.s.	**	n.s.	n.s.
Adults only	F	*n*	11	20	22	34	48	46	7
	M	*n*	28	25	36	41	73	49	8
		χ^2	7.4	0.6	3.4	0.7	5.2	0.1	
		P	**	n.s.	n.s.	n.s.	*	n.s.	n.s.
GSI									
Adults only	F	mean	2.8	3.5	1.4	1.3	1.6	2.1	1.7
		s.d.	1.4	1.8	1.2	1.0	1.1	1.1	1.3
	M	mean	0.5	1.5	0.2	0.3	0.4	0.6	0.4
		s.d.	0.2	1.3	0.1	0.2	0.2	0.3	0.2
	F+M	mean	1.4	2.6	0.8	0.8	1.0	1.3	1.1
		s.d.	1.5	1.9	1.0	0.9	1.0	1.1	1.2
GMSI									
Adults only	F	mean	4.2	4.2	2.9	2.9	3.3	3.6	3.6
		s.d.	1.1	0.9	0.9	1.1	1.0	0.8	1.1
	M	mean	3.5	4.4	2.3	2.4	3.0	3.3	2.5
		s.d.	1.2	1.3	0.5	0.8	0.8	0.8	1.5
	F+M	mean	3.7	4.3	2.6	2.7	3.2	3.4	3.1
		s.d	1.2	1.1	0.8	1.0	0.9	0.8	1.4

n = number; χ^2 = Chi-squared value; P = probability; n.s. = not significant (P > 0.05); * = 0.01 < P < 0.05; ** = 0.001 < P < 0.01; s.d. = standard deviation.

When the sex ratio was determined for individual habitats, it was found to be significantly different from 1:1 at a backflow billabong (Goanna Billabong) and a large escarpment-area pool (Deaf Adder Creek, Camp 1) during the 1978 Late-dry season, and at other backflow billabongs (Indium and Corndorl billabongs) during the 1979 Mid-dry season. The sex ratios were not significantly different from a 1:1 at other sites or in other seasons.

Breeding season

The GSI and GMSI were stable throughout the year, with a small peak in gonad development in the 1978–79 Early-wet season (fig 97).[160]

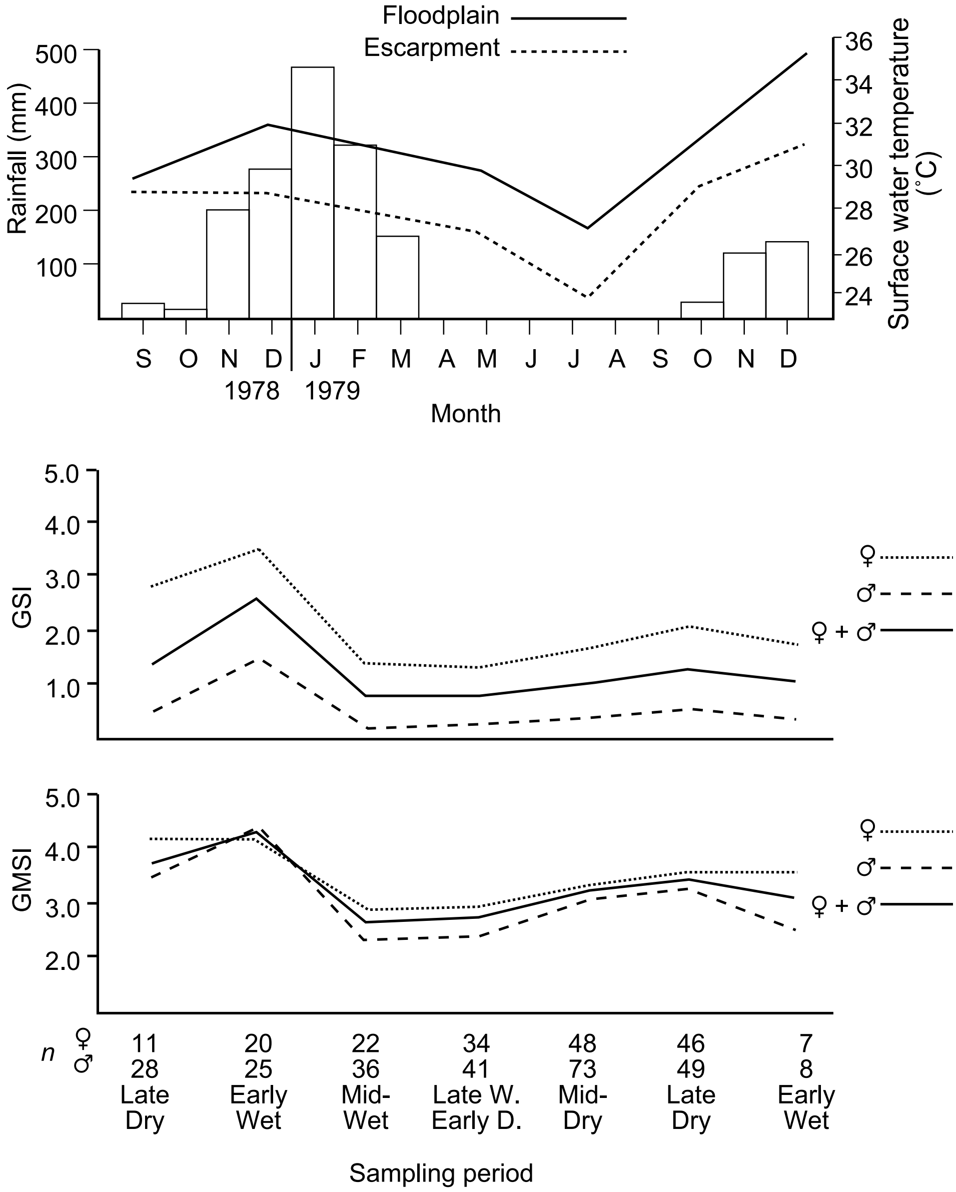


Figure 97 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *A. macleayi*

160 Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to have gonadosomatic index which remained relatively constant throughout the year in both sexes, indicating that spawning was occurring throughout the year. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland had highly seasonal breeding. The breeding period was October-November when water temperatures exceeded 22°C, preceding summer storms and correspondingly high and variable stream flows.

Mature fish were captured in all seasons, although ripe fish were only caught in the 1978 Late-dry and 1978–79 Early-wet seasons. The smallest juveniles were caught in the Mid-dry season, although this may reflect effort or mesh selectivity.

Spent fish were caught in many seasons, from the 1978–79 Mid-wet season through the Late-wet–Early-dry season to the 1979 Mid-dry season. This species may have a long recovery period after spawning or some fish may have spawned after the 1978–79 Early-wet season, although no ripe and few mature fish were captured after that time.

Site of spawning

Mature fish were captured in a wide range of sites (table 82), from backflow billabongs to the corridor waterbodies and floodplain billabongs. No mature fish were captured in escarpment mainchannel waterbodies. Ripe fish were caught only in a backflow billabong (Indium Billabong) and an adjacent sandy creekbed site. Ripe fish were also captured in a lowland sandy creekbed (Nourlangie Crossing 2) of the Nourlangie Creek. It appears that *A. macleayi* generally spawns in flowing sandy creeks. Juveniles were captured in the sandy creek areas and also corridor waterbodies.[161]

Table 82 Possible sites of spawning of *A. macleayi* as indicated by the abundance (*n*) of mature, ripe, spent and juvenile fish

	Gonad stage						
	Mature (V)		Ripe (VI)		Spent (VII)		Juveniles
Habitat	F	M	F	M	F	M	
Escarpment							
Mainchannel waterbody	–	–	–	–	1	1	–
Lowlands							
Sandy creekbed	1	–	1	7	–	–	4
Backflow billabong	13	20	1	1	–	2	–
Corridor	20	3	–	–	2	–	6
Floodplain billabong							
Upper	–	–	–	–	1	–	–
Artificial	1	–	–	–	–	–	–

Fecundity

Six ovaries were examined. The only eggs counted were in the size-class of the largest eggs, although occasional clusters of smaller eggs were noted. Egg numbers ranged from 320 (from a 45 mm LCF fish with a gonad weight of 0.06 g) to 2360 (from a 63 mm LCF fish with a gonad weight of 0.12 g); the average number of eggs was 1340. The number of eggs increased with increasing size of both fish and ovary. The mean egg diameter of 0.3 mm

161 Under laboratory conditions, Ivantsoff et al (1988) found that *A. macleayi* preferred dense aquatic vegetation for spawning. Eggs were laid high on the plants. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland laid adhesive eggs attached to aquatic plants.

(± 0.07) appeared to be independent of egg number and fish size. Thus *A. macleayi* generally had a relatively large number of very small eggs.[162]

The small eggs and probably short incubation period, as observed in *A. agrammus*, suggest that the prolarvae would be poorly developed, with poor swimming ability.

Summary

Ambassis macleayi had a uniformly low level of sexual development throughout the year, although a small peak was noted in the 1978–79 Early-wet season. In some habitats at some sampling times there were significantly more males than females, which suggests a localised sexual behavioural pattern. Evidence of spawning was only found in lowland sandy anabranches of the Magela and Nourlangie creeks. The many small eggs are probably laid amongst the aquatic vegetation. The incubation period is likely to be short, so the undeveloped larvae would be dispersed by the flowing creek water.[163]

Feeding habits

Overall diet

The stomachs of 519 specimens were examined; 485 contained food. The diet of *A. macleayi* is summarised in figure 98; the components are detailed in table 83. The main items were microcrustaceans (55%) (with which large quantities [18%] of unidentified organic material were associated) and aquatic insects (19%). The microcrustaceans were mainly cladocerans (*Diaphanosoma*) and copepods; the aquatic insects were mainly chironomid larvae and pupae, and baetid larvae.

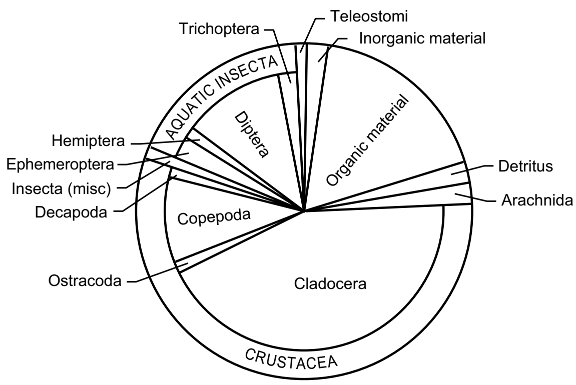


Figure 98 The main components of the diet of *A. macleayi*

162 Under laboratory conditions, Ivantsoff et al (1988) found that *A. macleayi* released a few eggs initially each day, but the number increased, possibly to above 200 on the second and third days. Spawning continued for about a week, followed by a period of reduced activity. Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to have a fecundity which varied from 29 000 to 310 000. Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland had a relatively low mean fecundity of 427 eggs per individual (mean egg size was 0.6 mm).

163 Ivantsoff et al (1988) subsequently described spawning behaviour, egg surface morphology and embryonic and larval development of *A. macleayi*.

Table 83 Dietary composition of *A. macleayi*

	Habitat								Season								
	Magela system					Nourlangie system			1978	1978–79	1978–79	1979	1979	1979	1979–80	Overall	
Stomach contents	Em	Ls	Bb	Cb	Fb	Em	Ls	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Aquatic plants																	
Algae																	0.9
Miscellaneous	–	–	–	0.8	–	–	–	–	–	–	–	–	–	0.9	–	0.2	
Dinophyceae	–	–	0.7	–	–	–	–	–	–	–	–	–	1.2	–	–	0.3	
Conjugatophyta																	
Mougeotia	0.3	–	–	–	–	–	–	11.8	–	–	0.2	2.4	–	–	–	0.4	
Aquatic animals																	
Arachnida																	1.5
Hydracarina	6.6	–	1.2	–	2.3	–	2.2	–	3.0	0.8	–	–	1.5	1.4	11.1	1.5	
Microcrustacea																	54.7
Conchostraca	–	–	–	–	–	–	–	–	2.3	–	–	–	–	–	–	0.2	
Cladocera																	
Miscellaneous	19.1	16.7	8.5	4.6	5.9	–	16.5	–	40.6	7.4	13.0	8.3	7.6	2.8	–	9.9	
Diaphanosoma	5.6	41.7	51.4	29.7	24.1	–	32.8	–	–	66.2	13.6	32.5	32.3	39.5	51.6	34.4	
Ostracoda	5.3	–	–	0.9	–	–	1.3	–	–	–	5.8	–	–	0.3	–	0.6	
Copepoda																	
Miscellaneous	1.7	–	8.4	9.2	2.9	–	–	–	8.8	1.9	7.0	4.6	17.3	1.0	0.3	7.2	
Cyclops	–	–	2.7	0.6	–	–	23.0	–	–	1.2	–	–	1.3	8.7	–	2.3	
Macrocrustacea																	0.6
Macrobrachium	–	–	–	2.6	–	–	–	–	–	1.5	–	–	–	1.9	–	0.6	
Insecta																	19.0
Fragmented	7.7	–	0.2	0.9	–	16.7	–	–	–	2.0	6.4	–	–	–	2.4	1.0	
Ephemeroptera																	
Baetidae	5.5	–	2.4	3.6	2.9	–	0.9	15.9	4.6	2.0	3.6	4.5	3.2	–	9.2	3.0	
Atalophlebia	–	–	–	–	–	–	–	5.9	–	–	–	–	0.8	–	–	0.2	
Hemiptera																	
Gerridae	–	–	0.5	–	–	–	–	–	–	–	–	–	0.8	–	–	0.2	
Veliidae	–	–	–	–	–	–	–	–	2.3	–	–	–	–	–	–	0.2	
Corixidae	0.6	–	0.6	–	2.9	–	–	–	–	–	3.2	–	0.2	2.0	–	0.8	
Coleoptera	–	5.0	0.2	–	–	–	–	–	–	–	–	0.7	0.2	–	–	0.2	

Table 83 continued

Stomach contents	Habitat								Season							Overall	
	Magela system					Nourlangie system			1978	1978–79	1978–79	1979	1979	1979	1979–80		
	Em	Ls	Bb	Cb	Fb	Em	Ls	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Diptera																	
Culicidae (larvae)	7.2	–	–	–	–	–	–	–	–	–	–	–	–	–	12.1	0.5	
Culicidae (pupae)	–	–	0.5	–	–	–	–	–	–	–	–	–	–	1.0	–	0.2	
Chaoborinae	–	–	1.0	–	–	–	–	–	–	–	–	–	1.6	–	–	0.4	
Chironomidae (larvae)	3.9	0.8	3.2	10.1	8.8	–	5.4	5.9	9.6	2.7	3.4	7.3	8.0	3.9	6.6	5.9	
Chironomidae (pupae)	7.8	2.5	1.6	5.8	2.9	16.7	3.9	11.8	3.9	0.2	4.7	2.7	7.7	2.3	–	3.7	
Ceratopogonidae	0.9	–	–	2.0	–	–	0.9	–	–	0.3	–	–	–	2.2	1.6	0.6	
Trichoptera																	
Hydroptilidae	–	–	0.5	–	–	–	–	–	–	–	–	–	0.8	–	–	0.2	
Leptoceridae	3.1	–	0.5	–	–	–	–	35.3	–	–	2.1	–	5.7	–	–	1.7	
Lepidoptera																	
Pyralidae	3.1	–	–	–	–	–	–	–	–	–	2.1	–	–	–	–	0.2	
Teleostomi																	1.0
Fragmented	–	–	–	0.9	–	–	–	–	–	–	2.1	–	–	–	–	0.2	
Scale	3.1	–	0.9	–	–	–	–	–	–	–	2.1	–	0.8	0.8	–	0.6	
Miscellaneous (larvae)	–	–	–	–	–	–	–	–	–	–	–	1.2	–	–	–	0.2	
Terrestrial plants																	
Angiospermae																	0.3
Fragmented	–	–	+	–	–	–	4.3	–	–	1.5	–	–	+	–	–	0.2	
Seed material	1.6	–	–	–	–	–	–	–	–	–	1.1	–	–	–	–	0.1	
Terrestrial animals																	
Insecta																	0.2
Hymenoptera																	
Formicidae	–	–	0.5	–	–	–	–	–	–	–	–	1.2	–	–	–	0.2	
Parasites																	
Nematoda	–	–	+	–	–	–	–	–	0.1	–	–	–	–	–	–	+	+
Detrital material	–	6.7	4.7	–	–	–	4.4	–	–	2.8	–	–	–	9.3	–	2.3	2.3
Inorganic material	–	4.2	2.4	0.6	–	16.7	–	–	–	0.8	2.1	–	0.1	5.4	–	1.5	1.5
Organic material	16.9	22.5	7.4	27.6	47.1	50.0	4.3	13.5	25.0	8.8	27.5	34.5	8.9	16.9	5.3	18.1	18.1
Number of empty fish	–	–	8	11	11	–	–	1	1	4	5	2	11	10	1	34	34
Number of fish with food	32	12	202	110	34	6	23	17	44	65	47	84	124	102	19	485	485

Figures represent the mean percentage volume determined by the estimated volumetric method. + = present, but in very small proportions

Em = escarpment mainchannel; Ls = lowland sandy creek bed; Bb = lowland backflow billabongs Cb = corridor billabongs; Fb = floodplain billabongs

Traces of algae, aquatic arachnids, macrocrustaceans, teleosts, terrestrial plant material and insects, detritus and inorganic material were also found in the stomachs. *Ambassis macleayi* can therefore be classified as a microphagous carnivore feeding mainly in midwater and occasionally from the benthic areas of the waterbodies.[164]

Pollard (1974) thought it was likely that the diet of this species would include small insects occurring in aquatic vegetation. Haines (1979) classified the closely related *Ambassis interruptus* as an insectivore in the Purari River.

Seasonal changes

In sampling periods 1–7, respectively, 45 (2% empty), 69 (6% empty), 52 (10% empty), 86 (2% empty), 135 (9% empty), 112 (9% empty) and 20 (5% empty) stomachs of *A. macleayi* were examined (all habitats combined). The highest proportion of specimens with empty stomachs occurred in the Mid-wet, Mid-dry and 1979 Late-dry seasons.

The microcrustacean component of the diet was important throughout the study. The cladocerans component increased and the copepod component decreased during the 1978–79 and the 1979–80 Early-wet seasons.

Aquatic insects were less important in the diet. Chironomid larvae and pupae were common in the stomachs during the 1978 Late-dry season, then became less common until the Late-wet–Early-dry and the Mid-dry seasons, when they increased in importance again. Most unidentified organic material was found in the stomachs in the 1978 Late-dry, 1978–79 Mid-wet and Late-wet–Early-dry seasons.

Habitat differences

Magela catchment

A total of 420 stomachs of *A. macleayi* were examined (all seasons combined): 32 (0% empty) from escarpment mainchannel waterbodies, 12 (0% empty) from lowland sandy creekbeds, 210 (4% empty) from lowland backflow billabongs, 121 (9% empty) from corridor billabongs, and 45 (24% empty) from floodplain billabongs.

In escarpment mainchannel waterbodies, aquatic insects (chironomid, culicid and baetid larvae) were the main component in the diet, although considerable numbers of cladocerans, ostracods and hydracarinids were found in the stomachs. There were large volumes of unidentified organic material in the stomachs in both this habitat and in lowland sandy creekbeds where large numbers of cladocerans, particularly *Diaphanosoma*, were also eaten. There was a large cladoceran component in the diet in the backflow billabongs. Copepods were also present in the diet in the backflow billabongs, as well as in the corridor waterbodies. The microcrustacean component of the diet was generally smaller in the corridor and floodplain billabongs, while chironomid larvae and pupae were more important, and so there was a large unidentified organic material component.

---

164 Milton and Arthington (1985) indicated that the closely related *A. nigripinnis* from south-eastern Queensland tends to feed within littoral vegetation and in the midwater. Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG to consume mainly small insect larvae but also insects from terrestrial sources and on small crustaceans. Martin and Blaber (1983) found that 3 species of ambassids in a Natal estuary of South Africa feed mainly on a wide variety of zooplanktoners, with some fish and insects also occasionally consumed. All the species mainly fed on food suspended in the water column. Martin and Blaber (1984) concluded that the well-developed dentition and gut morphology (distensible stomach and a low relative gut length) of all the 3 species also suggested a predatory and carnivorous habit.

Nourlangie catchment

A total of 47 stomachs of *A. macleayi* were examined (all seasons combined): 6 from escarpment mainchannel waterbodies, 23 from lowland sandy creekbeds and 18 from backflow billabongs. Only one specimen, from a backflow billabong, had an empty stomach.

The few specimens in the escarpment waterbodies that were examined were feeding mainly on aquatic insects (chironomid pupae), as in the equivalent habitat in the Magela Creek catchment. There were no microcrustaceans but large amounts of unidentified organic material in their stomachs. The diet in the lowland sandy creekbeds was based mainly on cladocerans and copepods, as in the Magela catchment. However, unlike the Magela catchment, the diet in the backflow billabongs did not include microcrustaceans; the main items were aquatic insects (leptocerid larvae, baetid, *Atalophlebia* larvae and chironomid larvae and pupae) and smaller quantities of incidentally ingested algae.

Fullness

The mean fullness indices of *A. macleayi* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments are summarised in table 84. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 84 Mean fullness indices of *A. macleayi* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments

Habitat	Sampling period							Habitat mean
	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80	
Magela Creek catchment (regular sites only)								
Upstream of RUPA:								
Escarpment main-channel waterbody	0 (1)	n/s	2.8 (20)	n/s	0 (1)	n/s	2.8 (10)	2.6 (32)
Lowland sandy creekbed	n/s	n/s	n/s	n/s	2.4 (10)	2.6 (10)	1.0 (2)	1.0 (2)
Downstream of RUPA:								
Lowland sandy creekbed	n/s	2.7 (7)	n/s	2.0 (5)	n/s	n/s	n/s	2.2 (13)
Lowland channel backflow billabong	2.0 (8)	2.0 (9)	n/s	1.8 (5)	2.8 (40)	3.1 (31)	3.1 (4)	2.7 (97)
Lowland shallow backflow billabong	0 (1)	3.8 (12)	0 (1)	2.8 (11)	2.9 (20)	2.1 (30)	n/s	2.6 (75)
Corridor sandy billabong	2.4 (5)	3.4 (5)	n/s	3.0 (2)	n/s	n/s	n/s	2.9 (12)
Corridor anabranch billabong	n/s	2.7 (10)	1.7 (11)	1.5 (13)	2.1 (10)	2.6 (10)	n/s	2.1 (54)
Floodplain billabong	2.5 (2)	2.3 (6)	n/s	2.1 (20)	1.9 (43)	1.6 (25)	n/s	1.9 (96)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	n/s	n/s	1.6 (5)	n/s	0 (1)	n/s	n/s	1.3 (6)
Lowland channel backflow billabong	n/s	n/s	2.0 (2)	1.8 (6)	3.0 (9)	n/s	n/s	2.5 (17)
Lowland sandy creekbed	n/s	3.9 (17)	n/s	n/s	n/s	4.0 (6)	n/s	3.9 (23)
Seasonal mean (all sites)	2.2	3.2	2.2	2.3	2.5	2.5	3.3	

Numbers examined are given in parentheses; n/s = not sampled in the habitat.

Seasonal changes

In the main, seasonal fullness indices were stable throughout most of the year, except for peaks in the Early-wet seasons.[165]

Habitat differences

In the Magela catchment, upstream of RUPA, the mean fullness indices were comparable with those recorded in downstream habitats. Downstream of RUPA they were highest in the sandy corridor waterbodies and lowest in the floodplain billabongs.

In the Nourlangie catchment the mean fullness indices were highest in the lowland sandy creekbed habitats and lowest in the escarpment mainchannel waterbodies.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

- escarpment mainchannel waterbody; 1978–79 Mid-wet season, 1979–80 Early-wet season
- lowland shallow backflow billabongs; 1978–79 Early-wet season
- lowland channel backflow billabongs; 1979 Late-dry season, 1979–80 Early-wet season

Nourlangie catchment

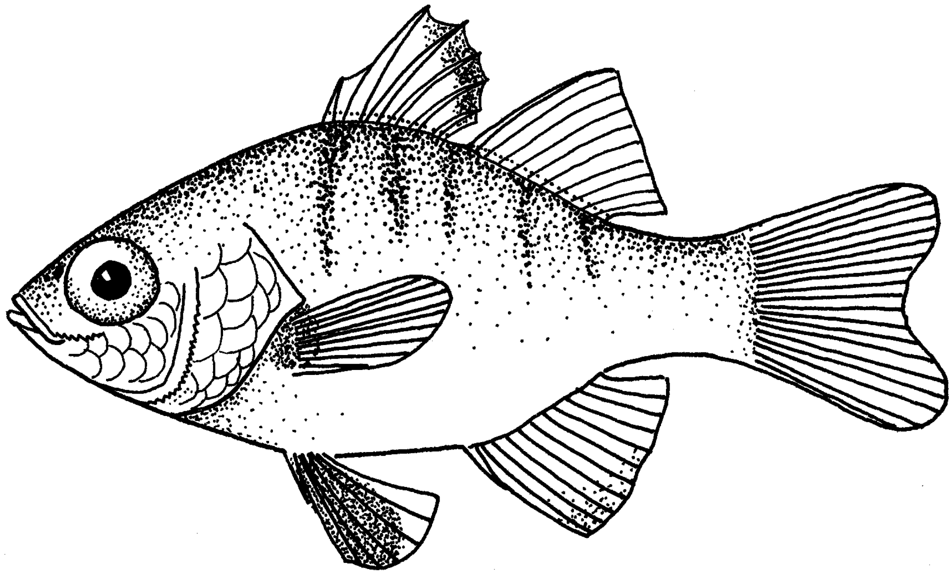
- lowland sandy creekbed; 1978–79 Early-wet season, 1979 Late-dry season.

[165] Coates (1990) found the closely related *A. interrupta* in the Sepik River of PNG had a stomach fullness index which exhibited little seasonality.

Family AMBASSIDAE

3.23 *Denariusa bandata* (Whitley)

Denariusa bandata is commonly known as the pennyfish. It is found in the Timor Sea and Gulf of Carpentaria drainage systems (see map 3) and southern rivers of Papua New Guinea. Midgley (1973) collected this species in floodplain and lowland backflow billabongs in the Magela Creek system. Miller (cited in Taylor 1964) found it in a large billabong in the Oenpelli area and in (Eastern) Red Lily Billabong. Little is known about its biology.



Denariusa bandata

Detailed information on catches at each site and in each season is given in volume 2. In summary, *D. bandata* was moderately abundant in all floodplain, corridor and lowland backflow (mainly shallow) billabongs. It was also found commonly in some lowland sandy creekbeds. It was found in the greatest number of sites in the Late-wet–Early-dry season (mainly in lowland backflow and floodplain billabongs); it was found in the fewest sites in the Mid-wet season (mainly in corridor waterbodies).

Size composition

The lengths and weights of 1340 specimens were determined. The slight positive skew of the overall distribution was probably an artefact of the mesh size (10 mm) of the seine net.

Length–weight relationship

The length–weight relationship for the sexes combined was:

$W = 2.44 \times 10^{-2} L^{2.75}$ r = 0.91 (length in cm, weight in g)

Seasonal mean lengths, weights and condition factors are shown in table 85. The seasonal condition factor was highest in the 1978 Late-dry and fell markedly by the 1978–79 Early-wet season; this fall may have been caused by a peak in spawning activity (as evidenced by the presence of juvenile recruits), changing environmental conditions caused by the onset of water flow, or both. The condition factor then gradually increased through the Wet season to reach a stable level (near unity) by the Late-wet–Early-dry season, where it remained for the remainder of the study. The condition attained by the 1979 Late-dry season was slightly less than that recorded in the same season in 1978.

Table 85 Mean length, mean weight and condition factor of *D. bandata*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	212	28.7	0.46	1.03
Early-wet (1978–79)	17	28.5	0.44	0.95
Mid-wet	74	26.7	0.36	0.98
Late-wet–Early-dry (1979)	206	27.6	0.39	1.01
Mid-dry	296	29.0	0.45	0.98
Late-dry	33	27.6	0.40	1.00
Overall	838	28.2	0.42	1.00

Length-frequency distribution

The smallest specimen captured was 9 mm LCF; the largest was 42 mm LCF. This species may grow to 35 mm (Lake 1978), though it is reputed to attain 50 mm (Pollard 1974).

The mean and modal lengths of *D. bandata* were 28.2 and 28–29 mm LCF respectively. The LFM for males was 31 mm LCF and for females 25 mm LCF (fig 99), indicating that fairly equal proportions of juveniles and adults were captured. A slight positive skew was apparent in the overall length-frequency distribution, possibly because many young specimens would not be captured by the 10 mm mesh seine net. A very low survival rate is indicated for specimens greater than 31 mm LCF.

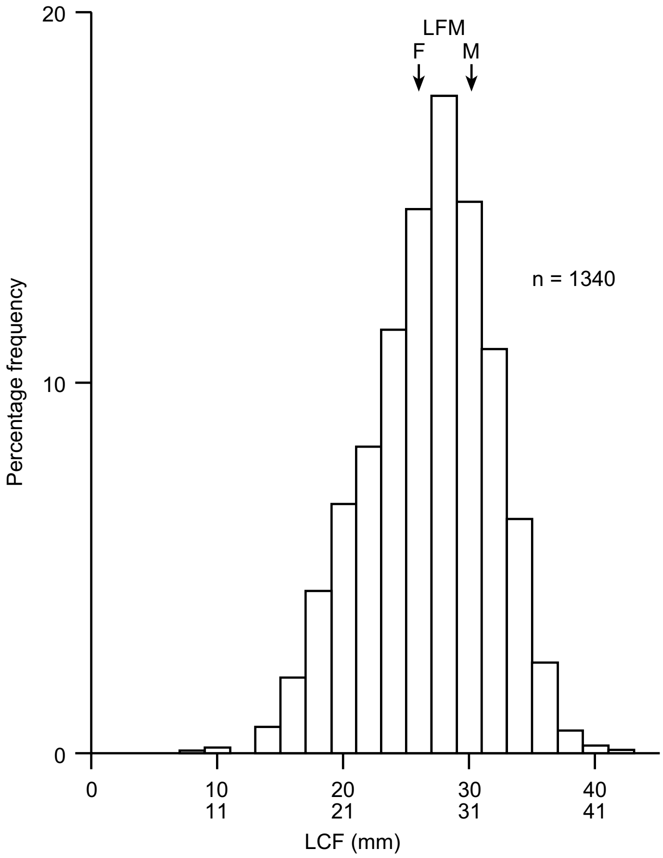


Figure 99 Length-frequency distribution of all *D. bandata* captured

Seasonal changes in distribution

The smallest specimens were captured in the 1978–79 Early-wet and 1979 Mid-dry seasons (fig 100). As small specimens were also captured in all other seasons except the 1979 Late-dry and 1979–80 Early-wet seasons, juveniles apparently recruited during most of the study period. The largest specimen was captured in the 1979 Mid-dry season.

The length-frequency distributions were unimodal in all sampling periods except the 1978–79 Early-wet season, when the distribution was bimodal, owing to the recruitment of large numbers of juveniles. The unimodal peaks indicate continuous recruitment in all other seasons except the 1979 Late-dry, which had a truncated, narrow size-range of specimens. The mean lengths (table 85) were greatest in the 1978 Late-dry and 1979 Mid-dry seasons; in between these seasons they were shorter because of the greater proportion of juveniles. The decrease in mean length in the 1979 Late-dry season may be attributable to higher mortality of large adults during this season.

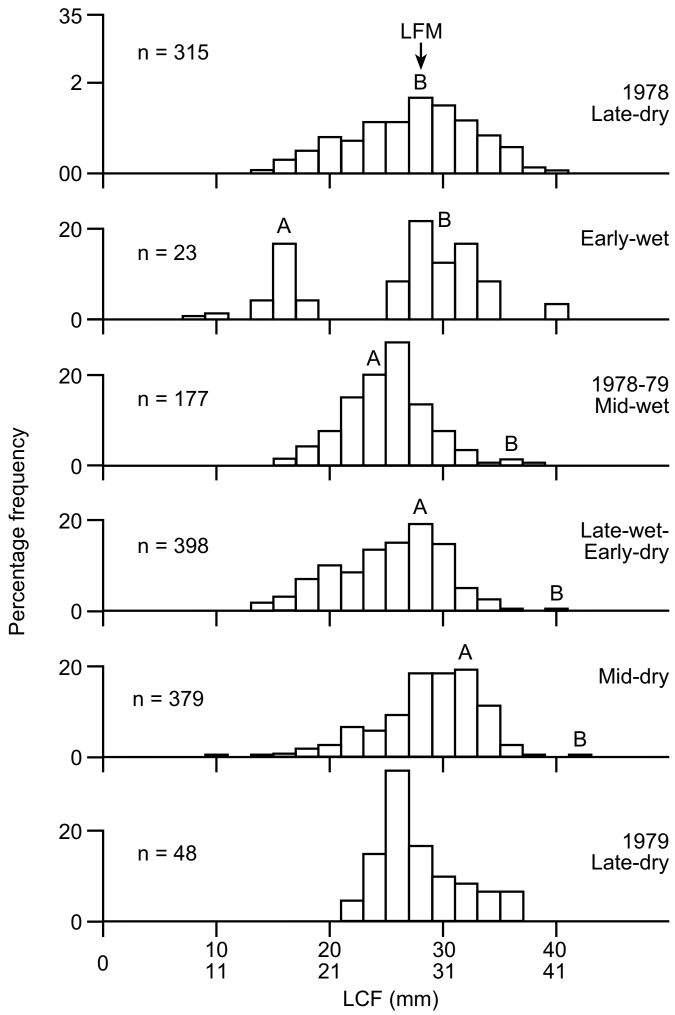


Figure 100 Seasonal length-frequency distribution of all *D. bandata* captured

Growth rate

No published information on the growth of *D. bandata* was found. It is difficult to estimate the growth rate from the seasonal length-frequency distributions because juvenile recruitment was almost continuous, and a wide range of habitats was sampled. However, the growth of

D. bandata may be described by following the seasonal modal progression of juveniles present in the 1978–79 Early-wet season (modal length 16–17 mm LCF; A on fig 100) until the 1979 Mid-dry season. The juveniles, which apparently grew fastest in the Early-wet season, may have grown 15 mm in the eight months.

A similar progression may be described for small adults (modal length 28–29 mm LCF; B on fig 100) which grew approximately 15 mm in the ten months between the 1978 Late-dry season and the 1979 Mid-dry season. The juveniles that were recruited in the 1978–79 Early-wet season had therefore reached their LFM within their first year of life.

Habitat differences in distribution

The habitat preferences of *D. bandata* captured in regular sampling sites of the Magela and Nourlangie Creek catchments are given in figure 101.

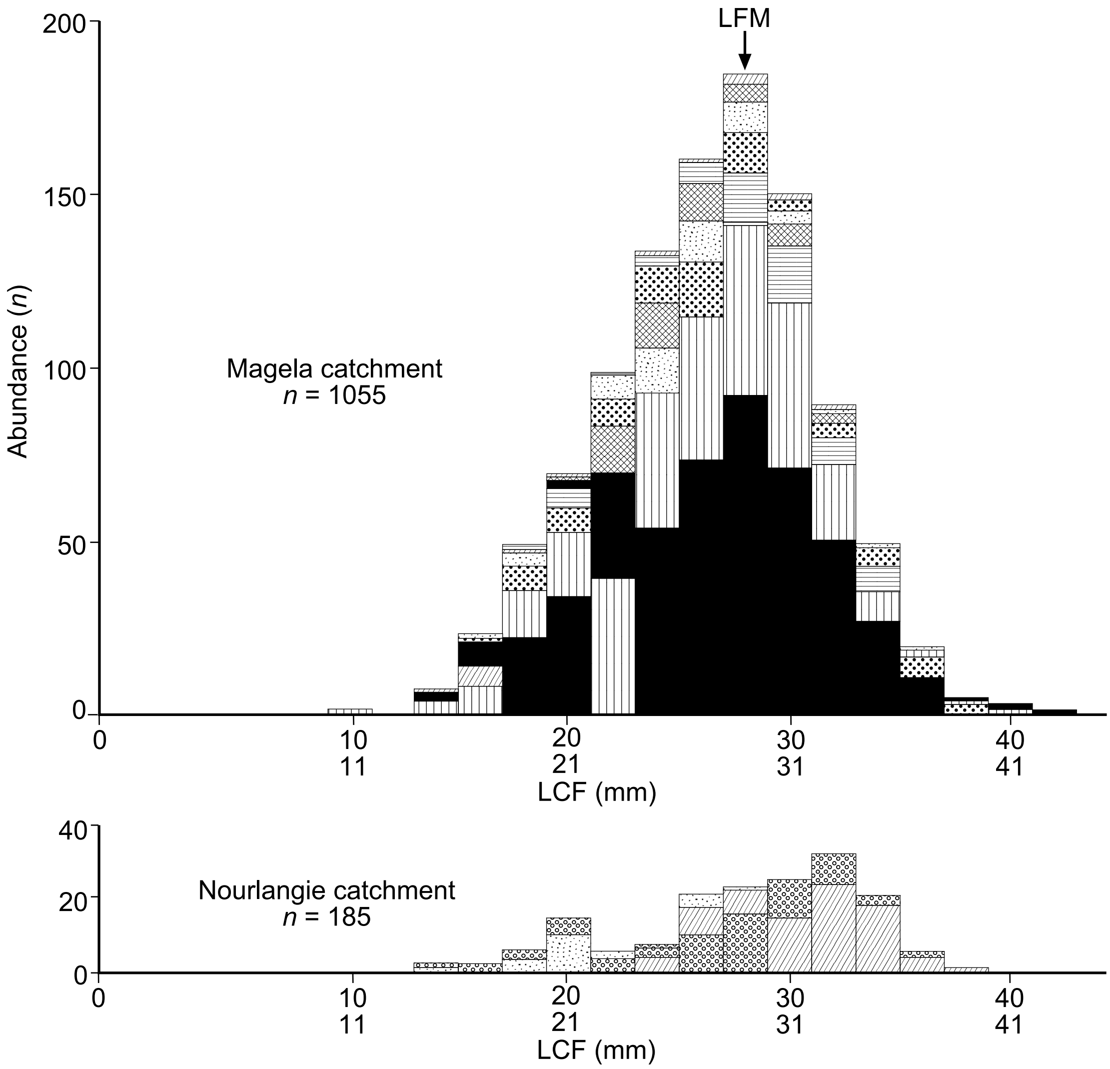


Figure 101 Length-frequency distributions and habitat preferences of *D. bandata* captured at regular sampling sites (see appendix 5 for key to the habitats)

Magela catchment

The LFM for males and females differed by 5 mm LCF. For ease of presentation, juvenile *D. bandata* are defined as those fish less than 28–29 mm LCF (the mean LFM and mode of the overall length-frequency distribution), and the adults are defined as those fish greater than this length.

The smallest juveniles were captured in lowland shallow backflow billabongs. Most juveniles were captured in these and floodplain billabongs up- and downstream of RUPA. Small numbers were found in channel backflow lowland billabongs and corridor waterbodies. A few specimens were captured in lowland sandy creekbeds (and then only amongst hydrophytes over clay banks). None were captured in escarpment habitats.

Small adults were captured in similar habitats, ie mainly in floodplain and lowland shallow backflow billabongs, but in larger numbers in anabranch corridor waterbodies and smaller numbers in channel backflow lowland billabongs. The largest adults were found in floodplain and lowland shallow backflow billabongs. No adults were found in escarpment habitats.

Nourlangie catchment

Most juveniles were found in lowland backflow billabongs. Small numbers of the larger juveniles and most adults were found in lowland sandy creekbeds. (The sandy creekbed had hydrophytes present throughout the study). Adults were also found in lowland shallow backflow billabongs, but no juveniles or adults were found in escarpment habitats.

Environmental associations

Rank numbers for *D. bandata* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

Surface-water temperatures ranged from 25° to 38°C (mean = 31.0°C); bottom-water temperatures ranged from 25° to 38°C (mean = 29.7°C). The mean temperatures were both ranked high in the upper-middle quarter (see fig 170). *Denariusa bandata* was captured in the billabongs of the lowlands, corridor and floodplain, in which high water temperatures were common.

Dissolved oxygen

Dissolved oxygen concentrations ranged from 3.7 to 7.8 mg/L (mean = 5.9) on the surface, and from 2.9 to 6.2 mg/L (mean = 4.3) on the bottom. Both of these means ranked in the lower-middle quarter (see fig 171).

Visibility

Secchi depth readings ranged from 1 to 110 cm (mean = of 35 cm) (see fig 172). This mean ranked in the lower quarter, indicating that this species prefers quite turbid conditions.

pH

The pH values ranged from 4.8 to 8.1 (mean = 6.4) on the surface, and from 4.5 to 6.7 (mean = 6.1) on the bottom. These means ranked in the lower-middle and upper-middle quarters respectively (see fig 173).

Conductivity

Conductivities ranged from 4 to 220 µS/cm on the surface, and from 8 to 60 µS/cm on the bottom. This range is close to the average range for all species.

Habitat–structural variables

Substrate

Denariusa bandata was most often captured over mud (upper quarter) followed by clay (lower-middle quarter), then sand, leaves and gravel (see fig 174). This apparent preference for muddy substrates corresponds with the high turbidities of waters in which this species is found.

Hydrophytes

Waters in which *D. bandata* was captured were generally heavily vegetated (vegetation-occurrence index 93.2%), with submergent (43.5%), emergent (30.6%) and floating-attached (20.7%) hydrophytes.[166]

Reproduction

A total of 505 gonads was examined; 45 fish were sexually indistinguishable, 205 were female and 255 were male. The length range for males was 12–41 mm LCF and for females 18–38 mm LCF.

Length at first maturity

The LFM was difficult to estimate, particularly for females, as in most seasons there were few mature fish of a given length. The estimated LFM was 25 mm LCF for females and 31 mm LCF for males (fig 102); only one female (23 mm LCF) and two males (29 and 30 mm LCF) were maturing below that length. One mature, one spent and no ripe males were recorded.

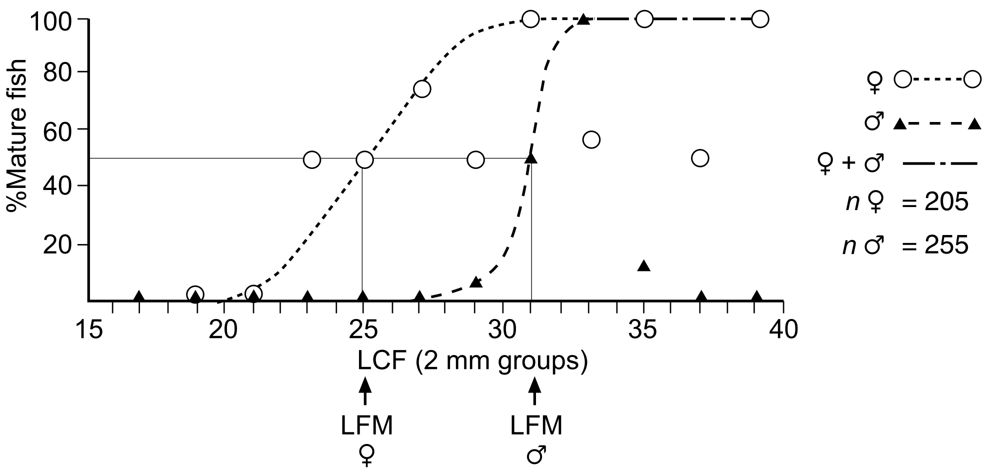


Figure 102 Estimated length at first maturity (LFM) of male and female *D. bandata*

Sex ratio

The 1978–79 Early-wet season (when the number of fish captured was low) was the only season to show no significant difference from a 1:1 sex ratio for both juvenile + adult fish and adult fish only (table 86). The 1978 Late-dry season had significantly more males in the juvenile + adult group, but an equal ratio for the adult group. A large number of juvenile males were identified (as this did not happen in later samples, errors in identification may have been the cause). From the 1978–79 Mid-wet season onwards, excluding the 1979–80 Early-wet when no *D. bandata* were captured, there were significantly more females in the

166 Herbert and Peeters (1995) indicated that in streams of Cape York Peninsula *D. bandata* are only found in areas with heavy aquatic vegetation.

adult group, although sex ratios for juveniles + adults were equal. Although amongst the few adult males there were some up to 48 mm LCF, only six had stage IV gonads and only two had gonads beyond this stage.

Table 86 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *D. bandata* over all habitats

			Sampling period					
Parameter	Sex	Statistic	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry
Sex ratio								
Juveniles	F	*n*	27	7	27	65	64	15
+ adults	M	*n*	64	9	43	75	51	13
		χ^2	15.0	0.3	3.7	0.7	1.5	0.1
		P	***	n.s.	n.s.	n.s.	n.s.	n.s.
Adults only	F	*n*	27	7	23	57	60	15
	M	*n*	23	4	6	10	32	3
		χ^2	0.3	0.8	10.0	33.0	8.5	8.0
		P	n.s.	n.s.	**	***	**	**
GSI								
Adults only	F	mean	2.2	5.3	4.0	1.9	2.1	2.7
		s.d.	1.2	1.6	1.8	0.7	0.6	0.9
	M	mean	0.4	0.8	0.6	0.5	0.4	1.1
		s.d.	0.2	0.1	0.1	0.0	0.3	0.2
	F+M	mean	1.5	4.0	2.5	1.5	1.4	2.3
		s.d.	1.3	2.6	2.2	0.9	1.0	1.1
GMSI								
Adults only	F	mean	3.3	4.2	3.4	2.4	2.9	3.0
		s.d.	0.6	1.3	0.7	0.5	0.5	0.4
	M	mean	2.3	4.0	1.7	2.5	2.2	3.0
		s.d.	0.4	0.0	0.5	0.8	0.7	0.0
	F+M	mean	2.9	4.1	2.6	2.4	2.6	3.0
		s.d	0.7	1.0	1.1	0.5	0.7	0.4

n = number; χ^2 = Chi-squared value; P = probability; n.s. = not significant (P > 0.05); ** = 0.001 < P < 0.01; *** = P < 0.001; s.d. = standard deviation.

Breeding season

Analysis of the GSI of *D. bandata* for each season indicated that gonad development peaked in the 1978–79 Early-wet season and that development extended through to the 1978–79 Mid-wet season (fig 103). While females showed significant changes in GSI during the reproductive period, the male GSI hardly varied throughout the year. Fish in breeding condition were rare (table 87), which was unexpected, as 460 sexually distinguishable fish were captured. This could have been due to fish moving out of the study area to breed, localised breeding behaviour resulting in mature and spawning fish not being captured by our fishing methods, or sexually mature fish showing very little change in their gonads and therefore being classed at a lower gonad stage.

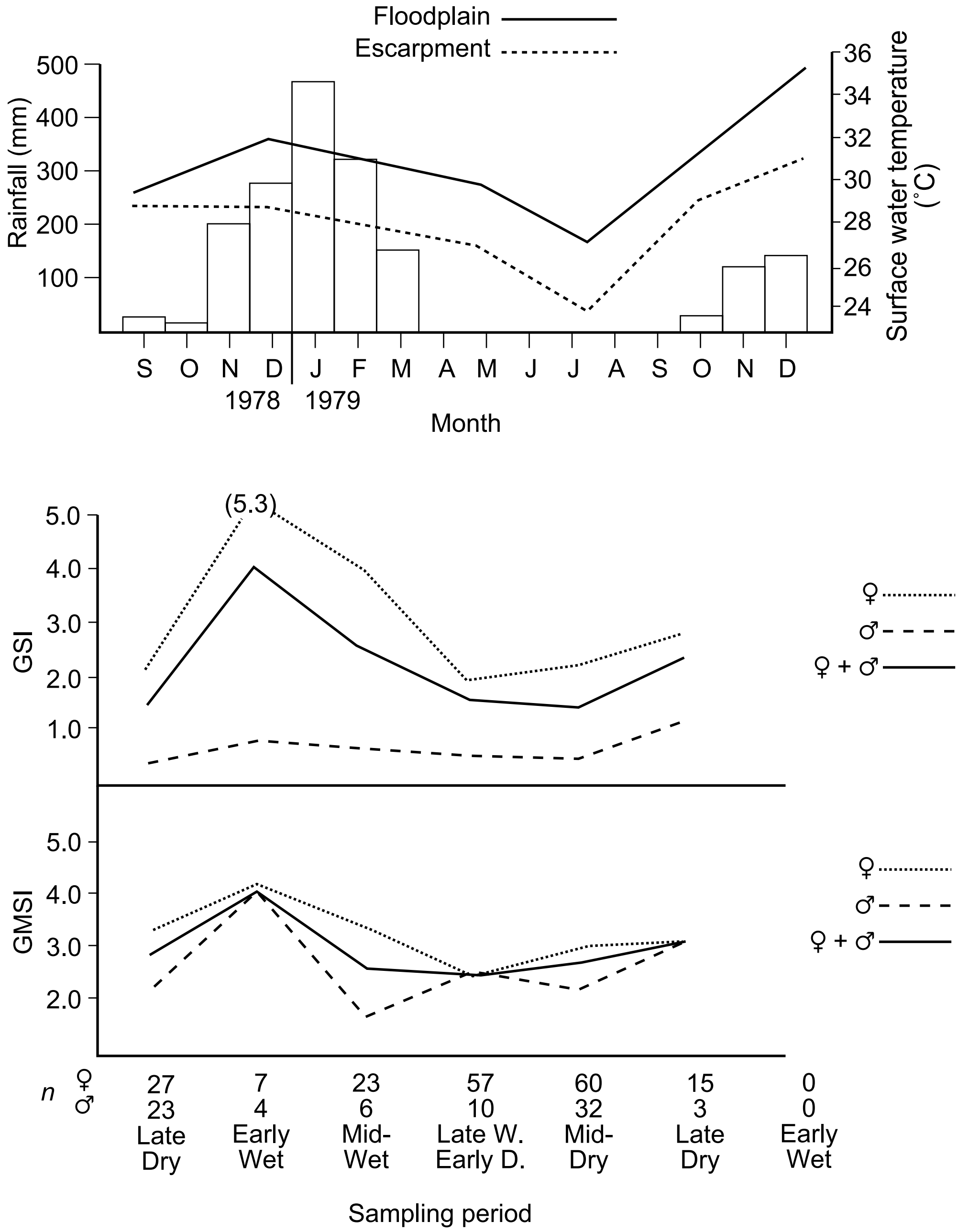


Figure 103 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *D. bandata*

Site of spawning

Only a few (8) mature, ripe or spent fish were identified amongst the 460 sexually distinguishable fish captured. Possibly *D. bandata* migrated out of the study area to spawn; however, at least some appear to have spawned in backflow billabongs such as Djalkmara Billabong and Fishless Billabong, and also in floodplain billabongs (table 87). Both the smallest fish (9 mm LCF) and a spent male were captured in a backflow billabong (Djalkmara Billabong) in the 1979 Mid-dry season, which suggests that spawning had occurred at this site some time before. Most of the small fish were captured during the 1979 Late-wet–Early-dry season from floodplain and corridor waterbodies and backflow billabongs. A small fish (12 mm LCF) was captured with a smaller than usual (2 mm) mesh seine net from the Magela Creek in the 1978–79 Early-wet season.

Table 87 Possible sites of spawning of *D. bandata,* as indicated by the abundance (*n*) of mature, ripe, spent and juvenile fish

	Gonad stage						
	Mature (V)		Ripe (VI)		Spent (VII)		Juveniles
Habitat	F	M	F	M	F	M	
Lowlands							
Sandy creekbed	–	–	–	–	–	–	6
Backflow billabong	1	–	–	–	–	1	51
Corridor	2	1	1	–	–	–	11
Floodplain billabong							
Upper	2	–	–	–	–	–	21

Summary

Many anomalies appeared in the data on this species: the unequal sex ratios, the very low number of sexually maturing fish of both sexes, and the small number of adult males recorded. Possibly a spawning migration occurred, either to areas outside the study area or to areas of the waterbody we did not sample. Generally, the gonad development of the males changed very little throughout the year, although one GSI of 5.00 was recorded. In contrast, females showed significant seasonal changes in GSI over the seasons, with a peak in development around the 1978–79 Early-wet season. The breeding season is probably extended, as the GSI was still relatively high in the following season (1978–79 Mid-wet season). Nothing is known of egg numbers, egg size or breeding strategy of this species.

Feeding habits

Overall diet

The stomachs of 506 specimens were examined; 477 contained food. The diet of *D. bandata* is summarised in figure 104; the components are listed in table 88.

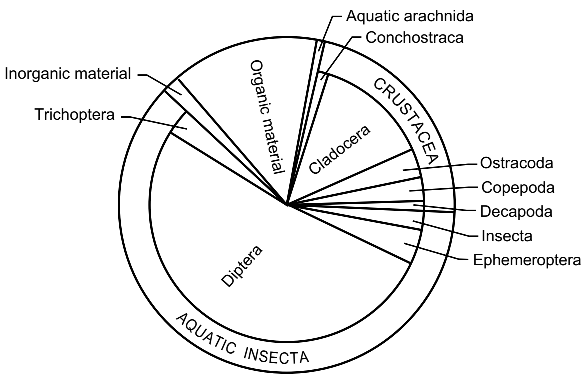


Figure 104 The main components of the diet of *D. bandata*

Table 88 Dietary composition of *D. bandata*

	Habitat						Season							
	Magela system				Nourlangie system		1978	1978–79	1978–79	1979	1979	1979	Overall	
Stomach contents	Ls	Bb	Cb	Fb	Ls	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Sub-mean	Main-mean
Aquatic plants														
Algae														0.3
Miscellaneous	–	–	–	0.4	–	–	–	–	–	–	0.5	–	0.1	
Conjugatophyta														
Mougeotia	–	–	–	0.6	–	–	–	–	–	0.5	–	–	0.2	
Aquatic animals														
Arachnida														0.6
Porohalacaridae	–	0.7	–	–	0.3	1.2	–	–	1.4	0.5	–	–	0.4	
Hydracarina	–	0.7	–	–	–	–	1.0	–	–	–	–	–	0.2	
Microcrustacea														20.8
Conchostraca														
Miscellaneous	–	0.7	–	–	–	–	1.0	–	–	–	–	–	0.2	
Cyzicus	–	0.2	3.7	–	–	–	–	4.2	–	–	–	–	0.7	
Cladocera														
Miscellaneous	–	2.4	5.7	7.5	–	3.5	8.7	10.7	0.1	5.5	–	6.7	4.3	
Diaphanosoma	–	12.6	8.6	12.4	8.1	8.4	–	–	6.6	15.5	13.4	21.0	10.2	
Ostracoda	–	3.2	2.6	1.0	1.6	7.3	4.4	–	8.7	0.9	0.7	–	2.8	
Copepoda	–	2.2	1.2	2.4	–	4.6	4.5	–	3.3	2.1	–	6.7	2.6	
Macrocrustacea														0.6
Macrobrachium (juveniles)	–	–	–	0.8	–	–	–	6.7	–	–	–	–	0.2	
Macrobrachium (adults)	–	–	1.2	–	–	1.8	1.0	–	–	0.7	–	–	0.4	
Insecta														59.5
Fragmented	–	0.7	–	2.1	–	1.8	6.1	–	–	–	–	5.7	1.6	
Ephemeroptera														
Baetidae	–	4.5	3.1	1.3	–	1.1	3.0	–	4.1	0.2	6.8	–	2.8	
Atalophlebia	–	–	–	–	–	1.8	–	–	–	–	1.0	–	0.2	
Tasmanocoenis	–	–	–	–	6.5	–	–	–	–	1.3	–	–	0.4	
Hemiptera														
Corixidae	–	0.1	–	0.5	–	1.8	1.0	–	0.3	–	0.6	–	0.4	

Table 88 continued

	Habitat						Season						Overall	
	Magela system				Nourlangie system		1978	1978–79	1978–79	1979	1979	1979		
Stomach contents	Ls	Bb	Cb	Fb	Ls	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Sub-mean	Main-mean
Coleoptera														
Miscellaneous (larvae)	–	–	–	–	–	1.3	1.0	–	1.0	–	–	–	0.4	
Hydrophilidae	–	–	–	0.3	–	–	–	–	0.5	–	–	–	0.1	
Diptera														
Chironomidae (larvae)	100.0	40.5	60.1	40.8	65.2	55.0	21.3	40.0	64.1	57.5	48.6	41.7	47.6	
Chironomidae (pupae)	–	5.3	0.5	2.6	–	–	1.9	6.7	–	–	8.9	0.7	2.6	
Ceratopogonidae	–	0.7	–	0.8	3.2	–	1.0	–	1.3	0.3	0.7	–	0.7	
Trichoptera														
Hydroptilidae	–	1.8	–	–	–	–	–	–	–	–	2.6	–	0.6	
Leptoceridae	–	–	1.2	2.6	15.2	–	–	6.7	1.3	–	5.6	4.3	1.9	
Lepidoptera														
Pyralidae	–	0.5	–	–	–	–	–	–	–	–	0.8	–	0.2	
Teleostomi														0.2
Scales	–	0.1	–	–	–	–	0.2	–	–	–	–	–	+	
Egg material	–	–	–	0.8	–	–	1.0	–	–	–	–	–	0.2	
Terrestrial plants														0.2
Fragmented	–	–	0.5	–	–	–	–	2.7	–	–	–	–	0.1	
Seed material	–	–	–	0.2	–	–	–	–	0.4	–	–	–	0.1	
Terrestrial animals														+
Insecta														
Trichoptera	–	0.1	–	–	–	–	–	–	0.3	–	–	–	+	
Parasites														
Nematoda	–	0.1	–	0.1	–	–	0.1	–	–	–	0.1	–	+	+
Detrital material	–	0.7	–	–	–	–	–	–	–	–	1.0	–	0.2	0.2
Inorganic material	–	4.0	–	0.7	–	–	5.4	–	0.8	–	1.0	–	1.5	1.5
Organic material	–	18.5	10.7	23.0	–	10.5	37.4	26.7	2.7	15.1	7.8	13.3	16.4	16.4
Number of empty fish	–	6	4	17	–	1	6	1	2	5	15	29	29	29
Number of fish with food	10	148	81	127	31	57	99	15	79	152	102	30	477	477

Figures represent the mean percentage volume determined by the estimated volumetric method.

Ls = lowland sandy creek bed; Bb = lowland backflow billabongs Cb = corridor billabongs; Fb = floodplain billabongs

The main components were small aquatic insects (60%) and microcrustaceans (21%), which were possibly associated with the considerable quantities of unidentified organic material. The aquatic insects consisted mainly of chironomid larvae, and the microcrustaceans mainly of cladocerans. Traces of algae, terrestrial plant material, aquatic arachnids, teleosts, detrital and inorganic matter were also found in the stomachs. *Denariusa bandata* can therefore be classified as a meiophagous carnivore feeding opportunistically, mainly in benthic littoral areas and frequently in the mid-water areas of the waterbodies. Pollard (1974) suggested that adults probably consumed small dipteran insect larvae. In Magela Creek floodplain habitats, *D. bandata* ate mainly *Chaoborus* larvae, ostracods (*Cypretta, Candonocypris* and *Newnhamia*), cladocerans (*Chydorus, Pleuroxus* and *Alona*) and organic detritus (Sanderson 1979).

Seasonal changes

In sampling periods 1–6, respectively, 105 (6% empty), 16 (6% empty), 86 (2% empty), 157 (3% empty), 117 (13% empty) and 30 (0% empty) stomachs of *D. bandata* were examined (all habitats combined). The highest proportion of specimens with empty stomachs was found in the 1979 Mid-dry season and the lowest in the Mid-wet to Late-wet–Early-dry seasons and the 1979 Late-dry season.

Chironomid larvae in the diet increased from a minimum in the 1978 Late-dry season through the Early-wet season to peak in the Mid-wet season, and then fall steadily to another low in the 1979 Late-dry season, but at roughly twice the level of the 1978 Late-dry season. Chironomid pupae appeared to be most important in the diet during the 1978–79 Early-wet season and the 1979 Mid-dry season. Baetid larvae were most important in the diet in the 1979 Mid-dry season.

The cladoceran component of the diet became slightly smaller in the Mid-wet season and then returned to a higher level during the rest of the study, to peak in the 1979 Late-dry season. Ostracods were most common in the diet in the 1978 Late-dry and Mid-wet seasons, as were copepods, which had an additional peak in the 1979 Late-dry season. Conchostracans were most common in the stomachs in the Mid-wet season.

Habitat differences

Magela catchment

A total of 393 stomachs of *D. bandata* were examined (all seasons combined) from the Magela Creek: 10 (0% empty) from lowland sandy creekbeds, 154 (4% empty) from lowland backflow billabongs, 85 (5% empty) from corridor billabongs, and 144 (12% empty) from floodplain billabongs. The highest proportion of empty stomachs was found in floodplain billabongs and the lowest proportion in lowland sandy creekbeds.

The few specimens caught in sandy pools were feeding only on chironomid larvae. In the lowland backflow billabongs, the diet was much more varied, although this may reflect the larger sample size. Chironomid larvae were the main food items in all habitats, and especially in the corridor waterbodies. Chironomid pupae were also important in the lowland backflow billabongs, as were baetids in corridor waterbodies. The largest microcrustacean component was found in the stomachs of fish from the floodplain billabongs; these stomachs also contained large quantities of unidentified organic material.

Nourlangie catchment

The stomach contents of 31 (0% empty) specimens from lowland sandy creekbeds and 58 (2% empty) specimens from backflow billabongs were examined. Very few fish had empty stomachs.

Chironomid larvae were the main food items in both habitats, as in the Magela catchment. Higher proportions of microcrustaceans (cladocerans, ostracods and copepods) and unidentified organic material were found in fish from the backflow billabongs, as in the Magela catchment. Mayfly larvae, *Tasmanocoenis*, were also important in the diet in the sandy creekbeds.

Fullness

The mean fullness indices of *D. bandata* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments are summarised in table 89. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 89 Mean fullness indices of *D. bandata* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments

Habitat	Sampling period						Habitat mean
	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	
Magela Creek catchment (regular sites only)							
Upstream of RUPA:							
Lowland shallow backflow billabong	2.4 (5)	n/s	2.7 (10)	n/s	2.9 (10)	n/s	2.7 (25)
Downstream of RUPA:							
Lowland sandy creekbed	n/s	n/s	n/s	3.1 (10)	n/s	n/s	3.1 (10)
Lowland channel backflow billabong	2.7 (3)	n/s	4.3 (4)	2.7 (28)	0 (1)	n/s	2.8 (36)
Lowland shallow backflow billabong	1.5 (25)	0 (1)	3.7 (3)	2.7 (37)	2.6 (24)	2.0 (4)	2.3 (94)
Corridor sandy billabong	0 (1)	n/s	1.7 (10)	n/s	2.0 (3)	n/s	1.6 (14)
Corridor anabranch billabong	2.0 (5)	4.0 (2)	2.0 (2)	1.8 (10)	2.2 (10)	n/s	2.1 (29)
Floodplain billabong	1.8 (33)	2.5 (13)	2.8 (25)	1.8 (42)	2.1 (49)	3.0 (25)	2.2 (187)
Nourlangie Creek catchment (regular sites only)							
Lowland channel backflow billabong	n/s	n/s	2.0 (2)	2.3 (10)	0 (1)	n/s	2.1 (13)
Lowland shallow backflow billabong	2.3 (10)	n/s	3.1 (14)	2.1 (10)	1.9 (10)	0 (1)	2.4 (45)
Lowland sandy creekbed	n/s	n/s	3.0 (11)	2.7 (10)	3.0 (10)	n/s	2.9 31)
Seasonal mean (all sites)	2.0	1.5	2.8	2.3	2.3	2.8	

Numbers examined are given in parenthesis; n/s = not sampled in the habitat

Seasonal changes

The mean seasonal index (all habitats combined) fell during the 1978–79 Early-wet season and then increased to peak in the Mid-wet season, after which it fell and remained stable in the Late-wet–Early-dry and the Mid-dry season. It rose again in the 1979 Late-dry season.

Habitat differences

In the Magela catchment, upstream of RUPA, *D. bandata* was found mainly in lowland shallow backflow billabongs, where the mean fullness index appeared to be slightly higher than in same habitats downstream. Downstream of RUPA, the highest mean fullness indices were recorded in lowland sandy creekbeds and channel backflow billabongs; the lowest mean indices were found in the corridor sandy billabongs.

In the Nourlangie catchment, the mean fullness indices were similar to those recorded in the Magela catchment; however, the mean index from the channel backflow billabong was the lowest recorded.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

- lowland channel backflow billabongs; 1978–79 Mid-wet season
- corridor anabranch billabong; 1978–79 Early-wet season
- lowland shallow backflow billabongs (downstream of RUPA); 1978–79 Mid-wet season
- lowland sandy creekbeds; 1979 Late-wet–Early-dry season

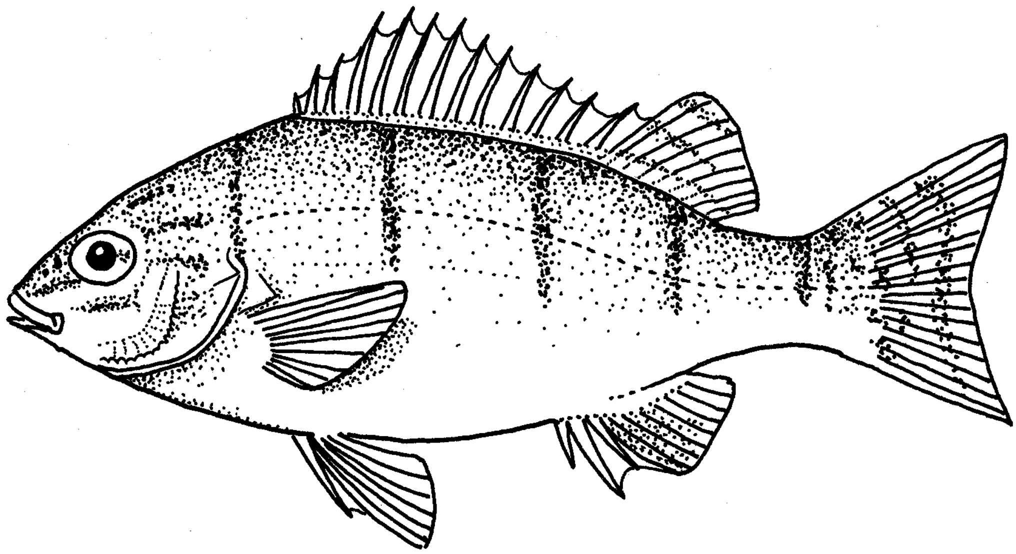
Nourlangie catchment

- lowland shallow backflow billabong; 1978–79 Mid-wet season
- lowland sandy creekbed; 1978–79 Mid-wet season, 1979 Mid-dry season.

Family TERAPONTIDAE

3.24 *Amniataba percoides* (Gunther)

Amniataba percoides (syn. *Terapon percoides*) is commonly known as the black-striped grunter or banded grunter. It is found in the drainage basins of the north-east coast, Gulf of Carpentaria, Timor Sea, Indian Ocean and Lake Eyre (see map 3). In the Magela Creek system, this species is generally found together with *L. unicolor*, but usually in smaller numbers (Pollard, 1974). It was abundant in a large billabong in the Oenpelli area (Miller [in Taylor 1964]).



Amniataba percoides

Although it belongs to a family with marine, estuarine and freshwater representatives, *A. percoides* is strictly an inhabitant of freshwaters.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was moderately abundant in lowland sandy creekbed sites and escarpment mainchannel billabongs, and common in lowland backflow billabongs, corridor and floodplain billabongs. Small numbers were observed in escarpment perennial streams in the Nourlangie Creek system. It was found in the greatest number of sites during the Late-wet–Early-dry season and in the fewest in the 1978 Late-dry season.

Size composition

The lengths and weights of 581 specimens were determined. The main peak in the overall length-frequency distribution was probably caused by selectivity of the 26 mm mesh gill net and the cumulative effect of specimens of this size also being captured by seine net. The smaller peak in the juvenile size range may have been exaggerated by the mesh of the seine net being clogged by filamentous algae.

Length–weight relationship

The length–weight relationship for the sexes combined was described by the following expression:

$W = 1.85 \times 10^{-2} L^{3.06}$ r = 1.00 (length in cm, weight in g)

Seasonal mean lengths, weights and condition factors are shown in table 90. The seasonal condition factor dropped slightly between the 1978 Late-dry and 1978–79 Early-wet seasons, probably due to spawning activity. It improved steadily through the Wet season to peak in the Late-wet–Early-dry season; it then dropped throughout the 1979 Dry season, and was lower in the Early-wet than in the previous year. The environmental conditions, food availability or both were therefore apparently more favourable to *A. percoides* in the Wet season than in the Dry, and more favourable in the 1978 Dry than the 1979.

Table 90 Mean length, mean weight and condition factor of *A. percoides*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	143	93.0	16.78	1.00
Early-wet (1978–79)	14	54.2	3.06	0.95
Mid-wet	95	94.0	17.82	1.02
Late-wet–Early-dry (1979)	113	87.2	14.76	1.07
Mid-dry	124	83.4	11.61	0.96
Late-dry	44	98.4	18.93	0.94
Early-wet	7	79.1	9.02	0.88
Overall	540	88.6	14.54	1.00

Length-frequency distribution

Specimens ranged in length from 11 mm to 188 mm LCF (fig 105). Lake (1978) reported that this species may grow up to 250 mm.

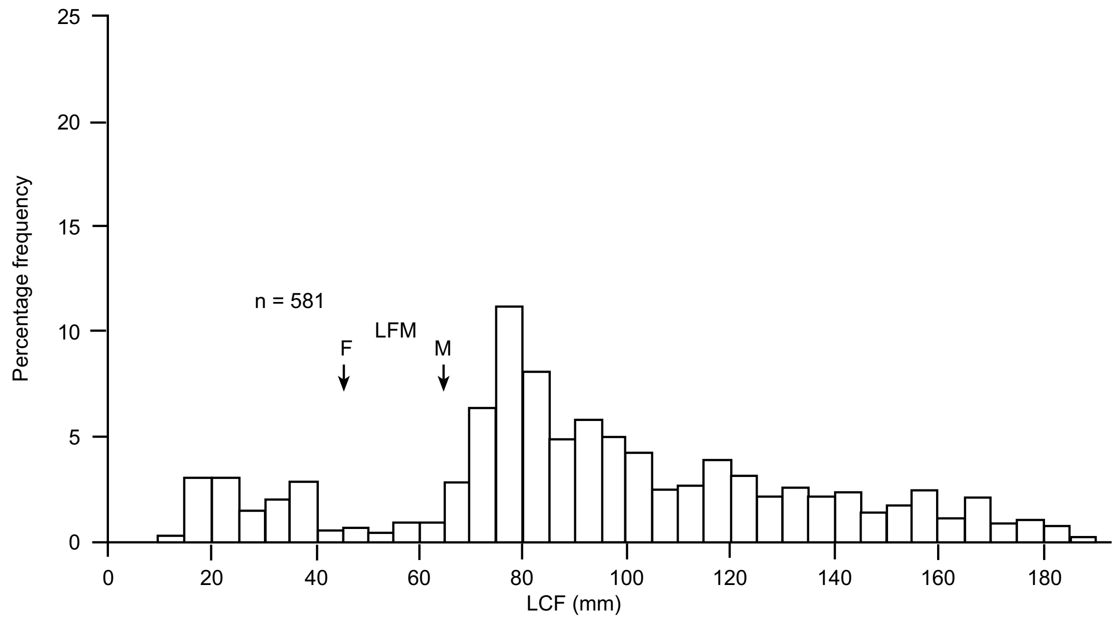


Figure 105 Length-frequency distribution of all *A. percoides* captured during study period

The mean and modal lengths of all specimens captured were 88.6 and 75–80 mm LCF, respectively. The LFM for males was 65 mm LCF and for females 45 mm LCF, which indicates that most of the specimens captured were adults.

There were two clear peaks in the length-frequency distribution: a small peak of specimens between 15 and 40 mm LCF, and a much larger peak (mode = 75–80 mm) showing negative skew.

Seasonal changes in distribution

The smallest specimen was captured in the 1978 Late-dry season; slightly larger specimens were found in the 1978–79 Early-wet, Late-wet–Early-dry and 1979 Mid-dry seasons. Most small juveniles were captured in the 1978–79 Early-wet season, indicating a peak in juvenile recruitment during this period. The largest specimens were captured in the Mid-wet and both Late-dry seasons.

The mean length of specimens (table 90) of *A. percoides* captured during the 1978 Late-dry season was relatively high, as there were large numbers of adults (mainly small adults). By the 1978–79 Early-wet season a large juvenile peak appeared and fewer adults were captured (the same applied to the related *L. unicolor*); the mean length was the lowest recorded. In the Mid-wet, the mean length increased as more adults (of similar sizes to those in the previous Late-dry season) were captured, while few juveniles were found.

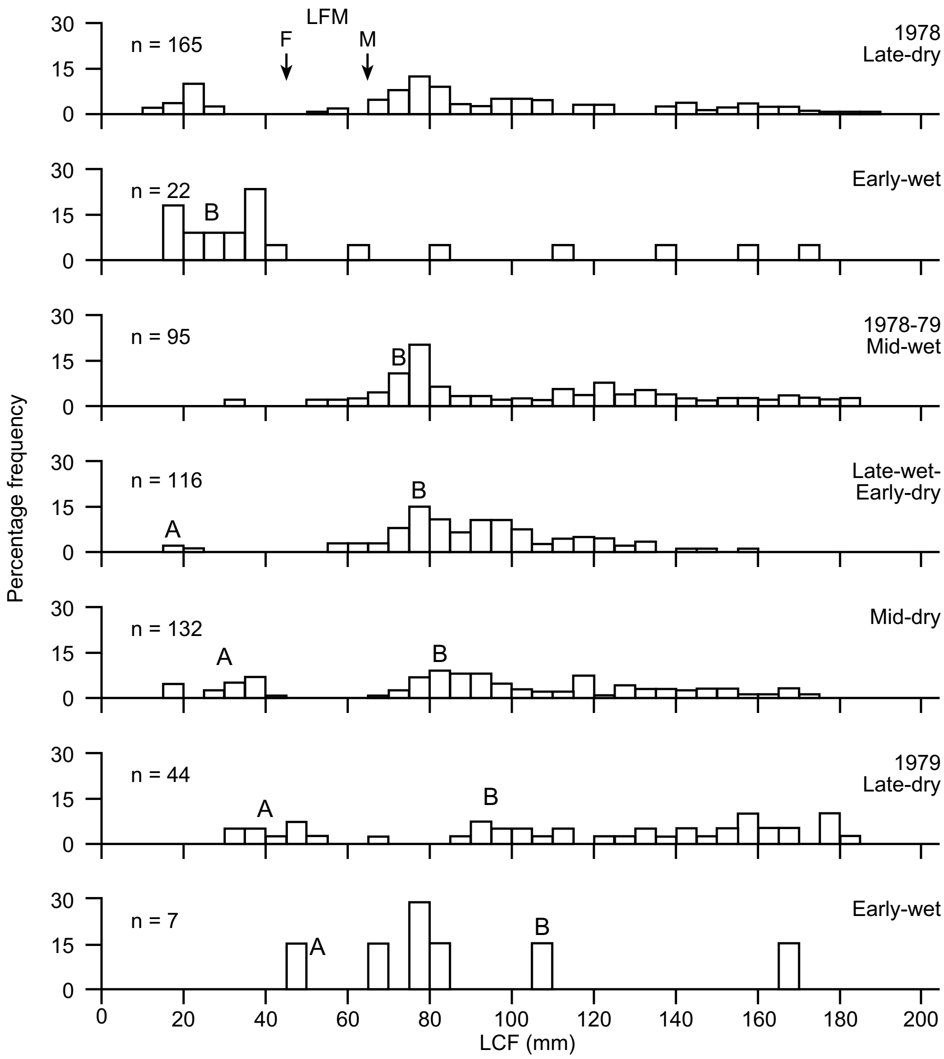


Figure 106 Seasonal length-frequency distributions of all *A. percoides* captured

Mean lengths in the Late-wet–Early-dry and Mid-dry seasons were lower, as few larger adults were captured and the numbers of juveniles increased. By the 1979 Late-dry season many more large adults were present in the population and fewer small adults; a wide and nearly continuous size range of specimens was recorded in this season (as in the equivalent season in 1978) and the mean length was the greatest recorded for this species during the study. During the 1979–80 Early-wet season few specimens were collected; the mean length was less than in other seasons, as the collection was dominated by small adults. No juveniles were present in this sample, unlike in the sample from the 1978 Early-wet season (probably because of the extreme nature of the 1979 Dry season and the fact that the creeks had not yet started to flow).

Growth rate

No published information on the growth of *A. percoides* was found. The growth rate of *A. percoides* was difficult to estimate from seasonal length-frequency distributions because of mesh selectivity, the near-continuous recruitment of juveniles and the range of habitats sampled.

However, the growth rate of *A. percoides* may be described by following the progression of juveniles (length range 15–25 mm) present in the Late-wet–Early-dry season (A on fig 106) until the 1979–80 Early-wet season. These specimens appeared to grow 25–30 mm in the six months.[167]

The growth of small adults present in the Mid-wet season (B on fig 106) can be followed until the 1979–80 Early-wet season. They appeared to grow 30–35 mm in the eight months (possibly these small adults were members of the large-juvenile group (B on fig 106) present in the 1978–79 Early-wet season).

It therefore appears that *A. percoides* (especially females) may attain the LFM by the end of their first year of life.

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *A. percoides* captured in regular sampling sites in the Magela and Nourlangie Creek catchments are given in figure 107.

Magela catchment

The LFM of males and females differed by 20 mm LCF. This difference in length corresponded to a trough in the overall length-frequency distribution; for ease of presentation juveniles are defined as those fish less than 60 mm LCF (centre of trough) and adults as those greater than 60 mm LCF.

Juvenile *A. percoides* were most frequently captured in sandy corridor waterbodies and, to a lesser extent, in lowland backflow and floodplain billabongs. Very small juveniles were also found in escarpment mainchannel waterbodies; these specimens were first observed grazing on periphyton on partly submerged *Pandanus aquaticus* branches during the 1978 Late-dry season.

Small adult *A. percoides* were captured mainly in lowland sandy creekbeds and lowland backflow billabongs; small numbers were also captured in corridor and floodplain billabongs and escarpment mainchannel waterbodies. Larger adults were mainly captured in deeper and more permanent waters such as escarpment mainchannel waterbodies and corridor and floodplain billabongs; these habitats probably function as Dry season refuge areas for the breeding populations of most species in the catchment.

---

167 Data from Wise et al (1994) on the estuarine relative *A. caudavittata* in the Swan River estuary in WA indicated the following growth rate: 1 year, 110–115 mm total length; 2 years, 175–180 mm; 3 years, 215–235 mm.

Nourlangie catchment
Juvenile *A. percoides* were found mainly in lowland sandy creekbeds, escarpment mainchannel waterbodies and channel backflow billabongs (fig 107). They also appeared in escarpment perennial streams during the Wet season.

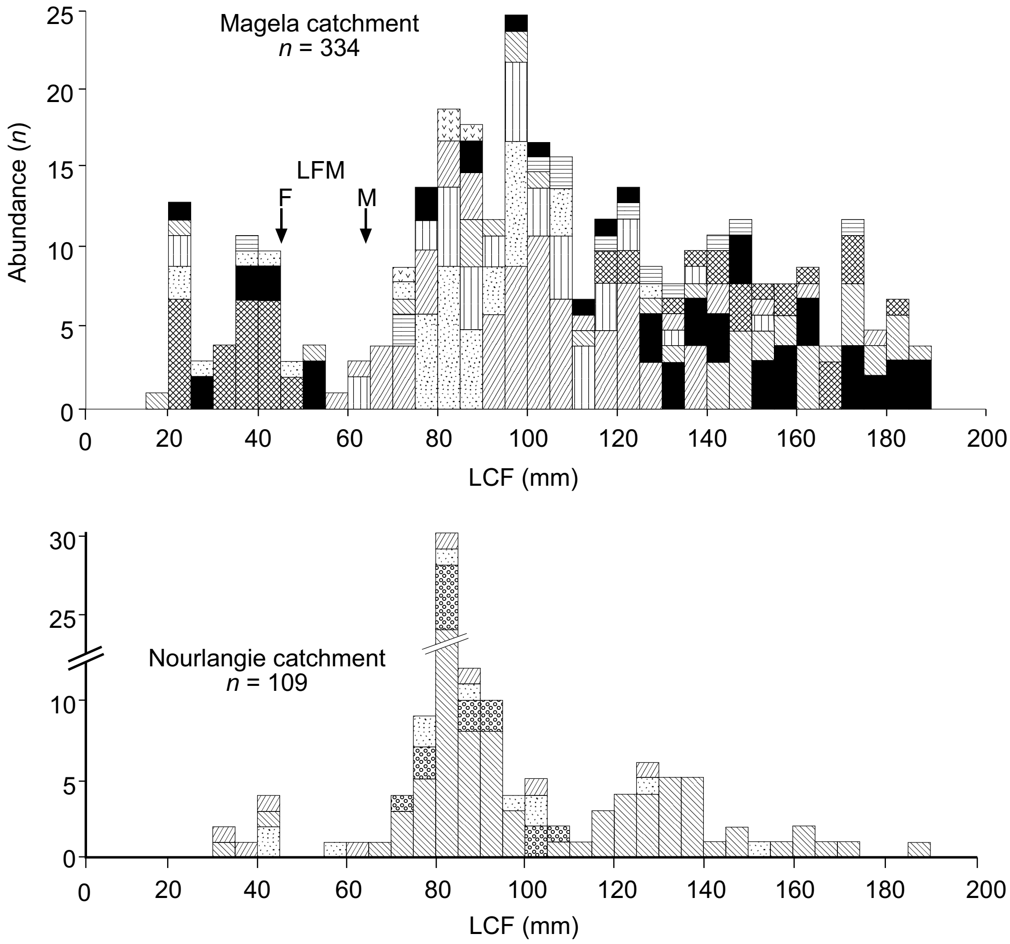


Figure 107 Length-frequency distributions and habitat preferences of *A. percoides* captured at regular sampling sites (see appendix 5 for key to the habitats)

Adult *A. percoides* were mainly captured in escarpment mainchannel waterbodies; however, a few of the small adults were found in lowland backflow billabongs and in lowland sandy creekbed. Small adults appeared in escarpment perennial streams during the Mid-wet season and persisted there for the remainder of the study.

Environmental associations

Rank numbers for *A. percoides* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature
Water temperatures at sites where *A. percoides* was captured ranged from 23° to 40°C (mean = 30.2°C) on the surface, and from 23° to 35°C (mean = 28.9°C) on the bottom. Both means ranked in the lower-middle quarter. These ranges are similar to those found for the closely related *Leiopotherapon unicolor*, with which *A. percoides* was often associated (see fig 170).

Dissolved oxygen

Dissolved oxygen concentrations in waters in which this species was found ranged from 3.9 to 9.7 mg/L on the surface (mean = 6.2), and from 0.2 to 9.5 mg/L (mean = 4.8) on the bottom. These means both ranked in the upper-middle quarter (see fig 171). As for *L. unicolor,* a wide range of tolerance to DO concentrations (including some very low concentrations) is indicated.

Visibility

Secchi depths ranged from 1 to 360 cm, with a mean depth of 112 cm (fig 172). This mean ranked at the top of the upper-middle quarter. Although this indicates *A. percoides* tolerates turbidity, it is usually found in clearer waters.

pH

The pH values of waters in which *A. percoides* was captured ranged from 5.0 to 8.6 (mean = 6.25) on the surface, and from 4.5 to 7.3 (mean = 6.0) on the bottom. These means both ranked in the upper-middle quarter (see fig 173). This range of pH values is similar to that for *L. unicolor.*

Conductivity

Amniataba percoides was taken from waters with conductivities ranging from 2 to 160 µS/cm on the surface, and from 2 to 230 µS/cm on the bottom. This range is not as broad as for *L. unicolor.*

Habitat–structural variables

Substrate

As expected from its wide distribution, *A. percoides* was captured over a variety of substrates. The main one was sand (lower-middle quarter) followed by mud (lower-middle quarter), clay, leaves, rocks, gravel and boulders. This range of substrates was nearly identical to that for *L. unicolor.*

Hydrophytes

Amniataba percoides was found in waters with moderate to low vegetation (vegetation-occurrence index 54.2%). Submergent hydrophytes were dominant (45.6%), followed by emergent (26.4%) and then floating hydrophytes (25.7%). Both *A. percoides* and *L. unicolor* feed on the submergent hydrophyte *Najas tenuifolia* and show a similar preference for other hydrophytes.

Reproduction

In all, 501 *A. percoides* were examined for reproductive condition: 94 were sexually indistinguishable (12–149 mm LCF), 188 were females (40–180 mm LCF) and 219 were males (50–180 mm LCF).

Length at first maturity

The length at first maturity (LFM) was calculated from 10-mm-length groups. Unfortunately, very few fish were captured during the apparent breeding season (1978–79 Early-wet). The LFM was estimated to be 65 mm for males and 45 mm LCF for females (fig 108), as maturing fish were found at these lengths and at all lengths above them. This estimate may to some extent be a reflection of the size range of fish captured, as only three identifiable males less than 65 mm LCF and two identifiable females less than 45 mm LCF were captured during the study, and all of these were caught outside the breeding period.

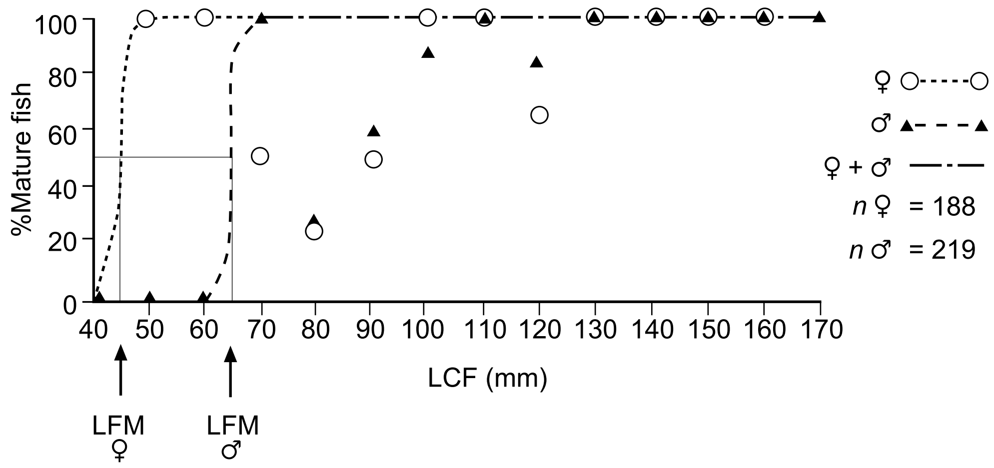


Figure 108 Estimated length at first maturity for male and female *A. percoides*

Sex ratio

Chi-squared tests on the sex ratios for adults + juveniles and adults only indicated no significant difference from 1:1 ratios in any season (table 91).

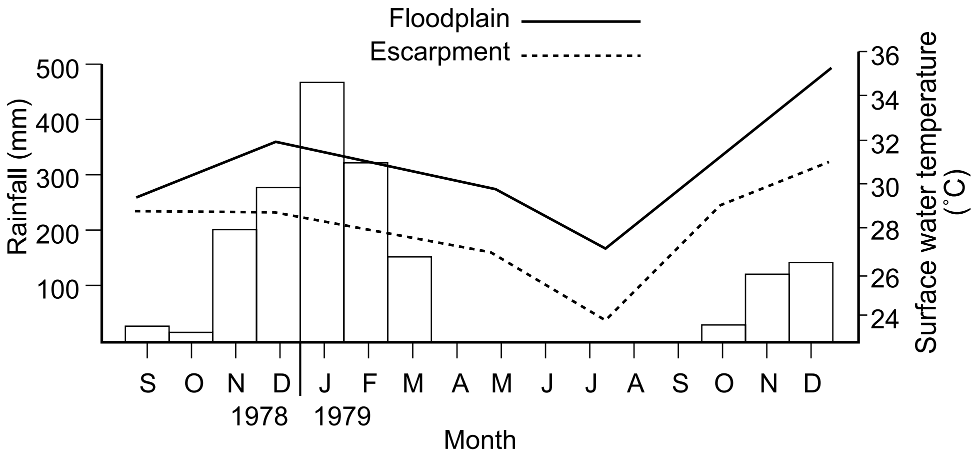
Table 91 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *A. percoides* over all habitats

Parameter	Sex	Statistic	Sampling period						
			Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80
Sex ratio									
Juveniles	F	*n*	48	2	36	35	39	23	5
+ adults	M	*n*	66	3	42	45	49	13	1
		χ^2	2.8	0.2	0.5	1.25	1.1	2.8	2.7
		P	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Adults only	F	*n*	48	2	36	35	38	22	5
	M	*n*	66	3	40	45	49	12	1
		χ^2	2.8	0.2	0.2	1.25	1.4	2.9	2.7
		P	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
GSI									
(Adults only)	F	mean	1.4	5.2	0.4	0.5	6.7	2.7	1.8
		s.d.	1.0	4.4	0.4	0.3	0.4	2.0	1.2
	M	mean	0.7	1.7	0.2	0.1	0.3	0.7	3.0
		s.d.	0.4	0.6	0.1	0.1	0.2	0.7	–
	F+M	mean	1.1	3.1	0.3	0.4	0.5	1.8	2.0
		s.d.	0.6	3.0	0.2	0.5	0.4	1.8	1.2
GMSI									
(Adults only)	F	mean	3.7	5.0	2.6	2.0	2.4	3.8	3.0
		s.d.	0.7	1.4	0.9	0.5	0.7	1.3	0.7
	M	mean	3.5	6.0	2.6	2.3	2.5	3.8	5.0
		s.d.	1.2	0.0	0.8	1.3	1.2	1.6	–
	F+M	mean	3.7	5.6	2.6	2.2	2.5	3.8	3.3
		s.d	0.7	0.9	0.8	1.0	0.9	1.4	1.1

n = number; χ^2 = Chi-squared value; P = probability; n.s. = not significant (P > 0.05); s.d. = standard deviation.

Breeding season

Of the 407 sexually distinguishable fish examined, only 5 were captured in the 1978–79 Early-wet season; however, the GSI and GMSI values for these five were significantly higher than for the rest (fig 109). Figure 109 also indicates that the gonads regressed very quickly after the breeding season and remained at a low level of development from the 1978–79 Mid-wet season through to the 1979 Mid-dry season; by the 1979 Late-dry season the gonads had begun to develop. Further confirmation that *A. percoides* had bred during the 1978–79 Early-wet is that most of the mature fish were found in the 1978 Late-dry season, just before the 1978–79 Early-wet season, and that most of the spent fish were found in the following season (table 91). Some fish may have spawned in the 1978 Late-dry season, as running-ripe males were captured in this season.



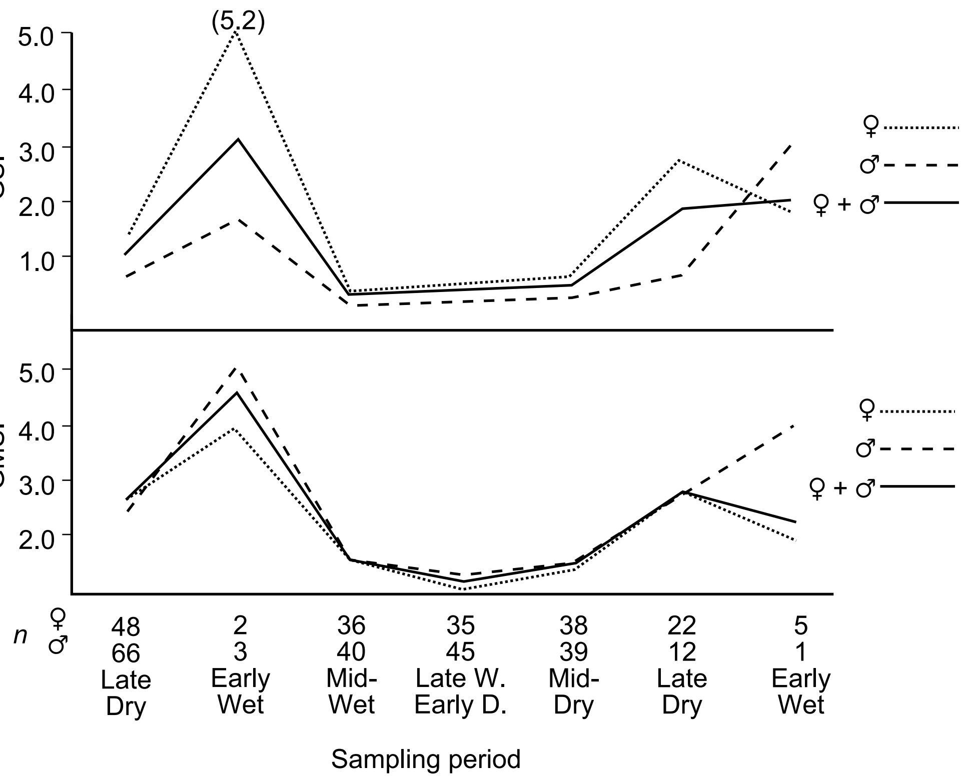


Figure 109 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *A. percoides*

Because few fish were captured in the 1979–80 Early-wet season, it is difficult to determine whether spawning had occurred before the creeks began to flow (with the true onset of the Wet season, which did not happen until January). It appears that there may have been some spawning as early as the 1979 Late-dry, as running-ripe fish were found in this season.[168]

Midgley (1980) collected running-ripe *A. percoides* from the Magela Creek system in January after the onset of the Wet season.

Most of the juvenile fish (11–40 mm LCF) were captured in the 1978–79 Early-wet season. The smallest of these were most likely progeny from the 1978 Late-dry season spawning. Interestingly, only one juvenile was captured in the 1978–79 Mid-wet season, when the progeny of the 1978–79 Early-wet season spawning would be most likely to be found.

Site of spawning

Examination of the sites where ripe fish were captured (table 92) indicated that spawning may have occurred over a wide range of habitats: from escarpment mainchannel waterbodies through lowland backflow billabongs and the lowland sandy creekbed sites to corridor waterbodies and floodplain billabongs.

Table 92 Possible sites of spawning of *A. percoides,* as indicated by the abundance (*n*) of mature, ripe, spent and juvenile fish

	Gonad stage						
	Mature (V)		Ripe (VI)		Spent (VII)		Juveniles
Habitat	F	M	F	M	F	M	
Escarpment							
Mainchannel waterbody	2	–	–	3	1	6	3
Lowlands							
Sandy creekbed	2	1	1	2	–	–	3
Backflow billabong	3	3	–	2	–	2	9
Corridor	11	11	1	3	–	–	58
Floodplain billabong							
Upper	–	–	1	–	3	6	1
Lower	–	–	–	–	–	–	1
Artificial	3	1	–	–	–	–	–

Fecundity

Nine ovaries, ranging in weight from 0.29 g (GSI = 6.04) to 5.44 g (GSI not recorded), were examined. Fecundity was generally higher for the heavier gonads, although not directly proportional. Fecundities ranged from 800 (a running-ripe fish that had probably spawned most of its eggs) to 400 000 the mean egg count for the nine ovaries was 125 000 (s.d. = 120 500).[169] Oocyte diameters were variable, but most commonly around 0.24 to 0.32 mm; however, diameters ranged from 0.16 to 0.4 mm. Midgley (1980) recorded eggs

168 Herbert & Peeters (1995) indicated the banded grunters breed in northern Queensland from August to March, that is, during the warmer months of the year.

169 Herbert & Peeters (1995) indicate that an average size female (75–85 g) lays around 50 000 to 60 000 eggs.

from a spawning female as having a diameter of 0.4 mm when hardened in water. The eggs were demersal and non-adhesive.

Summary

Amniataba percoides did not exhibit any secondary sexual dimorphism. No significant difference from a 1:1 sex ratio was found in any season (it is believed that the family Terapontidae generally pair during breeding [Breder & Rosen 1966]). Breeding occurred during the Late-dry season, with most spawning activity most likely taking place around the onset of the Wet season. Running-ripe fish were captured in a wide range of habitats, from the escarpment to the floodplain. Members of the family Terapontidae are believed to spawn in shallow places in rivers, often in holes or under stones (Breder & Rosen 1966); however, *A. percoides* has also been recorded as breeding in dams (Lake 1971; Midgley, pers comm). A large number (around 125 000) of small (0.16–0.4 mm) demersal, non-adhesive eggs are laid. Male terapontids of some species may guard and aerate the eggs (Breder & Rosen 1966).

Feeding habits

Overall diet

The stomach contents of 484 specimens were examined; 479 contained food. The diet of *A. percoides* is summarised in figure 110; the components are listed in table 93. The main components of the diet were aquatic insects (44%), algae (13%), terrestrial plant material (11%), hydrophytes (11%) and microcrustaceans (8%). The aquatic insects were mainly chironomid larvae and baetids. The identifiable algae were mainly green filamentous species such as *Mougeotia* and *Spirogyra;* the most common hydrophyte was *Najas.* The microcrustaceans were mainly cladocerans (*Diaphanosoma*). Macrocrustaceans (*Macrobrachium* and *Caridina*), teleosts (including *C. stercusmuscarum* and *G. giuris*) and traces of gastropods, oligochaetes, hydracarinids, terrestrial insects, detrital material and inorganic and unidentified organic material were also found in the stomachs. *Amniataba percoides* can therefore be classified as a meiophagous omnivore feeding in benthic and midwater areas of the waterbodies.[170] The significant herbivorous component in the diet of this species in the present study was not found in Pollard's (1974) study; he considered its diet was similar to *L. unicolor*'s, but with few or no small fishes.

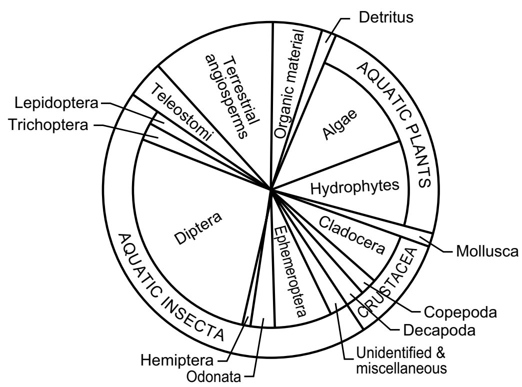


Figure 110 The main components of the diet of *A. percoides*

170 Wise et al (1994) indicated the estuarine relative *A. caudavittata* in the Swan River estuary in WA is a benthic omnivore.

Table 93 Dietary composition of *A. percoides*

Stomach contents	Habitat								Season							Overall	
	Magela system					Nourlangie system			1978	1978–79	1978–79	1979	1979	1979	1979–80		
	Em	Ls	Lb	Cb	Fb	Em	Ls	Lb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Aquatic plants																	
Algae																	13.4
Miscellaneous	12.6	7.7	0.5	0.5	–	2.7	10.0	–	5.1	–	1.7	7.0	1.8	0.7	–	3.4	
Conjugatophyta																	
Mougeotia	19.1	3.4	4.3	4.0	–	32.1	1.3	–	–	–	24.1	4.5	11.0	2.1	–	7.8	
Spirogyra	–	2.9	1.2	0.3	–	3.2	2.5	1.1	–	–	2.0	0.2	1.3	5.9	–	2.2	
Hydrophytes																	10.5
Hydrilla	–	–	1.2	–	12.9	–	–	–	–	–	4.5	–	0.6	–	–	0.9	
Najas	–	7.2	29.9	24.1	–	–	–	13.4	–	4.2	0.7	31.5	5.9	18.1	–	9.4	
Vallisneria	–	1.1	–	–	–	–	–	–	–	2.6	–	0.4	–	–	–	0.2	
Aquatic animals																	
Oligochaeta	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	+
Gastropoda																	1.2
Miscellaneous	–	–	3.3	0.1	11.9	–	–	0.8	–	–	4.2	2.1	0.2	–	–	1.2	
Segnitila	–	–	–	–	–	–	–	0.5	–	–	–	–	0.1	–	–	+	
Arachnida																	+
Hydracarina	–	–	–	0.1	–	–	–	–	–	–	–	–	–	0.2	–	+	
Microcrustacea																	8.1
Conchostraca																	
Cyzicus	–	2.0	0.3	–	–	–	–	0.3	–	–	0.1	0.2	1.4	–	–	0.4	
Cladocera																	
Miscellaneous	0.6	0.1	–	0.6	3.5	10.3	–	–	0.2	7.6	–	0.1	6.4	–	–	1.9	
Diaphanosoma	–	9.3	16.4	1.3	–	–	–	–	–	7.9	–	10.1	3.3	–	66.7	3.9	
Ostracoda	–	–	0.8	0.3	–	0.6	–	0.5	–	4.0	0.5	–	0.1	–	–	0.3	
Copepoda																	
Miscellaneous	–	0.7	–	0.8	–	–	–	–	–	5.5	–	–	–	–	–	0.2	
Cyclops	–	–	0.2	8.8	–	–	–	–	–	–	–	–	6.2	–	–	1.4	
Macrocrustacea																	1.7
Macrobrachium (juv)	–	–	0.8	–	–	–	–	–	0.7	–	–	–	–	–	–	0.2	
Macrobrachium (adults)	2.9	0.7	1.7	4.9	0.5	–	1.3	–	2.1	2.6	0.4	0.3	1.2	5.3	–	1.5	

Table 93 continued

Stomach contents	Habitat: Magela system Em	Ls	Lb	Cb	Fb	Habitat: Nourlangie system Em	Ls	Lb	Season: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Overall: Sub-mean	Main-mean
Insecta																	43.5
Fragmented	0.3	1.6	0.7	1.6	–	3.0	–	4.7	1.9	1.1	3.6	0.3	2.1	0.7	–	1.8	
Ephemeroptera																	
Baetidae	2.9	5.8	5.6	2.2	0.2	3.4	23.8	16.8	5.8	9.5	5.1	6.6	4.8	1.6	11.7	5.4	
Atalophlebia	–	2.3	–	–	–	1.5	12.5	–	–	15.3	–	–	0.9	–	–	0.8	
Tasmanocoenis	–	1.8	–	1.2	–	–	–	–	–	–	–	0.8	2.1	–	–	0.7	
Tasmanophlebia	–	–	–	0.5	–	–	–	–	–	–	–	–	0.4	–	–	0.1	
Odonata																	
I. heterosticta	–	–	0.2	–	–	–	–	2.1	–	–	–	0.5	–	–	–	0.1	
Gomphidae	–	1.0	–	–	0.9	–	–	–	0.7	–	0.3	–	–	–	–	0.2	
Libellulidae	–	2.0	1.5	2.6	26.2	–	–	7.9	0.6	–	12.4	1.1	2.5	–	–	3.1	
Hemiptera																	
Naucoridae	–	–	–	0.4	–	1.5	–	–	0.8	–	–	–	0.3	–	–	0.3	
Corixidae	–	0.4	1.3	1.3	1.0	0.4	–	–	0.3	4.0	0.4	–	0.3	2.3	–	0.6	
Coleoptera																	
Miscellaneous (adults)	–	0.5	–	–	–	0.3	–	–	+	–	0.2	–	–	0.9	–	0.1	
Miscellaneous (larvae)	–	–	–	–	–	0.3	–	–	0.2	–	–	–	–	–	–	+	
Diptera																	
Miscellaneous (larvae)	–	1.2	–	–	–	–	–	–	–	5.3	–	–	–	–	–	0.2	
Tipulidae	–	–	1.4	–	–	–	–	–	–	–	1.0	–	–	–	–	0.2	
Chaoborinae	–	0.1	1.3	–	–	–	–	–	–	–	–	–	0.1	1.8	–	0.2	
Chironomidae (larvae)	14.0	19.6	17.4	15.7	14.8	17.9	11.2	40.2	39.4	15.8	14.2	19.3	23.0	21.0	19.2	24.7	
Chironomidae (pupae)	–	0.1	1.5	0.9	–	0.4	2.5	4.2	0.2	2.4	0.5	0.5	1.2	0.9	–	0.7	
Ceratopogonidae	0.3	1.7	0.5	2.0	–	2.1	–	–	1.2	–	1.8	–	2.6	0.7	0.8	1.3	
Simuliidae	–	–	–	–	–	–	10.0	–	–	4.2	–	–	–	–	–	0.2	
Trichoptera																	
Hydroptilidae	–	1.0	–	–	–	–	–	0.5	–	–	–	0.9	0.1	–	–	0.2	
Leptoceridae	1.4	2.9	–	2.2	9.0	1.3	2.5	1.6	0.3	1.1	3.4	1.2	2.9	2.3	1.7	1.9	
Miscellaneous (pupae)	–	–	0.1	–	–	–	–	–	–	–	–	0.1	–	–	–	+	
Lepidoptera																	
Pyralidae	–	–	–	1.0	13.3	–	–	–	–	–	5.6	–	–	–	–	1.0	
Teleostomi																	3.7
Fragmented	4.9	1.2	–	1.7	1.2	0.9	2.5	–	0.6	–	1.6	0.2	1.8	2.1	–	1.1	

Table 93 continued

Stomach contents	Habitat: Magela system Em	Ls	Lb	Cb	Fb	Nourlangie system Em	Ls	Lb	Season: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Overall: Sub-mean	Main-mean
Scales	10.7	1.8	–	0.3	–	2.1	–	–	4.0	1.6	1.7	–	0.6	2.3	–	1.7	
Miscellaneous (larvae)	–	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1	
C. stercusmuscarum	–	1.1	–	–	–	–	–	–	–	–	–	2.0	–	–	–	0.4	
G. giuris	–	0.6	–	–	–	–	–	–	–	2.6	–	–	–	–	–	0.1	
Egg material	–	–	–	–	–	0.2	11.2	–	0.2	–	0.2	1.0	–	–	–	0.3	
Terrestrial plants																	
Angiospermae																	11.2
Fragmented	9.4	9.1	1.5	13.2	–	6.1	8.8	–	19.8	1.1	3.7	6.4	5.0	14.6	–	9.3	
Root material	11.3	4.4	–	–	–	–	–	–	–	–	–	–	4.0	7.8	–	1.7	
Seed material	–	0.2	1.1	–	–	–	–	–	–	–	–	0.7	0.1	–	–	0.2	
Terrestrial animals																	
Arachnida	–	–	–	–	0.7	–	–	–	–	–	0.2	–	–	–	–	+	+
Insecta																	0.7
Fragmented	–	0.7	–	0.5	–	–	–	–	–	–	0.5	–	–	2.3	–	0.3	
Odonata																	
Zygoptera (adults)	–	–	–	0.1	–	–	–	–	0.1	–	–	–	–	–	–	+	
I. heterosticta	–	–	–	0.8	–	–	–	–	–	–	–	–	–	1.4	–	0.1	
Anisoptera (adults)	–	–	–	0.5	–	–	–	–	0.6	–	–	–	–	0.9	–	0.2	
Neuroptera																	
Sisyridae	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	+	
Trichoptera																	
Leptoceridae (adults)	–	0.3	–	–	–	–	–	–	–	–	–	–	0.2	–	–	0.1	
Parasites																	
Trematoda	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	+
Nematoda	0.6	–	0.7	0.6	–	0.1	–	–	0.7	1.8	0.1	0.4	–	0.2	–	0.4	0.4
Microcrustacea																	+
Argulus	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	
Detrital material	4.3	–	–	–	–	0.6	–	–	0.8	–	–	–	1.7	–	–	0.6	0.6
Inorganic material	2.3	1.2	0.6	0.5	–	4.0	–	–	0.7	–	–	–	–	–	–	0.2	0.2
Organic material	2.6	2.4	3.4	4.4	4.8	5.2	–	5.3	12.8	–	4.5	1.7	3.3	2.3	–	4.6	4.2
Number of empty fish	1	–	–	1	1	–	–	1	2	–	1	–	1	–	1	5	5
Number of fish with food	35	60	82	77	29	68	8	19	123	19	83	92	112	44	6	479	479

Figures represent the mean percentage volume determined by the estimated volumetric method.
Em = escarpment mainchannel; Ls = lowland sandy creekbed; Lb = lowland backflow billabong; Cb = corridor billabong; Fb = floodplain billabong; + = present (<0.1%)

Seasonal changes

In sampling periods 1–7, respectively, 125, 19, 84, 92, 113, 44 and 7 stomachs of *A. percoides* were examined (all habitats combined). Very few specimens had empty stomachs.

The diet in the 1978 Late-dry season was based primarily on aquatic insects (mainly chironomid and baetid larvae) and terrestrial plant material. During the 1978–79 Early-wet season the terrestrial plant component became much smaller and the microcrustacean component larger. There was a new hydrophyte component and a new mayfly species, *Atalophlebia,* became important in the diet. By the Mid-wet season algae had increased in the diet and microcrustaceans decreased; libellulid larvae had replaced *Atalophlebia* mayfly larvae, but chironomid larvae remained important.

The algal component of the diet decreased during the Late-wet–Early-dry season, while the hydrophyte (mainly *Najas*) component increased dramatically. During the Dry season, microcrustaceans (mainly *Diaphanosoma*) and terrestrial plants increased in importance and the aquatic insects (except for chironomid and baetid larvae) became less common in the stomachs. The hydrophyte component decreased in the 1979 Mid-dry season as the variety and abundance of all the other components increased.

During the 1979 Late-dry season the algal component and an increased hydrophyte component persisted (unlike in the previous year); however, aquatic insects (chironomid larvae) and terrestrial plants were still common in the stomachs.

During the 1979–80 Early-wet season the few specimens examined had eaten mainly *Diaphanosoma,* which corresponded to the increased microcrustacean component recorded in the 1978–79 Early-wet season; similarly, aquatic insects (chironomid and baetid larvae) were found in the stomachs but were of only secondary importance.

Habitat differences

Magela catchment

A total of 286 stomachs of *A. percoides* were examined (all seasons combined): 36 from escarpment mainchannel waterbodies, 60 from lowland sandy creekbeds, 82 from lowland backflow billabongs, 78 from corridor billabongs and 30 from floodplain billabongs. Very few stomachs were empty.

In the escarpment mainchannel waterbodies *A. percoides* was mainly eating algae, and also aquatic insects (mainly chironomid larvae), terrestrial plant material and teleost remains (mainly scales). The diet in the lowland sandy creekbeds had smaller algae, teleost and terrestrial plant material components, and additional hydrophyte (*Najas*) and microcrustacean (*Diaphanosoma*) components; aquatic insects (especially chironomid and baetid larvae) were still the main food.

In the lowland shallow backflow billabongs, hydrophytes (mainly *Najas*) were eaten most frequently, followed by aquatic insects (mainly chironomid and baetid larvae) and microcrustaceans (mainly *Diaphanosoma*). The diet in corridor waterbodies was also based on *Najas,* chironomid and baetid larvae, and microcrustaceans (with a shift from cladocerans to copepods); in this habitat *Macrobrachium* and terrestrial plant material were also found in the stomachs, along with traces of terrestrial insects. No algae were found in the stomachs of specimens captured in the floodplain billabongs; hydrophytes (*Hydrilla*) and adherent gastropods appeared regularly in the diet. Aquatic insects (mainly libellulid, chironomid, pyralid and leptocerid larvae) were the main component in the floodplains.

Nourlangie catchment

A total of 96 specimens were examined from the Nourlangie Creek catchment: 68 from escarpment mainchannel waterbodies, 8 from lowland sandy creekbeds, and 20 from lowland backflow billabongs (where the one specimen with an empty stomach was captured).

The diet in the escarpment mainchannel waterbodies was based on algae, as in the Magela catchment, but microcrustaceans and terrestrial plant material were more common, and teleosts less common (chironomid and baetid larvae were still the main aquatic insects). Aquatic insects were by far the largest component of the diet in the sandy creekbeds, with baetid larvae, *Atalophlebia* and chironomid and simuliid larvae being the main items. The teleost (especially egg material) and terrestrial plant material components were more important in the sandy creekbeds of the Nourlangie catchment than in the Magela catchment, while microcrustaceans and hydrophytes did not appear in the diet, unlike in the Magela catchment.

In the 1979 Mid-dry season, one *A. percoides* specimen in an escarpment mainchannel waterbody (Twin Falls, Jim Jim Creek catchment) was observed apparently cleaning an *Anodontiglanis dahli* (TL approx. 50 cm). The bigger fish was lying motionless on sandy substrate when an *A. percoides* approached and appeared to feed around the head and particularly around the gill cavity. *Anodontiglanis dahli* moved away, followed by *A. percoides,* which resumed its cleaning behaviour. *Amniataba percoides* is the only fish known to eat *Argulus* (a brachiuran ectoparasite).

In the backflow billabongs, aquatic insects (mainly chironomid, baetid and libellulid larvae) dominated the diet. Hydrophytes were also eaten, but few microcrustaceans (unlike in the equivalent Magela catchment habitat).

Fullness

A summary of mean fullness indices of *A. percoides* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchment is shown in table 94. These data are presented on the assumption that feeding times do not vary with habitat or season.

Seasonal changes

Mean fullness indices were generally high throughout the study, though slightly lower in the 1978–79 Early-wet and 1979 Mid-dry seasons and higher in the 1978–79 Mid-wet and Late-wet–Early-dry seasons.

Habitat differences

Mean fullness indices were high throughout the Magela catchment. Upstream of RUPA the index was highest in the lowland sandy creekbeds. Downstream of RUPA the index was highest in the lowland shallow backflow billabongs and floodplain billabongs.

The mean fullness indices in the Nourlangie catchment were generally similar to those in the Magela Creek catchment.

Table 94 Mean fullness indices of *A. percoides* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments

Habitat	Sampling period							Habitat mean
	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80	
Magela Creek catchment (regular sites only)								
Upstream of RUPA:								
Escarpment main-channel waterbody	3.8 (16)	n/s	n/s	n/s	3.0 (14)	3.8 (4)	3.0 (3)	3.4 (37)
Lowland sandy creekbed	n/s	n/s	n/s	n/s	n/s	n/s	4.0 (4)	4.0 (4)
Downstream of RUPA:								
Lowland sandy creekbed	4.5 (6)	3.8 (5)	0 (1)	3.7 (30)	2.7 (27)	3.4 (10)	n/s	3.3 (79)
Lowland channel backflow billabong	0 (1)	0 (1)	0 (1)	4.5 (15)	3.6 (7)	3.0 (2)	n/s	3.4 (27)
Lowland shallow backflow billabong	0 (1)	3.5 (2)	0 (1)	4.2 (23)	4.5 (6)	n/s	n/s	4.0 (33)
Corridor sandy billabong	4.5 (2)	n/s	n/s	n/s	3.2 (32)	4.3 (6)	n/s	3.4 (40)
Corridor anabranch billabong	n/s	n/s	5.0 (3)	3.3 (4)	0 (1)	4.3 (4)	n/s	3.8 (12)
Floodplain billabong	3.5 (6)	2.5 (4)	4.3 (31)	n/s	n/s	3.8 (17)	n/s	3.9 (58)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	2.6 (8)	3.0 (2)	4.0 (39)	n/s	3.1 (20)	n/s	n/s	3.5 (69)
Lowland channel backflow billabong	n/s	n/s	5.0 (3)	0 (1)	3.7 (3)	0 (1)	n/s	3.3 (8)
Lowland shallow backflow billabong	1.5 (2)	n/s	n/s	4.0 (7)	3.8 (4)	n/s	n/s	3.6 (13)
Lowland sandy creekbed	n/s	3.3 (3)	n/s	3.8 (5)	n/s	n/s	n/s	3.6 (8)
Seasonal mean (all sites)	3.9	3.3	4.1	4.0	3.2	3.7	3.6	

Numbers examined are given in parentheses; n/s = not sampled in the habitat.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

- corridor anabranch billabong; 1978–79 Mid-wet season
- lowland sandy creekbed (downstream of RUPA); 1978 Late-dry season
- lowland channel backflow billabong; 1979 Late-wet–Early-dry season
- lowland shallow backflow billabong; 1979 Mid-dry season
- corridor sandy billabong; 1978 Late-dry season

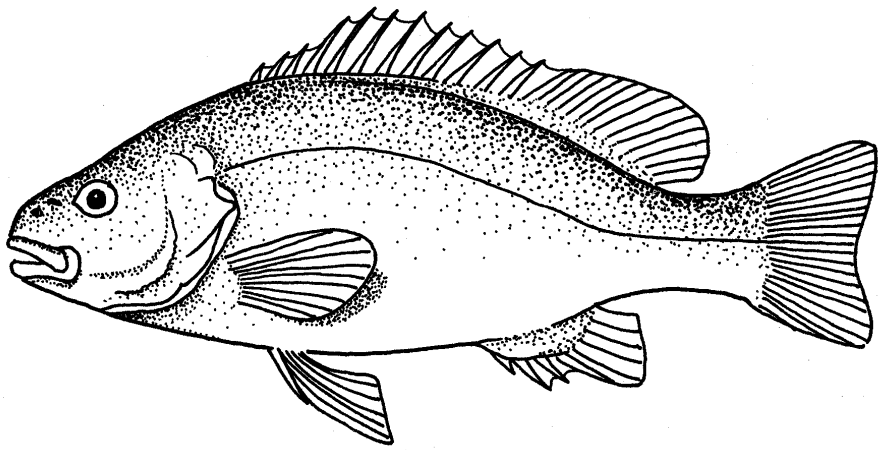
Nourlangie catchment

- lowland channel backflow billabongs; 1978–79 Mid-wet season
- escarpment mainchannel waterbody; 1978–79 Mid-wet season
- lowland shallow backflow billabong; 1979 Late-wet–Early-dry season.

Family TERAPONTIDAE

3.25 *Hephaestus fuliginosus* (Macleay)

Hephaestus fuliginosus is commonly known as the black bream or sooty grunter. It is found in drainage systems of the north-east coast, Gulf of Carpentaria and Timor Sea (see map 3), and in Papua New Guinea. Pollard (1974) found this species mainly in the upper reaches of streams in rocky upland waterbodies, and he also observed some juveniles under and around submerged tree roots in lowland sandy creekbeds near Jabiru.



Hephaestus fuliginosus

Hephaestus fuliginosus is a strictly freshwater species, usually found in the rocky upper reaches of coastal rivers,[171] where it provides excellent sport when fished on light tackle; its flesh is good eating. However, overfishing of *H. fuliginosus* in escarpment mainchannel habitats could threaten existing populations of this species if such amateur fisheries are not properly managed.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was found abundantly in escarpment terminal mainchannel waterbodies, moderately abundantly in escarpment perennial streams, and commonly in escarpment mainchannel waterbodies and seasonal streams. It was found rarely in lowland sandy creekbeds.

Hephaestus fuliginosus was found in the greatest number of sites during the Mid-wet season and in the fewest in the 1978 Late-dry season.

Size composition

The lengths and weights of 54 specimens were determined. Most of the specimens were caught by baited hook, but a few were by caught gill and seine nets. The series of peaks found in the overall length-distribution was not, therefore, due to mesh selectivity.

Length–weight relationship

The length–weight relationship for the combined sexes was described by the following expression:

$$W = 1.38 \times 10^{-2} L^{3.10}$$ r = 1.00 (length in cm, weight in g)

171 Herbert and Peeters (1995) indicated that *H. fuliginosus* are often found at the headwaters of streams in Cape York Peninsula, particularly in the spawning season.

Seasonal mean lengths, weights and condition factors are shown in table 95. The condition factor was highest in the 1978 Late-dry season and lowest in the 1979 Mid-dry and Late-dry seasons. By the end of the 1979 Dry season, the condition appeared to be poorer than that recorded in the 1978 Dry season.

Table 95 Mean length, mean weight and condition factor of *H. fuliginosus*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	10	185.4	126.56	1.08
Mid-wet (1978–79)	29	205.4	162.92	1.01
Mid-dry (1979)	8	252.9	281.72	0.92
Late-dry	7	224.3	199.11	0.94
Overall	54	210.2	173.05	1.00

Length-frequency distribution

The smallest specimen was 57 mm LCF and the largest was 340 mm LCF (fig 111). In the Purari River catchment, Papua New Guinea (Haines 1979), *H. fuliginosus* ranged in length from 120 to 350 mm. This species might grow to 500 mm (Lake 1978).

The mean length of all specimens captured was 210 mm LCF; there were modes at the 190 and 220-mm-length intervals. The LFM for males was 200 mm and for females was 250 mm, indicating that fairly equal proportions of juveniles and adults were captured.

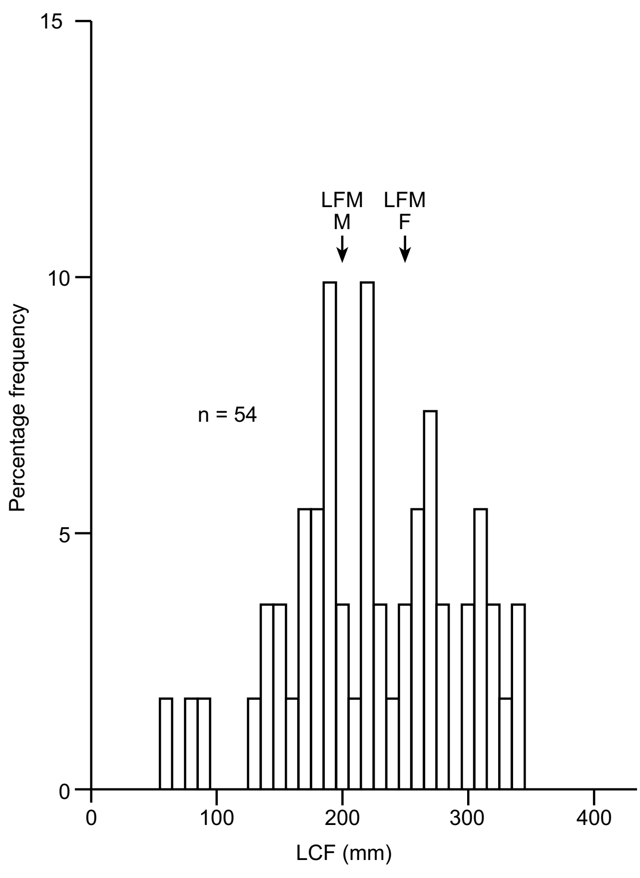


Figure 111 Length-frequency distribution of all *H. fuliginosus* captured

Seasonal changes in distribution

The smallest specimens were captured in the Mid-wet season in escarpment mainchannel waterbodies and were observed in the Late-wet–Early-dry season and 1979–80 Early-wet seasons in escarpment perennial streams of the Magela Creek system (fig 112). The main periods of juvenile recruitment appear to be the Mid-wet and Late-wet–Early-dry seasons; however, this may not be the case in the escarpment perennial streams.

The largest specimens were captured in the Mid-wet and 1979 Mid-dry seasons in the escarpment mainchannel billabongs; in the escarpment perennial streams the largest specimens were observed in the 1979 Late-dry and Late-wet–Early-dry seasons in the Magela and Nourlangie catchments, respectively.

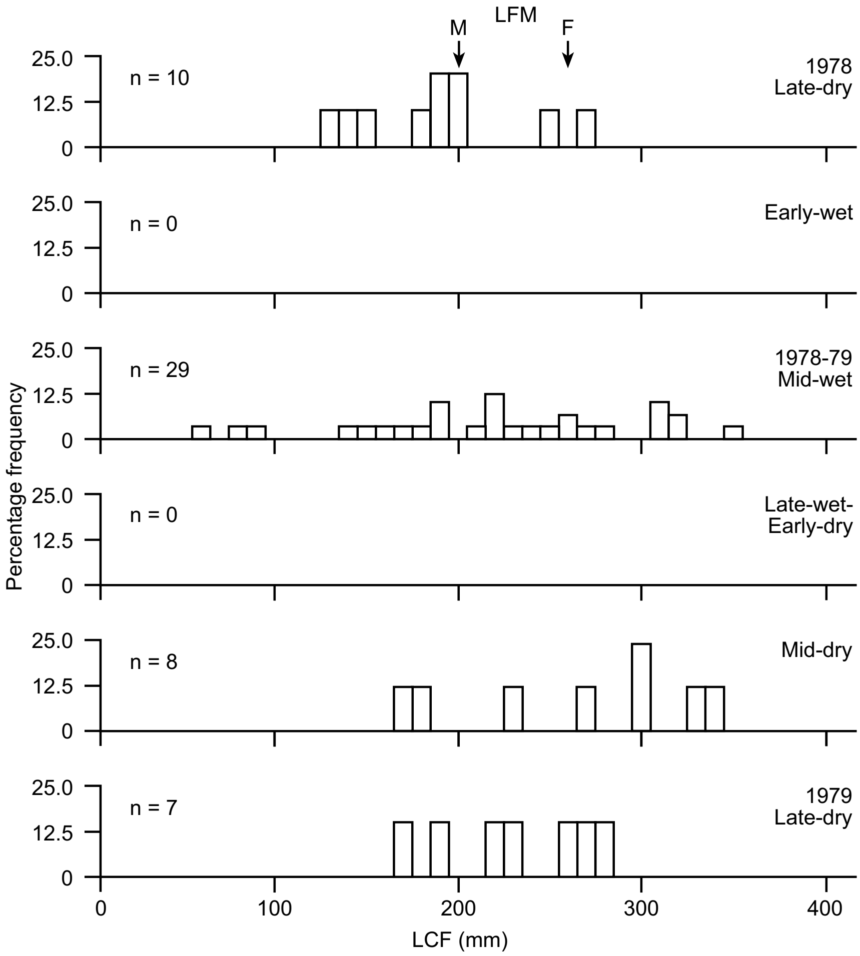


Figure 112 Seasonal length-frequency distribution of all *H. fuliginosus* captured

Habitat differences in distribution

Magela catchment

Most specimens (encompassing a wide size-range) were captured in escarpment mainchannel waterbodies. A few small juveniles were captured in rapidly flowing lowland sandy creekbed channels in the 1978–79 Mid-wet season. Adults were also captured as far downstream as the corridor waterbodies. They are regularly fished from deep sandy creekbeds in RUPA (see *Jabiru Journal*, February 1980) during the Mid-wet season. These adults and juveniles no doubt came from escarpment populations during the Mid-wet season, when high floodwaters would have displaced them downstream from their Dry season refuges. A wide size-range of specimens was observed in escarpment perennial streams throughout the study.

Nourlangie catchment
All *H. fuliginosus* were captured in escarpment mainchannel waterbodies. Their size-range was wide, as was that of specimens observed in escarpment perennial streams throughout the study.

Environmental associations

Rank numbers for *H. fuliginosus* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature
Both surface and bottom water temperatures ranged from 23° to 34°C (surface mean = 28.2°C; bottom mean = 27.7°C). Both means ranked at the base of the lower quarter (see fig 170). These generally low water temperatures reflects this species' distribution in the cooler escarpment streams and rocky waterbodies (Pollard 1974, Mees & Kailola 1977).

Dissolved oxygen
Dissolved oxygen concentrations in waters in which *H. fuliginosus* was captured ranged from 3.8 to 7.4 mg/L (mean = 6.0) on the surface, and from 5.0 to 7.4 mg/L (mean = 6.4) on the bottom. These mean DO concentrations were ranked in the lower-middle and upper quarters respectively (see fig 171). The relatively high bottom-water DO concentrations are indicative of well-mixed, cooler waters, such as may be found in escarpment streams.

Visibility
Secchi depth readings ranged from 90 to 360 cm (mean = 180 cm) (see fig 172). This mean ranked at the top of the upper quarter, indicating that *H. fuliginosus* is often found in very clear waters. Its apparent preference for clear waters was also noted by Pollard (1974) and Mees and Kailola (1977).

pH
Surface and bottom water pH readings at sites where *H. fuliginosus* was captured ranged from a low 4.0 to 6.7 (mean = 5.6) and 4.5 to 6.5 (mean = 5.7), respectively (see fig 173). Both means ranked at the base of the lower quarter; thus *H. fuliginosus* was captured in relatively acidic waters.

Conductivity
Surface water conductivity readings ranged from 6 to 80 µS/cm; corresponding bottom water conductivities ranged from 6 to 12 µS/cm. Such low conductivities suggest low concentrations of dissolved solids, as might be expected in escarpment waters. Pollard (1974) regarded *H. fuliginosus* as a strictly freshwater species.[172]

Habitat–structural variables

Substrate
Most specimens of *H. fuliginosus* were captured over sandy substrates, followed closely by boulders,[173] then rocks and leaf-litter substrates. The percentage dominance values for sand and boulders ranked in the upper-middle and upper quarters, respectively (see fig 174). This agrees with Mees and Kailola's (1977) report that this species lives over sand and gravel

172 Hogan and Nicholson (1987) showed that the sperm of *H. fuliginosus* was most active in salinities of 0 ppt and 5 ppt, and not motile in salinities above 15 ppt.

173 Hogan (1994) found *H. fuliginosus* spawned in small caverns underneath boulders within rapids in the Tully River in north-eastern Queensland. Herbert and Peeters (1995) indicated that this species spawns at selected sites among rocks and boulders at the edge of rapids at dusk.

substrates in southern Papua New Guinea, and Pollard's (1974) that it is usually found in the rocky upper-reaches of coastal rivers.

Hydrophytes

Hephaestus fuliginosus was found in exceptionally sparsely vegetated waters (vegetation-occurrence index 14.6%). In waters with hydrophytes, emergent vegetation was dominant (43.5%), followed by a comparatively low reading for submergent vegetation (26.1%). Pollard (1974) noted that this species has a high proportion of plant material, including algae and the fruits of terrestrial plants, in its diet; bank vegetation may thus be of some importance to this species.

Reproduction

Hephaestus fuliginosus was caught mainly by handline. As only 54 specimens were captured, the information on this species is sparse. They were captured in only four of the seven seasons sampled. The sex of four fish (length range 57–143 mm LCF) could not be determined; the remainder comprised 16 females (length range 170–340 mm LCF) and 34 males (80–320 mm LCF).

Length at first maturity

No mature or ripe females were captured; however, no fishing for this species was undertaken during the 1978–79 Early-wet season, which is when spawning is most likely. The smallest female with spent gonads was 261 mm LCF. The LFM, using data from five spent fish only, was estimated to be around 250 mm LCF. If the smallest spent fish was a precocious spawner, then the LFM would be closer to 320 mm LCF (fig 113). Fifteen males with developing or spent gonads (stages IV and VII) were captured. The estimated LFM was around 200 mm LCF, but if the two smallest fish (150 and 183 mm LCF) were not precocious spawners, the LFM could be around 150 mm LCF.

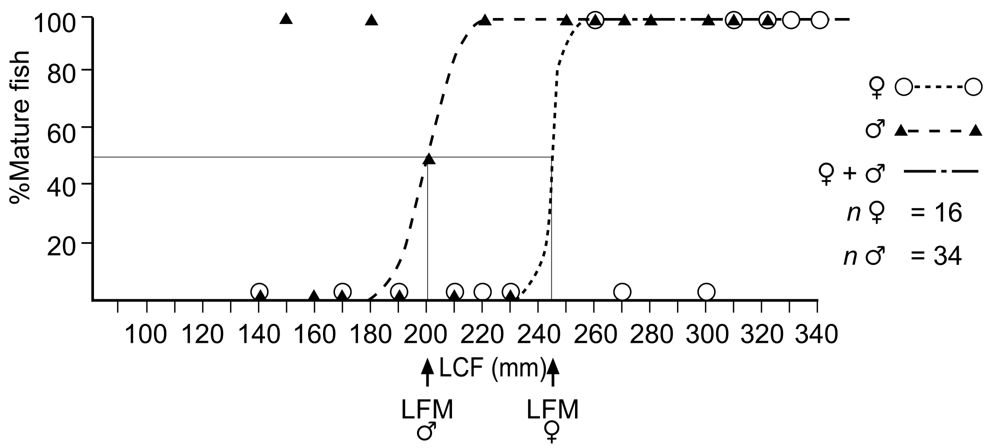


Figure 113 Estimated length at first maturity of *H. fuliginosus*

The numbers of mature fish were too low to be more certain of the LFM, but the GSI and GMSI were calculated on 200 mm LCF as the LFM for males and 250 mm LCF for females. Lake (1978) suggested that *H. fuliginosus* females probably do not mature until over 260 mm in length.

Sex ratio

Although generally more males than females were captured in each season, only in the 1978 Late-dry season was the difference significant ($0.001 < P < 0.01$ for adults + juveniles and

0.01 < P < 0.05 for adult fish; table 96). This unequal sex ratio may be a result of the difficulty in distinguishing between immature female and male gonads.

Table 96 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *H. fuliginosus* over all habitats

			Sampling period						
Parameter	Sex	Statistic	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80
Sex ratio									
Juveniles	F	*n*	0	–	9	–	4	3	–
+ adults	M	*n*	9	–	17	–	4	4	–
		χ^2	9.0	–	2.5	–	0.0	0.1	–
		P	**	–	n.s.	–	n.s.	n.s.	–
Adults only	F	*n*	0	–	4	–	4	1	–
	M	*n*	4	–	11	–	2	4	–
		χ^2	4.0	–	3.3	–	0.7	1.8	–
		P	*	–	n.s.	–	n.s.	n.s.	–
GSI									
Adults only	F	mean	–	–	0.5	–	0.6	0.5	–
		s.d.	–	–	0.1	–	0.4	–	–
	M	mean	0.5	–	0.2	–	0.4	0.4	–
		s.d.	0.5	–	0.1	–	0.1	0.3	–
	F+M	mean	–	–	0.3	–	0.5	0.4	–
		s.d.	–	–	0.1	–	0.3	0.2	–
GMSI									
Adults only	F	mean	–	–	2.0	–	2.0	2.0	–
		s.d.	–	–	0.0	–	0.0	–	–
	M	mean	4.3	–	2.0	–	3.5	5.3	–
		s.d.	1.5	–	0.0	–	0.7	1.5	–
	F+M	mean	–	–	2.0	–	2.5	4.6	–
		s.d	–	–	0.0	–	0.8	1.9	–

n = number; χ^2 = Chi-squared value; P = probability; n.s. = not significant (P > 0.05); * = 0.01 < P < 0.05; ** = 0.001 < P < 0.01; s.d.= standard deviation.

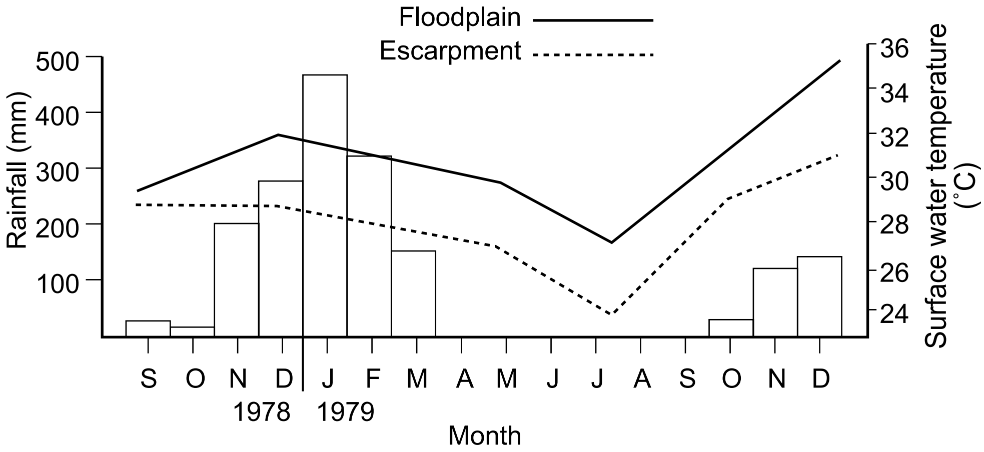
Breeding season

Although data are sparse, the GMSI does suggest that the male gonads started to develop (without much increase in weight) towards the end of the Dry season, while the females were still in a resting state (fig 114). Mature and ripe gonads were found only in the 1978 Late-dry season (two males) and all but one spent fish were from the 1978–79 Mid-wet season sample; spawning thus appears to have occurred during the early part of the 1978–79 Wet season.

Midgley (1980) found running-ripe males in escarpment streams during the 1979–80 Early-wet season; the females were not ready for spawning. When stream flow began (January 1980) the fish were no longer to be found in escarpment streams; in February, individuals with large gonads were captured (by angling) from Magela Creek downstream of the escarpment area and in lowland sandy creekbed streams.

Specimens were also caught in corridor waterbodies (Magela Crossing) and where Gulungul Creek crosses the Arnhem Highway. Thus, from of Midgley's and our data, it appears that

H. fuliginosus spawns during the Early-wet to Mid-wet seasons and that females do not start maturing until around the start of stream flow.[174] Lake (1978) recorded that this species spawned in the Wet season following an increase (and subsequent fall) in water level.



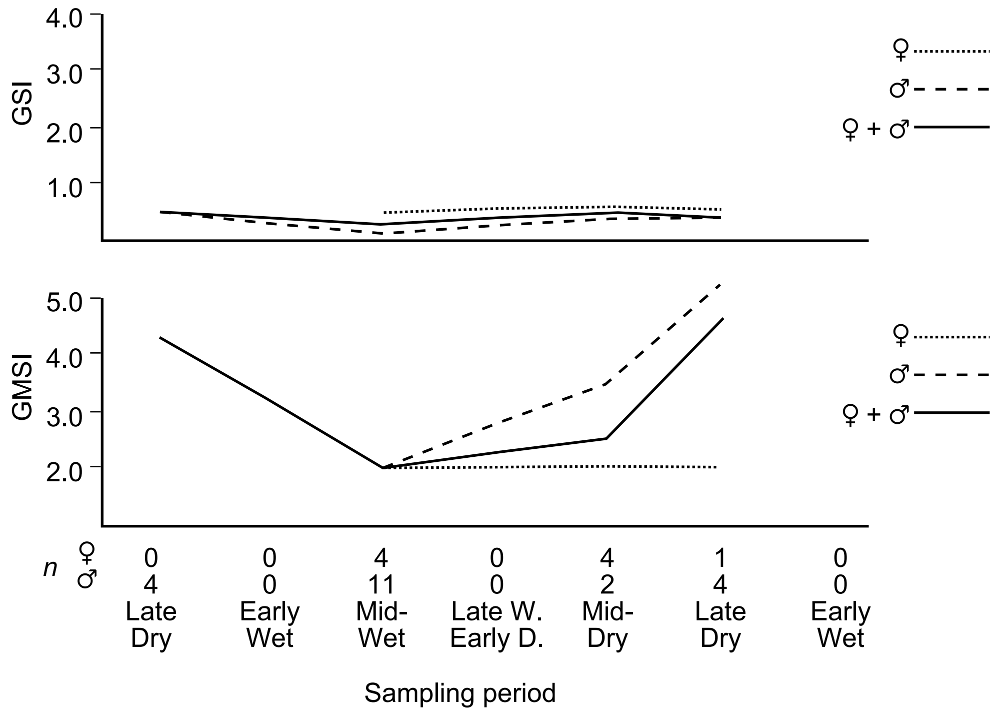


Figure 114 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *H. fuliginosus*

Site of spawning

Although one maturing and one ripe male and all spent fish (five females and 10 males) were captured from the mainchannel waterbody in the escarpment area, Midgley (1980) records that some *H. fuliginosus* move down Magela Creek towards the corridor areas to spawn.

174 Herbert and Peeters (1995) indicated that *H. fuliginosus* spawning activity peaks in October–November in far northern Queensland.

However, there are no records of angling in corridor waterbodies and lowland sandy creekbeds during the Wet season to determine how far downstream the fish migrates to its spawning sites. This species reputedly does not spawn in dams (Lake 1971).[175]

Fecundity

Hephaestus fuliginosus produces tens of thousands of eggs, depending on the size of the fish. The eggs are golden, demersal, non-adhesive and up to 3 mm in diameter; two or more partial spawnings may occur over a period of days (Lake 1978). The only ovaries available for examination during this study were spent. They contained between 200 000 and 800 000 eggs of 0.08 mm diameter; most likely they were developing for the next year's breeding.[176]

Specimens from north Queensland spawn at the heads of stony rapids. Their eggs are apparently distributed into gravel crevices by water currents (Midgley, pers comm). The eggs hatch in 24 hours at 26°C, and the larvae begin feeding at about 96 hours.

Summary

Hephaestus fuliginosus was generally captured in escarpment mainchannel waterbodies. Male gonads mature towards the end of the Dry season; however, female gonads do not ripen until the Wet season starts and the creeks begin to flow. Early in the Wet season some mature fish leave the escarpment area and probably migrate downstream towards the corridor waterbodies, though it is not known how far downstream they go to spawn. Queensland specimens lay a very large number of eggs (up to 3 mm in diameter) in gravel beds at the heads of stony rapids when the flood peak subsides; however, such stony gravel beds are generally found only in escarpment areas in the Alligator Rivers Region. Adults that spawn downstream of the escarpment area may have a different breeding strategy from populations that spawn over gravel.

The eggs have a very short incubation period (24 hours at 26°C) and the larvae begin feeding after 96 hours. Spawning in groups of up to 50 individuals has been observed (Lake 1978).

Feeding habits

Overall diet

The stomachs of 52 specimens were examined; 51 contained food. The diet of *H. fuliginosus* is summarised in figure 115; the components are listed in table 97.

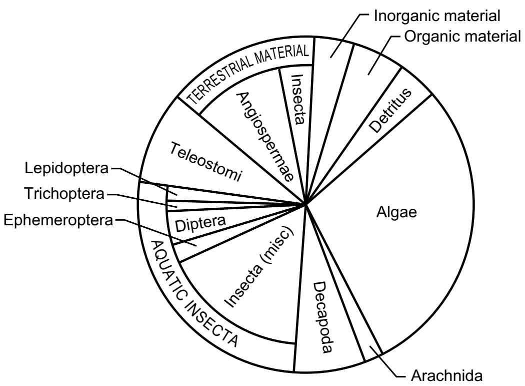


Figure 115 The main components of the diet of *H. fuliginosus*

175 Hogan (1994) found *H. fuliginosus* spawned in rapids in the Tully River in north-eastern Queensland. Small caverns under boulders were the specific microhabitat.

176 Hogan (1994) found that six female *H. fuliginosus* from north-eastern Queensland produced at least 429 000 eggs following induced spawning.

Table 97 Dietary composition of *H. fuliginosus*

	Habitat			Seasons					
	Magela system		Nourlangie system	1978	1978–79	1979	1979	Overall	
Stomach contents	Em	Ep	Em	Late-dry	Mid-wet	Mid-dry	Late-dry	Sub-mean	Main-mean
Aquatic plants									
Algae									27.5
Miscellaneous	3.1	–	–	–	–	7.1	–	1.0	
Conjugatophyta									
Mougeotia	–	–	25.8	–	25.7	10.0	–	15.5	
Spirogyra	–	–	18.0	–	20.0		–	11.0	
Aquatic animals									
Arachnida									1.5
Hydracarina	4.7	–	–	–	–	10.7	–	1.5	
Macrocrustacea									7.9
Macrobrachium	2.5	25.0	5.2	5.0	4.6	4.3	6.7	4.9	
Euastacoides	–	50.0	–	10.0	–	–	–	2.0	
Insecta									25.2
Fragmented	18.1	–	16.9	4.0	18.9	8.6	35.0	16.4	
Ephemeroptera									
Baetidae	0.6	–	3.2	–	3.9	–	–	2.2	
Diptera									
Chironomidae	1.6	–	5.6	10.5	3.4	–	–	3.9	
Ceratopogonidae	–	–	0.2	–	0.2	–	–	0.1	
Trichoptera									
Leptoceridae	2.5	–	–	–	–	5.7	–	0.8	
Lepidoptera									
Pyralidae	5.6	–	–	–	3.2	–	–	1.8	
Teleostomi									8.6
Fragmented	–	–	8.7	–	7.5	8.6	–	5.3	
Scales	5.9	–	2.4	3.0	2.7	2.1	8.3	3.3	
Terrestrial plants									
Angiospermae									10.2
Fragmented	10.0	25.0	1.6	19.0	1.1	5.7	–	5.1	
Bark material	1.3	–	–	–	–	–	3.3	0.4	
Flower material	1.9	–	–	–	–	–	5.0	0.6	
Root material	1.9	–	–	–	–	–	5.0	0.6	
Seed material	10.6	–	–	–	–	–	28.3	3.3	
Pandanus seeds	–	–	0.3	–	0.4	–	–	0.2	
Terrestrial animals									
Insecta									4.1
Fragmented	–	–	2.6	–	2.9	–	–	1.6	
Odonata									
Zygoptera (adults)	–	–	0.2	–	0.2	–	–	0.1	
Orthoptera	–	–	0.3	–	0.4	–	–	0.2	
Lepidoptera									
Miscellaneous (larvae)	–	–	3.2	–	–	14.3	–	2.0	
Hymecoptera									
Oecophylia	0.6	–	–	1.0	–	–	–	0.2	
Parasites									
Nematoda	–	–	0.2	–	0.2	–	–	0.1	0.1
Detrital material	1.9	–	–	14.0	–	4.3	–	3.3	3.3
Bait material	18.4	–	–	29.5	–	–	–	5.8	5.8
Inorganic material	4.4	–	2.9	4.0	1.8	8.6	8.3	3.9	3.9
Organic material	4.4	–	5.5	–	6.1	10.0	–	4.7	4.7
Number of empty fish	1	–	–	–	–	1	–	1	1
Number of fish with food	16	2	31	10	28	7	6	51	51

Figures represent the mean percentage volume determined by the estimated volumetric method.
Em = escarpment mainchannel; Ep = escarpment perennial stream

The main components were algae (28%), aquatic insects (25%), terrestrial plant material (10%) and some teleost remains (9%). The algae were mainly filamentous green species such as *Mougeotia* and *Spirogyra*. The main identifiable aquatic insects were chironomid larvae. The terrestrial plant material consisted of scrapings of bark and root (possibly from submerged tree trunks and roots, eg of *Pandanus*) as well as numerous seeds and flowers that had fallen into the water. Macrocrustaceans (8%), mainly *Macrobrachium* and *Euastacoides,* were also eaten. Traces of terrestrial animals, aquatic arachnids, detritus and inorganic material were also found in the stomachs. *Hephaestus fuliginosus* can therefore be classified as a macrophagous omnivore. Pollard (1974) also considered this species to be an omnivore, eating plant material (including algae and often the small fruits or berries of terrestrial plants) as well as crustaceans and insects. This species is reputedly not a fish eater; however, teleost remains were found in several stomachs. Haines (1979) classified *Terapon* (= *Hephaestus*) *fuliginosus* from the Purari River, Papua New Guinea as a herbivore (its diet including other plant material).[177]

Seasonal changes

In sampling periods 1, 3, 5 and 6, respectively, 10, 28, 8 and 6 stomachs were examined (all habitats combined). Only one specimen (from the 1979 Mid-dry season) had an empty stomach.

The diet in the 1978 Late-dry season was based fairly evenly on terrestrial plant material, aquatic insects (mainly chironomid larvae), macrocrustaceans (*Euastacoides* and *Macrobrachium*), and detritus. During the Mid-wet season the emphasis shifted towards algae, with less terrestrial plant material, detritus and macrocrustaceans; terrestrial insects appeared in the diet during this season.

By the 1979 Mid-dry season the diet had shifted from algae to aquatic and terrestrial food items and teleosts. The inorganic and unidentified organic material components were larger in the Mid-dry season. In the 1979 Late-dry season, *H. fuliginosus* ate mainly aquatic insects, terrestrial plant material, teleosts, aquatic arachnids and macrocrustaceans. Algae were not eaten in this or the 1978 Late-dry season.

Habitat differences

Magela catchment

Totals of 17 and 2 stomachs of *H. fuliginosus* were examined (all seasons combined) from escarpment mainchannel waterbodies and perennial streams, respectively. Only one specimen (in the mainchannel habitat) had an empty stomach.

The main dietary items (other than the bait used to catch the specimens in the mainchannel habitat) were aquatic insects (mainly pyralid larvae) and terrestrial plant material (mainly seeds); macrocrustaceans, fish scales, aquatic arachnids, algae, inorganic and detrital material were also found in the stomachs. The few specimens examined from perennial streams had eaten only macrocrustaceans (*Euastacoides* and *Macrobrachium*) and terrestrial plant material.

Many juvenile and adult specimens were observed feeding in lowland sandy creekbeds during the Mid-wet season.

---

177 Pusey et al (1995b) found *H. fuliginosus* to consume large quantities of vegetable matter, either as terrestrial material, aquatic macrophytes or particularly filamentous alga in two rivers of the Australian wet tropics, north-eastern Queensland.

Nourlangie catchment

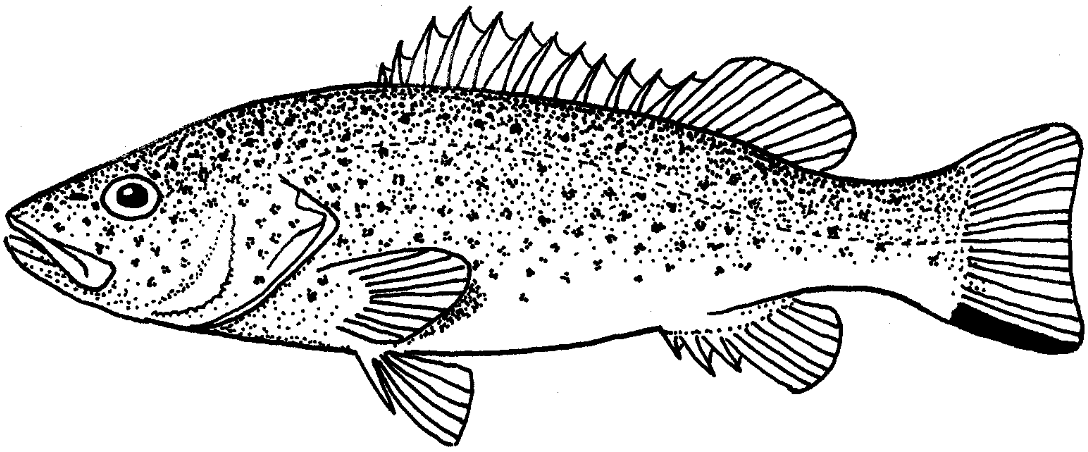
A total of 31 stomachs of *H. fuliginosus* were examined (all seasons combined) from an escarpment mainchannel waterbody. All contained food.

The diet encompassed a variety of food items, with the main components being algae (*Mougeotia* and *Spirogyra*), aquatic insects (mainly chironomids identifiable), teleost remains, macrocrustaceans (*Macrobrachium*) and traces of terrestrial insects and plants and inorganic material. In this catchment the diet appeared to be based more on algae than in the specimens examined in the Magela catchment.

Family TERAPONTIDAE

3.26 *Leiopotherapon unicolor* (Gunther)

Leiopotherapon unicolor is commonly known as the spangled grunter or perch. It is a wide-ranging species, found in the drainage systems of the north-east coast, Gulf of Carpentaria, Timor Sea, Indian Ocean, Lake Eyre, Bulloo and Murray–Darling (see map 3). Pollard (1974) reported it was common in almost all waterbodies in the Magela Creek system, and Miller (in Taylor 1964) that it was abundant in large billabongs and creeks in the Oenpelli area. The black marking on the tail is only found in specimens of less than 90 mm.



Leiopotherapon unicolor

Leiopotherapon unicolor (syn. *Madigania unicolor*) belongs to a family with marine, estuarine and freshwater representatives, but it is strictly an inhabitant of freshwaters. It is a good eating fish, although generally small.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was abundant in escarpment terminal mainchannel waterbodies, moderately abundant in escarpment perennial and seasonal streams, and common in all escarpment mainchannel waterbodies, lowland sandy creekbeds, lowland backflow billabongs and corridor waterbodies. It was found in only a few floodplain billabongs. It was found in the greatest number of sites in the Late-wet–Early-dry season and in the fewest in the 1978 Late-dry season.

Size composition

The lengths and weights of 439 specimens were recorded. Peaks apparent in the overall length-frequency distribution were caused to some extent by the mesh selectivity of the gillnets (mainly 26, 44 and 58 mm mesh); however, the large overlap in sizes of fish caught by the various nets, and of those caught by seine net, suggests mesh selectivity did not disguise trends in growth of this species.

Length–weight relationship

The length–weight relationship for the combined sexes was described by the expression:

$W = 2.04 \times 10^{-2} L^{2.95}$ r = 0.99 (length in cm, weight in g)

Seasonal mean lengths, weights and condition factors are shown in table 98. The seasonal condition factor was stable (near unity) between the 1978 Late-dry and 1978–79 Mid-wet seasons; it is surprising that condition was not depressed during the Early-wet season spawning. By the Late-wet–Early-dry season, condition peaked, due to extensive feeding in the Wet. After the Wet season, a change in environmental conditions, food supply or both caused condition to deteriorate through the 1979 Dry season.[178] The condition of specimens in the 1979 Late-dry and 1979–80 Early-wet seasons was considerably poorer than in the same seasons the previous year. Specimens with especially poor body condition (k = 0.75–0.80) were found in escarpment perennial streams (mainly Baroalba Springs) during both Late-dry seasons.

Table 98 Mean length, mean weight and condition factor of *L. unicolor*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	25	129.5	38.79	1.00
Early-wet (1978–1979)	44	32.6	0.68	1.02
Mid-wet	55	98.3	17.28	1.00
Late-wet–Early-dry (1979)	49	124.2	38.71	1.13
Mid-dry	122	124.6	34.11	0.98
Late-dry	44	114.1	24.63	0.92
Early-wet (1979–80)	10	123.8	30.87	0.91
Overall	349	100.4	18.38	1.00

Length-frequency distributions

Specimens ranged in length from 11 mm to 236 mm LCF (fig 116). The largest was near the reputed maximum size (250 mm; Pollard 1974) attained by this species, but specimens up to 260 mm LCF were observed in escarpment perennial streams in the Magela Creek catchment.

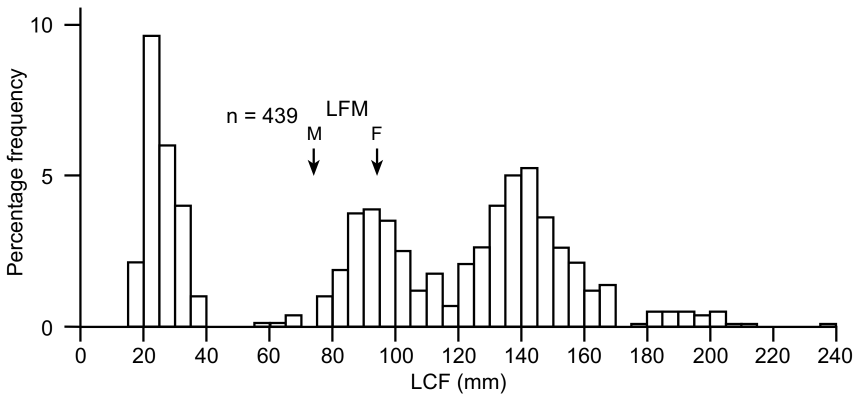


Figure 116 Length-frequency distribution of *L. unicolor*

The mean length of all specimens captured was 100 mm LCF. The LFM (fig 116) for males was 74 and for females 94 mm LCF, indicating that most of the specimens were adults. There were three peaks with modal sizes of 20–25, 90–95 and 140–145 mm in the length-frequency

178 Gehrke (1988b) recorded reduced condition for *L. unicolor* during winter in south-east Queensland.

distribution. A strongly kurtosed size group occurred between 175 and 215 mm LCF. Few specimens were captured between 40–75 mm LCF.

Seasonal changes in distribution

The smallest specimens were captured in the 1978–79 Early-wet season (fig 117), indicating that juveniles recruit during this period; no juveniles were found in the 1979–80 Early-wet season, probably because the 1979 Dry season was extreme and the flow had not started in the catchments. In escarpment perennial streams, small juveniles were found mainly in the Mid-wet and Late-wet–Early-dry seasons, and again in the 1979 Late-dry season.

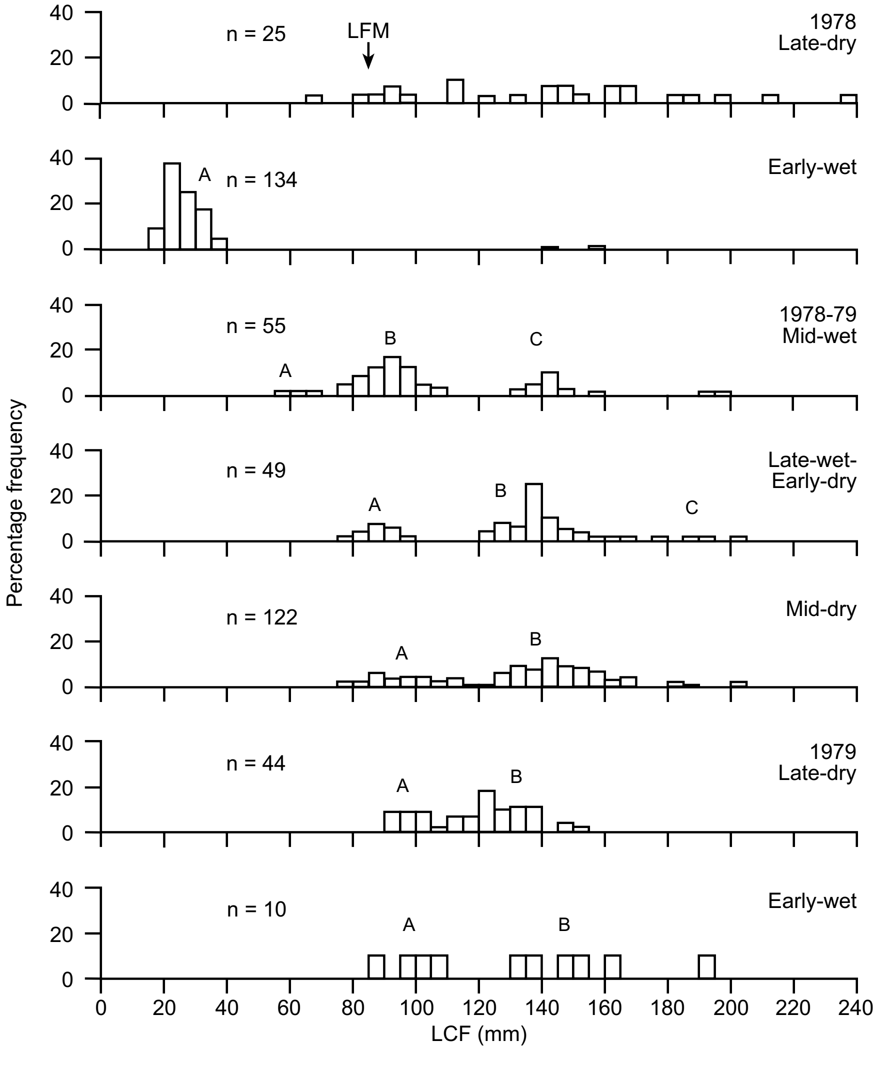


Figure 117 Seasonal length-frequency distribution of *L. unicolor*

The largest specimen was captured in the 1978 Late-dry season. The largest adults were observed in escarpment perennial streams in the 1978–79 Mid-wet and 1979–80 Early-wet seasons.

The mean seasonal lengths of specimens, shown in table 98, were greatest in the 1978 Late-dry season, when a wide range of sizes of predominantly adult fish was captured (fig 117). The mean lengths fell dramatically by the 1978–79 Early-wet season, when large numbers of juvenile recruits entered the populations of apparently few adults. By the Mid-wet season mean length had increased, as large juveniles and small adults dominated the populations; intermediate-sized and large adults had also reappeared. The mean lengths continued to increase until the 1979 Late-dry season, when the peaks of small and intermediate-sized adults almost merged and growth appeared to slow. The reduction of mean length may be an artefact of sampling, an indication of increased mortality, or result from larger-sized specimens moving out of sampling sites. The mean lengths and size ranges in the season were much less than those recorded in the 1978 season.

By the 1979–80 Early-wet season the small and intermediate-sized adult peaks had again separated and mean lengths were comparable with those in the 1979 Mid-dry season; the length-frequency distribution resembled that recorded in the 1978 Late-dry season, with small discrepancies due to differences in sample sizes.

Growth rate

Male and female specimens of *L. unicolor* can attain their LFM (58 and 78 mm LCF) within one year if kept in drastically understocked ponds with an abundant food supply (Llewellyn 1973).

Growth in *L. unicolor* may be described from the seasonal length-frequency distributions by following the progression of small juveniles (modal length 20–25 mm) from the 1978–79 Early-wet season (A on fig 117). The fastest growth appeared to be in the six months between the Mid-wet and the Late-wet–Early-dry seasons, when a modal length of 85–90 mm LCF was attained. These large juveniles/small adults appeared to grow through the Dry season to a mean length of 95–100 mm LCF by the 1979–80 Early-wet season (ie 10 mm in six months).

The growth of *L. unicolor*, therefore, appears to be faster than that noted by Llewellyn (1973): our study suggests it reaches its LFM in the six months over the Wet season. The environment may be described (as Llewellyn described his growth ponds) as drastically understocked, with an abundant food supply.[179]

Habitat differences in distributions

Length-frequency distributions showing habitat preferences of *L. unicolor* captured in regular sampling sites of the Magela and Nourlangie Creek catchments are given in figure 118.

Magela catchment

The smallest juveniles were most abundant in lowland sandy creekbeds and to a lesser extent in lowland shallow backflow billabongs and sandy corridor waterbodies; a few specimens were captured in channel backflow, corridor anabranch and floodplain billabongs. The larger juveniles were captured less often in sandy creekbeds and more usually in lowland backflow billabongs upstream and downstream of RUPA. A few specimens were found in escarpment mainchannel waterbodies. Juveniles were present in escarpment perennial streams throughout the study.

The small and intermediate-sized adults were found mainly in lowland backflow billabongs up- and downstream of RUPA; small numbers were also found in escarpment mainchannel waterbodies, sandy creekbeds, and corridor and floodplain billabongs. Intermediate-sized adults were captured more frequently in lowland sandy creekbeds.

Large adults were found mainly in backflow billabongs (especially in channel types) as well as in sandy creekbed and escarpment mainchannel waterbodies. Adults of all sizes (including the largest specimens observed) were found in escarpment perennial streams throughout the study.

---

179 Gehrke (1988b) held *L. unicolor* weighing 54–96 g in aquaria at 16.8°C and found no significant growth over a period of 180 days, whereas individuals held at 22.6°C showed a weight increase of 32.8% over the same period.

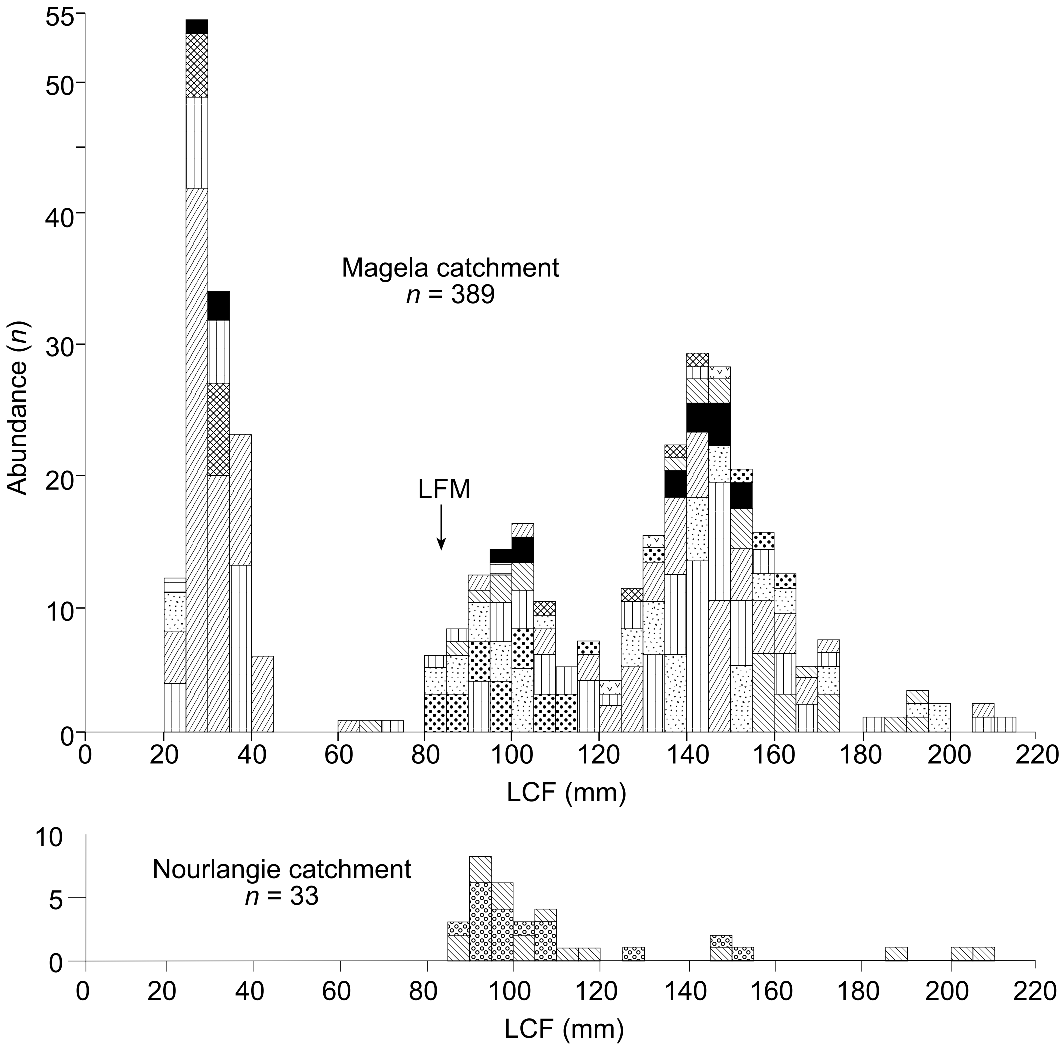


Figure 118 Length-frequency distributions and habitat preferences of *L. unicolor* captured at regular sampling sites (see appendix 5 for key to the habitats)

Nourlangie catchment

No juveniles were captured in this catchment; however, sampling in this catchment was limited. Small adults were found in shallow backflow billabongs and escarpment mainchannel waterbodies, as were intermediate-sized adults. Large adults were captured in the escarpment mainchannel waterbodies.

Juveniles and adults were found in escarpment perennial streams throughout this study, and adults were frequently observed in seasonal escarpment streams.

Environmental associations

Rank numbers for *L. unicolor* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

Temperatures of waters from which *L. unicolor* was captured ranged from 23° to 40°C (mean = 30.2°C) on the surface, and from 23° to 35°C (mean = 28.9°C) on the bottom. Both means were placed in the lower-middle quarter (see fig 170). *Leiopotherapon unicolor* was commonly found in escarpment waters, but was also found in smaller numbers in almost all other habitats sampled. The broad local (and continental; Pollard [1974]) distribution of this species is reflected in its tolerance of a range of water temperatures. Other workers (eg Beumer 1979a, Llewellyn 1973) have also found that *L. unicolor* can tolerate extremely high water temperatures (up to 41.8°C for adult fish).[180]

Dissolved oxygen

Dissolved oxygen concentrations in waters in which *L. unicolor* was found ranged from 0.9 to 9.1 mg/L (mean = 6.3) on the surface, and from 0.2 to 9.5 mg/L (mean = 4.5) on the bottom. These mean DO concentrations were placed in the upper-middle and lower-middle quarters respectively (see fig 171). This species apparently tolerates a wide range of DO concentrations, as might be expected of a fish with a broad local and continental distribution.[181]

Visibility

Secchi depths ranged widely from 1 to 360 cm with a mean depth of 62 cm, which ranked in the lower-middle quarter (fig 172). This species was thus found in both very turbid and very clear waters.

pH

The pH of surface waters ranged from 4.0 to 8.6 (mean = 6.1), and of bottom waters from 4.5 to 7.3 (mean = 5.8). These means ranked in the upper-middle and lower-middle quarters respectively (see fig 173).

Conductivity

The conductivity of waters in which this species was found ranged from 6 to 620 µS/cm on the surface and from 4 to 620 µS/cm on the bottom. Both ranges are extremely wide, which is in accord with *L. unicolor*'s wide distribution from the upper to the lower reaches of the catchment. Pollard (1974) stated that this species, although a member of a family with marine and estuarine representatives, is a strictly freshwater fish. However, Beumer (1979a) found that *L. unicolor* could tolerate salinities of up to 36 ppt.

Habitat–structural variables

Substrate

Leiopotherapon unicolor was found over a wide range of substrates, predominantly sand (lower-middle quarter), followed by mud (lower-middle quarter), then clay, leaf litter and boulders/rocks (see fig 174). This species is reputed to be able to aestivate in the mud of dried watercourses (Llewellyn 1973). After heavy rains and floods, it rapidly disperses into areas that were previously dry and apparently devoid of fish (Beumer 1979a, Llewellyn 1973).

Hydrophytes

Leiopotherapon unicolor was found in waters with relatively little vegetation (vegetation-occurrence index 62.7%): the order of dominance was submergent, emergent then floating-attached hydrophytes. This species eats considerable quantities of hydrophytes.

---

180 Gehrke (1988b) investigated the feeding energetics of *L. unicolor* and found in aquaria their daily food consumption reduced as water temperature decreased. Fish held at 16.8°C did not grow significantly over a period of 180 days, whereas individuals held at 22.6°C showed a weight increase of 32.8% over the same period. Gehrke (1988c) examined cardio-respiratory responses of *L. unicolor* to temperature. Gehrke and Fielder (1988) examined the effects of temperature on the heart rate, ventilation rate and oxygen consumption of *L. unicolor*.

181 Gehrke (1988c) examined cardio-respiratory responses of *L. unicolor* to dissolved oxygen. Gehrke and Fielder (1988) examined the effects of dissolved oxygen on the heart rate, ventilation rate and oxygen consumption of *L. unicolor*.

Reproduction

Of the 383 *L. unicolor* examined to determine reproductive state, 113 were sexually indistinguishable (length range 11–189 mm LCF), 138 were females (64–231 mm LCF) and 132 were males (61–205 mm LCF).

Length at first maturity

The smallest identifiable maturing female (gonad stage approx. III) was 94 mm LCF; the smallest identified maturing male was 81 mm LCF. Beumer (1979b) found females of 33 mm LCF and males of 34 mm LCF, with the smallest maturing female at 58 and the smallest maturing male at 66 mm. The largest female was 194 mm and the largest male 151 mm, (compare 231 and 205 mm from the Alligator Rivers Region). Llewellyn (1973) found mature females and males at 78 and 58 mm, respectively, amongst fish collected from southern Queensland.

The estimated LFM was around 94 mm LCF for females and 74 mm LCF for males. Calculations for the LFM were based on 10-mm-length groups (fig 119). The length at first maturity of fish collected in north Queensland was 60 mm for both sexes (Beumer 1979b), which is smaller than in the Alligator Rivers Region. The largest specimen was also smaller.

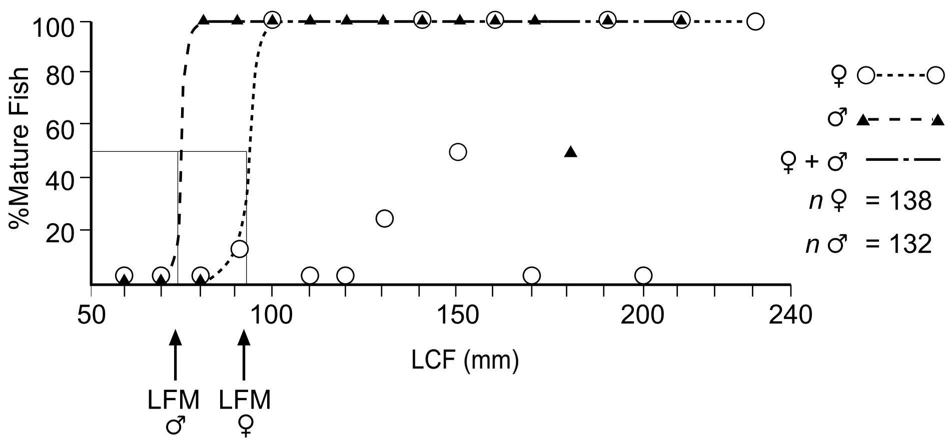


Figure 119 Estimated length at first maturity (LFM) of male and female *L. unicolor*

Sex ratio

During the 1978 Late-dry season significantly more males than females were captured ($0.001 < P < 0.01$), and significantly more adult males than adult females ($0.01 < P < 0.05$); however, there was no significant difference from a 1:1 ratio in any other season (table 99). The 1979 Late-wet–Early-dry season showed a slight increase in the proportion of females, although the difference was not significant. Beumer (1979*b*) found that the ratio was generally 1:1 throughout the system, with a slight increase in the number of males in the pre-flood, and of females in the post-flood, periods.

Breeding season

Leiopotherapon unicolor had a well-defined breeding season during the 1978–79 and 1979–80 Early-wet seasons, although the highest GSIs found in the 1978–79 Early-wet season were higher than in the previous year (fig 120). This may have been because the Wet season proper (ie heavy and frequent rains with stream flow) did not begin until after the 1979–80 Early-wet season sample was taken. The GSI was constant and low for all other seasons, with a slight increase in the Late-dry seasons, which precede spawning.

Table 99 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *L. unicolor* over all habitats

Parameter	Sex	Statistic	Sampling period						
			Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80
Sex ratio									
Juveniles	F	*n*	5	2	20	29	59	29	3
+ adults	M	*n*	18	2	22	17	42	24	7
		χ^2	7.3	0.0	0.1	3.1	2.9	0.4	1.6
	P	**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Adults only	F	*n*	5	2	15	26	55	20	3
	M	*n*	17	2	21	17	42	24	7
		χ^2	6.5	0.0	1.0	1.9	1.7	0.4	1.6
		P	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
GSI									
Adults only	F	mean	0.9	4.3	0.3	0.2	0.4	0.8	3.1
		s.d.	0.5	1.5	0.1	0.1	0.1	0.3	2.3
	M	mean	0.8	5.8	0.1	0.1	0.7	4.5	4.7
		s.d.	0.5	2.7	0.1	0.0	0.1	0.6	1.3
	F+M	mean	0.8	5.1	0.2	0.2	0.2	0.7	3.9
		s.d.	0.5	2.0	0.1	0.1	0.2	0.3	1.7
GMSI									
Adults only	F	mean	3.2	5.5	2.0	2.1	2.1	2.3	4.0
		s.d.	1.1	0.7	1.0	0.2	0.3	0.5	1.0
	M	mean	3.6	4.0	2.2	1.7	1.6	3.8	5.0
		s.d.	1.0	2.8	0.5	0.6	0.7	1.4	0.0
	F+M	mean	3.5	4.8	2.1	1.9	1.9	3.0	4.6
		s.d	1.0	1.9	0.6	0.4	0.5	1.3	0.7

n = number; χ^2 = Chi-squared value; P = probability; n.s. = not significant (P > 0.05); * = 0.01 < P < 0.05; ** = 0.001 < P < 0.001; s.d. = standard deviation.

Mature fish were captured only in the Late-dry and Early-wet seasons (table 100). Two ripe fish were found in the 1978–79 Early-wet season and three males in the 1979 Late-dry season. As with *H. fuliginosus, L. unicolor* males were found running-ripe before the floods but females were not yet ready to spawn.

Most of the spent females were caught in the 1978–79 Mid-wet and Late-wet–Early-dry seasons, with one spent female being caught in the 1979–80 Early-wet, indicating there may have been some spawning before the floods. Juveniles (11–35 mm LCF) were captured only during the 1978–79 Early-wet season.

Other studies on *L. unicolor* support these results. Llewellyn (1973) found running-ripe fish in south-eastern Queensland during September–October. In ponds at Narrandera, this fish spawned from November through to mid-February, when water temperatures rose to about 26°C at the surface and 22°C at the bottom. An increase in water level seemed to trigger spawning if the temperatures were suitable.

In north Queensland, both sexes mature rapidly between September and October (Beumer 1979b), and spawn around December–February, depending on the time of onset of Wet season flooding. Ripe specimens were found only before and during floods, and spent fish were found during the floods. No juveniles were captured before the floods.

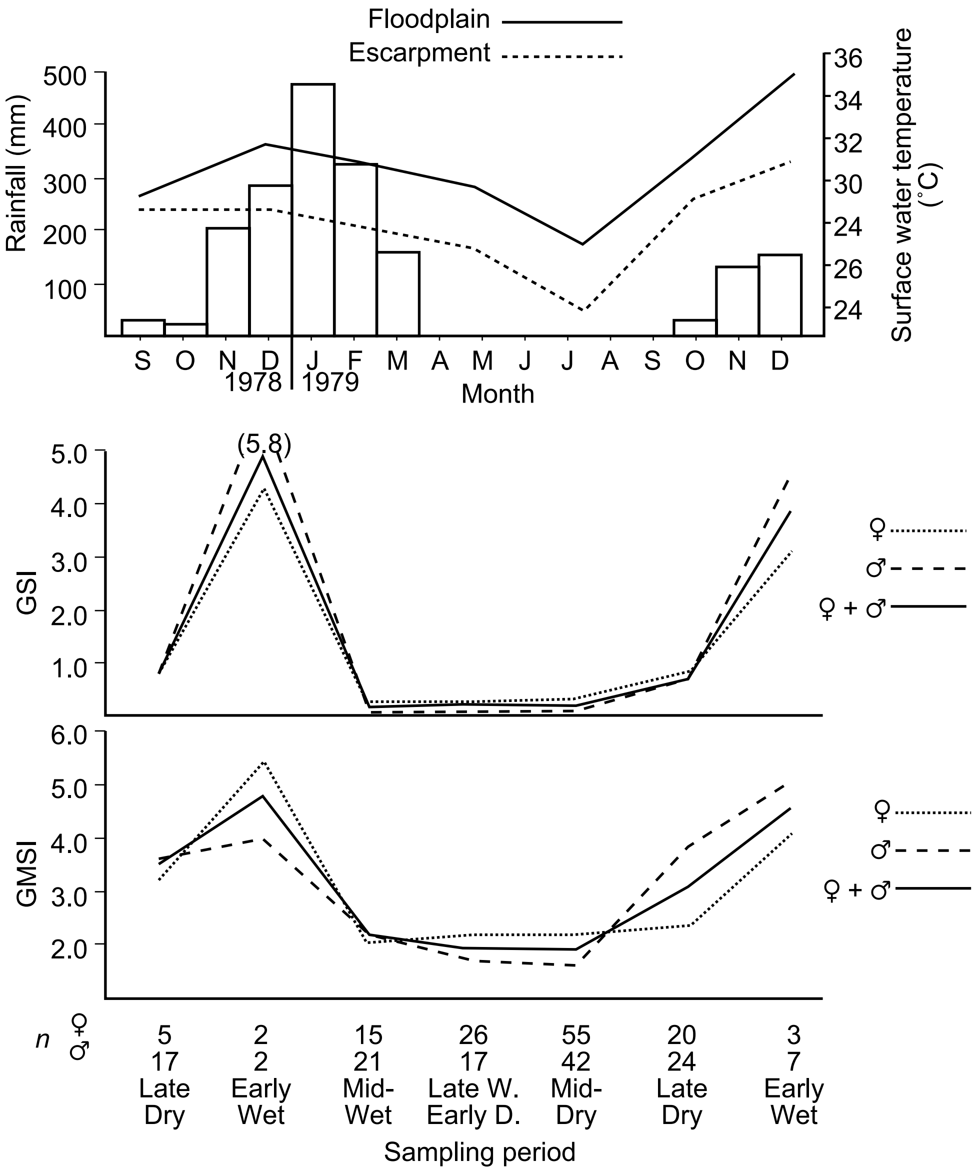


Figure 120 Seasonal fluctuations in the gonadosomatic index (GSI) and the gonad maturing stage index (GMSI) of male and female *Leiopotherapon unicolor*

Table 100 Possible sites of spawning of *Leiopotherapon unicolor,* as indicated by the abundance (*n*) of mature, ripe, spent and juvenile fish

	Gonad stage						
	Mature (V)		Ripe (VI)		Spent (VII)		Juveniles
Habitat	F	M	F	M	F	M	
Escarpment							
Mainchannel waterbody	–	2	–	–	1	4	–
Lowlands							
Sandy creekbed	1	3	–	–	2	1	79
Backflow billabong	–	9	1	4	8	6	32
Corridor	–	–	–	–	–	1	17
Floodplain billabong							
Upper	–	–	–	–	–	1	–

Site of spawning

Mature, ripe, spent and juvenile fish were captured from lowland shallow backflow billabongs. Although running-ripe fish were not captured from any other habitat, mature, spent and juvenile fish were captured from sandy creekbeds, spent and juvenile fish from corridor waterbodies, and spent fish from floodplain billabongs (table 100).

The fish was probably spawning in the backflow billabongs and possibly the sandy creekbeds, and the eggs, larvae or juveniles were washed down into the corridor waterbodies.

Beumer (1979b) recorded a spawning migration for this species in coastal north Queensland with fish moving towards the upper reaches during floods.

Although *L. unicolor* does not readily spawn in small bodies of water (Llewellyn 1973), it will breed in dams (Merrick 1980). Spawning is believed to take place at night (Llewellyn 1973, Merrick 1980) in the shallows of lentic waterbodies (Llewellyn 1973).

Since *L. unicolor* breeds during the Wet season, the above information suggests that it could be spawning in backwaters and still pools of the billabongs and sandy creekbeds.

Fecundity

Two ovaries only were examined. One weighed 0.92 g and contained 15 600 eggs with diameters ranging from 0.24–0.32 mm, while the other weighed 3.36 g and contained about 80 000 eggs with a mean diameter of 0.27 mm (± 0.03). The mean fecundity was therefore around 48 000, and the mean egg diameter around 0.27 mm.

Llewellyn (1973) found that the fecundity increased with the increasing weight of the fish: fish of 24 and 64 g contained 24 000 and 113 200 eggs, respectively. Beumer (1979b) recorded fecundities ranging from 1727 to 81 755, and means for two consecutive breeding seasons of 16 030 and 23 978.

The egg diameters reported in the literature are larger than those found in the present study; probably these eggs were not fully mature. Llewellyn (1973) records a diameter of 0.68 mm when fresh and 0.71 mm when water-hardened. Beumer (1979b) records the average egg diameter from ripe fish as 0.6 mm, with egg diameters from all parts of the ovary generally showing a unimodal distribution.

The eggs are demersal, spherical, transparent and non-adhesive. They contain a single oil globule and have a thin perivitelline space. The eggs are spawned and randomly dispersed as the fish swims through the shallows, where they settle on the bottom. They hatch 45–55 hours after fertilisation at 23–26.4°C and the newly hatched prolarvae are small (2.2 mm) and generally not well developed (Llewellyn 1973). The yolk sac is completely resorbed in about three days (Llewellyn 1971).

Summary

Leiopotherapon unicolor had a well-defined breeding period during the Early-wet season, and probably spawned in the shallows of still backwaters and pools in the lowland backflow billabongs and sandy creekbed. Spawning probably occurred at night and the eggs were randomly dispersed over the bottom as the fish swam through the shallows (Llewellyn 1973). A large number of tiny, demersal, non-adhesive eggs are scattered over the substrate. After a very short (less than 50 hours) incubation period, they hatch into small (2.2 mm), poorly developed prolarvae (Llewellyn 1973). The yolk sac is resorbed after about three days. Our results suggest growth is rapid, with fish attaining at least 11 mm within a few weeks. *Leiopotherapon unicolor* have grown to greater than the LFM within one year in good conditions (Llewellyn 1973).

The LFM was estimated at 90 mm for females and 80 mm for males. Llewellyn (1973) and Beumer (1979b) recorded that the species was sexually dimorphic at breeding: female urinogenital papillae are enlarged and bulbous and exceed the anus in diameter, whereas those of males are smaller than the diameter of the anus.

Feeding habits

Overall diet

The stomachs of 371 specimens were examined; 342 contained food. The diet of *L. unicolor* is summarised in figure 121; the components are listed in table 101. The main components were aquatic insects (46%), hydrophytes (12%) and teleosts (9%). The aquatic insect component consisted mainly of baetid and chironomid larvae. *Najas* was the main hydrophyte eaten and *C. marianae* and *Ambassis* spp. were the most common identifiable teleosts. A wide variety of other plants and animals was eaten, including algae (5%) (mainly green filamentous species), terrestrial plant material (6%), microcrustaceans (6%, mainly cladocerans), macrocrustaceans (3%) and traces of oligochaetes, gastropods, arachnids, terrestrial insects, detritus and unidentified organic material. *Leiopotherapon unicolor* can therefore be classified as an opportunistic meiophagic omnivore taking food items from mid-water and benthic areas of the waterbodies.[182]

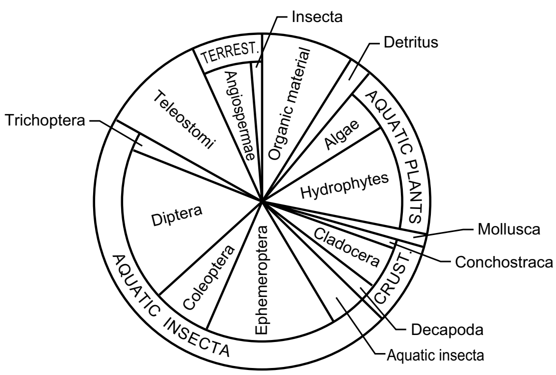


Figure 121 The main components of the diet of *L. unicolor*

Lake (1978) reported that the food of this species was mainly small invertebrates, including aquatic insects, crustaceans, molluscs and some plant material. Pollard (1974) noted that this species feeds principally on freshwater shrimps and insects, but will readily eat smaller fishes. Merrick (1974) concluded from examining the stomach contents of nine specimens that *Madigania* (syn. *L. unicolor*) was primarily a carnivore, but due to 'accidental uptake', the terrestrial plant content was high in some specimens. However, the herbivorous component of the diet in the Alligator Rivers Region appears to be an important part of this species' food.

182 Gehrke (1988a) investigated the gut morphology of *L. unicolor* and concluded that the small conical teeth on the jaws and pharynx, a simple Y-shaped stomach and a short gut were characteristic of an opportunistic carnivorous fish. Gehrke further found that the capture of prey small enough to swallow whole was assisted by suction created as the mouth opened to engulf prey. Crustaceans to large to ingest whole were broken into smaller pieces against the substrate. Directional and oscillatory movement were the most effective sensory cues in eliciting feeding behaviour. The frequency with which *L. unicolor* responded to cues increased with hunger.

Table 101 Dietary composition of *L. unicolor*

Stomach contents	Habitat: Magela system Em	Ls	Lb	Cb	Fb	Nourlangie system Em	Ep	Lb	Season: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Overall Sub-mean	Main-mean
Aquatic plants																	
Algae																	4.8
Miscellaneous	–	0.4	1.1	–	–	–	–	–	–	–	–	0.6	1.8	–	–	0.6	
Conjugatophyta																	
Mougeotia	2.6	–	0.3	–	9.1	14.6	–	–	4.8	–	6.8	–	0.5	–	–	1.5	
Spirogyra	10.2	0.4	1.4	–	–	29.2	–	1.6	–	–	12.8	–	2.7	–	–	2.7	
Hydrophytes																	12.0
Eriocaulon	–	0.4	1.7	–	–	–	–	–	–	–	3.9	2.5	–	–	–	0.9	
Najas	–	10.3	14.7	–	–	–	–	5.0	–	0.8	3.7	39.7	12.7	–	–	9.1	
Vallisneria	–	2.1	2.4	–	9.1	–	–	–	–	–	–	11.9	1.0	–	–	2.0	
Aquatic animals																	
Oligochaeta	–	–	0.5	–	–	–	–	–	–	–	1.6	–	–	–	–	0.2	0.2
Gastropoda																	0.9
Amerianna	–	–	1.5	–	–	–	–	2.5	–	–	–	0.4	2.8	–	–	0.9	
Segnitilia	–	–	–	–	–	–	–	6.3	–	–	–	–	0.1	–	–	+	
Arachnida																	0.2
Hydracarina	–	–	0.3	–	–	–	–	–	–	–	–	–	–	1.3	–	0.2	
Microcrustacea																	6.4
Conchostraca																	
Cyzicus	–	1.2	1.4	2.2	–	–	–	–	–	3.5	0.1	–	–	2.4	–	1.0	
Cladocera																	
Miscellaneous	–	–	2.2	19.4	–	–	–	–	–	6.8	–	0.8	–	–	–	1.6	
Diaphanosoma	–	3.7	3.7	10.6	–	–	–	6.3	–	6.2	–	–	1.3	5.0	27.8	3.0	
Ostracoda	–	1.0	0.2	2.8	–	–	–	0.3	–	2.0	–	–	0.1	–	–	0.4	
Copepoda																	
Miscellaneous	–	–	–	–	–	–	–	–	4.8	–	–	–	–	–	–	0.3	
Cyclops	–	–	0.2	–	–	–	–	–	–	–	–	–	–	1.0	–	0.1	
Macrocrustacea																	2.6
Macrobrachium	–	3.8	1.9	–	3.6	8.3	–	–	4.8	–	5.7	0.1	3.5	–	4.4	2.3	
Hymanosomatidae																	
P. transversa	–	–	0.6	–	–	–	–	–	–	–	–	2.0	–	–	–	0.3	

Table 101 continued

Stomach contents	Habitat: Magela system Em	Ls	Lb	Cb	Fb	Nourlangie system Em	Ep	Lb	Season: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Overall Sub-mean	Main-mean
Insecta																	45.7
Fragmented	11.9	5.9	0.6	–	8.2	10.8	40.0	3.7	14.3	1.4	6.3	–	5.3	4.5	–	4.2	
Ephemeroptera																	
Baetidae	0.2	20.3	13.7	10.6	–	0.4	–	17.5	1.0	38.4	2.8	9.1	9.9	–	–	12.9	
Atalophlebia	–	1.2	1.9	–	–	–	–	–	–	5.8	–	–	–	–	–	1.3	
Odonata																	
Coenagrionidae	–	3.2	–	–	–	–	–	–	–	3.5	–	–	–	–	–	0.8	
I. heterosticta	–	–	2.5	–	–	–	–	26.9	–	–	7.5	5.9	1.9	–	–	2.5	
Gomphidae	–	0.7	0.6	–	–	–	–	–	4.8	0.8	–	–	–	–	–	0.5	
Libellulidae	0.2	2.6	3.0	–	9.1	6.7	–	–	0.5	0.7	8.0	1.6	3.6	0.3	–	2.7	
Aeshnidae	–	–	–	–	7.3	–	–	–	–	–	1.6	–	–	–	–	0.2	
Hemiptera																	
Miscellaneous	–	–	0.2	–	9.1	–	–	–	–	–	–	0.8	–	–	–	0.1	
Naucoridae	–	–	1.8	–	–	–	–	–	–	0.5	2.3	2.7	1.2	–	–	1.2	
Anisops	–	–	–	–	–	1.3	–	–	–	–	–	–	0.2	–	–	+	
Corixidae	–	6.2	2.1	11.1	–	–	–	0.9	0.5	7.4	0.1	0.6	2.4	4.2	–	2.9	
Coleoptera																	
Miscellaneous (adults)	1.3	5.2	0.2	–	–	–	–	–	9.8	–	–	–	1.8	5.5	–	1.8	
Miscellaneous (larvae)	–	1.8	1.3	–	–	–	–	–	–	5.0	–	–	–	–	–	1.1	
Diptera																	
Miscellaneous (larvae)	–	–	0.4	–	–	–	–	–	–	–	–	1.3	–	–	–	0.2	
Culicidae	0.2	–	–	–	–	–	–	–	–	–	0.1	–	–	–	–	+	
Chaoborinae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	21.1	0.3	
Chironomidae (larvae)	10.4	12.2	8.3	7.8	–	6.7	–	–	6.2	12.5	0.3	1.4	19.1	10.3	–	10.1	
Chironomidae (pupae)	–	1.0	0.8	3.3	–	–	–	–	–	2.0	–	0.6	0.1	1.8	–	0.7	
Ceratopogonidae	–	0.5	–	–	–	–	–	–	–	–	–	–	0.4	–	–	0.1	
Tabanidae	–	0.6	–	–	–	–	–	–	–	–	–	–	–	1.3	–	0.2	
Trichoptera																	
Hydroptilidae	–	–	0.1	–	–	–	–	–	–	–	–	–	0.2	–	–	0.1	
Leptoceridae	2.2	0.9	2.4	–	–	–	–	3.1	–	0.2	6.6	0.4	2.2	–	–	1.7	
Lepidoptera																	
Pyralidae	–	–	0.2	–	–	–	–	–	–	–	–	–	0.3	–	–	0.1	
Teleostomi																	9.0
Fragmented	–	2.4	4.9	10.0	10.9	2.5	–	1.3	–	–	4.9	4.3	3.2	11.5	6.7	3.8	

Table 101 continued

Stomach contents	Habitat: Magela system Em	Ls	Lb	Cb	Fb	Nourlangie system Em	Ep	Lb	Season: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Overall Sub-mean	Main-mean
Scales	3.7	0.2	0.1	–	–	11.7	–	–	–	–	2.6	0.4	1.0	0.5	1.1	0.8	
Scleropages (scale)	–	–	0.1	–	–	–	–	–	–	–	–	0.4	–	–	–	0.1	
Neosilurus spp.	–	–	0.6	–	–	–	–	–	–	–	–	–	1.0	–	–	0.3	
M. splendida	–	–	0.4	11.1	–	–	–	–	–	–	2.0	1.2	–	–	–	0.5	
C. marianae	3.5	4.5	–	–	–	–	–	–	2.9	–	–	–	–	9.3	10.6	1.5	
Ambassis spp.	–	–	2.2	–	–	–	–	–	1.4	–	–	1.5	3.0	–	–	1.2	
D. bandata	–	–	–	11.1	–	–	–	–	–	–	2.0	–	–	–	–	0.3	
G. giuris	–	–	0.5	–	–	–	–	–	–	–	–	–	0.9	–	–	0.3	
M. mogurnda	–	–	0.4	–	–	–	–	–	–	–	1.4	–	–	–	–	0.2	
Terrestrial plants																	
Angiospermae																	6.3
Miscellaneous	18.2	1.7	8.3	–	–	–	–	–	11.0	1.3	2.0	6.5	4.9	21.0	5.0	5.2	
Seed material	–	–	0.2	–	–	–	–	–	–	–	–	0.4	0.1	–	–	0.1	
Terrestrial animals																	
Insecta																	1.2
Fragmented	7.0	0.2	0.5	–	–	–	–	–	–	–	–	0.2	0.7	0.5	21.1	0.9	
Orthoptera																	
Miscellaneous	3.7	–	–	–	–	–	–	–	–	–	–	–	1.0	–	–	+	
Egg material	–	–	0.5	–	–	–	–	–	–	–	1.8	–	–	–	–	0.1	
Hymenoptera																	
Miscellaneous	–	–	0.2	–	–	–	–	–	–	–	–	–	–	1.0	–	0.1	
Formicidae	1.7	–	–	–	–	–	–	–	–	–	–	–	0.4	–	0.6	0.1	
Parasites																	0.5
Cestoda	–	–	0.6	–	–	–	–	–	–	–	–	–	–	–	11.7	0.3	
Nematoda	0.4	0.2	0.2	–	–	–	–	–	–	0.1	0.5	0.6	0.1	–	–	0.2	
Detrital material	–	–	3.2	–	–	–	–	–	–	–	–	–	–	13.8	–	1.6	1.6
Bait material	10.9	–	–	–	–	–	–	–	14.1	–	–	–	–	–	–	0.9	0.9
Inorganic material	–	0.1	–	–	–	0.4	–	–	–	–	0.1	–	0.1	–	–	+	+
Organic material	11.9	5.2	3.0	–	33.6	7.5	60.0	24.6	19.5	1.4	11.5	1.8	8.5	5.0	–	6.5	6.5
Number of empty fish	3	4	14	–	1	3	3	1	4	2	4	–	14	4	1	29	29
Number of fish with food	27	82	171	9	11	5	2	16	21	74	51	49	98	40	9	342	342

Figures represent the mean percentage volume determined by the estimated volumetric method.

Em = escarpment mainchannel; Ep = escarpment perennial stream; Ls = lowland sandy creekbed; Lb = lowland backflow billabong; Cb = corridor billabong; Fb = floodplain billabong; + = present (<0.1%)

Seasonal changes

In sampling periods 1–7, respectively, 25 (16% empty), 76 (3% empty), 55 (7% empty), 49 (0% empty), 112 (13% empty), 44 (9% empty) and 10 (10% empty) stomachs of *L. unicolor* were examined (all habitats combined). The highest proportions of specimens with empty stomachs was in the 1979 Late-dry season and the lowest in the 1979 Late-wet–Early-dry season.

The diet in the 1978 Late-dry season was based primarily on aquatic insects, terrestrial plant material, and smaller teleost, micro- and macrocrustacean and algal components; large amounts of unidentified organic material were also found in the stomachs. During the 1978–79 Early-wet season the aquatic insect component of the diet strengthened (shifting to mainly baetid larvae) as did the microcrustacean (mainly cladoceran) component. The diet in the Mid-wet season had a more varied but slightly less important aquatic insect component, and filamentous green algae, hydrophytes and teleosts became more important.

By the Late-wet–Early-dry season the hydrophyte component of the diet had increased dramatically (mainly *Najas* and *Vallisneria*), as had the terrestrial plant material.

The diet in the 1979 Mid-dry season was varied and still had a strong aquatic insect (mainly chironomid and baetid larvae) component and a smaller hydrophyte component.

During the 1979 Late-dry and 1979–80 Early-wet seasons the algal and hydrophyte components had disappeared from the diet, as was more or less apparent during the same seasons in 1978. During the 1979 Late-dry season, teleosts (mainly *Ambassis* spp.) and terrestrial plant material were important in the diet, together with aquatic insects (mainly chironomid larvae) and detritus. The few specimens examined in the 1979–80 Early-wet season had eaten microcrustaceans (*Diaphanosoma*), aquatic insects (chaoborinid larvae), teleosts (mainly *C. marianae* from sandy creeks) and terrestrial insects. Many cestode parasites were found in the stomachs in this season.

Habitat differences

Magela catchment

A total of 322 stomachs of *L. unicolor* were examined (all seasons combined): 30 (10% empty), 86 (5% empty), 185 (8% empty), 9 (0% empty) and 12 (8% empty), 30 (10% empty) from escarpment mainchannel waterbodies, 86 (5% empty) from lowland sandy creekbeds 185 (8% empty) from lowland backflow billabongs, 9 (0% empty) from corridor billabongs and 12 (8% empty) from floodplain billabongs. The highest proportions of specimens with empty stomachs were in escarpment waterbodies and the lowest proportions in corridor waterbodies (sample sizes were small).

In the escarpment mainchannel waterbodies, *L. unicolor* ate terrestrial plant material and fairly equal proportions of green filamentous algae, aquatic insects (mainly chironomid larvae), teleosts (many *C. marianae*) and terrestrial insects. In the lowland sandy creekbeds it ate more aquatic insects (baetid and chironomid larvae). Few terrestrial insects and little plant material were eaten, though more micro- and macrocrustaceans were eaten and the algal component was replaced by hydrophytes.

The diet in the backflow billabongs was again based primarily on aquatic insects, but with more hydrophytes and a greater variety of teleosts (plotosids, *M. splendida inornata, Ambassis* spp., *G. giuris* and *M. mogurnda*). In the corridor waterbodies *L. unicolor* had not eaten algae or hydrophytes, but had eaten fairly equal proportions of microcrustaceans (mainly cladocerans), aquatic insects (baetid and chironomid larvae and corixids) and teleosts (*M. splendida inornata* and *D. bandata*). The diet in the floodplain habitats had a large organic component (presumably digested fish flesh) and fairly equal proportions of aquatic insects, algae, hydrophytes and teleosts.

Nourlangie catchment

A total of 31 stomachs of *L. unicolor* were examined (all seasons combined): 8 (38% empty) from escarpment mainchannel waterbodies and 5 (60% empty) from perennial streams, and 18 (6% empty) from backflow billabongs. The highest proportions of specimens with empty stomachs were in escarpment perennial streams and the lowest proportions in backflow billabongs. The proportion of empty fish in the escarpment mainchannel waterbody was much higher than in the equivalent Magela Creek habitat.

The green filamentous algae and aquatic insects components in the diet in the escarpment mainchannel waterbody were large; macrocrustaceans were also found in the stomachs though, unlike the Magela Creek catchment, no terrestrial insects or plant material. The diet of the few specimens examined in the escarpment perennial stream was based mainly on aquatic insects, together with large volumes of unidentified organic material. In the lowland backflow billabongs the diet was again based mainly on aquatic insects (*I. heterosticta* and baetid larvae) with smaller hydrophyte and gastropod components.

Fullness

A summary of mean fullness indices of *L. unicolor* in different sampling periods and habitat types is shown in table 102. These data are presented on the assumption that feeding times do not vary with habitat or season.

Seasonal changes

After the 1978 Late-dry season the mean fullness index (all habitats combined) peaked in the 1978–79 Early-wet season. It then fell during the Mid-wet season, increased in the Late-wet–Early-dry season, and gradually fell through the Mid-dry season to reach a low in the 1979 Late-dry season (close to the level of the 1978 Late-dry season). The index increased dramatically in the 1979–80 Early-wet season, as it had done the previous year.[183]

Habitat differences

In the Magela catchment upstream from RUPA, mean fullness indices were highest in the shallow backflow billabongs and lowest in the lowland sandy creekbeds (and much lower than in equivalent downstream habitats; however, sample sizes were small). Downstream of RUPA the mean indices were highest in shallow backflow billabongs and sandy creekbeds and lowest in corridor waterbodies.

In the Nourlangie catchment, fullness indices were also highest in the shallow backflow billabongs. The fullness indices in escarpment mainchannel habitats were lower than those recorded in the equivalent Magela Creek habitat.

183 Gehrke (1988b) found that *L. unicolor* caught by angling in winter has less food in their stomachs (0.31% body weight) than fish caught in other seasons (4.9% in spring to 3.1% in autumn).

Table 102 Mean fullness indices for *Leiopotherapon unicolor* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments

Habitat	Sampling period							Habitat mean
	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80	
Magela Creek catchment (regular sites only)								
Upstream of RUPA:								
Escarpment main-channel waterbody	4.3 (4)	n/s	1.8 (6)	n/s	2.1 (18)	0 (1)	4.0 (3)	2.5 (32)
Lowland shallow backflow billabong	0 (1)	n/s	3.5 (15)	n/s	4.0 (6)	3.3 (6)	n/s	3.4 (28)
Lowland sandy creekbed	n/s	0 (1)	n/s	n/s	2.0 (2)	n/s	n/s	0.7 (3)
Downstream of RUPA:								
Lowland sandy creekbed	4.0 (2)	3.3 (36)	2.7 (7)	3.4 (8)	1.8 (17)	2.8 (13)	n/s	2.9 (83)
Lowland channel backflow billabong	0 (1)	2.0 (4)	0 (1)	3.3 (11)	2.4 (27)	2.3 (7)	2.8 (4)	2.5 (55)
Lowland shallow backflow billabong	n/s	4.2 (31)	0 (1)	3.0 (24)	3.3 (29)	1.3 (15)	4.5 (2)	3.1 (102)
Corridor sandy billabong	n/s	n/s	3.0 (2)	n/s	n/s	1.0 (2)	n/s	1.0 (4)
Corridor anabranch billabong	n/s	0 (1)	0 (1)	n/s	n/s	n/s	n/s	0 (2)
Floodplain billabong	n/s	3.7 (3)	1.8 (9)	3.5 (2)	0 (1)	n/s	n/s	2.3 (15)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	n/s	n/s	1.4 (12)	n/s	1.7 (3)	n/s	n/s	1.5 (15)
Lowland shallow backflow billabong	0.5 (2)	n/s	n/s	3.8 (4)	3.8 (11)	n/s	n/s	3.4 (17)
Seasonal mean (all sites)	2.2	3.5	2.5	3.2	2.7	2.1	3.6	

Numbers analysed are given in parentheses; n/s = not sampled in the habitat.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

- lowland shallow backflow billabongs (downstream of RUPA); 1979–80 Early-wet season
- lowland shallow backflow billabongs; 1978–79 Early-wet season
- escarpment mainchannel waterbody; 1978 Late-dry season

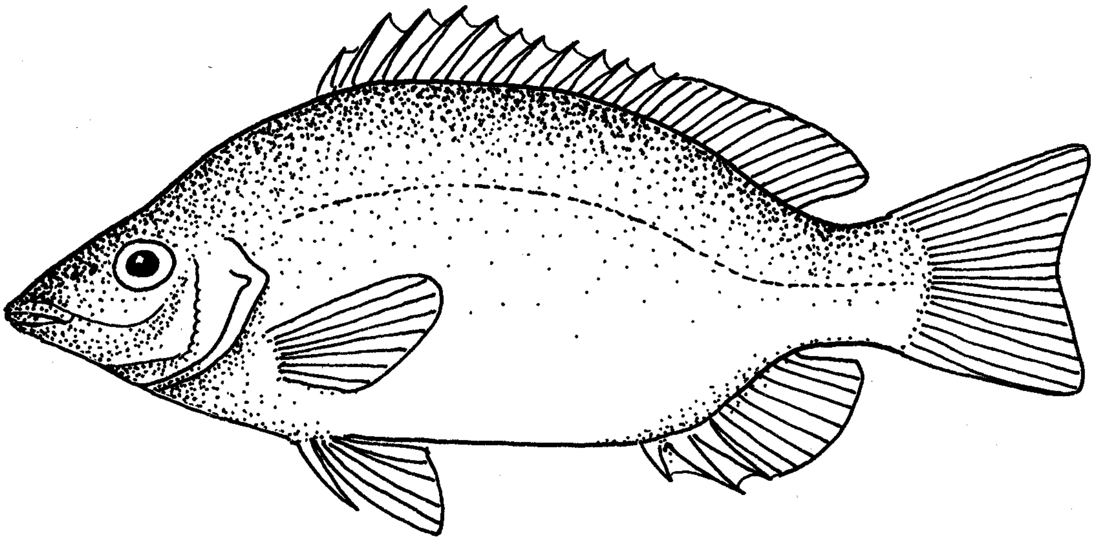
Nourlangie catchment

- lowland shallow backflow billabongs; 1978–79 Late-wet–Early-dry season
- lowland shallow backflow billabongs; 1979 Mid-dry season.

Family TERAPONTIDAE

3.27 *Syncomistes butleri* (Vari)

Syncomistes butleri is commonly known as Butler's grunter, or the sharp-nose grunter, as Lake (1978) called it before it was described. It is endemic to Australia. Its known distribution is from the Bow River in northern Western Australia to the East Alligator River in the Northern Territory. Pollard (1974) and Midgley (1973), who referred to this species as *Mesopristes* sp. and *Therapon* sp., respectively, collected them from Tin Camp and Magela Creeks (East Alligator River system) and from Deaf Adder and Hickey Creeks (South Alligator River system).



Syncomistes butleri

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was found commonly in all escarpment mainchannel waterbodies and perennial streams, and in sandy corridor waterbodies. It was found rarely in lowland sandy creekbeds. It was found in the greatest number of sites in the Mid-wet season and in the fewest in the 1978 Late-dry season.

Size composition

The lengths and weights of 43 specimens were determined.

Length–weight relationship

The length–weight relationship for the combined sexes was described by the expression:

$$W = 7.38 \times 10^{-3} L^{3.29} \qquad r = 0.86 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 103. The few specimens captured in the 1978–79 Early-wet, 1979 Mid-dry and 1979 Late-dry seasons had very high condition factors, in contrast to those captured in the Mid-wet and 1979–80 Early-wet seasons. Poor condition in the Mid-wet season may be attributable to spawning activity. Annual variation in condition between the Late-dry and Early-wet seasons was high.

Table 103 Mean length, mean weight and condition factor of *S. butleri*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	12	253.6	315.19	1.03
Early-wet (1978–79)	3	267.2	429.12	1.18
Mid-wet	11	206.0	126.13	0.82
Mid-dry(1979)	10	241.8	312.16	1.19
Late-dry	2	288.5	556.08	1.19
Early-wet (1979–80)	5	187.1	96.60	0.86
Overall	43	238.1	227.48	1.00

Length-frequency distribution

Specimens captured ranged in size from 122 mm to 320 mm LCF (fig 122). Lake (1978) noted that this species grows to only 120 mm, while Vari (1978) said that it reaches 200 mm TL. The specimens captured in the study area are therefore considerably larger than the largest previously recorded.

The mean length of all specimens captured was 232 mm LCF. The LFM for males and females was estimated to be 125 and 235 mm LCF, respectively, indicating that most of the specimens captured were adults. The peaks in the overall distribution can be attributed to the mesh selectivity of the gillnets in which most *S. butleri* were captured. The absence of juveniles in the samples is puzzling; however, small unidentified theraponids were observed in escarpment and lowland sandy creekbeds in the Mid-wet season.

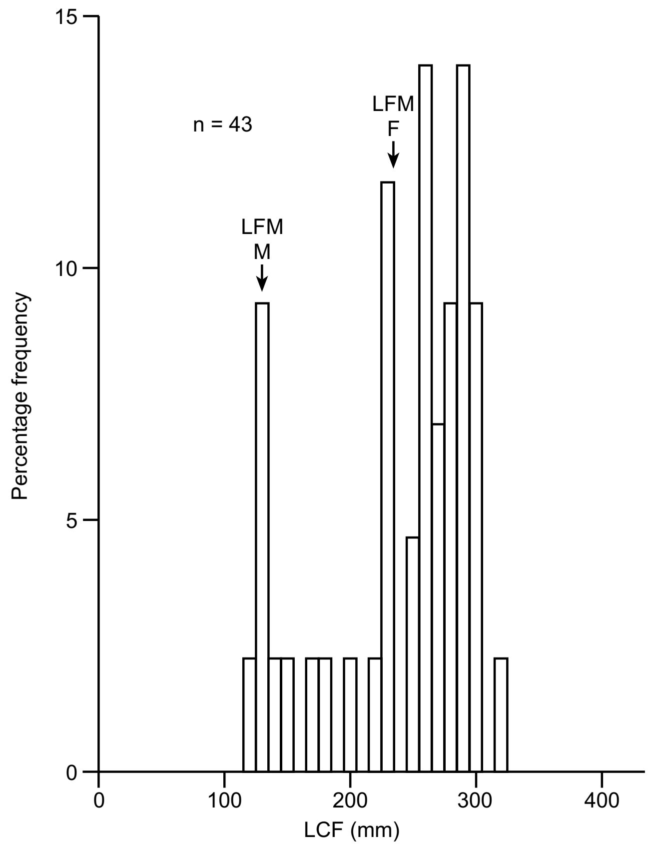


Figure 122 Length-frequency distribution of *S. butleri*

Seasonal changes in distribution

The smallest specimen was captured in the Mid-dry season and the largest in the 1979 Late-dry season. The mean seasonal lengths were highest during the 1979 Late-dry season and lowest in the 1979–80 Early-wet season (table 103); low mean lengths were also recorded in the Mid-wet season. The period of juvenile recruitment to the populations is unknown, as few small specimens were captured.

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *S. butleri* captured in regular sampling sites in the Magela catchments are given in figure 123.

Magela catchment

The smallest specimens were captured mainly in escarpment mainchannel waterbodies and to a lesser extent in lowland sandy creekbeds. Most of the larger specimens captured were in sandy corridor waterbodies; however, large specimens were also captured in escarpment mainchannel waterbodies, and some appeared in the lower reaches of escarpment perennial streams during the Late-wet–Early-dry season.

Nourlangie catchment

A wide size range of *S. butleri* were observed in escarpment mainchannel waterbodies. A similar size range was found in escarpment perennial streams in the Mid-wet season and during the remainder of the study. A few large specimens were captured in occasionally sampled sandy corridor waterbodies.

Environmental associations

Rank numbers for *S. butleri* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

Both surface and bottom temperatures ranged from 23° to 34°C, with means of 28.9°C and 28.4°C, respectively. These means were ranked in the lower and lower-middle quarters (see fig 170). Most *S. butleri* captured in this study were found in cooler escarpment streams, although a few were taken from corridor waterbodies in the lower reaches.

Dissolved oxygen

Dissolved oxygen concentrations in waters in which *S. butleri* was captured ranged from 5.0 to 7.4 mg/L (mean = 6.2) on the surface, and from 3.8 to 7.2 mg/L. (mean = 5.7) on the bottom. These means ranked in the upper-middle and upper quarters, respectively (see fig 171). As with other generally escarpment-dwelling fish (eg *H. fuliginosus*), the high bottom water DO is indicative of the cooler, well-mixed waters of escarpment streams.

Visibility

Secchi depths ranged from 50 to 360 cm, with a mean of 171 cm (see fig 172). This mean was placed in the upper quarter, indicating the clear waters in which *S. butleri* was typically found (see also Vari 1978).

pH

Surface and bottom pH values had the same range (4.5–6.7) and mean (5.9). The mean surface water pH was placed in the lower quarter, whilst the mean bottom water pH was placed in the lower-middle quarter (see fig 173).

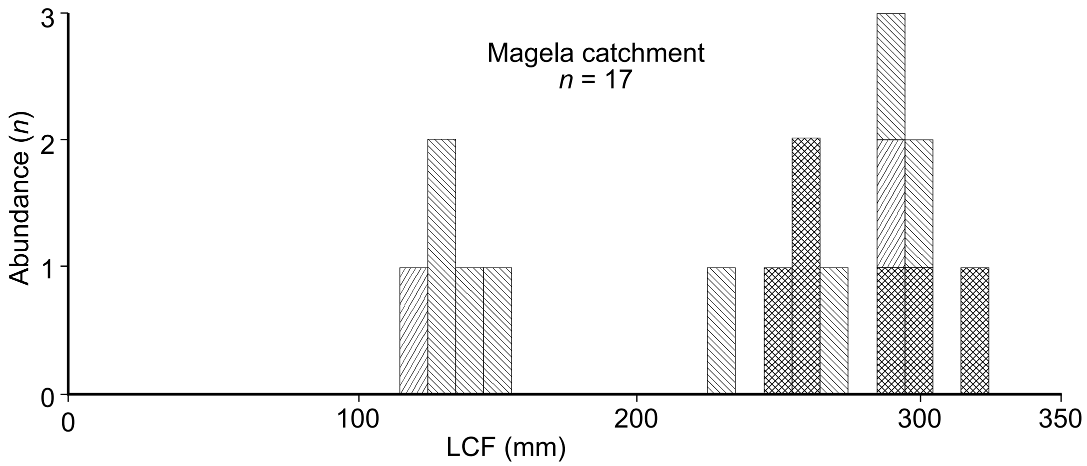


Figure 123 Length-frequency distributions and habitat preferences of *S. butleri* captured at regular sampling sites (see appendix 5 for key to the habitats)

Conductivity

Conductivity readings on the surface were between 2 and 50 µS/cm, and on the bottom between 2 and 60 µS/cm. Such low conductivities suggest that this species is associated with perennially flowing waters, which is confirmed by its distribution in escarpment streams.

Habitat–structural variables

Substrate

Syncomistes butleri was most commonly found in waters with a sand substrate, followed in descending order of dominance by rock, clay, and boulder substrates. The percentage dominance values for sand and boulders both ranked in the upper quarter (see fig 174). Sandy, rocky or boulder substrates are characteristic of the escarpment streams in which this species was commonly found (see also Vari 1978).

Hydrophytes

As with other primarily escarpment-dwelling species, *S. butleri* was found in waters with a very low hydrophyte content (vegetation-occurrence index 40%). The most abundant vegetation was emergent, followed distantly by submergent and then floating unattached hydrophytes.

Reproduction

A total of 42 *S. butleri* were examined for reproductive condition: 21 females (length range 122–304 mm LCF), 19 males (125–320 mm LCF) and 2 that were sexually indistinguishable (129 and 166 mm LCF).

Length at first maturity

Because the sample is small, the usual method for estimating the LFM could not be used. Estimation of the LFM is further complicated by the length range of fish captured, particularly of females. No female fish were captured between 150 mm (all to this size were immature) and 225 mm LCF (one spent female) (fig 124). The LFM may be somewhere between these two lengths; it is taken here to be 235 mm LCF. The smallest males captured were mature, and the LFM was taken as that length (125 mm LCF); the actual LFM could be smaller.

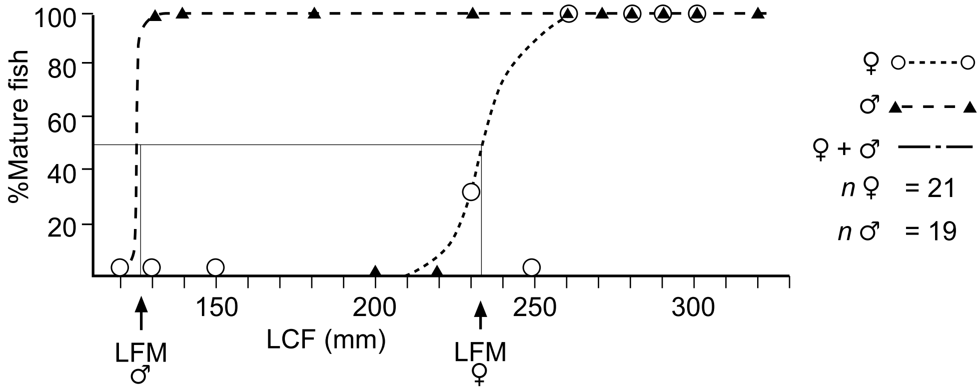


Figure 124 Estimated length at first maturity (LFM) of *S. butleri*

Sex ratio

No significant differences from a 1:1 ratio of males to females were found for either juvenile + adult fish or adult fish only in any season (table 104).

Table 104 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *S. butleri* over all habitats

Parameter	Sex	Statistic	Sampling period						
			Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80
Sex ratio									
Juveniles	F	*n*	5	2	4	0	7	1	2
+ adults	M	*n*	4	1	7	0	3	1	3
		χ^2	0.1	0.3	0.8	–	1.6	0.0	0.2
		P	n.s.	n.s.	n.s.	–	n.s.	n.s.	n.s.
Adults only	F	*n*	5	2	3	0	6	1	1
	M	*n*	4	1	7	0	3	1	3
		χ^2	0.1	0.3	1.6	–	1.0	0.0	1.0
		P	n.s.	n.s.	n.s.	–	n.s.	n.s.	n.s.
GSI									
Adults only	F	mean	4.8	4.2	1.8	–	0.2	1.5	10.7
		s.d.	1.5	1.4	2.3	–	0.2	–	–
	M	mean	2.7	2.7	0.2	–	0.2	2.5	2.1
		s.d.	0.7	–	0.1	–	0.2	–	3.0
	F+M	mean	4.0	3.5	0.6	–	0.2	2.0	4.25
		s.d.	1.5	1.1	1.3	–	0.2	0.7	4.9
GMSI									
Adults only	F	mean	5.8	2.0	1.0	–	1.1	3.0	5.0
		s.d.	0.4	0.0	0.0	–	0.4	0.0	0.0
	M	mean	6.0	6.0	2.1	–	2.7	6.0	5.3
		s.d.	0.0	0.0	0.9	–	1.2	0.0	0.6
	F+M	mean	5.9	4.0	2.1	–	2.3	4.5	5.3
		s.d	0.2	2.8	0.7	–	0.7	2.1	0.5

n = number ; χ^2 = Chi-squared value; P = probability; n.s. = not significant; s.d. = standard deviation.

Breeding season

Although not many fish were captured, the data indicate an extended breeding season from the Late-dry through to the Early-wet season for both 1978 and 1979 (fig 125). The gonads were in a resting state from the Mid-wet until the Mid-dry (assuming there was no activity during the Late-wet–Early-dry when no *S. butleri* were captured).

The seasons when mature, ripe and spent fish were captured (table 104) confirm a Late-dry–Early-wet breeding season although no ripe fish were captured during the 1979 Late-dry season, possibly because there had been very little rain, unlike the previous year.

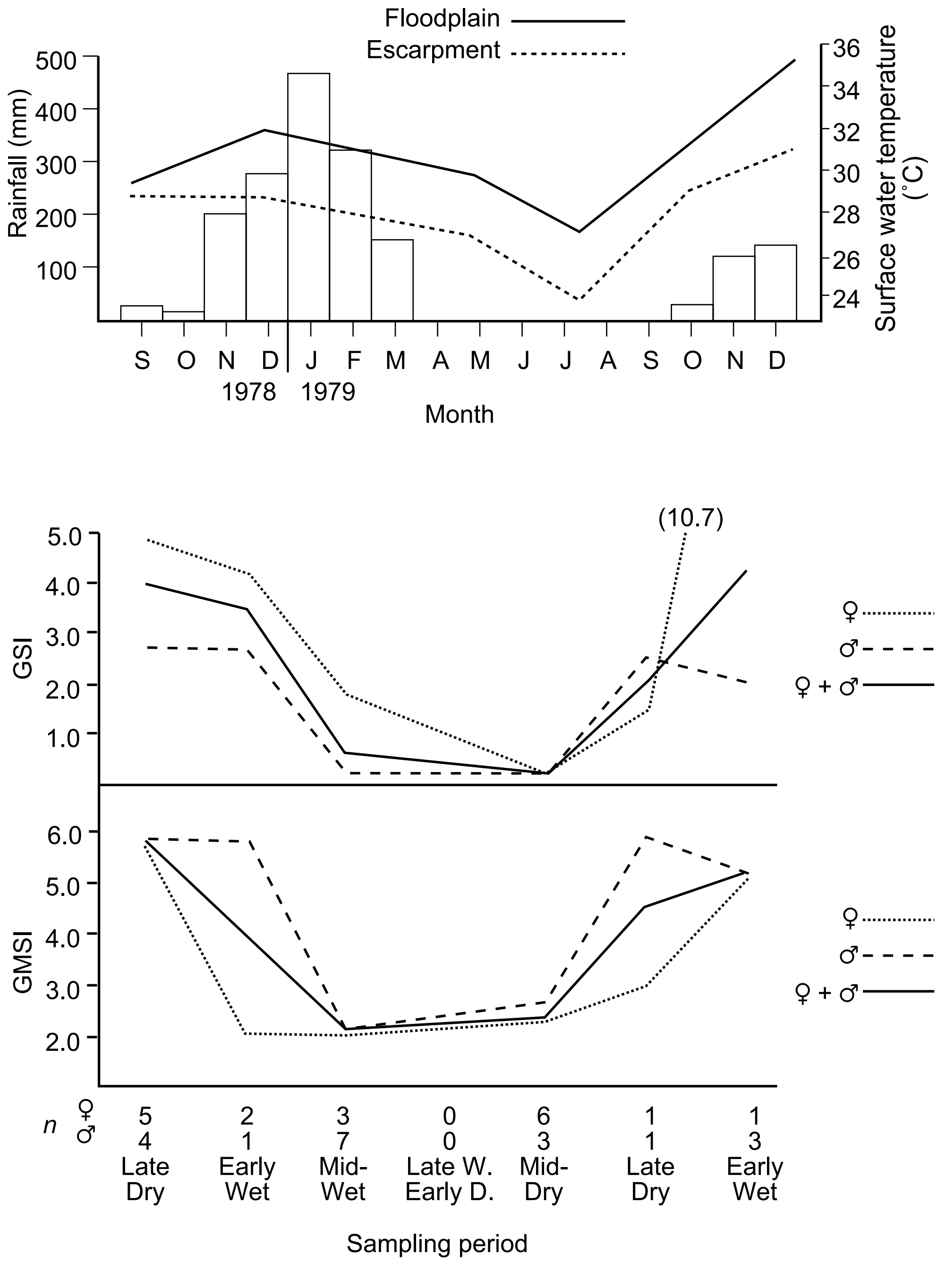


Figure 125 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *S. butleri*

Table 105 Possible sites of spawning of *S. butleri,* as indicated by the abundance (*n*) of mature, ripe and spent fish

	Gonad stage					
	Mature (V)		Ripe (VI)		Spent (VII)	
Habitat	F	M	F	M	F	M
Escarpment						
Mainchannel waterbody	2	2	4	5	–	–
Lowlands						
Sandy creekbed	–	–	–	1	–	–
Corridor	–	–	–	1	4	4

It is interesting to note the presence of spent fish during the Mid-dry season; these may be very late spawners or slow recoverers from the previous spawning period (Late-dry–Early-wet season) or they may indicate that there are occasional aseasonal spawnings.

Site of spawning

Evidence of spawning (ie ripe or spent fish) was found at all habitats where this species was collected (table 105).

Fecundity

Two gonads only were examined. One fish (285 mm LCF, GSI = 10.74) had approximately 40 000 eggs with a mean diameter of 0.88 mm (± 0.089); the other (304 mm LCF, GSI = 3.79) had approximately 17 000 eggs with a mean diameter of 0.84 mm (± 0.13). A few clusters of very tiny eggs (1.1 ± 0.1 mm) were found amongst the ripe eggs.

Summary

Syncomistes butleri has an extended breeding period, from the Late-dry through to the Early-wet season, and may breed throughout in all its habitats. It spawns a large number of small eggs.

Feeding habits

Overall diet

The stomachs of 41 specimens were examined; 40 contained food. The diet of *S. butleri* is summarised in figure 126; the components are listed in table 106.

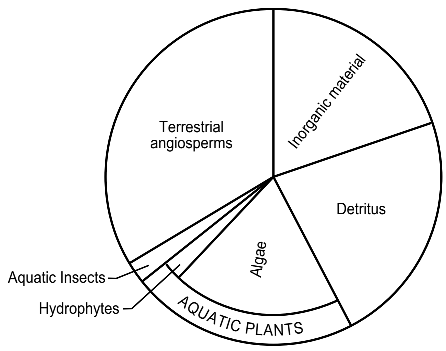


Figure 126 Main dietary components of *S. butleri*

Table 106 Dietary composition of *S. butleri*

	Habitat			Seasons						Overall	
	Magela system		Nourlangie system	1978	1978–79	1978–79	1979	1979	1979–80		
Stomach contents	Em	Cb	Em	Late-dry	Early-wet	Mid-wet	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Aquatic plants											
Algae											19.7
Miscellaneous	1.1	30.0	9.2	–	66.7	–	14.4	–	–	8.1	
Desmidacea	–	–	–	–	–	–	–	–	–	0.5	
Conjugatophyta											
Mougeotia	7.2	–	7.7	–	–	15.0	–	–	–	4.0	
Spirogyra	21.1	–	–	–	–	11.8	–	–	32.0	7.1	
Hydrophytes											1.7
Najas	–	–	–	–	6.7	–	–	–	–	0.5	
Vallisneria	–	–	–	–	16.7	–	–	–	–	1.2	
Aquatic animals											
Insecta											2.5
Fragmented	–	–	6.9	–	–	8.2	–	–	–	2.2	
Diptera											
Chironomidae	–	1.0	–	–	–	1.8	–	–	–	0.1	
Ceratopogonidae	–	–	0.8	–	–	0.9	–	–	–	0.2	
Terrestrial plants											
Angiospermae											33.7
Fragmented	26.1	20.0	45.0	1.8	6.7	60.5	11.1	–	–	1.5	
Bark material	–	12.0	–	–	–	–	–	60.0	12.0	6.8	
Root material	6.7	24.0	3.9	–	–	–	21.1	30.0	47.0	25.4	
Parasites											0.1
Nematoda	–	1.0	–	–	–	–	–	–	–	0.1	
Detrital material	20.0	12.0	12.7	55.5	–	–	30.6	5.0	4.0	23.3	23.3
Inorganic material	17.8	–	13.9	42.7	3.3	1.8	23.3	5.0	5.0	19.5	19.5
Number of empty fish	–	–	–	1	–	–	–	–	–	1	1
Number of fish with food	9	5	13	11	3	11	9	1	5	40	40

Figures represent the mean percentage volume determined by the estimated volumetric method.

Em = escarpment mainchannel; Cb = corridor billabong

The main components were terrestrial plant material (34%), detritus (23%) and algae (20%). The terrestrial plant material consisted mainly of scrapings of bark and root material, possibly from submerged tree trunks and roots (eg *Pandanus*). The identifiable algae were mainly filamentous green species such as *Mougeotia* and *Spirogyra* as well as desmids. Traces of aquatic hydrophytes and aquatic animals were also found in the stomachs along with substantial quantities of inorganic material. *Syncomistes butleri* can therefore be classified as a herbivore/detritivore feeding over hard substrates such as wood and rocks, as well as on sand. H. Midgley (pers comm) classifies this species as a 'scunge' eater. The related species *Syncomistes rastellus* and *S. trigonicus* have been observed together swimming in schools (Vari & Hutchins 1978) and grazing on algae-covered rocks in the Drysdale River, North Kimberley, Western Australia.

Syncomistes butleri has an elaborate intestinal morphology, modified jaws (Plate 2) and teeth that appear to be adapted to eating filamentous algae, which Vari (1978) considers the staple diet of the adults. However, our study suggests Vari underestimated the variety of items it eats. Both the specialised dentition and alimentary tract would also be useful for scraping and digesting plant material, detritus and algae.

Habitat differences

Magela catchment

The stomachs of nine fish from escarpment mainchannel waterbodies and of five from corridor waterbodies were examined (all seasons combined). No specimens had empty stomachs.

In the escarpment mainchannel waterbody *S. butleri* were eating fairly equal proportions of green filamentous algae (*Spirogyra* and *Mougeotia*), terrestrial plant material (including root material) and detritus; the large inorganic component of the diet indicates they ate mainly over sandy substrates. The diet in the corridor waterbodies had a large algal component with an even larger terrestrial plant material component. The absence of inorganic material in the stomachs indicates that it was feeding by scraping bark and protruding roots from terrestrial vegetation (eg *Pandanus*) submerged by the billabong waters.

Nourlangie catchment

A total of 13 stomachs of *S. butleri* were examined (all seasons combined) from escarpment mainchannel waterbodies. None had empty stomachs. The diet consisted mainly of terrestrial plant material, algae, detritus and inorganic material. It appeared that in this habitat *S. butleri* was feeding over sand, as well as scraping algae, bark and root material from submerged terrestrial plants.

Seasonal changes

In sampling periods 1 to 3 and 5 to 7, respectively, 11, 3, 11, 9, 1 and 5 stomachs of *S. butleri* were examined. One specimen with an empty stomach was found in the 1978 Late-dry season.

The diet in the 1978 Late-dry season consisted of detritus and inorganic material. By the 1978–79 Early-wet season there was a large algal component and a significant hydrophyte component. In the Mid-wet season large quantities of terrestrial plant material and some aquatic insects also appeared in the stomachs while the algal component was smaller. In the 1979 Mid-dry season, the detrital and inorganic component was bigger, with a sizeable terrestrial plant material component, and less algae. The single specimen analysed in the 1979 Late-dry season had eaten mainly bark and root material from submerged terrestrial plants. The latter component persisted into the 1979–80 Early-wet season and the algal component increased, as in the previous Early-wet season.

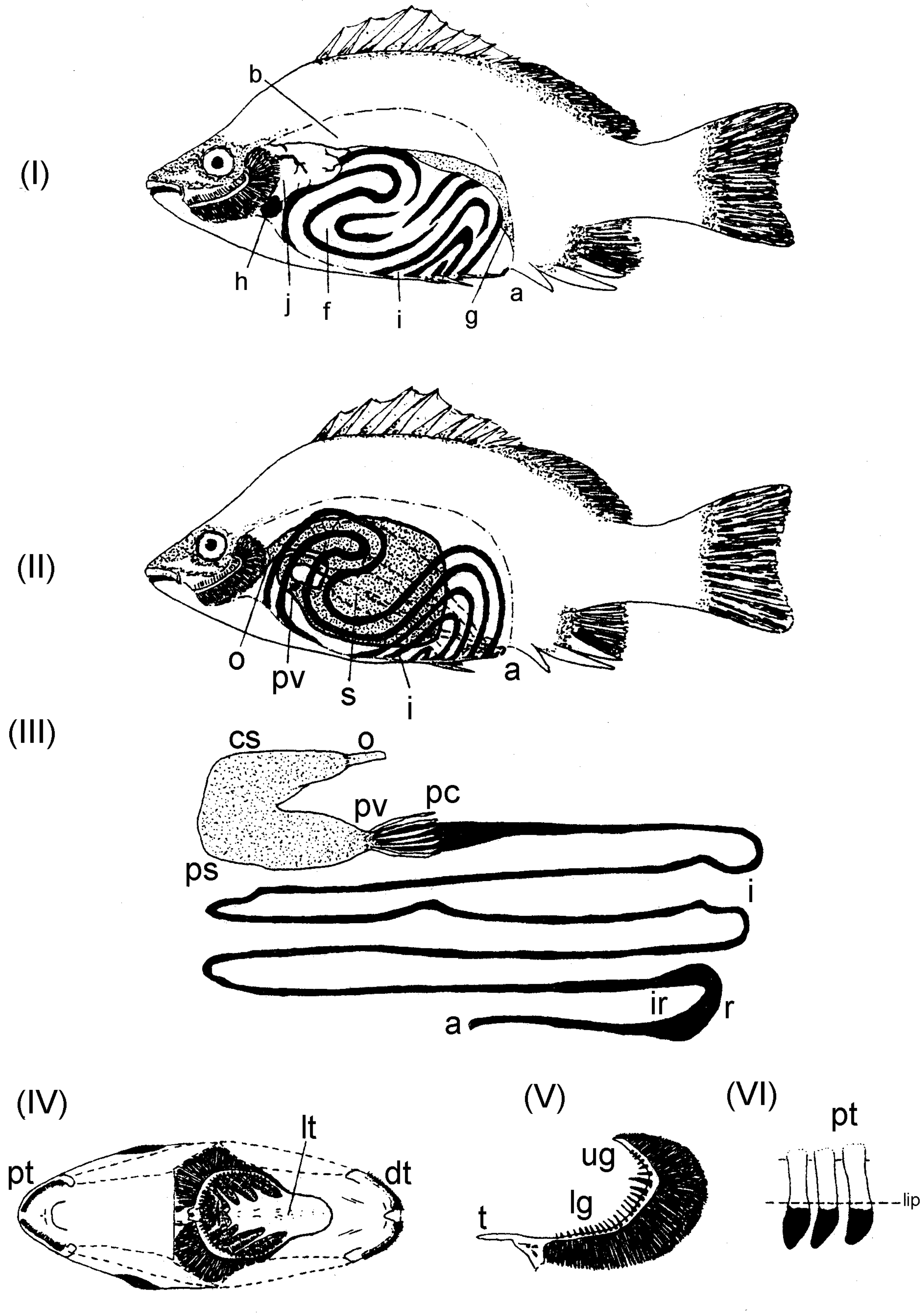


Plate 2 Details of various sections of the alimentary tract of *S. butleri* (LCF 230mm). (I) Viscera in situ. (II) Alimentary tract in situ. (III) Alimentary tract dissected out. (IV) Buccopharyngeal cavity. (V) First gill arch. (VI) Premaxillary teeth. a) anus b) air bladder cs) cardiac region of stomach dt) dentary teeth (flattened) f) fat tissue g) gonad h) heart i) intestine (five loops) ir) intestino-rectal valve l) liver lg) lower gillrakers (n=19) lt) lingual teeth o) oesophagus pt) premaxillary teeth (curved slightly inwards, flattened, depressible and brown tipped) pc) pyloric caecum (n=11), 25–35 mm in length) ps) pyloric region of stomach (thinwalled) pv) pyloric valve r) rectum t) tongue ug) upper gillrakers (n=6). Overall dimensions (mm): oesophagus 15, stomach 105, intestine 500, rectum 120.

Fullness

A summary of mean fullness indices of *S. butleri* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments is shown in table 107. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 107 Mean fullness indices of *S. butleri* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments

Habitat type	Sampling period							Habitat mean
	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80	
Magela Creek catchment (regular sites only)								
Upstream of RUPA:								
Escarpment main-channel waterbody	0 (1)	n/s	0 (1)	n/s	0 (1)	0 (1)	4.8 (5)	1.9 (9)
Downstream of RUPA:								
Lowland sandy creekbed	n/s	0 (1)	n/s	n/s	0 (1)	n/s	n/s	0 (2)
Corridor sandy billabong	n/s	5.0 (2)	n/s	n/s	4.7 (3)	0 (1)	n/s	4.0 (6)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	n/s	n/s	4.8 (8)	n/s	4.2 (5)	n/s	n/s	4.6 (13)
Seasonal mean (all sites)	4.5	4.7	4.8	n/s	4.4	4.0	4.8	

Numbers analysed are given in parentheses; n/s = not sampled in the habitat.

Seasonal changes

Syncomistes butleri appeared to have very high mean fullness indices throughout the study.

Habitat differences

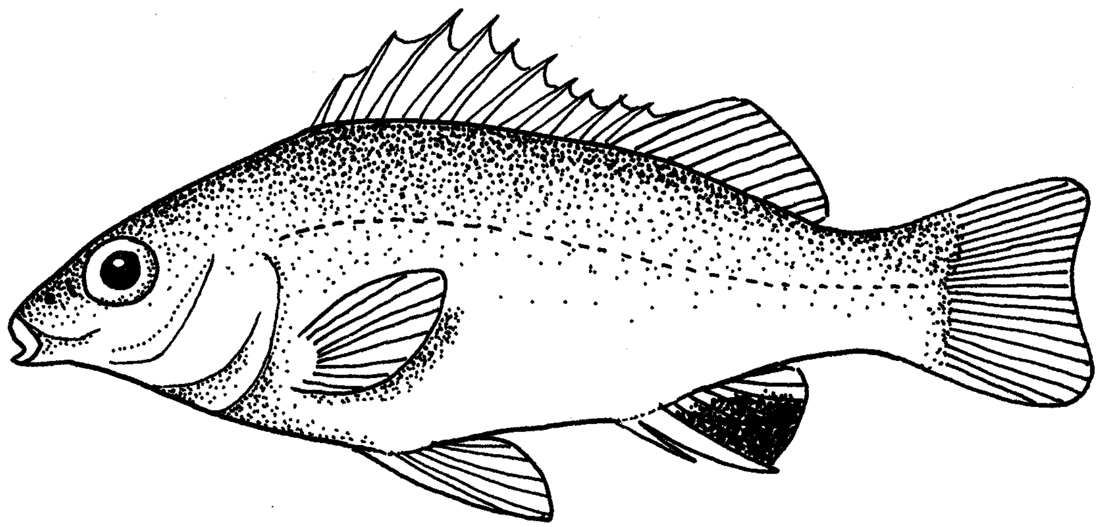
In the Magela catchment mean fullness indices were highest in the sandy corridor waterbodies. Indices were lower in the escarpment mainchannel waterbody upstream of RUPA, while the few specimens captured in lowland sandy creekbeds downstream of RUPA had no food in their stomachs; however, during the Mid-wet season many juveniles were observed feeding in these habitats.

In the Nourlangie catchment all *S. butleri* captured in the escarpment mainchannel waterbodies had very high fullness indices, as had specimens captured at occasional sites in similar habitats and in sandy corridor waterbodies.

Family TERAPONTIDAE

3.28 *Pingalla midgleyi* (Allen & Merrick 1984)

Pingalla midgleyi is also known as the black-blotched anal fin grunter. An Australian endemic, it is found in the Timor Sea drainage system of the Northern Territory and Western Australia (see map 3). It was collected in the small escarpment tributaries of the East and South Alligator Rivers by Pollard (1974) and by Midgley (1973), who referred to it as *Mesopristes cancellatus* (?) and *Therapon* sp., respectively. Lake (1978) noted that the sub-terminal mouth, like a tapir's snout, is also seen in Gilbert's grunter (*P. gilberti*); however, Lake thought it was almost certainly a new species, whereas Vari (1978) misidentified specimens from the South Alligator River catchment as *P. gilberti.*



Pingalla midgleyi

Detailed information on catches by site and season is given in volume 2. In summary, this species was moderately abundant in escarpment mainchannel waterbodies and perennial streams of the Nourlangie Creek system and slightly less abundant in the Magela Creek system. It was also common in escarpment mainchannel terminal waterbodies and in some seasonal streams; it was found rarely in lowland sandy habitats downstream of the RUPA. In the 1978 Late-dry season it was found in only three sites and in the Mid-wet season in four sites (in both seasons, mainly in escarpment perennial streams); by the Late-wet–Early-dry season it was found in five sites (some downstream from escarpment reaches in lowland sandy creekbeds).

Size composition

The lengths and weights of 85 specimens were recorded.

Length-weight relationship

The length-weight relationship for the combined sexes was described by the following expression:

$$W = 1.46 \times 10^{-2} L^{3.16} \qquad r = 0.98 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 108. The condition factor was highest between the 1978–79 Early-wet and the Late-wet–Early-dry seasons, and lowest in the 1979 Mid-dry. The condition of the single specimen examined in the 1979 Late-dry season was close to the mean condition of all specimens examined in the equivalent 1978 season.

Table 108 Mean length, mean weight and condition factor of *P. midgleyi*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	27	84.2	12.14	1.00
Early-wet (1978–79)	1	80.0	12.20	1.18
Mid-wet	32	80.9	10.98	1.03
Late-wet–Early-dry (1979)	1	69.0	7.70	1.19
Mid-dry	23	81.1	10.29	0.95
Late-dry	1	78.0	9.50	1.00
Early-wet (1979–80)		–	–	–
Overall	85	81.8	11.09	1.00

Length composition

The smallest specimen captured was 68 mm LCF, and the smallest observed was approximately 40 mm LCF. The largest specimen captured was 120 mm LCF and the largest observed was approximately 130 mm LCF (fig 127).

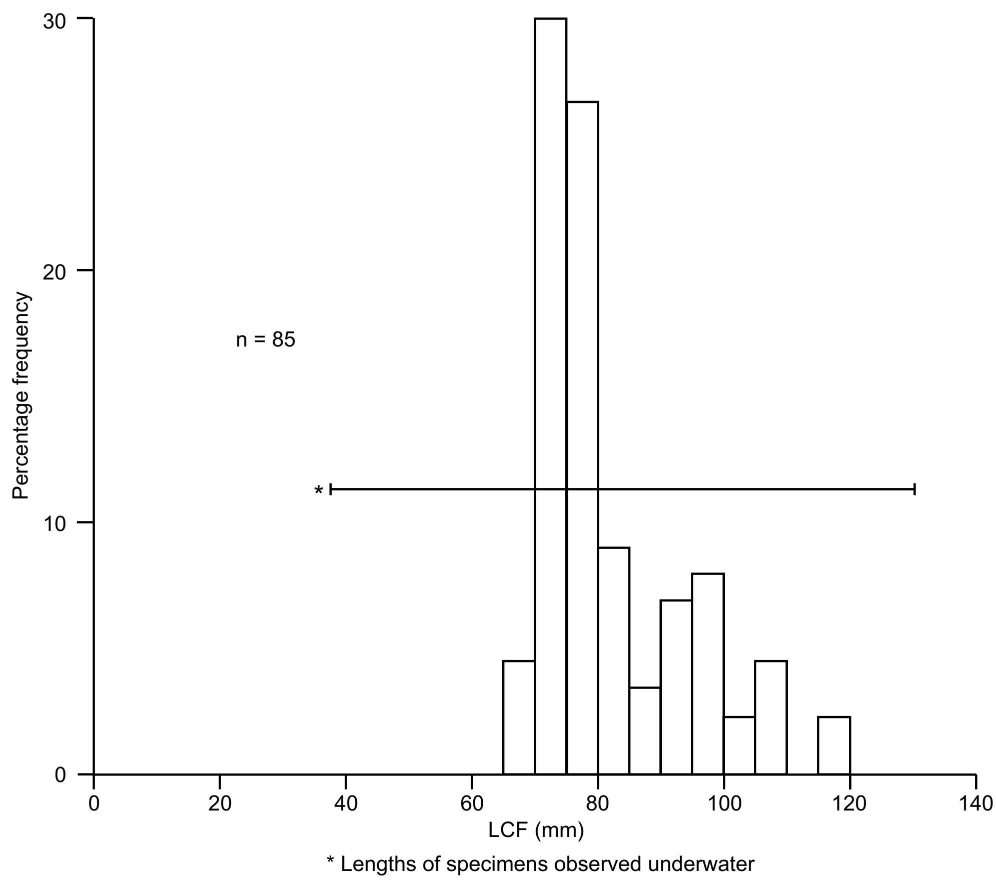


Figure 127 Length-frequency distribution of all *P. midgleyi* captured

Lake (1978) reported that the 'black blotched anal fin' grunter (presumably *P. midgleyi*) grows to 145 mm and the closely related *P. gilberti* grows to 105 mm. Mees and Kailola (1977), when describing the closely related *Therapon lorentzi,* examined specimens up to 162 mm TL.

Length-frequency distribution

The mean and modal lengths of specimens examined were 81.8 mm and 70 mm LCF, respectively (fig 127). The distribution showed negative skew, indicating lower survival rates for larger specimens. The absence of specimens less than 64 mm long is puzzling, as they were observed in interstitial waters of rock and gravel substrates. This species was captured mainly by gillnets, so the major and minor peaks in the length-frequency distribution is caused by selectivity of the 26 and 44 mm mesh, respectively. A few of the smallest specimens were captured by 10 mm mesh seine net.

The smallest specimens were captured in the Mid-dry season, and the next smallest in the Late-wet–Early-dry and 1979 Late-dry seasons (fig 128).

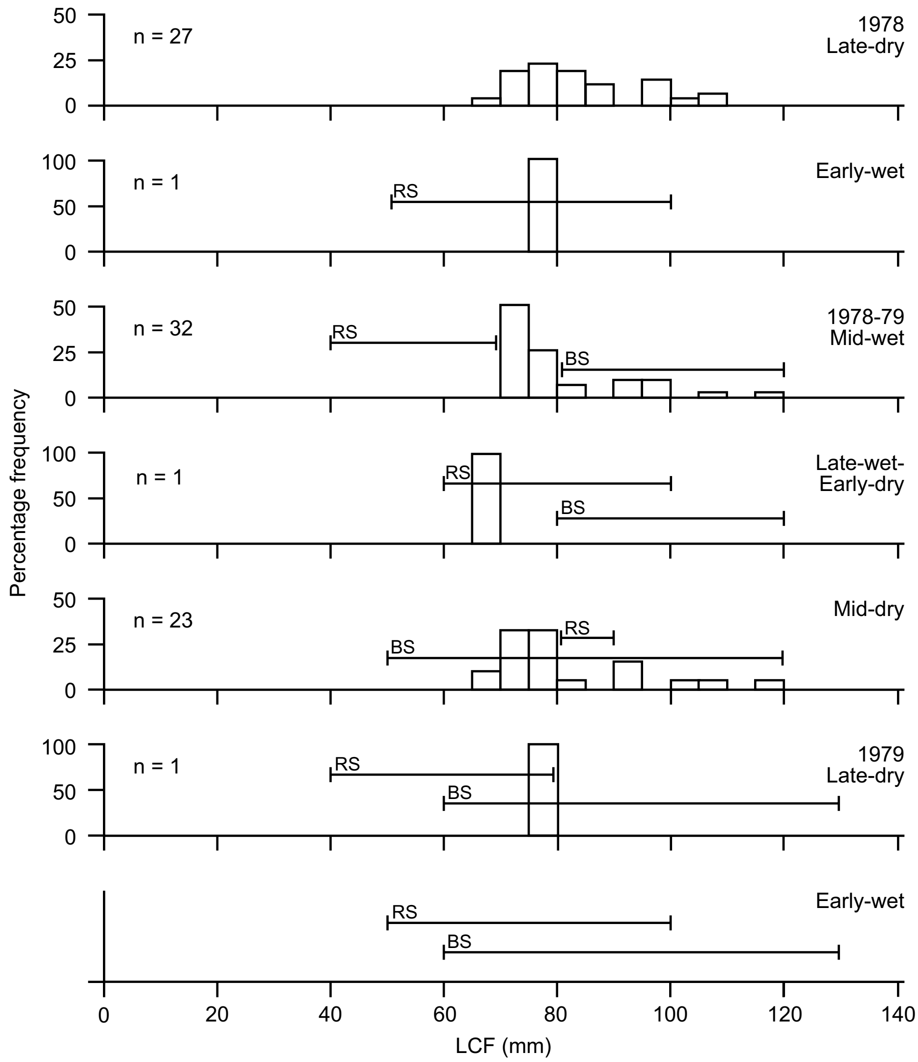


Figure 128 Seasonal length-frequency distribution of all *P. midgleyi* captured

The smallest specimens observed in escarpment perennial streams were at Radon Springs (RS) in the Mid-wet and 1979 Late-dry seasons and at Baroalba Springs (BS) in the 1979 Mid-dry season. The model of juvenile recruitment into the populations is therefore likely to be complex.

The largest specimens were captured in the Mid-wet and Mid-dry seasons. In the escarpment perennial streams the largest specimens were observed in the 1979 Late-dry and 1979–80 Early-wet season. The seasonal mean lengths of all specimens captured was highest in the 1978 Late-dry season.

The seasonal length-frequency distributions of *P. midgleyi* captured during the study are shown in figure 128.

Habitat differences in distribution

Magela catchment

This species was found in most escarpment habitats, with the widest range of sizes being captured in perennial streams. Specimens that presumably came from escarpment populations were occasionally found in lowland sandy creekbeds downstream of the RUPA. Unidentified juvenile theraponids were observed in these habitats in the Mid-wet season.

Nourlangie catchment

Pingalla midgleyi was only found in escarpment habitats in the Nourlangie Creek catchment; however, some fish may move to the lowland during the Wet season. The widest size range of specimens was observed in escarpment perennial streams.

Environmental associations

Rank numbers for *P. midgleyi* for the physico–chemical and habitat–structural variables during the study period are shown in table 155.

Physico–chemical variables

Temperature

Both surface and bottom water temperatures at sites where *P. midgleyi* was captured ranged from 23 to 35°C, with means of 27.6°C for surface waters and 27.4°C for bottom waters. These means were both ranked at the base of the lower quarter (see fig 170). These low water temperatures are characteristic of the escarpment waterbodies in which *P. midgleyi* was generally found. This species is related to *H. fuliginosus* and *S. butleri,* which had markedly similar ranges of associated water temperatures (and other environmental parameters).

Dissolved oxygen

Dissolved oxygen concentrations in waters at sites where *P. midgleyi* was found ranged from 3.8 to 8.3 mg/L (mean = 5.9 mg/L) on the surface, and from 5.0 to 7.4 mg/L (mean = 5.9 mg/L) on the bottom (see fig 171). The mean for surface waters was ranked in the upper-middle quarter, and the mean for bottom water was ranked in the upper quarter. As with other primarily escarpment-dwelling fish, the DO concentration in the bottom waters in which the species was captured was generally high.

Visibility

Secchi depths recorded for waters where *P. midgleyi* was caught ranged from 100 to 360 cm (mean = 188 cm) (see fig 172). This mean ranked high in the upper quarter, as might be expected for a fish commonly found in clear escarpment streams.

pH

The pH values of water in which this species was captured ranged at the surface from 4.0 to 7.1 (mean = 5.4) and at the bottom from 4.5 to 7.0 (mean = 5.7). Both means were placed in the lower quarter (fig 173). As with other mainly escarpment-dwelling species, its aquatic environment is relatively acidic.

Conductivity

Pingalla midgleyi was captured in waters with conductivities ranging from 2 to 80 µS/cm on the surface, and from 2 to 64 µS/cm on the bottom. The low levels of dissolved solids are typical of escarpment channels.

Habitat–structural variables

Substrate

Pingalla midgleyi was most often found in waters with a sandy bottom, and to a lesser extent in waters with boulder, rock, leaf litter and gravel substrates. The percentage dominance values for sandy substrates were ranked in the upper quarter, and that for boulders at the apex of the upper quarter (see fig 174).

Hydrophytes

This species is usually found in sparsely vegetated waters (vegetation-occurrence index 27.9%). Thus *P. midgleyi* showed similar ranges of habitat–structural parameters to other primarily escarpment-dwelling fish species.

Reproduction

A total of 81 *P. midgleyi* were examined for reproductive condition: 25 females (length range 71–116 mm LCF), 34 males (70–120 mm LCF) and 22 sexually indistinguishable fish (68–84 mm LCF).

Length at first maturity

The LFM could not be determined for females as, apart from three spent fish, no females were captured with a gonad maturity stage greater than III. No females were captured during the 1978–79 Early-wet season, which the capture of one running-ripe male suggests was the breeding season. The highest GSI for a female was only 0.66.

The LFM for males was estimated to be around 75 mm LCF (fig 129). Since no LFM was determined for females, the ratio of adult males to adult females was not tested; also, GSI and GMSI were calculated from the data on all male and female fish.

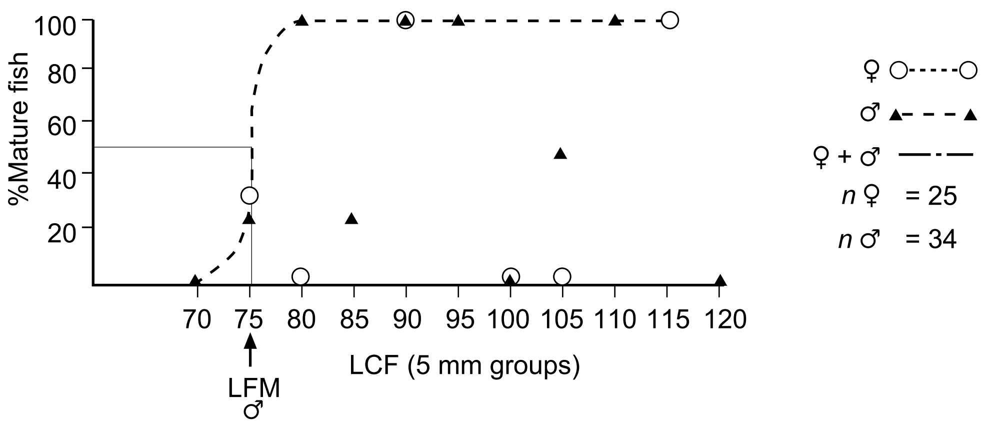


Figure 129 Estimated length at first maturity of *P. midgleyi*

Sex ratio

Only the ratio of males to females over the entire length range was tested, as the LFM for females was not adequately determined and therefore adult fish could not be defined. No significant difference from 1:1 was found except in the 1978 Late-dry season when more males than females (0.01 > P > 0.05) were captured (table 109). However, the small samples were, in the other seasons, too small to draw firm conclusions.

Table 109 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *P. midgleyi* over all habitats

			Sampling period						
Parameter	Sex	Statistic	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80
Sex ratio									
Juveniles +	F	*n*	5	0	11	–	9	0	–
adults	M	*n*	18	1	9	–	5	1	–
		χ^2	6.0	1.0	0.2	–	1.1	1.0	–
		P	*	n.s.	n.s.	–	n.s.	n.s.	–
GSI									
Adults only	F	mean	0.4	–	0.2	–	0.2	–	–
		s.d.	0.2	–	0.1	–	0.1	–	–
	M	mean	0.6	5.9	0.1	–	0.1	0.13	–
		s.d.	0.6	–	0.1	–	0.03	–	–
	F+M	mean	0.5	–	0.1	–	0.2	–	–
		s.d.	0.5	–	0.1	–	0.1	–	–
GMSI									
Adults only	F	mean	2.6	–	1.5	–	1.8	–	–
		s.d.	0.5	–	1.5	–	1.8	–	–
	M	mean	3.3	6.0	1.7	–	1.8	2.0	–
		s.d.	1.1	–	0.5	–	0.4	–	–
	F+M	mean	3.1	–	1.6	–	1.8	–	–
		s.d	1.0	–	0.5	–	0.4	–	–

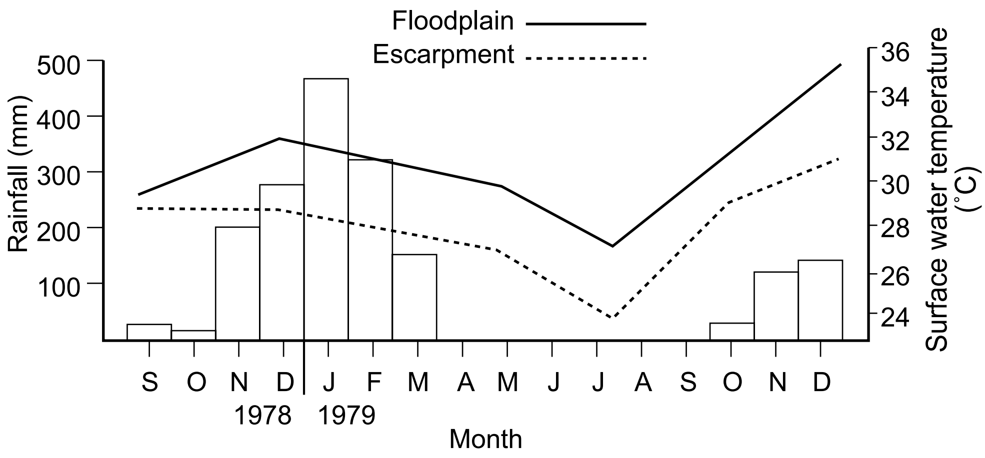
n= number; χ^2 = Chi-squared value; P = probability; n.s. = not significant (P > 0.05); * = 0.01 < P < 0.05; s.d. = standard deviation.

Breeding season

Only one fish, a ripe male, was captured during the 'most likely' reproductive season (the 1978–79 Early-wet). Mature and maturing males were identified in the preceding 1978 Late-dry season and spent males and females in the following 1978–79 Mid-wet season. Figure 130 also indicates that males may have bred over the 1978–79 Early-wet season; however, these conclusions are based on only very few fish.

Site of spawning

Due to the extremely small numbers of mature and ripe males and the absence of females at these stages, the site of spawning cannot be determined; however, a mature fish was found in an escarpment perennial stream (Baroalba Springs), and a ripe fish was found in a lowland sandy creekbed (Magela bed) (table 110). Spent fish were captured in two escarpment area habitats: Baroalba Springs and Bowerbird Billabong.



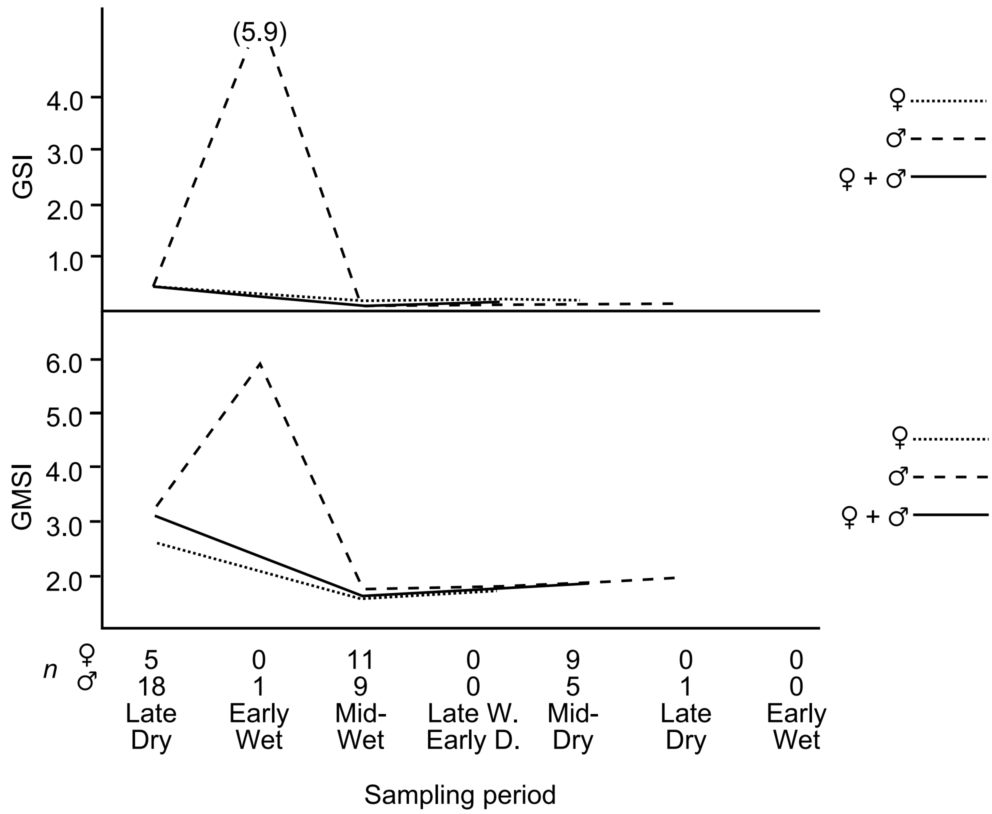


Figure 130 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *P. midgleyi*

Table 110 Possible sites of spawning for *P. midgleyi* as indicated by the abundance (*n*) of mature, ripe and spent fish

	Gonad stage					
	Mature (V)		Ripe (VI)		Spent (VII)	
Habitat	F	M	F	M	F	M
Escarpment						
Perennial stream	–	1	–	–	4	4
Lowlands						
Sandy creekbed	–	–	–	1	–	–

Summary

Data on this previously undescribed species were extremely scarce. No maturing females were captured and therefore no female LFM could be determined. Males were found at both mature and ripe stages and their LFM was estimated to be 75 mm LCF. Significantly more males than females were captured during the 1978 Late-dry season; however, too few fish were caught in most other seasons to adequately determine the sex ratios.

Breeding most likely occurred in the 1978–79 Early-wet season; however, only one fish was captured in that season and no fish were captured in the 1979–80 Early-wet season. Mature and ripe fish were captured in Baroalba Springs, and Magela bed on Magela Creek, which suggests the fish may spawn both in the escarpment area habitats and in the Magela Creek downstream of the escarpment.

Feeding habits

Overall diet

The stomachs of 82 specimens were analysed; 80 contained food. The diet of *P. midgleyi* is summarised in figure 131; the components are listed in table 111. The main components were algae (49%) and detritus (25%), and considerable amounts of incidentally ingested inorganic material (14%). The identifiable algae were mainly filamentous green species such as *Mougeotia* and *Spirogyra*; desmids were also found abundantly in the stomachs on a few occasions. Aquatic insects (mainly chironomids, 7%) were also eaten, as well as terrestrial plant material (4%). *Pingalla midgleyi* can therefore be classified as a herbivore (mainly algae) and detritivore, and occasionally an omnivore, feeding over sand and rocky substrates and sometimes over submerged tree trunks and other plant material. H. Midgley (pers comm) classified this species as a 'scunge' eater. Lake (1978) noted that the main food of the 'black-blotched anal fin grunter' (the *P. midgleyi* pictured in Lake's book is a specimen from Magela Creek) was benthic algae, which supports our results.

The very small mouth, protruding upper jaw (giving the mouth a sub-terminal snout like a tapir), strongly curved maxilla, and very flattened noncuspidate teeth that distinguish the genus *Pingalla* are adaptations to graze on the algae that grow on a variety of substrates.

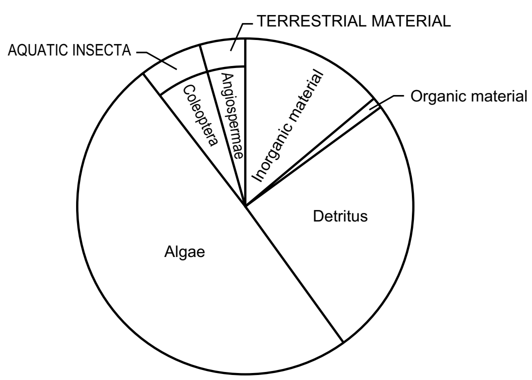


Figure 131 The main components of the diet of *P. midgleyi*

Habitat differences

A total of 25 stomachs of *P. midgleyi* were analysed (all seasons combined): 5 from the Magela Creek catchment escarpment mainchannel waterbodies and 16 from its perennial streams, and 4 from lowland sandy creekbeds. No fish had empty stomachs.

Table 111 Dietary composition of *P. midgleyi*

Stomach contents	Habitat: Magela system Em	Magela system Ep	Magela system Ls	Nourlangie system Em	Nourlangie system Ep	Seasons: 1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	Overall Sub-mean	Overall Main-mean
Aquatic plants													
Algae													48.8
Miscellaneous	–	87.8	7.5	4.9	22.5	60.0	–	–	–	7.9	30.0	22.1	
Desmidaceae	–	–	–	–	14.2	–	–	5.9	–	–	–	2.1	
Conjugatophyta													
Mougeotia	10.0	–	8.8	24.3	–	–	30.0	34.0	5.0	9.6	–	15.4	
Spirogyra	68.0	–	–	11.0	–	–	–	25.3	–	–	–	9.2	
Aquatic animals													
Insecta													6.6
Fragmented	–	1.3	–	–	–	0.8	–	–	–	–	–	0.2	
Hemiptera													
Corixidae	–	–	5.0	–	–	–	–	–	–	–	20.0	0.3	
Coleoptera	–	–	–	0.1	–	–	–	0.2	–	–	–	0.1	
Diptera													
Chironomidae	1.0	6.3	21.3	2.2	5.0	8.3	25.0	2.9	20.0	4.6	–	5.6	
Ceratopogonidae	–	–	3.8	–	1.7	–	5.0	0.7	–	0.5	–	0.4	
Terrestrial Plants													
Angiospermae													4.1
Miscellaneous	11.0	–	20.0	–	5.8	4.6	30.0	4.3	–	–	50.0	4.1	
Detrital material	8.0	3.1	26.3	37.9	17.5	18.9	–	3.4	75.0	60.7	–	25.0	25.0
Inorganic material	2.0	1.6	7.5	17.6	30.8	7.5	10.0	19.8	–	16.8	–	14.4	14.4
Organic material	–	–	–	1.9	2.5	–	–	3.5	–	–	–	1.3	1.3
Number of empty fish	–	–	–	1	1	–	–	2	–	–	–	2	2
Number of fish with food	5	16	4	36	12	26	1	29	1	22	1	80	80

Figures represent the mean percentage volume determined by the estimated volumetric method.

Em = escarpment mainchannel; Ep = escarpment perennial; Ls = lowland sandy creekbed

Specimens in the escarpment habitats were feeding mainly on algae and a small amount of detritus. In the mainchannel waterbodies, terrestrial plant material was eaten, and in the perennial streams, chironomid larvae. The small inorganic material component in the stomachs indicated that *P. midgleyi* was feeding mainly over hard substrates in these habitats. The inorganic component was higher in the sandy creekbed lowland billabongs, where the fish ate fairly equal portions of detritus, terrestrial plant material, chironomid larvae and algae.

Catchment differences

A total of 50 stomachs of *P. midgleyi* were analysed (all seasons combined) from the Nourlangie Creek catchment: 37 from escarpment mainchannel waterbodies and 13 from perennial streams. Only one fish from each of the above habitats had an empty stomach. In both habitats the diet included a large inorganic material component, indicating that this species was feeding predominantly over sandy substrates. Algae were the main food item with detritus of secondary importance. A few chironomid larvae and some terrestrial plant material were eaten at both sites. Algae appeared to be less important in the diet in the Nourlangie Creek habitats than in the Magela Creek system.

Seasonal changes

In sampling periods 1–6, respectively, 26, 1, 31, 1, 22 and 1 stomachs of *P. midgleyi* (all habitats combined) were analysed. Only during the Mid-wet season were a few fish found with empty stomachs.

The diet in the 1978 Late-dry season was dominated by algae, as was the case in the Mid-wet season. Chironomids were present in the diet in both seasons though they were more abundant in the former. Terrestrial plant material was also present in both seasons. During the Mid-dry season detritus was the main food item, followed by algae and chironomid larvae.

Fullness

A summary of mean fullness indices of *P. midgleyi* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments is shown in table 112. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 112 Mean fullness indices of *P. midgleyi* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments

	Sampling period						
Habitat	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry 1979	Habitat mean
Magela Creek catchment (regular sites only)							
Upstream of RUPA:							
Escarpment main-channel waterbody	n/s	n/s	3.5 (4)	n/s	0 (1)	n/s	2.8 (5)
Escarpment perennial stream	4.5 (16)	n/s	n/s	n/s	n/s	n/s	4.5 (16)
Downstream of RUPA:							
Lowland sandy creekbed	n/s	0 (1)	n/s	0 (1)	0 (1)	0 (1)	0 (4)
Nourlangie Creek catchment (regular sites only)							
Escarpment main-channel waterbody	n/s	n/s	3.4 (16)	n/s	3.6 (20)	n/s	3.5 (36)
Escarpment perennial stream	4.3 (13)	n/s	n/s	n/s	n/s	n/s	4.3 (13)
Seasonal mean (all sites)	4.4	0	3.8	0	3.6	0	

Numbers analysed are given in parentheses; n/s = not sampled in the habitat.

Habitat differences

In the Magela catchment upstream of RUPA, the mean fullness indices for *P. midgleyi* were highest in the escarpment perennial streams and lowest in the escarpment mainchannel waterbody. No specimen captured downstream of RUPA had food in its stomach.

In the Nourlangie catchment the mean fullness indices were also highest in the escarpment perennial streams and lowest in the mainchannel habitat, although they were generally higher than in the equivalent Magela habitat.

Seasonal changes

Interpretation of seasonal changes of mean fullness indices is difficult owing to small sample sizes and inconsistent sampling of habitats, eg the high levels in the 1979 Late-dry season were due to sampling exclusively in escarpment perennial streams.

Summary

Mean fullness indices were highest in escarpment habitats and particularly in perennial escarpment streams of both catchments.