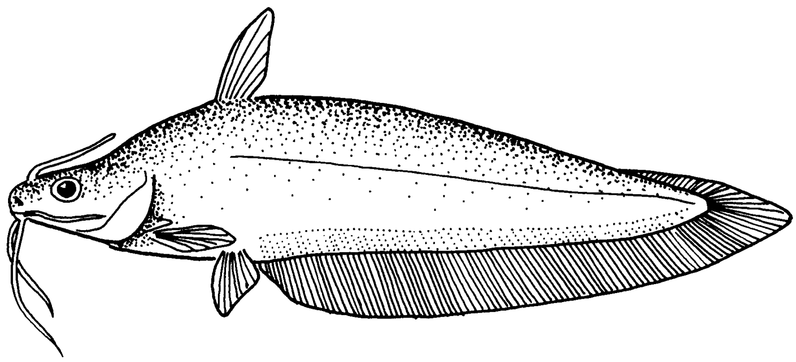
Family PLOTOSIDAE

3.11 *Porochilus rendahli* (Whitley)

In the Oenpelli area, the Aboriginal name of this genus of eel-tailed catfishes is Maroonung or Nahgool. It is also generally known as Rendahl's catfish. Data on *P. rendahli* will be presented together with that on *Neosilurus* sp. C.

Porochilus rendahli is endemic to Australia. Miller (in Taylor 1964) found this species in billabongs and creeks of the Oenpelli area and in lower riverine floodplain billabongs of the East Alligator River. Previously it had been found in the Northern Territory only in the Howard, Roper and Emerald (Groote Eylandt) Rivers.



Porochilus rendahli

Detailed information on catches at each site and in each season is given in volume 2. In summary, *P. rendahli* (and *Neosilurus* sp. C) was common to moderately abundant in all lowland backflow billabongs and floodplain billabongs; it also occurred in some corridor waterbodies and escarpment perennial streams. The fewest specimens of *Neosilurus* sp. C were caught in the Mid-wet season; the greatest number of *P. rendahli* were caught in the Mid-dry.

Size composition

The lengths and weights of 328 *P. rendahli* and 147 *Neosilurus* sp. C were recorded.

Seasonal length-frequency distributions and condition factors are based on *Neosilurus* sp. C through the Mid-wet season and then on *P. rendahli*. *Neosilurus* sp. C was probably contaminated by *N. hyrtlii*.

Neosilurus sp. C and *P. rendahli* captured by the 26 mm mesh gillnet and the seine net were similar in size; *Neosilurus* sp. C was also captured by 44 and 58 mm mesh gillnets and the resultant peaks are apparent in the distribution.

Length–weight relationship

The length–weight relationships for *Neosilurus* sp. C and *P. rendahli* were described respectively by the expressions:

$W = 0.68 \times 10^{-2} L^{3.02}$ r = 0.89 (length in cm, weight in g)

$W = 0.44 \times 10^{-2} L^{3.16}$ r = 0.99 (length in cm, weight in g)

Seasonal mean lengths, weights and condition factors of *Neosilurus* sp. C and *P. rendahli* are shown in table 37. Seasonal condition factors were near unity for both groups except during the Mid-wet season, when they dropped to a very low level, possibly because of spawning activity.

Table 37 Mean length, mean weight and condition factor of *Neosilurus* sp. C and *P. rendahli*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Neosilurus sp. C				
Late-dry (1978)	65	177.9	41.12	1.01
Early-wet (1978–79)	28	128.1	14.99	0.99
Mid-wet	15	157.1	21.15	0.76
Overall	108	156.5	27.56	1.00
P. rendahli				
Late-wet–Early-dry (1979)	78	97.6	6.25	1.05
Mid-dry	117	123.2	12.14	0.98
Late-dry	109	120.8	11.50	0.99
Early-wet (1979–80)	14	140.8	18.71	0.99
Overall	318	116.3	10.32	1.00

Length-frequency distribution

The lengths of *Neosilurus* sp. C ranged from 91 to 385 mm TL and of *P. rendahli* from 36 to 195 mm TL (fig 40). The difference in the minimum length may be attributed to seasonal growth effects; the large difference in maximum length was most likely caused by contamination of *Neosilurus* sp. C by large *N. hyrtlii* and *N. ater*. Pollard (1974) reported that Midgley found a yellow-finned plotosid catfish (*Neosilurus* sp. C) of 585 mm TL in the study area during 1972; however, this specimen was possibly a large *N. ater*.

The mean length of all *Neosilurus* sp. C was 156 mm TL and that of *P. rendahli* was 116 mm TL. The difference is most likely an artefact of contamination of *Neosilurus* sp. C by other plotosid species. The LFM for male and female *P. rendahli* were 100 and 110 mm TL respectively, indicating that more adults than juveniles were captured. The length-frequency distribution of *Neosilurus* sp. C showed negative skew and the distribution of *P. rendahli* showed slight positive skew; the two groups had coincident peaks with modes of 120–130 mm TL.

Seasonal changes in distribution

The smallest specimens of *Neosilurus* sp. C were caught in the 1978–79 Early-wet season (fig 41). They were much larger than the smallest specimens of *P. rendahli,* which were caught in the Late-wet–Early-dry season. This difference may result from the seasonal recruitment of juveniles.

The largest specimens of *Neosilurus* sp. C were captured in the Mid-wet and Late-dry seasons, and of *P. rendahli* in the Mid-dry season.

The small-adult size-range of both *Neosilurus* sp. C and *P. rendahli* had major peaks throughout the study. A large peak of juvenile *P. rendahli* occurred together with small adults during the Late-wet–Early-dry season. By the Mid-dry season the juvenile peak had apparently merged towards the small adult peak, with slightly larger adults also being captured. During the 1979 Late-dry season the length-frequency distribution was very similar in form to the previous season, with a reduction in the number of large adults captured. Only a few small adults (with a modal progression from the previous season) were captured in the 1979–80 Early-wet season.

Juveniles appear therefore to have recruited in the Late-wet–Early-dry season.

Growth rate

No published information on the growth of *P. rendahli* was found. Estimation of growth rates from the seasonal length-frequency distributions was very difficult due to contamination of *Neosilurus* sp. C, mesh selectivity, and the range of habitats sampled. However, the apparent merging of juveniles, which were initially present in the Late-wet–Early-dry season, into the small adult component in the Mid-dry season indicates that this species may attain its LFM within the first year of life.

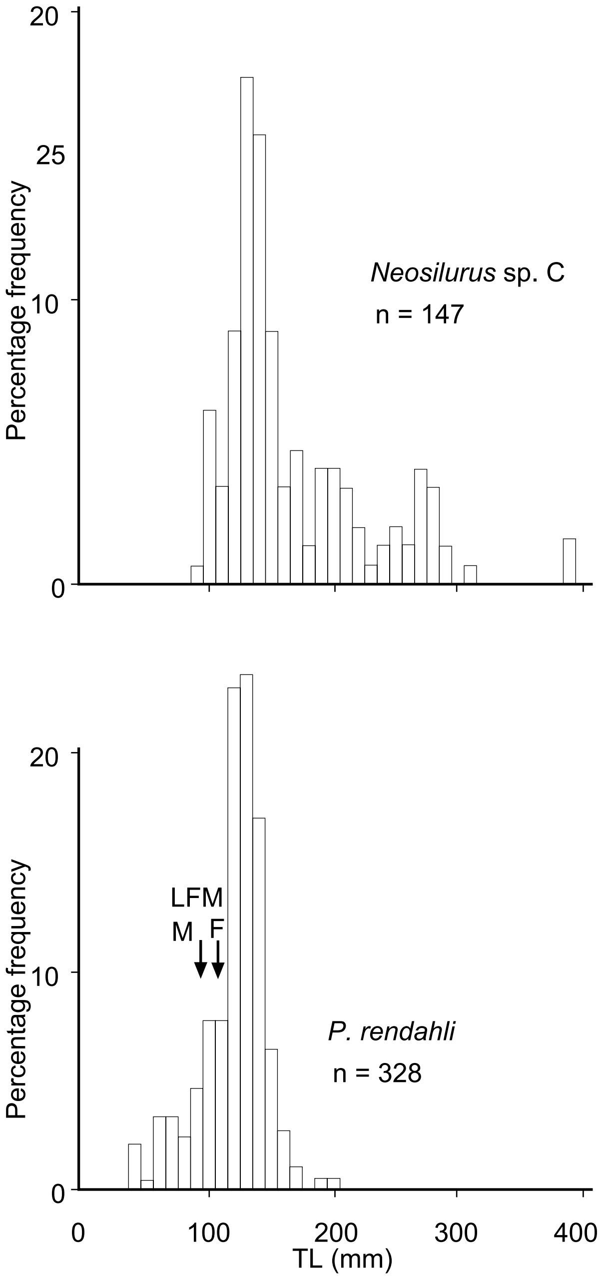


Figure 40 Length-frequency distribution of all *Neosilurus* sp. C and *P. rendahli* captured

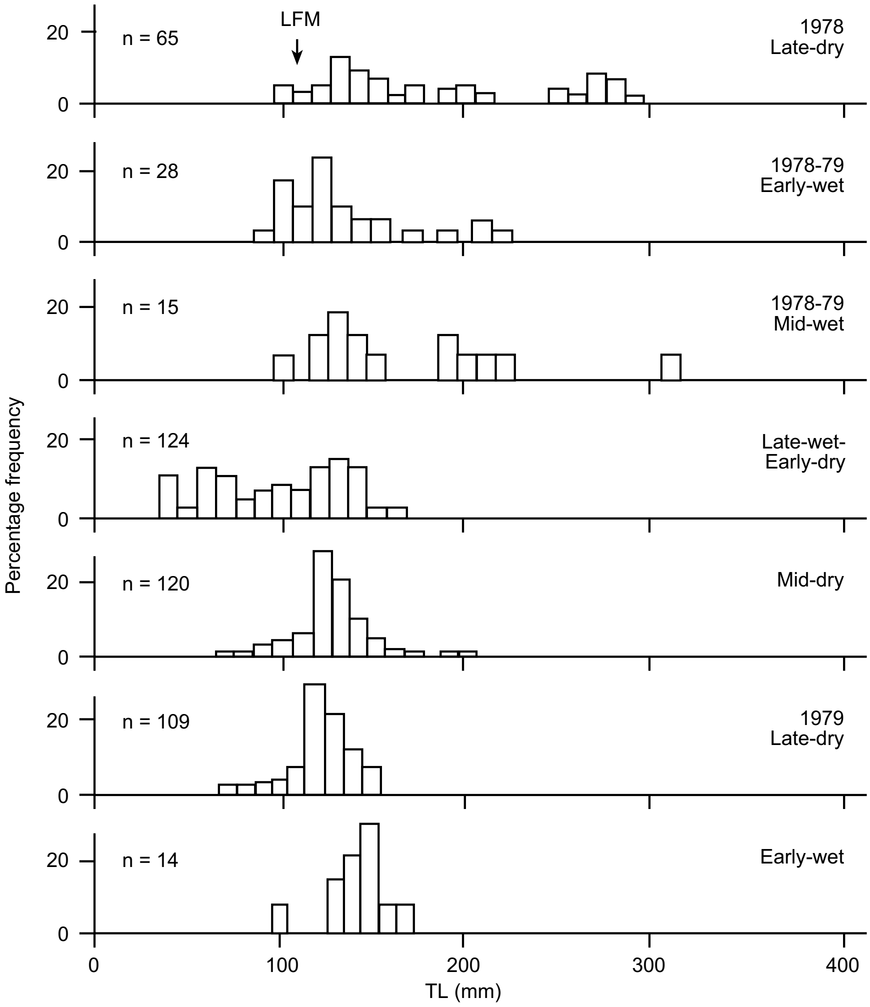


Figure 41 Seasonal length-frequency distribution of all *Neosilurus* sp. C and *P. rendahli* captured

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *Neosilurus* sp. C and *P. rendahli* captured in regular sampling sites of the Magela and Nourlangie Creek catchments are given in figure 42.

Porochilus rendahli juveniles were found only in backflow billabongs (mainly the shallow ones) and floodplain billabongs; the smallest juveniles were most common in the latter habitat and larger juveniles in the former. Juvenile *P. rendahli* were observed in the escarpment perennial streams of the Nourlangie Creek catchment during the 1979 Late-dry season.

Adults were found in the same habitats as juveniles. Most adults were found in lowland shallow backflow billabongs up and downstream of RUPA; the largest adult was found in the latter habitat. Adults were observed in escarpment perennial streams of the Nourlangie Creek catchment during the Late-wet–Early-dry season.

In the Magela Creek catchment *Neosilurus* sp. C was mainly caught in lowland channel backflow billabongs and, less often, in the lowland shallow backflow billabongs and in floodplain billabongs. As *N. hyrtlii* were captured in mainly lowland channel backflow billabongs, it may have contaminated the data on *Neosilurus* sp. C. The largest specimen, which was caught in an escarpment mainchannel waterbody, was most likely *N. ater*.

In the Nourlangie Creek catchment *Neosilurus* sp. C was caught only in backflow billabongs, with a slight preference for channel types.

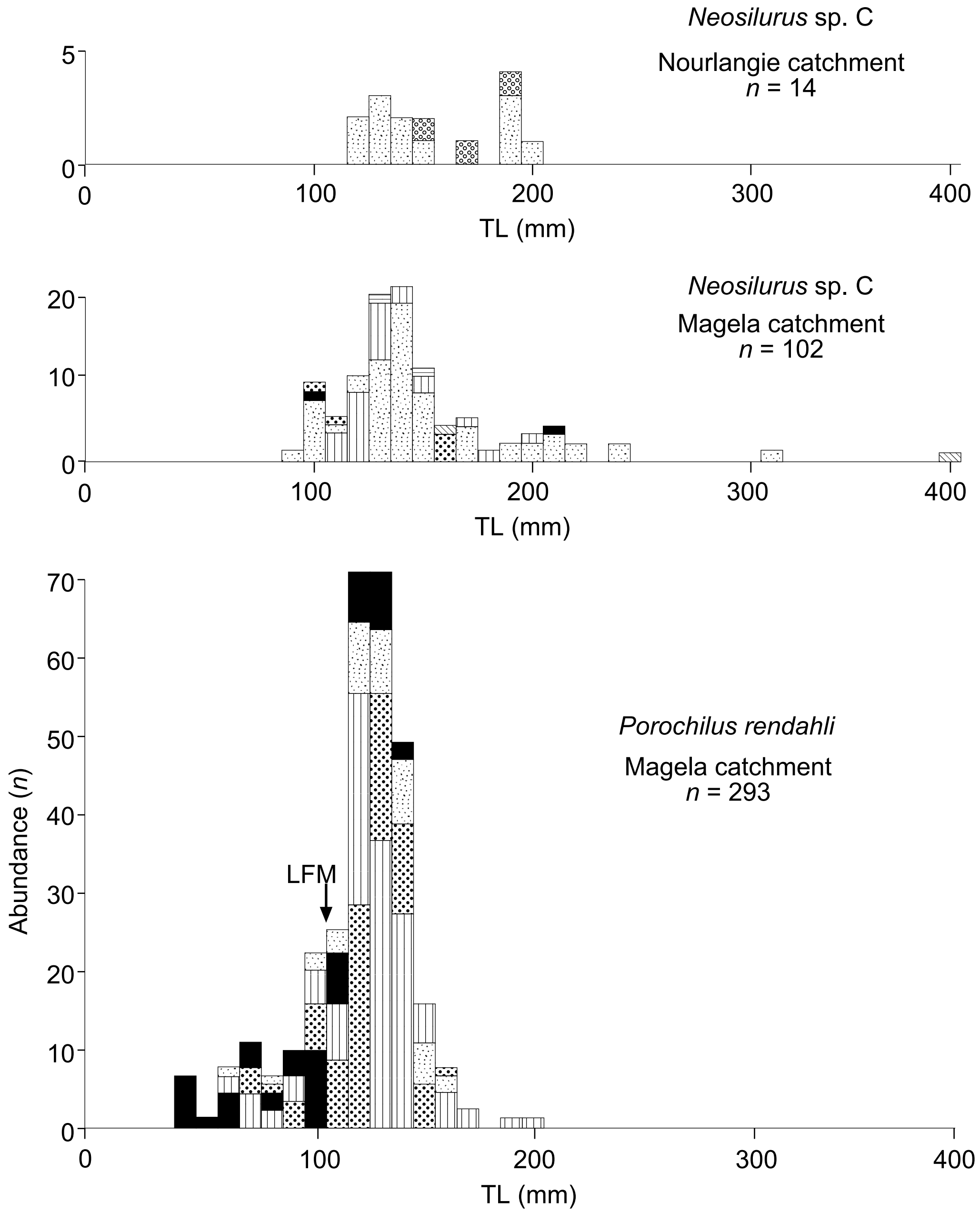


Figure 42 Length-frequency distributions and habitat preferences of *Neosilurus* sp. C and *P. rendahli* captured at regular sampling sites (see appendix 5 for key to the habitats)

Environmental associations

Rank numbers for *P. rendahli* and *Neosilurus* sp. C for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

Water temperatures at sites where *P. rendahli* was captured ranged from 26° to 38°C (mean = 30°C) on the surface, and from 23° to 34°C on the bottom (mean = 28°C). These means both ranked in the lower quarter. This species was found in habitats ranging from escarpment perennial streams to floodplain billabongs, as reflected in the range of water temperatures. *Neosilurus* sp. C was found in waters with temperatures between 27° and 41°C (mean = 31°C) on the surface, and between 27° and 34°C (mean = 28.9°C) on the bottom (see fig 170). These means ranked in the upper-middle and lower quarters. A tolerance of extremely high water temperatures is indicated.

Dissolved oxygen

Dissolved oxygen concentrations in waters in which *P. rendahli* was caught ranged from 1.0 to 9.7 mg/L (mean = 5.6) on the surface, and from 2.0 to 9.5 mg/L (mean = 3.8) on the bottom. These means were ranked in the lower and lower-middle quarters. *Neosilurus* sp. C was also caught in waters with a wide range of DO concentrations: from 3.8 to 8.8 mg/L (mean = 6.0) on the surface, and from 0.5 to 6.0 mg/L (mean = 3.3) on the bottom (see fig 171). These means ranked in the lower-middle and lower quarters, respectively. Like other plotosid catfishes, this species can apparently tolerate low DO concentrations.

Visibility

Secchi depths recorded at sites where *P. rendahli* was caught ranged from 1 to 170 cm (mean = 31 cm), indicating a tendency to be found in turbid waters; this mean depth ranked at the base of the lower quarter. *Neosilurus* sp. C showed a similar range of associated Secchi depths: from 3 to 150 cm (mean = 42 cm) (see fig 172). This mean ranked at the base of the lower-middle quarter.

pH

The pH of waters from which *P. rendahli* was taken ranged from 4.8 to 7.7 (mean = 6.2) on the surface, and from 5.2 to 7.3 (mean = 6.0) on the bottom. These means were both ranked at the top of the lower-middle quarter. *Neosilurus* sp. C was found in similar pH conditions: surface readings ranged from 4.3 to 8.8 (mean = 6.4) and bottom readings from 4.5 to 7.4 (mean = 5.9). These means were placed in upper and lower-middle quarters, respectively (see fig 173).

Conductivity

Porochilus rendahli was captured in waters with conductivities between 10 and 600 µS/cm on the bottom. This wide range corresponds with the distribution of the species from perennially flowing to lentic waterbodies. *Neosilurus* sp. C was found in waters with surface conductivities between 6 and 230 µS/cm, and with bottom conductivities between 6 and 280 µS/cm.

Habitat–structural variables

Substrate

Porochilus rendahli was mainly found over muddy substrates (top of upper quarter) followed by clay (upper quarter), then gravel and sand. This association with mud and clay substrates corresponds with the high turbidities of waters in which this species was captured. *Neosilurus* sp. C had a similar range: it was most commonly found in waters with mud substrates (upper quarter), followed by clay (upper-middle quarter), then sand, leaves, boulders and gravel.

Hydrophytes

Porochilus rendahli was typically found in heavily vegetated waters (vegetation-occurrence index 89.8%) with submergent (41.7%), emergent (27.2%) and floating-attached (25.6%) hydrophytes.[75] *Neosilurus* sp. C was found in moderately vegetated waters (vegetation-occurrence index 63.6%) with submergent (38.8%), emergent (27.7%) and floating-attached (26.6%) hydrophytes. For both species, as for the other plotosids, the percentage of floating unattached hydrophytes was high.

---

75 Herbert and Peeters (1995) and Herbert et al (1995) indicated that in Cape York Peninsula streams *P. rendahli* are usually associated with aquatic vegetation.

Reproduction

The generalised gonad description given in volume 1 does not fit this species accurately. A more accurate description of gonad stages found in the plotosid family is given in Davis (1977b).

A total of 350 *P. rendahli* and *Neosilurus* sp. C (both henceforth referred to as *P. rendahli*) were examined for reproductive condition. This resulted in 29 juvenile or sexually indistinguishable fish (length range 36–144 mm TL), 209 females (60–288 mm TL) and 112 males (70–385 mm TL) being identified. The larger males and females were most likely specimens of *N. ater* that were included with *Neosilurus* sp. C before a taxonomic key was available.

Length at first maturity

The LFM for *P. rendahli,* calculated on 10-mm-length groups, was estimated to be 100 mm for males and 110 mm for females (fig 43). Two females (100 mm TL, stage V; and 99 mm TL, stage IV) and one male (95 mm TL, stage IV) were found maturing at a length less than the LFM.

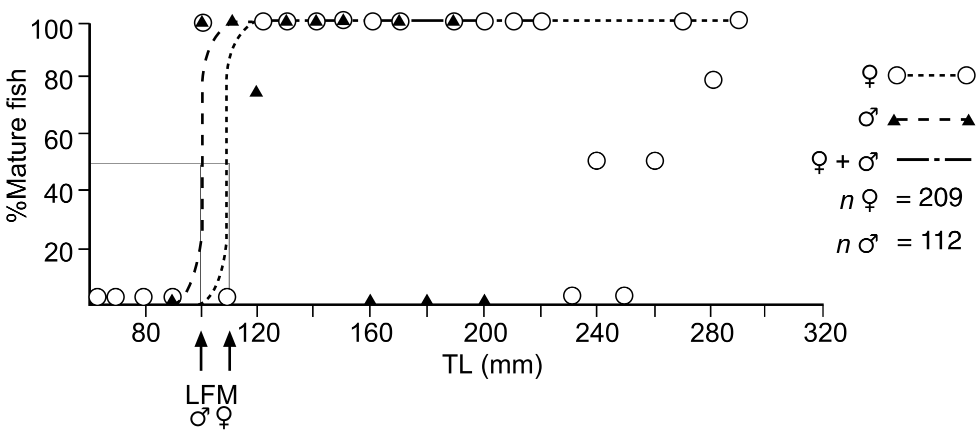


Figure 43 Estimated length at first maturity (LFM) of male and female *P. rendahli*

Sex ratio

Chi-squared tests (Zar 1974) indicated that significantly more females than males were present in the samples of all fish (except during the 1978–79 Early-wet and Mid-wet seasons) and of adults only (except during the 1978–79 Early-wet to the Late-wet–Early-dry seasons) (see table 38). These results suggest that females became distinguishable at an earlier stage before spawning than the males.

Breeding season

The GSI and GMSI indicated *P. rendahli* has a well-defined breeding season with clear peaks of gonad development during the 1978–79 and 1979–80 Early-wet seasons; after the 1978–79 Early-wet season peak the GSI and GMSI fell to the baseline level and remained low until the 1979–80 Early-wet season peak (table 38 and fig 44).

Mature fish were captured during the 1978 Late-dry and the 1978–79 and 1979–80 Early-wet seasons and, although no ripe fish were collected, spent fish were identified in the 1978–79 Mid-wet and Late-wet–Early-dry seasons. These data confirm that spawning is in the Early-wet season and suggest that the resorption and recovery of gonads after spawning can take a long time, as spent gonads were identified up to two seasons (four months) after the spawning period.

Table 38 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *P. rendahli* in 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*	45	15	6	36	58	39	10
adults	M	*n*	17	13	7	19	33	19	4
		χ^2	12.64	0.14	0.08	5.25	6.9	6.9	2.6
		P	***	n.s.	n.s.	*	**	**	n.s.
Adults only	F	*n*	44	11	6	28	47	38	9
	M	*n*	15	13	6	18	25	19	4
		χ^2	14.3	0.2	0	2.2	6.7	6.3	1.9
		P	***	n.s.	n.s.	n.s.	**	*	n.s.
GSI									
Adults only	F	mean	1.1	4.8	0.4	0.2	0.3	0.5	5.2
		s.d.	1.1	1.4	0.5	0.1	0.08	0	1.7
	M	mean	0.3	0.6	0.5	0.06	0.1	0.2	0.7
		s.d.	0.3	0.4	0.06	0.05	0.05	0.1	0.1
	F+M	mean	0.8	2.5	0.2	0.1	0.2	0.3	3.3
		s.d.	1.0	2.4	0.4	0.1	0.1	0.2	2.7
GMSI									
Adults only	F	mean	3.1	4.7	2.0	2.1	2.4	2.2	4.3
		s.d.	0.6	0.4	0	0.4	0.5	0.2	0.4
	M	mean	2.6	4.3	1.7	1.7	1.9	2.1	3.5
		s.d.	0.5	0.4	0.9	0.7	0.4	0.6	0.9
	F+M	mean	2.9	4.5	1.8	1.9	2.2	2.1	4.0
		s.d	0.6	0.5	0.6	0.5	0.5	0.5	0.7

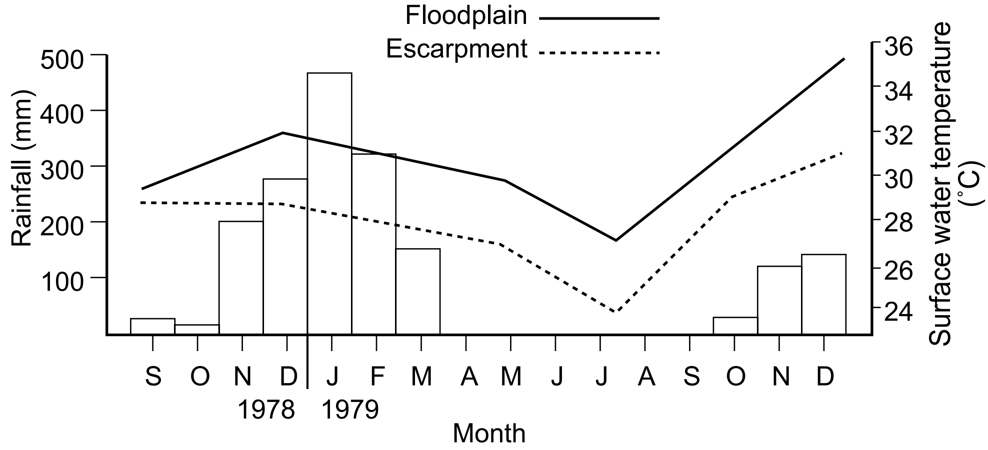
n = number; χ^2 = Chi-squared value; n.s. = not significant (P > 0.05); * = 0.01 < P < 0.05; ** = 0.001 < P < 0.01; *** = P < 0.001; s.d. = standard deviation

Site of spawning

All mature and spent fish were caught in backflow billabongs (table 39) or artificial dams such as those near Nabarlek mining camp and Retention Pond 1 in RUPA.

Table 39 Possible sites of spawning of *P. rendahli* as indicated by the abundance (*n*) of mature, ripe and spent fish

Habitat	Gonad stage					
	Mature (V)		Ripe (VI)		Spent (VII)	
	F	M	F	M	F	M
Lowlands						
Sandy creekbed	–	–	–	–	–	–
Backflow billabong	6	4	–	–	9	3
Artificial	3	–	–	–	–	–



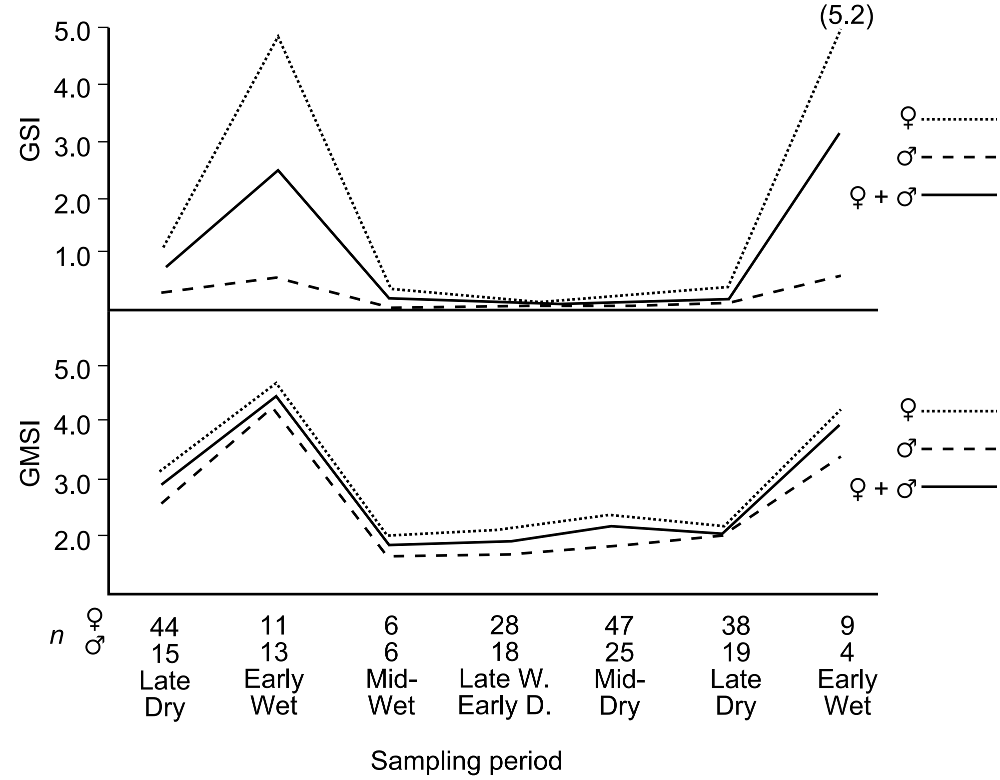


Figure 44 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *P. rendahli*

Fecundity

The ovaries of eight fish were examined. Egg numbers ranged from 240 (fish length 100 mm TL, weight 6.3 g, GSI 3.62) to 3465 (fish length 209 mm TL, weight 80 g, GSI 7.25), with an average egg count of 900 eggs. The egg diameter means ranged from 1.1 mm (fish length 139 mm TL, weight 19.3 g, GSI 5.36) to 1.5 mm (fish length 148 mm TL, weight 25 g, and GSI 4.18), with an average diameter of around 1.3 mm.

Summary

Male and female *P. rendahli* matured at approximately the same length: 100 mm for males and 110 mm TL for females. Females appeared to start gonad development earlier than males and were, therefore, sexually distinguishable before the males; this produced unequal sex ratios in the samples preceding the spawning period.

There was a well-defined breeding season during the 1978–79 and 1979–80 Early-wet seasons, with both GSI and GMSI falling rapidly to a baseline level after spawning and remaining low until the next breeding season. *Porochilus rendahli* appears to spawn only in backflow billabongs and in artificial dams. It lays around 900 eggs with an average diameter of 1.3 mm.

Feeding habits

Overall diet

The stomachs of 125 *Neosilurus* sp. C and 301 *P. rendahli* were examined; 114 and 283, respectively, contained food. The overall diets are presented in fig 45; details of the components are given in table 40. The main components were aquatic insects (45% and 42%, respectively) and microcrustaceans (19% and 36%). The main aquatic insects were chironomid larvae and the main microcrustaceans were cladocerans. Other items in the stomachs were unidentified organic material (17%), detrital material (3%) and traces of algae, gastropods, aquatic arachnids, macrocrustaceans and teleost scales.

Porochilus rendahli and *Neosilurus* sp. C can therefore be classified as meiophagous carnivores that feed predominantly on benthic fauna. Apparent differences in their diets may partly be caused by seasonal differences in the availability of food items when these classification types were in use. No literature on the feeding habits of *P. rendahli* was found.[76]

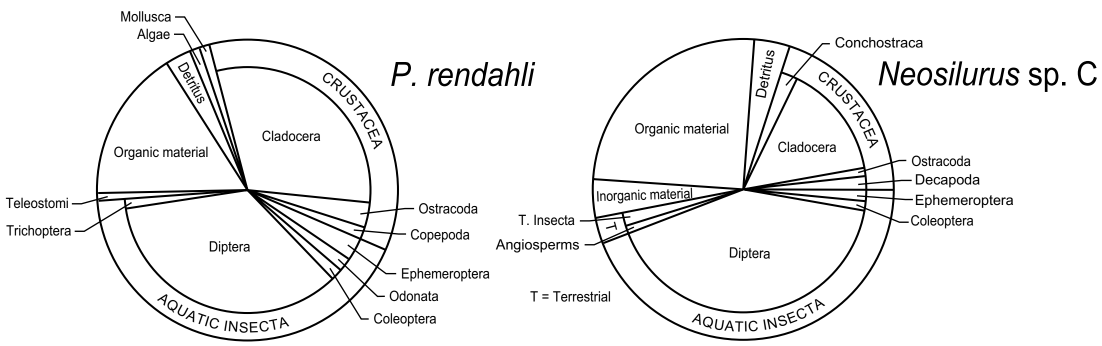


Figure 45 The main components of the diet of *Neosilurus* sp. C and *P. rendahli*

Seasonal changes

In sampling periods 1–3, respectively, 69 (13% empty), 39 (33% empty) and 16 (37% empty) stomachs of *Neosilurus* sp. C were examined (all habitats combined). The highest proportions of specimens with empty stomachs were found in the 1978–79 Early-wet and Mid-wet seasons.

The diet in the 1978 Late-dry season consisted mainly of chironomid larvae and cladocerans. During the 1978–79 Early-wet and Mid-wet seasons large amounts of unidentified organic material were found in the stomachs; however, chironomid larvae remained important and conchostracans and ostracods were eaten instead of the cladocerans in the Late-dry season. Mainly chironomid larvae, with only traces of microcrustaceans, were eaten in the Mid-wet season.

76 Smith (1998) indicated that in the Fly River system of Papua New Guinea, the closely-related *P. obbesi* primarily consumed aquatic insects, detritus/mud, crustaceans and aquatic plants in that order. Worms, terrestrial plants and terrestrial insects were also consumed, but in low quantities.

Table 40 Dietary composition of *Neosilurus* sp. C and *P. rendahli*

	Neosilurus sp. C					*P. rendahli*						Habitat		
	Season			Overall		Season				Overall		Magela system		Nourlangie system
Stomach contents	1978 Late-dry	1978–79 Early-wet	1978–79 Mid-wet	Sub-mean	Main-mean	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Sub-mean	Main-mean	Bb	Fb	Bb
Aquatic plants														
Algae					0.1						0.3			
Miscellaneous	–	0.4	–	0.1		–	–	–	–	–		–	–	–
Conjugatophyta														
Mougeotia	–	–	–	–		1.2	–	–	–	0.3		–	1.4	–
Aquatic animals														
Gastropoda					–						1.1			
Amerianna	–	–	–	–		1.6	0.7	1.7	–	1.1		0.9	1.9	1.5
Arachnida											0.5			
Hydracarina	–	–	–	–		–	1.3	–	–	0.5		–	2.4	–
Microcrustacea					19.0						35.5			
Conchostraca														
Cyzicus	–	10.4	–	2.4		0.3	0.5	–	–	0.3		0.4	–	–
Cladocera														
Miscellaneous	25.1	–	–	15.5		26.3	4.2	–	–	8.5		6.4	17.1	7.7
Diaphanosoma	–	–	2.0			14.5	20.3	24.1	50.0	22.0		18.8	22.9	41.5
Ostracoda	0.3	2.3	1.0	1.0		4.1	3.4	0.4	–	2.5		1.3	7.4	–
Copepoda														
Miscellaneous	–	–	–	0.1		0.8	2.5	–	–	1.2		1.0	2.4	–
Cyclops	–	–	–	–		–	–	3.5	–	1.0		1.4	–	–
Macrocrustacea					1.8						–			
Macrobrachium	3.3	–	–	1.8		–	–	–	–	–		–	–	–
Insecta					44.5						41.5			
Ephemeroptera														
Baetidae	1.0	–	–	0.5		2.0	6.0	–	–	2.9		2.7	2.4	7.7
Odonata														
I. heterosticta	–	–	–	–		–	5.3	–	–	2.1		1.5	4.8	–
Hemiptera														
Corixidae	0.2	–	–	1.0		–	–	–	–	–		–	–	–

Table 40 continued

Stomach contents	*Neosilurus* sp. C					*P. rendahli*						Habitat		
	Season			Overall		Season				Overall		Magela system		Nourlangie system
	1978 Late–dry	1978–79 Early-wet	1978–79 Mid-wet	Sub-mean	Main-mean	1979 Late-wet–Early-dry	1979 Mid-dry	1979 Late-dry	1979–80 Early-wet	Sub-mean	Main-mean	Bb	Fb	Bb
Coleoptera														
Miscellaneous	–	2.7	–	0.7		–	–	0.6	–	0.2		0.2	–	–
Berosus	–	–	–	–		1.2	–	–	–	0.3		–	1.4	–
Diptera														
Chaoborinae	0.5	–	–	0.8		–	–	–	7.1	0.5		–	–	–
Chironomidae (larvae)	46.4	21.9	34.0	38.7		38.6	33.9	30.7	7.1	32.3		38.5	21.7	23.9
Chironomidae (pupae)	0.4	0.2	–	0.7		0.6	3.0	2.6	–	2.1		2.9	–	1.5
Ceratopogonidae	1.5	–	–	1.3		–	0.7	–	–	0.3		0.4	–	–
Trichoptera														
Hydroptilidae	–	–	–	–		0.1	0.1	–	–	0.1		–	–	0.8
Lepteroceridae	–	4.2	3.0	1.7		1.0	0.6	0.7	–	0.7		1.0	–	–
Teleostomi					+						0.5			
Scales	–	0.2	–	+		–	–	–	–	–		–	–	–
Egg material	–	–	–	–		–	1.3	–	–	0.5		–	2.4	–
Terrestrial plants					0.5						–			
Angiospermae	0.7	–	–	0.5		–	–	–	–	–		–	–	–
Terrestrial animals														
Insecta					1.6						–			
Odonata														
Zygopteran (adults)	1.5	–	–	0.8		–	–	–	–	–		–	–	–
Anisopteran (adults)	1.6	–	–	0.8		–	–	–	–	–		–	–	–
Parasites														
Trematoda	0.2	–	–	0.3	0.3	–	1.3	–	–	0.5	0.5	–	–	7.7
Nematoda	0.1	–	–	+	+	–	–	–	–	–	–			
Detrital material														
Inorganic material	3.2	8.3	3.0	3.8	3.8	–	–	–	–	–	–	–	–	–
Organic material	12.3	41.7	52.0	25.2	25.2	7.8	14.9	24.1	35.7	17.1	17.1	17.7	11.9	7.7
Number of empty fish	9	13	6	11	11	1	13	4	–	18	18	9	6	2
Number of fish with food	60	26	10	114	114	51	76	54	14	283	283	132	42	13

Figures represent the mean percentage volume determined by the estimated volumetric method. Fb = Floodplain billabong; Bb = Lowland backflow billabong

In sampling periods 4–7, respectively, 52 (2% empty), 89 (15% empty), 58 (3% empty) and 14 (4% empty) stomachs of *P. rendahli* were examined (all habitats combined). The highest proportions of specimens with empty stomachs occurred in the 1979 Mid-dry season.

Chironomid larvae were the main food items in the stomachs from the Late-wet–Early-dry season to the 1979 Late-dry season. Microcrustaceans (mainly cladocerans) were also important food items in those seasons and in the 1979–80 Early-wet season they were the most common food item.

Habitat differences

Magela catchment

A total of 141 (6% empty) stomachs of *P. rendahli* were examined (all seasons combined) from backflow billabongs, and 48 (13% empty) from floodplain billabongs.

The diet in the backflow billabongs was based mainly on chironomid larvae followed by cladocerans (mainly *Diaphanosoma*). In the floodplains the variety of major food items was slightly greater: the aquatic insects included chironomid, baetid and *Ischnura heterosticta* larvae, and the microcrustaceans included cladocerans, ostracods and copepods.

Nourlangie catchment

A total of 15 stomachs of *P. rendahli* was examined (all seasons combined) from backflow billabongs; 2 did not contain food.

In the Nourlangie catchment, *P. rendahli*'s diet was very similar to that in the Magela Creek catchment; however, the proportion of microcrustaceans (mainly cladocerans) was slightly higher.

Fullness

A summary of mean fullness indices of *P. rendahli/Neosilurus* sp. C for different sampling periods and habitat types is shown in table 41. These data are presented on the assumption that feeding times do not vary with habitat or season.

Seasonal changes

The mean seasonal fullness index (all habitats combined) increased during the 1978–79 Early-wet season and then decreased into the Mid-wet season. It increased again in the Late-wet–Early-dry season, fell in the Mid-dry season, and index rose again in the 1979–80 Early-wet season, as in the previous year.

Habitat differences

In the Magela catchment, the mean two fullness indices calculated for specimens from the shallow backflow billabongs upstream of RUPA were lower than for specimens from backflow billabongs downstream.

Downstream of RUPA the highest mean indices were recorded from the shallow backflow billabongs, with slightly lower indices from channel backflow and floodplain billabongs.

The mean fullness indices of specimens from lowland habitats in the Nourlangie catchment were lower than those recorded from equivalent Magela Creek habitats; however, the shallow backflow billabong specimens had similar mean indices to those from the channel backflow billabongs in the Magela catchment.

Table 41 Mean fullness indices of *P. rendahli* in different sampling periods and habitats

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:								
Lowland shallow backflow billabong	n/s	n/s	n/s	n/s	1.3 (11)	1.8 (19)	n/s	1.6 (30)
Downstream of RUPA:								
Lowland channel backflow billabong	2.1 (20)	1.8 (6)	4.5 (2)	2.6 (17)	2.0 (18)	1.8 (6)	2.3 (3)	2.2 (72)
Lowland shallow backflow billabong	1.8 (9)	3.1 (20)	n/s	3.7 (34)	2.4 (23)	2.4 (39)	3.0 (3)	2.8 (128)
Corridor anabranch billabong	n/s	3.0 (1)	n/s	1.0 (1)	n/s	n/s	n/s	2.0 (2)
Floodplain billabong	n/s	n/s	5.0 (1)	2.8 (23)	1.2 (10)	1.5 (2)	n/s	2.3 (36)
Nourlangie Creek catchment (regular sites only)								
Lowland channel backflow billabong	n/s	3.0 (1)	0.8 (11)	3.5 (2)	n/s	n/s	n/s	1.3 (14)
Lowland shallow backflow billabong	1.7 (3)	3.0 (5)	n/s	4.0 (1)	1.7 (14)	n/s	n/s	2.1 (23)
Seasonal mean (all sites)	2.0	2.8	1.6	3.0	2.0	2.1	3.2	

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

Summary

The habitats and periods of greatest apparent feeding activity where more than one fish was captured were:

Magela catchment

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

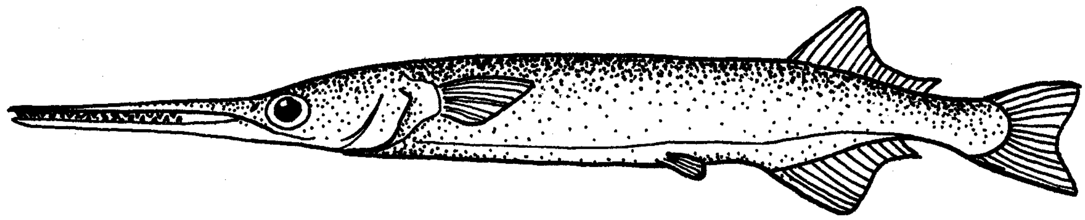
Nourlangie catchment

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

Family BELONIDAE

3.12 *Strongylura krefftii* (Gunther)

Strongylura krefftii is commonly known as the freshwater longtom or needle fish. It is found in the drainage systems of the north-east coast, Gulf of Carpentaria and Timor Sea (see map 3) and in southward-flowing rivers of Papua New Guinea. Pollard (1974) found this species to be plentiful in the Magela Creek catchment in sandy corridor waterbodies, floodplain billabongs, lowland backflow billabongs, and lowland sandy creekbeds. In the Nourlangie system he found it in lowland sandy creekbeds and escarpment mainchannel billabongs. Miller (in Taylor 1964) found it in large billabongs in the Oenpelli area.



Strongylura krefftii

This species is a member of a predominantly marine genus and family, but is restricted to freshwaters in northern Australia and southern New Guinea.[77] It normally swims and feeds on the surface, but is also found lurking under overhanging vegetation and amongst tree roots.

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 floodplain, corridor and lowland backflow billabongs; it was also common in lowland sandy creekbeds downstream of RUPA and in escarpment mainchannel waterbodies, but rarely in escarpment perennial streams. It was found in the most sites in the Late-wet–Early-dry season, and in the fewest in the Late-dry season.

Size composition

The lengths and weights of 224 specimens were determined. The main peak in the overall length-frequency distribution was caused by the cumulative effect of overlapping sampling methods (ie seine nets and gillnets). The mesh selectivity of gillnets is magnified with this species due to the elongated body shape and its relation to the critical girth at capture.

Length–weight relationship

The length–weight relationship was described by the expression:

$W = 0.98 \times 10^{-3} L^{3.2}$ $r = 0.94$ (length in cm, weight in g)

Seasonal mean lengths, weights and condition factors are shown in table 42. The seasonal condition factor decreased slightly in the transition from the 1978 Late-dry season to the 1978–79 Early-wet season (probably due to spawning activity) and then increased into the Mid-wet. It then decreased through the Late-wet–Early-dry season to reach a low by the Mid-dry season. Increasing availability of small forage fish in contracting Dry-season billabongs

77 Herbert and Peeters (1995) indicated that *S. krefftii* can also be found in estuaries in north-eastern Queensland.

may have caused the improvement in body condition by the 1979 Late-dry season. The single specimen captured in the 1979–80 Early-wet season was in good condition (K = 1.22).

Table 42 Mean length, mean weight and condition factor of *S. krefftii*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	48	358.3	87.8	0.96
Early-wet	16	424.0	144.2	0.93
Mid-wet (1978–79)	54	257.8	31.9	1.10
Late-wet–Early-dry (1979)	34	288.3	44.4	0.98
Mid-dry	39	326.5	54.6	0.81
Late-dry	25	386.3	113.8	0.98
Overall	216	316.1	61.00	1.00

Length-frequency distribution

The smallest specimen caught was 50 mm LCF, and the largest was 640 mm LCF (fig 46). Lake (1971) reported that this species grows to only 750 mm. The mean and modal lengths were 316 and 300 mm LCF respectively. The LFM was 290 mm LCF for males and 410 mm LCF for females. Most specimens captured (mainly with the seine net and the smaller mesh gillnets) were between 210 and 360 mm LCF. There was a series of small peaks, possibly caused by mesh selectivity of the various gillnets used, for specimens with lengths greater than 400 mm LCF.

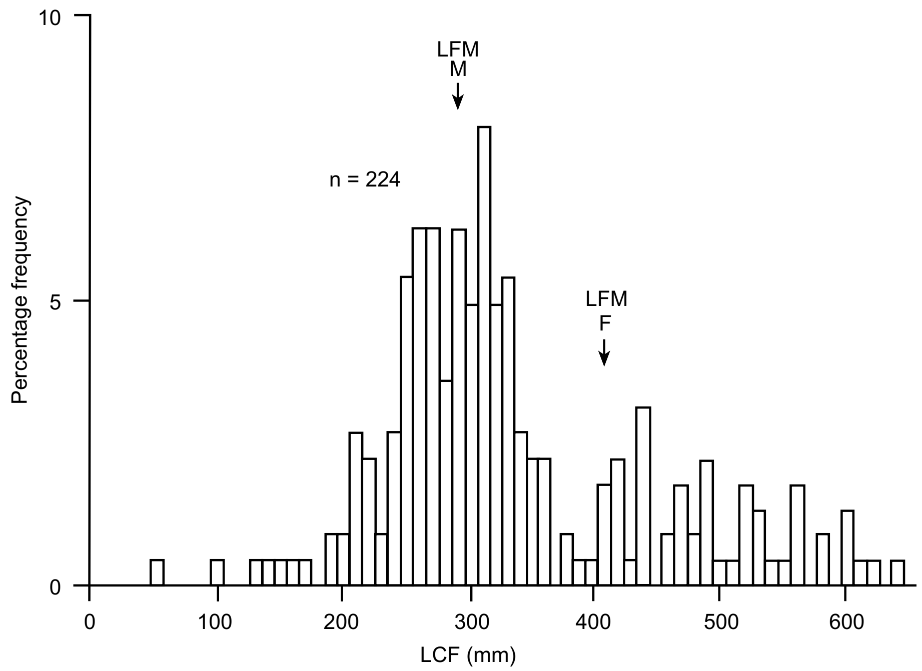


Figure 46 Length-frequency distribution of all *S. krefftii* captured

Seasonal changes in distribution

As the smallest specimens were captured in the Mid-wet season (fig 47), this is probably the main period for juvenile recruitment. The smallest specimens collected in the 1978–79 Early-wet season and both Late-dry seasons were much larger than the smallest specimens collected in the other seasons. The largest specimen was caught in the 1979 Late-dry season.

The seasonal mean lengths of all specimens captured are shown in table 42. The mean lengths peaked in both Late-dry to Early-wet transition seasons, but then fell dramatically when large numbers of small recruits entered the populations in the Mid-wet season. These recruits were present in catches for the remainder of the study (except in the 1979–80 Early-wet season, when the sample size was small) and mean lengths increased due to their growth; the resulting 1979 Late-dry length-frequency distribution was similar in form to the distribution recorded in the 1978 Late-dry season.

Growth rate

No published information could be found on the growth rate of *S. krefftii*. Estimation of growth rate from the seasonal length-frequency distributions is difficult due to mesh selectivity, the frequency with which small specimens appear to be recruited into the populations, and the wide range of habitats sampled.

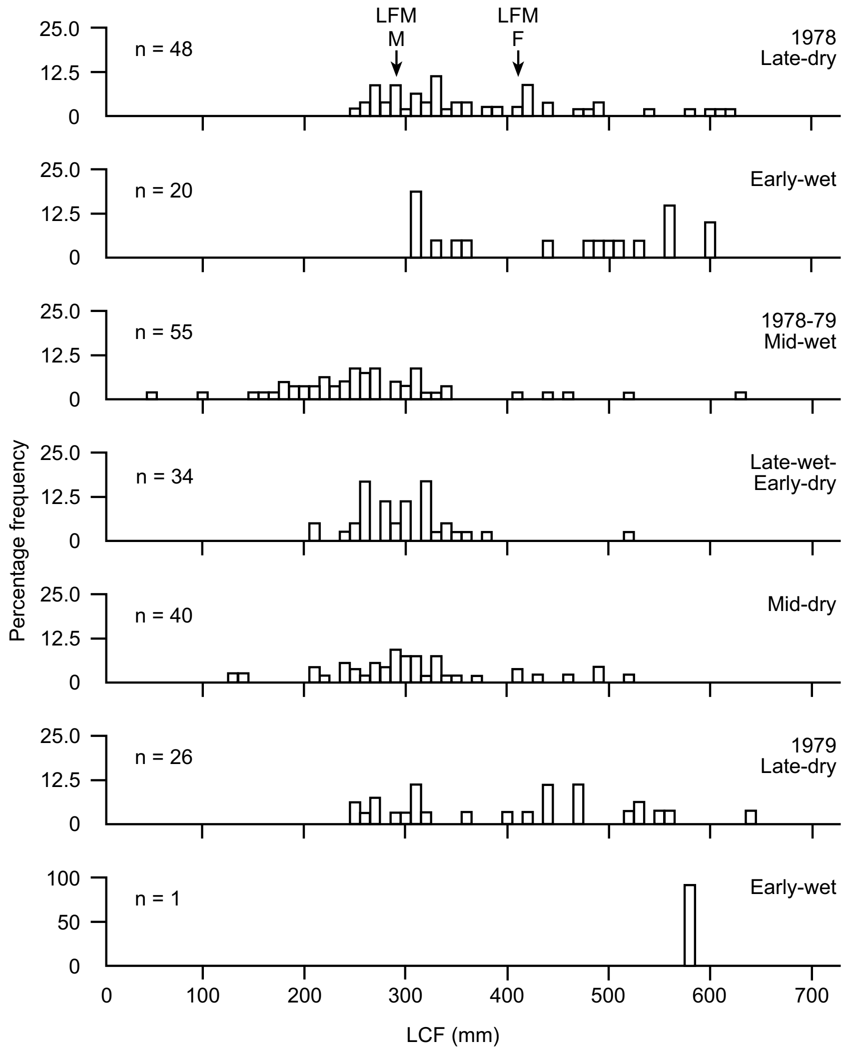


Figure 47 Seasonal length-frequency distribution of all *S. krefftii* captured

However, the increase in mean lengths of the recruits that first appeared in the Mid-wet season (table 42) gives a tentative estimate of growth if followed to the 1979 Late-dry season, although it would be a slight overestimate, as larger numbers of adults were captured towards the end of the 1979 Dry season. The growth increment in the roughly eight-month period is about 130 mm, indicating a yearly increment of 200 mm. Therefore, the small specimens that appeared in the Mid-wet season were possibly over a year old, and males may attain the LFM during their second year and females by the end of their second year of life. The whereabouts of the small recruits (0–1 year olds) before the Wet seasons is unknown.

Habitat differences in distribution

Length-frequency distributions showing the habitat preferences of *S. krefftii* captured in regular sampling sites in the Magela and Nourlangie Creek catchments are given in figure 48.

As a result of the apparently large difference (130 mm) between the LFM of males and females, it is difficult to distinguish juveniles from adults in length-frequency distributions for the sexes combined. The specimens were therefore divided into three groups: small (< 200 mm LCF, all juveniles); intermediate (201–360 mm LCF, large juveniles and small adults; most specimens fell into this group); and large (> 361 mm LCF, mostly adults).

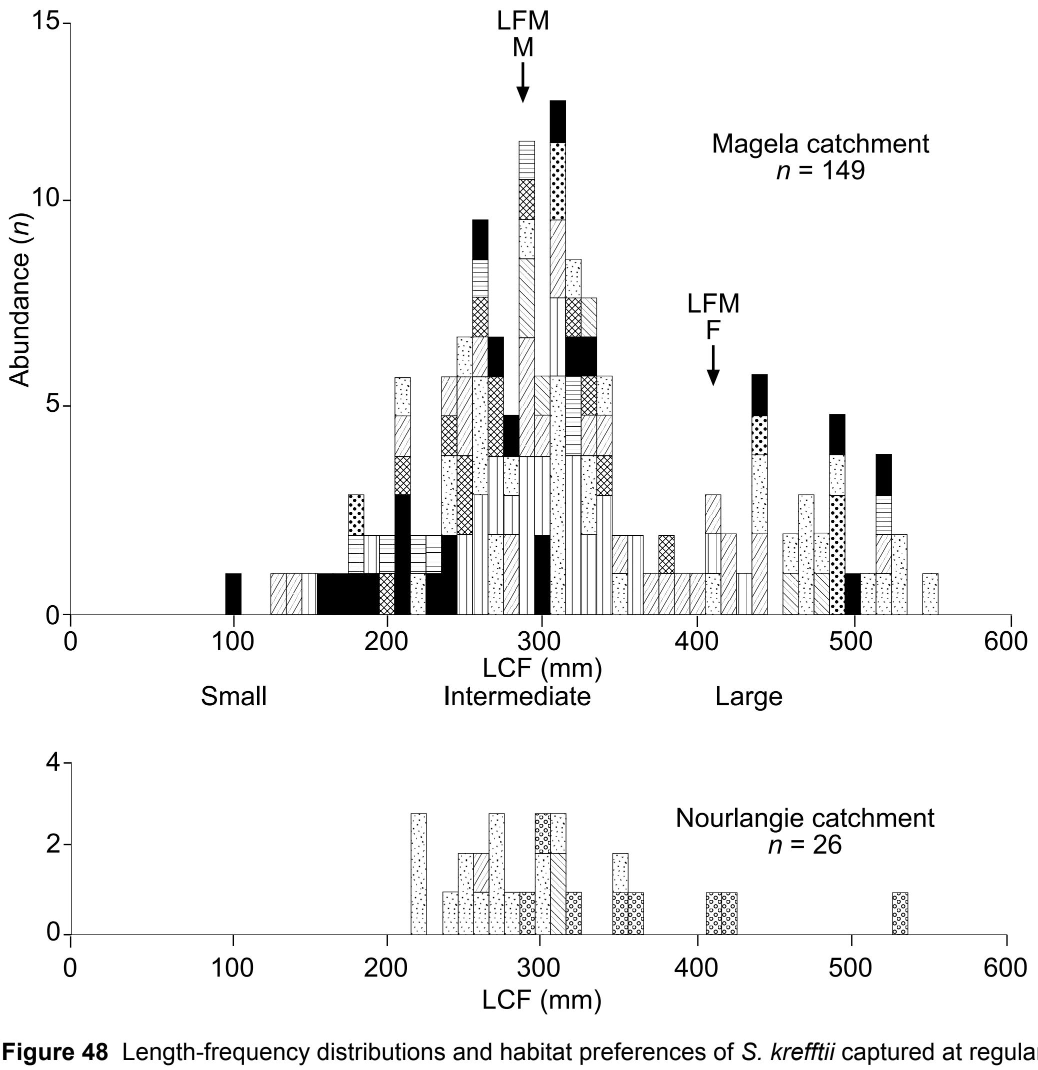


Figure 48 Length-frequency distributions and habitat preferences of *S. krefftii* captured at regular sampling sites (see appendix 5 for key to the habitats)

Magela catchment

The small specimens were collected mainly from floodplain billabongs, but were also found in lowland sandy creekbeds, corridor waterbodies (dispersal routes) and shallow backflow billabongs. The smallest specimen (50 mm LCF) was collected from a floodplain billabong.

The few intermediate-sized specimens collected in floodplain billabongs were towards the lower end of the size range. Most were captured in backflow billabongs (mainly shallow types) and sandy creekbeds, with smaller numbers being found in corridor and escarpment mainchannel waterbodies.

The large specimens, including the largest (550 mm LCF), were found in a lowland channel backflow billabong. The smaller specimens of this group were captured mainly in lowland sandy creekbeds. Large specimens were also captured in escarpment mainchannel billabongs, floodplain and corridor waterbodies, and lowland shallow backflow billabongs.

Nourlangie catchment

No small specimens were captured, probably as a result of low sampling effort. Most of the intermediate-sized specimens were captured in lowland backflow billabongs; the smaller ones mainly in the channel-type billabongs, and the larger mainly in shallow backflow billabongs. Some intermediate-sized specimens appeared in escarpment perennial streams during the Mid-wet season. All large specimens were found in shallow backflow billabongs.

Environmental associations

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

Physico–chemical variables

Temperature

The water temperature at sites where *S. krefftii* was captured ranged from 24° to 38°C (mean = 30°C) on the surface, and from 24° to 34°C (mean = 29°C) on the bottom. Both of these means ranked in the lower-middle quarter (see fig 170). The implied tolerance of a wide range of water temperatures corresponds to the wide distribution of this species from lower escarpment to floodplain waters. The range of surface-water temperatures may be more indicative of this species' range of tolerance, since *S. krefftii* is primarily a surface swimmer and feeder (Pollard 1974).

Dissolved oxygen

Dissolved oxygen concentrations ranged from 3.7 to 9.1 mg/L (mean = 6.3) on the surface, and from 0.2 to 7.0 mg/L (mean = 3.9) on the bottom. The means were ranked in the upper and lower-middle quarters respectively (see fig 171). The range of DO concentrations reflects the wide distribution of the species, from escarpment to lowland waters. This species was present in the Leichhardt Billabong fish kill (Bishop 1980), during which DO concentrations in surface waters fell below 0.1 mg/L.

Visibility

Secchi depths ranged from 1 to 360 cm, with a mean depth of 72 cm. This mean ranked in the upper-middle quarter (see fig 172).

pH

Strongylura krefftii was taken from waters with surface pH from 4.5 to 8.6 (mean = 6.4), and bottom pH from 4.5 to 7.3 (mean = 6.1). These means ranked in the lower and lower-middle quarters respectively (see fig 173). As with the preceding physico–chemical variables, a wide range of tolerance is indicated.

Conductivity

Surface conductivities ranged from 6 to 98 μS/cm; bottom water conductivities from 4 to 78 μS/cm. These ranges are narrow compared with the conductivities associated with other species, and with the other physico–chemical variables recorded for this species.

Habitat–structural variables

Substrate

As might be expected from its wide distribution in the system, *S. krefftii* was captured over the entire range of substrate types defined in this study. Mud (upper quarter) was the most common, followed by sand (lower-middle quarter), then clay, gravel, leaves, rocks and boulders (see fig 174).

Hydrophytes

Strongylura krefftii was found in moderate to highly vegetated waters (vegetation-occurrence index 74.2%) with submergent (43.1%), emergent (29.1%) and floating-attached hydrophytes (26.1%). Pollard (1974) often observed this species lurking under overhanging vegetation and amongst tree roots (eg *Pandanus* sp.), and Lake (1971) noted that this species lays tendrilled eggs that adhere to submerged vegetation; hydrophytes and bank vegetation may therefore play a significant role in the ecology of this species.

Reproduction

Of the 217 *S. krefftii* examined for reproductive condition, 47 were sexually indistinguishable (length range 52–362 mm LCF), 68 were females (133–640 mm LCF) and 102 were males (195–615 mm LCF).[78]

Length at first maturity

The smallest maturing specimens (gonad stage greater than III) were a 317 mm LCF female and a 267 mm LCF male; however, the LFM was estimated to be 410 mm and 290 mm, respectively (fig 49); all calculations were based on 10 mm-length groups.

The LFM for the females was surprisingly high (no maturing females were identified between 317 and 420 mm). Length frequencies were plotted for each sex to investigate the possibility of a sex reversal (fig 49), however, this phenomenon was not evident from the distribution.

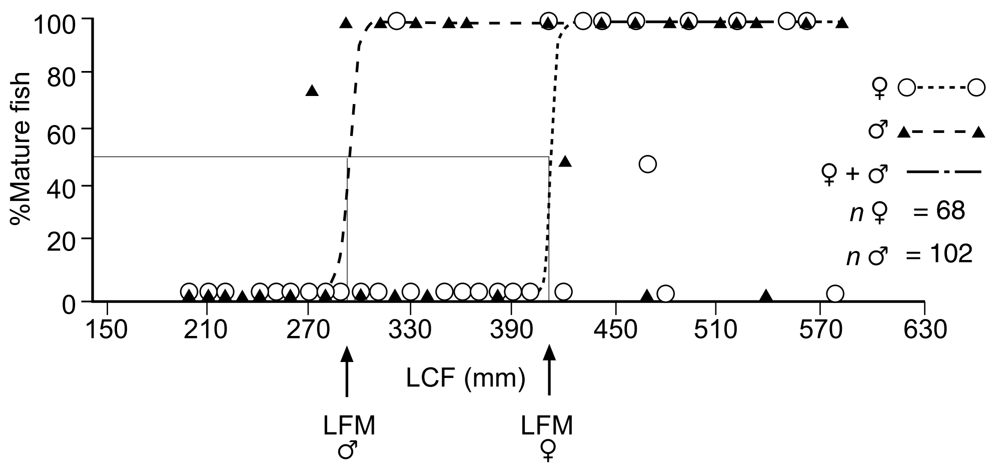


Figure 49 Estimated length at first maturity (LFM) of male and female *S. krefftii*

78 Hortle (1988) demonstrated that this species was sexually dimorphic, with males above 175 mm standard length becoming spotted and males above 400 mm developing a dorsal hump.

Sex ratio

A chi-squared test on the sex ratio of all adults and juveniles indicated a significantly ($P < 0.001$) greater proportion of males during the 1978–79 Mid-wet season (all other seasons had a 1:1 ratio) (table 43); the preponderance of males may have been due to a localised behavioural characteristic or migration during that season.

The ratio of adult males to adult females was significantly different ($P<0.001$) from 1:1 in the 1978–79 Mid-wet season and, at <0.05 level, in the 1978 Late-dry, 1978–79 Early-wet, 1979 Late-wet–Early-dry and Mid-dry seasons.

Most of the females captured were juveniles (fig 50); whereas the small LFM for males resulted in most males being classed as adults, which gave an unequal sex ratio.

Breeding season

Less than 0.1% of the specimens were identified as mature, ripe or spent. The GSI was low and changed very little throughout the year (fig 51 and table 43). There was a slight increase in gonad development during the 1978–79 Early-wet season, as indicated by both the GSI and GMSI.

Table 43 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *S. krefftii* 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*	15	5	6	12	14	14	2
Adults	M	*n*	22	12	32	8	18	10	0
		χ^2	1.3	2.9	17.8	0.8	0.5	0.7	2.0
		P	n.s.	n.s.	***	n.s.	n.s.	n.s.	n.s.
Adults only	F	*n*	6	2	0	1	4	6	1
	M	*n*	17	10	12	7	12	9	0
		χ^2	5.3	5.3	12	4.5	4	0.6	1
		P	*	*	***	*	*	n.s.	n.s.
GSI									
Adults only	F	mean	0.7	2.2	–	0.4	0.4	0.7	2.8
		s.d.	0.4	1.6	–	–	0.05	0.1	–
	M	mean	0.2	0.4	0.2	0.03	6.4	0.2	–
		s.d.	0.1	0.2	0.1	0.05	0.5	0.1	–
	F+M	mean	0.3	0.7	–	0.1	0.4	0.4	–
		s.d.	0.3	0.9	–	0.2	0.4	0.3	–
GMSI	F	mean	3.3	4.5	–	2	4	3.9	3
Adults only		s.d.	1.0	2.1	–	–	0	0.7	–
	M	mean	2.7	4.8	3	1.4	3.5	3.5	–
		s.d.	1.1	1.1	0.9	0.5	0.8	0.9	–
	F+M	mean	2.8	4.7	–	1.5	3.6	3.7	–
		s.d	1.1	1.2	–	0.5	0.7	0.8	–

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

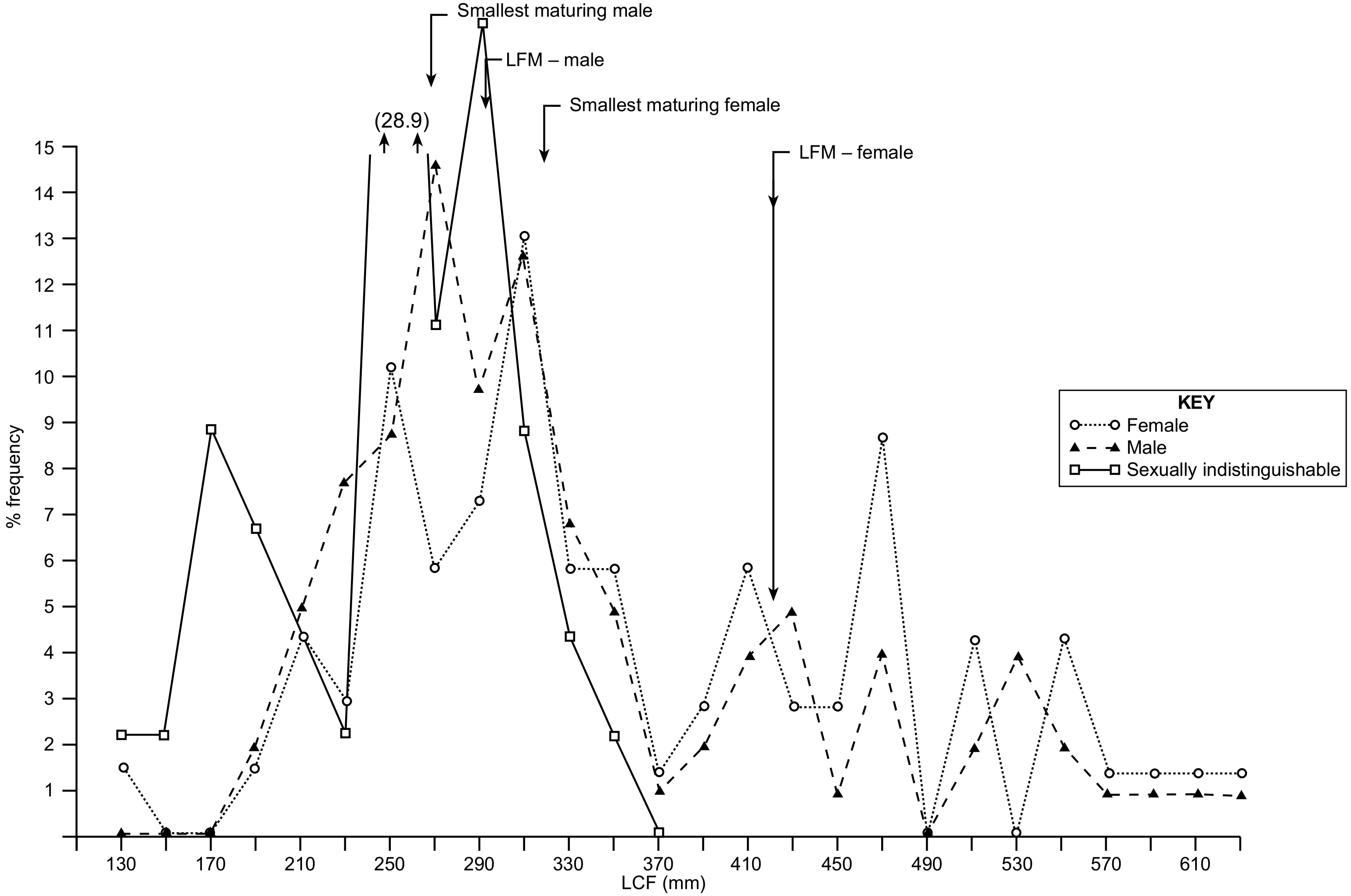


Figure 50 Length-frequency distributions of male, female and sexually indistinguishable *S. krefftii*

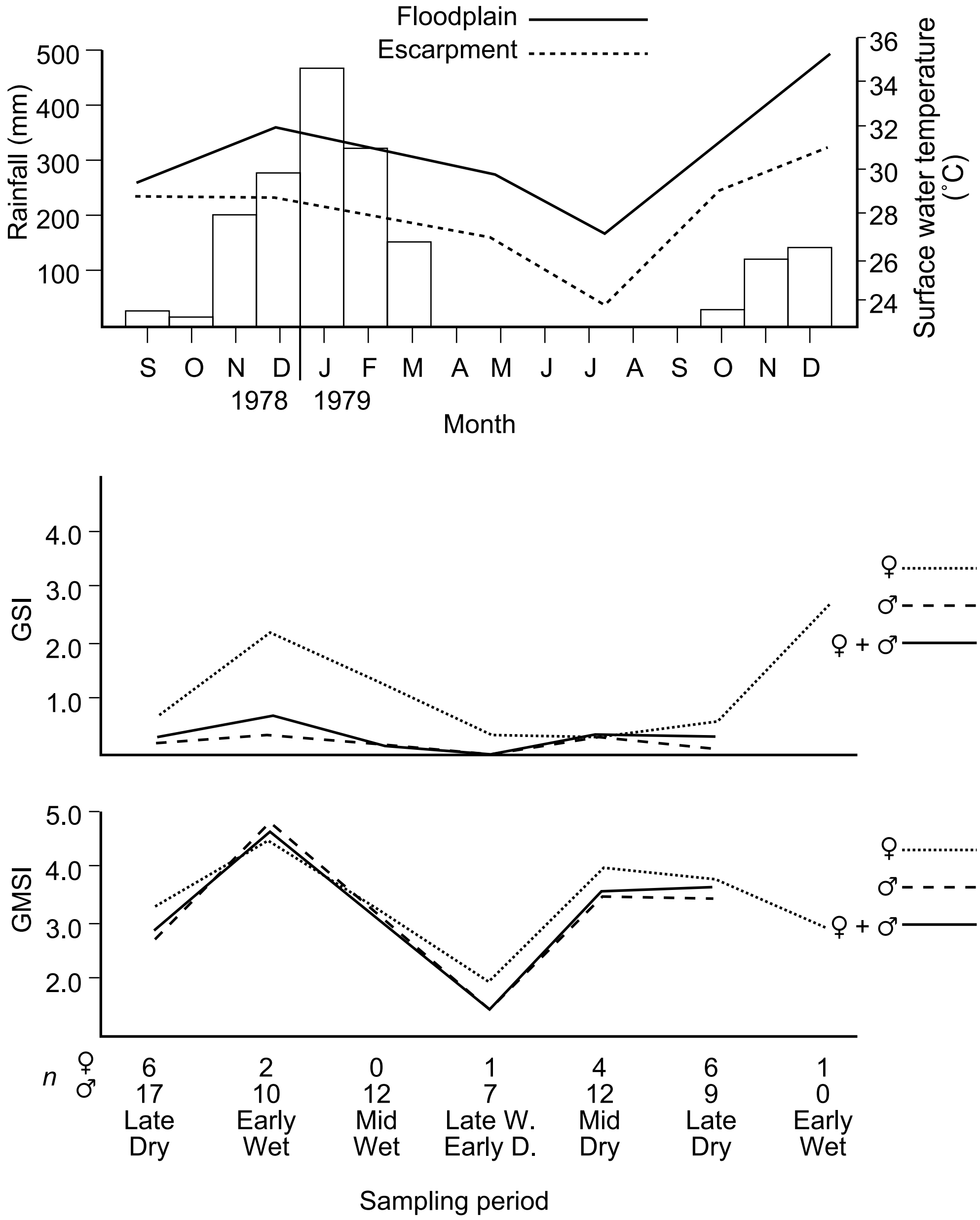


Figure 51 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *S. krefftii*

Mature fish were captured during the 1978 Late-dry and 1978–79 Early-wet and the 1979 Mid-dry and Late-dry seasons. Ripe fish were captured in the 1978 Late-dry and Early-wet seasons only, while spent fish were captured in the 1978–79 Mid-wet and Late-wet–Early-dry seasons.

Thus, the evidence suggests that *S. krefftii* matured towards the end of the 1978 Dry season and spawned around the 1978 Late-dry and 1978–79 Early-wet seasons. Most of the juvenile fish were collected during the 1978–79 Mid-wet; fish in the smallest size class (50–99 mm LCF) were most likely progeny from the previous Late-dry and/or Early-wet season spawning, which indicates a very fast rate of growth.

Site of spawning

Running-ripe fish were collected from a wide range of habitats (table 44), including an escarpment mainchannel waterbody (Sawcut Gorge), two lowland sandy creekbed sites (Magela bed) and three lowland shallow backflow billabongs (Djalkmara Billabong, Goanna Billabong and Nourlangie Rock).

Table 44 Possible sites of spawning for *S. krefftii* 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	–	–	1	–
Lowlands							
Sandy creekbed	–	–	–	4	–	–	1
Backflow billabong	3	4	1	4	1	–	2
Corridor	–	–	–	–	–	1	4
Floodplain billabong							
Upper	–	–	–	–	–	–	7

Spent fish were found in the escarpment area (Sawcut Gorge), a backflow billabong (Goanna Billabong) and a corridor waterbody (Mudginberri corridor).

Most of the juvenile fish were collected in the corridor and floodplain billabongs; possibly the planktonic eggs or larvae or both are carried to the lower reaches of the system by the flood waters that begin flowing during or soon after spawning has occurred in the higher reaches.

Fecundity

No ovaries of *S. krefftii* were collected and very little data are available on the reproductive biology of this species.

Summary

There was a large proportion of males in the population during the 1978–79 Mid-wet season, and there appears to be a large difference between the LMF for males and females (290 and 420 mm respectively). No sex reversal or hermaphroditism was evident. Only a very small proportion of fish (0.01% of the total number of males and females) had gonad maturation stages greater than IV; however, this small sample suggested that the gonads were maturing towards the end of the Dry season and that spawning was taking place around the Late-dry and Early-wet seasons. Possible spawning sites ranged from an escarpment mainchannel waterbody to backflow billabongs and sandy creekbed habitats (table 44).[79] Juveniles were predominantly collected from corridor and floodplain billabongs, which suggests that eggs or larvae or both may have been carried downstream with the flood waters.

The eggs of this family generally have adhesive tendrils, which act as hold-fasts to each other and to objects in the water. They are relatively large (up to 4 mm in diameter), and incubation takes 1–5 weeks, at temperatures around 24°C (Lake 1971; Breder & Rosen 1966), (probably less in the warmer waters of the Alligator Rivers Region).

79 Quoting communication with A. Orr of James Cook University, Smith (1998) indicated that *S. krefftii* have been observed spawning within macrophyte beds along the shore of Lake Moondarra in north-western Queensland. In the Fly River system of Papua New Guinea it is apparent that *S. krefftii* prefer to breed in floodplain lagoons rather than the main river channel (Smith 1998).

Feeding habits

Overall diet

The stomachs of 215 specimens were examined; 132 contained food. The overall diet of *S. krefftii* is summarised in fig 52; the components of the diet are listed in table 45.

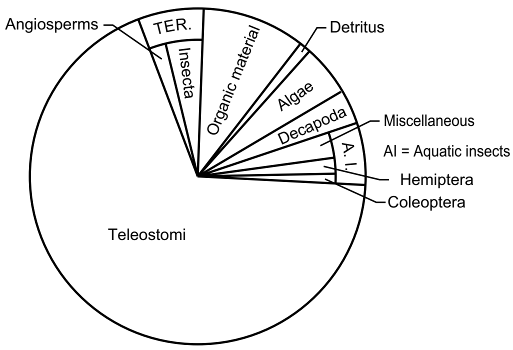


Figure 52 The main components of the diet of *S. krefftii*

The main components were teleosts (69%) and unidentified organic material (11%) (possibly mainly digested teleost flesh). The identifiable teleosts were mainly *Ambassis* spp., *M. splendida inornata*, *P. rendahli* and *A. percoides*. The remains of five other fish species were also identified. Small quantities of filamentous green algae, aquatic crustaceans (mainly *Macrobrachium*), surface-dwelling insects, terrestrial plant material and terrestrial insects were also in the stomachs. *Strongylura krefftii* can therefore be classified as a macrophagous carnivore/piscivore feeding opportunistically in (mainly) surface waters.[80] These data correlate well with those of Pollard (1974), who noted that it was a predatory species feeding on smaller fishes (especially atherinids, although few identifiable fish of this family were found in the stomachs in the present study, and melanotaeniids). Haines (1979) noted this species and the closely related *S. strongylura* are piscivores in the Purari River. Both jaws of this species are lengthened into a beak and have needle-sharp teeth for holding fish; the prey is first bitten sideways and then turned end-on to be swallowed head first (Lake 1971).

A total of 159 stomachs of *S. krefftii* were examined (all seasons combined) 8 (50% empty) from escarpment mainchannel waterbodies, 27 (30% empty) from lowland sandy creekbeds, 82 (55% empty) from shallow backflow billabongs, 24 (17% empty) from corridor waterbodies and 18 (28% empty) from floodplain billabongs in the Magela Creek catchment. The highest proportions of empty stomachs were in fish from shallow backflow billabongs and escarpment mainchannel waterbodies, and the lowest from corridor waterbodies.

Seasonal changes

In sampling periods 1–6, respectively, 47 (32% empty), 17 (64% empty), 52 (27% empty), 34 (38% empty), 39 (39% empty) and 25 (56% empty) stomachs of *S. krefftii* were examined (all habitats combined). The fish with the highest proportions of empty stomachs were caught in the Late-dry seasons and those with the lowest proportion in the Mid-wet season.

---

80 In an estuarine situation in northeastern Florida Bay USA, Ley et al (1994) found the diet of the closely-related *S. notata* to be dominated by fishes and insects. This species was observed capturing foods in a variety of ways — lunging down on benthic prey from above, skimming prey from the surface, and leaping out of the water to capture insects on overhanging trees. Diets varied greatly but not systematically among sites sampled.

Table 45 Dietary composition of *S. krefftii*

	Habitat						Season						Overall	
	Magela system					Nourlangie system	1978	1978–79	1978–79	1979	1979	1979		
Stomach contents	Em	Ls	Bb	Cb	Fb	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Sub-mean	Main-mean
Aquatic plants														
Algae														4.3
Miscellaneous	–	–	2.4	–	–	–	7.5	–	–	4.3	–	–	2.5	
Conjugatophyta														
Mougeotia	–	10.5	0.3	–	2.3	–	–	–	–	11.4	–	–	1.8	
Aquatic animals														
Macrocrustacea														3.1
Macrobrachium	–	12.6	4.1	–	–	–	8.4	16.7	–	–	2.1	–	3.1	
Insecta														5.8
Fragmented	–	5.3	–	–	–	–	9.4	–	–	–	–	9.1	3.0	
Hemiptera														
Gerridae	–	1.6	–	–	–	–	0.9	–	–	–	–	–	0.2	
Anisops	–	0.3	2.7	–	–	–	2.0	–	–	–	4.2	–	1.3	
Corixidae	–	–	2.7	–	–	–	–	–	–	4.8	–	–	0.8	
Coleoptera	–	–	–	–	–	–	2.2	–	–	–	–	–	0.5	
Teleostomi														69.3
Fragmented	25.0	10.5	30.8	50.0	38.5	55.6	26.6	50.0	52.6	28.1	35.4	36.4	37.8	
Scale	12.5	–	–	–	–	–	1.6	–	–	–	–	–	0.4	
N. erebi	–	–	–	–	7.7	–	–	–	2.6	–	–	–	0.8	
Neosilurus spp.	–	–	2.7	–	–	–	–	–	–	–	4.2	–	0.8	
P. rendahli	–	–	5.4	–	–	5.6	–	–	–	4.8	4.2	9.1	2.3	
M. splendida inornata	25.0	–	16.2	20.0	7.7	16.7	–	–	23.6	23.8	4.2	–	11.4	

Table 45 continued

	Habitat						Season						Overall	
	Magela system					Nourlangie system	1978	1978–79	1978–79	1979	1979	1979		
Stomach contents	Em	Ls	Bb	Cb	Fb	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Sub-mean	Main-mean
Craterocephalus spp.	–	–	–	–	–	–	2.5	–	–	–	–	–	0.6	
C. stercusmuscarum	–	–	–	–	7.7	–	–	–	–	4.8	–	–	0.8	
Ambassis spp.	–	10.5	10.8	20.0	15.4	22.2	9.4	–	18.4	4.8	20.8	–	12.1	
A. percoides	–	5.3	–	–	–	–	–	–	–	–	4.2	9.1	1.5	
L. unicolor	25.0	–	2.7	–	–	–	–	–	2.6	–	–	–	0.8	
Terrestrial plants														
Angiospermae														3.6
Miscellaneous	–	8.7	5.4	5.0	–	–	2.3	–	–	4.8	4.2	18.2	3.6	
Terrestrial animals														
Insecta														1.0
Fragmented	–	3.2	–	–	–	–	1.9	–	–	–	–	–	0.5	
Orthoptera	–	–	–	–	5.0	–	–	–	–	–	–	5.9	0.5	
Parasites														0.8
Nematoda	–	5.3	–	–	0.4	–	3.1	–	–	–	–	0.5	0.8	
Detrital material	–	–	–	–	–	–	3.7	–	–	–	–	–	0.9	0.9
Inorganic material	–	–	0.3	–	–	–	–	–	–	0.5	–	–	0.1	0.1
Organic material	12.5	26.3	13.5	5.0	15.4	–	18.4	33.3	–	8.1	16.7	11.8	11.3	11.3
Number of empty fish	4	8	45	4	5	5	15	11	14	13	15	14	83	83
Number of fish with food	4	19	37	20	13	18	32	6	38	21	24	11	132	132

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

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

The fish component of the diet varied seasonally: the proportion was lowest in the two Late-dry seasons and the Early-wet season, and highest in the Mid-wet season. In the Late-dry season, *Ambassis* and *Craterocephalus* were typical foods, and in the Mid- to Late-wet season, *M. splendida inornata*, *Ambassis* spp., *P. rendahli*, *C. stercusmuscarum* and *L. unicolor*. In the Late-dry seasons, the diet included traces of algae, *Macrobrachium*, various surface-dwelling aquatic insects, terrestrial insects and terrestrial plant material. In the Late-wet–Early-dry season, large volumes of filamentous green algae (which bloomed during this season), corixids and some terrestrial plant material were eaten; during the Mid-dry season *Macrobrachium*, *Anisops* (a surface-dwelling hemipteran insect) and terrestrial plant material were eaten.

Organic material (possibly partly digested fish flesh) was highest in the 1978–79 Early-wet and lowest in the Mid-wet and Late-wet–Early-dry seasons. Spiruroid nematodes were found in greatest abundance in the stomachs during the Late-dry seasons.

Habitat differences

Magela catchment

The small number of *S. krefftii* examined from the escarpment mainchannel waterbody were feeding exclusively on fish, of which *M. splendida inornata* and *L. unicolor* were identifiable. Fish were less important (although the large amount of unidentified organic material was probably digested fish flesh) in the diet in sandy creekbeds, where the prey were *Ambassis* spp. and *A. percoides*. *Strongylura krefftii* ate a variety of other foods in the sandy pools, including filamentous green algae (which it may have ingested incidentally when preying on species that seek shelter in the extensive algal mats that grow in some pools at the end of the Wet season), *Macrobrachium*, miscellaneous aquatic and terrestrial insects, and terrestrial plant material. Spiruroid nematodes (probably *Philometra*) were often found in abundance in the stomachs of fish from the sandy creekbeds.

Fish were the most important food items in the lowland backflow billabongs, where *M. splendida inornata*, *Ambassis* spp., plotosid catfishes and *L. unicolor* were the identifiable species. Traces of filamentous green algae, *Macrobrachium*, surface-dwelling aquatic insects and terrestrial plant material were a smaller portion of the diet than in the sandy pools. *S. krefftii* in the corridor waterbodies were feeding almost exclusively (except for some terrestrial plant material) on fish, as in the escarpment habitat. *Ambassis* spp. and *M. splendida inornata* were identifiable in the stomachs from the corridor waterbodies. Fish were also the most important food items in the floodplain billabongs (*Ambassis* spp., *C. stercusmuscarum, M. splendida inornata* and *N. erebi* were identifiable); some filamentous green algae and terrestrial orthopterans were also found in the stomachs.

Nourlangie catchment

The stomach contents of 23 specimens from lowland shallow backflow billabongs were examined; 18 stomachs contained food. *Strongylura krefftii* fed exclusively on fish in this catchment, unlike in comparable habitats in the Magela Creek system; however, the sample size from the Nourlangie catchment was smaller. The most abundant identifiable fish prey were the same in both catchments: *Ambassis* spp., *M. splendida inornata*, *P. rendahli* (which are among the most abundant small fish species found in these areas).

Fullness

Mean fullness indices of *S. krefftii* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments are summarised in table 46. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 46 Mean fullness indices of *S. krefftii* in different sampling periods and habitats

Habitat	Sampling period: Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80	Habitat mean
Magela Creek catchment (regular sites only)								
Upstream of RUPA:								
Escarpment main-channel waterbody	1.0 (2)	n/s	n/s	n/s	n/s	n/s	n/s	0.5 (2)
Lowland shallow backflow billabong	n/s	n/s	0 (1)	n/s	n/s	n/s	n/s	0 (1)
Downstream of RUPA:								
Lowland sandy creekbed pool	1.6 (11)	n/s	1.0 (2)	0.7 (3)	1.0 (7)	1.4 (5)	n/s	1.3 (28)
Lowland channel backflow billabong	0.3 (3)	0.6 (11)	1.0 (1)	0.7 (7)	0.8 (13)	0 (10)	0 (1)	0.4 (46)
Lowland shallow backflow billabong	1.0 (1)	0 (2)	1.0 (2)	1.8 (12)	1.0 (10)	1.4 (7)	n/s	1.3 (32)
Corridor sandy billabong	n/s	n/s	2.5 (11)	2.0 (2)	0.5 (2)	n/s	n/s	2.1 (15)
Corridor anabranch billabong	n/s	n/s	3.6 (5)	0 (2)	2.0 (2)	n/s	n/s	2.4 (9)
Floodplain billabong	1.0 (2)	3.0 (1)	1.8 (11)	0.8 (4)	2.0 (1)	1.0 (1)	n/s	1.5 (20)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	2.5 (2)	n/s	0 (2)	n/s	n/s	n/s	n/s	1.3 (4)
Lowland channel backflow billabong	n/s	2.5 (6)	1.5 (11)	0.5 (2)	1.0 (1)	n/s	n/s	1.7 (20)
Lowland shallow backflow billabong	2.0 (1)	0.3 (3)	n/s	4.0 (2)	2.4 (5)	n/s	n/s	2.2 (12)
Lowland sandy creekbed	1.6 (5)	n/s	n/s	1.0 (2)	n/s	n/s	n/s	1.1 (7)
Seasonal mean (all sites)	1.2	0.7	1.8	1.1	1.1	0.8	0	

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

Seasonal changes

The mean fullness index (all habitats combined) fell to its lowest during the 1978–79 Early-wet season and then rapidly reached a peak during the Mid-wet season, after which it fell close to the level recorded in the 1978 Late-dry. It fell again in the 1979 Late-dry season; only one fish from the 1979–80 Early-wet season was examined.

Habitat differences

In the Magela catchment upstream of RUPA, the sample sizes were too small for the mean fullness indices to have significance. Downstream of RUPA, the highest indices occurred in the corridor waterbodies. Channel backflow billabongs had the lowest indices.

In the Nourlangie catchment, mean fullness indices were highest in backflow billabongs (in contrast to the Magela catchment).

Summary

The habitats and periods of greatest apparent feeding activity where more than one fish was captured were:

Magela catchment

- corridor waterbodies; 1978–79 Mid-wet season, 1979 Late-wet–Early-dry season, 1979 Mid-dry season

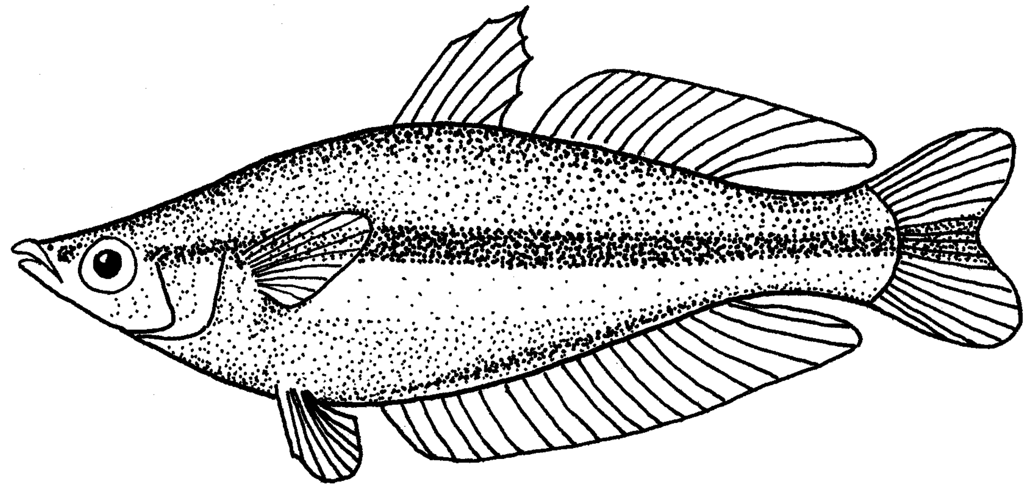
Nourlangie catchment

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

Family MELANOTAENIIDAE

3.13 *Melanotaenia nigrans* (Richardson)

Melanotaenia nigrans is commonly known as the black-banded rainbowfish. It is found in the freshwater streams of far northern Australia and on several offshore islands such as Groote Eylandt in the Gulf of Carpentaria and Prince of Wales Island in Torres Strait, and in south-west Papua New Guinea. The western limit of its Australian distribution appears to be streams feeding into Bynoe Harbour, about 40 km south of Darwin. Pollard (1974) found juveniles over sandy areas in Magela Creek and observed large specimens while diving in Hickey Creek (Nourlangie Creek system) and in Cooper Creek (near Nabarlek). Miller (cited in Taylor 1964) found this species in billabongs and streams in the Oenpelli area.



Melanotaenia nigrans

This and all other melanotaeniids are permanent inhabitants of freshwaters and make good tropical aquarium fishes. Very little is known, however, about the biology of this species.[81] It usually lives in streams with *M. splendida australis* and/or *M. splendida inornata* (Allen 1978a) or both. Most specimens have been collected from the lower reaches of streams within about 50 km of the coast; however, two specimens examined by Allen from the Upper South Alligator River catchment had been collected some 130 km upstream.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was found to be abundant in escarpment perennial and seasonal streams and to be common in all escarpment mainchannel waterbodies and some lowland sandy creekbed habitats (mainly upstream of RUPA); it was rare in lowland backflow and floodplain billabongs.

Melanotaenia nigrans was seldom found rarely in escarpment mainchannel terminal waterbodies but was abundant in some plateau habitats. It was found in the greatest number

81 Information on the biology of this species has since become available in Ivantsoff et al (1988). *Biology and early development of eight fish species from the Alligator Rivers Region.* Technical memorandum 22, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

of sites during the Late-wet season (mainly escarpment sites), and in the fewest sites in the Late-dry season (mainly escarpment streams).

Size composition

The lengths and weights of 579 specimens were determined. *Melanotaenia nigrans* was captured by seine nets (10 and 2 mm mesh) and dipnets (2 mm mesh). The latter caught more of the smaller specimens.

Length–weight relationship

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

$W = 1.40 \times 10^{-2} L^{2.80}$ r = 0.96 (weight in g, length in cm)

Seasonal mean lengths, weights and condition factors are shown in table 47. From the 1978 Late-dry season the seasonal condition factor increased from its lowest point to reach a stable level (near unity) between the 1978–79 Early-wet and the Mid-wet seasons. By the Late-wet–Early-dry season, condition peaked, but fell by the Mid-dry season; condition in the 1979 Late-dry season was slightly higher than in the 1978 Late-dry season. As in the previous year, the condition improved in the 1979–80 Early-wet season, which may have been caused by spawning activity or greater food availability or both (terrestrial insects, which are a large part in the diet, may be washed into the water with the first Wet season flushes in escarpment perennial streams).

Table 47 Mean length, mean weight and condition factor of *M. nigrans*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	76	35.9	0.48	0.95
Early-wet (1978–79)	36	40.2	0.70	1.01
Mid-wet	15	31.1	0.34	1.00
Late-wet–Early-dry (1979)	68	34.6	0.50	1.11
Mid-dry	57	38.1	0.58	0.98
Late-dry	111	38.8	0.61	0.97
Early-wet (1979–80)	24	36.8	0.56	1.04
Overall	387	37.0	0.55	1.00

Length-frequency distribution

The smallest specimen captured was 10 mm LCF; the largest was 68 mm LCF (fig 53). Specimens between 100 and 120 mm were occasionally observed in escarpment perennial streams in the Nourlangie Creek catchment. Roberts (1978) found *M. nigrans* ranging in length from 9.1 to 94.7 mm in the Fly River catchment, Papua New Guinea. Pollard (1974) states that this species reputedly grows to 120 mm.

The mean and modal lengths of the specimens captured were 37 and 40–41 mm LCF, respectively (there was a secondary mode at 36–37 mm). The LFM for males was 39 mm and for females 27 mm, indicating that more adults than juveniles were captured. Most specimens captured were between 16 and 49 mm LCF.

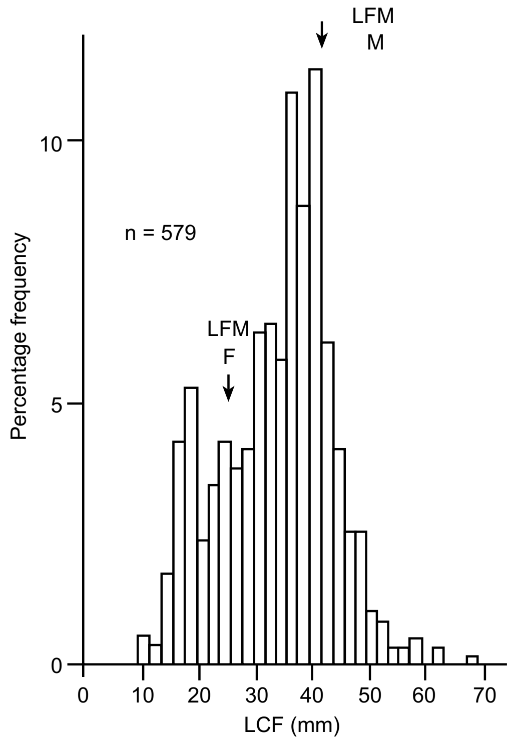


Figure 53 Length-frequency distribution of all *M. nigrans* captured

Seasonal changes in distribution

The smallest juveniles were caught in the 1979–80 Early-wet season, the Late-dry seasons and the Mid-dry season. In escarpment perennial streams the smallest juveniles were observed in the Early-wet seasons. The smallest specimens caught during the Late-wet–Early-dry season were much larger than the smallest specimens caught in other seasons (as was the case with *M. splendida inornata*). In escarpment perennial streams, the smallest specimen observed in the Mid-dry season was larger than the smallest observed in other seasons. The largest specimens were captured in the Late-dry seasons in escarpment perennial streams, and observed in the 1978–79 Early-wet season.

There appear to be differences in the timing of the presence of small juveniles and large adults in escarpment perennial streams and other habitats. They may be caused by differences in the most favourable spawning times, the dispersion times of juveniles and adults between escarpment populations, or both.

The size-range of specimens in the 1978 Late-dry season was wide, with small peaks for juvenile and intermediate-sized specimens (fig 54). By the 1978–79 Early-wet season mainly larger-sized specimens were caught; only a few juveniles were caught, though many were seen in escarpment perennial streams.

During the Mid-wet season the larger specimens disappeared from catches, to be replaced by intermediate-sized juveniles; the size-range of specimens observed in escarpment perennial streams was the same as the range of those captured. By the Late-wet–Early-dry season the juvenile intermediate peak had progressed approximately 10 mm; no other peaks had appeared in the distribution though some larger specimens were observed in escarpment perennial streams.

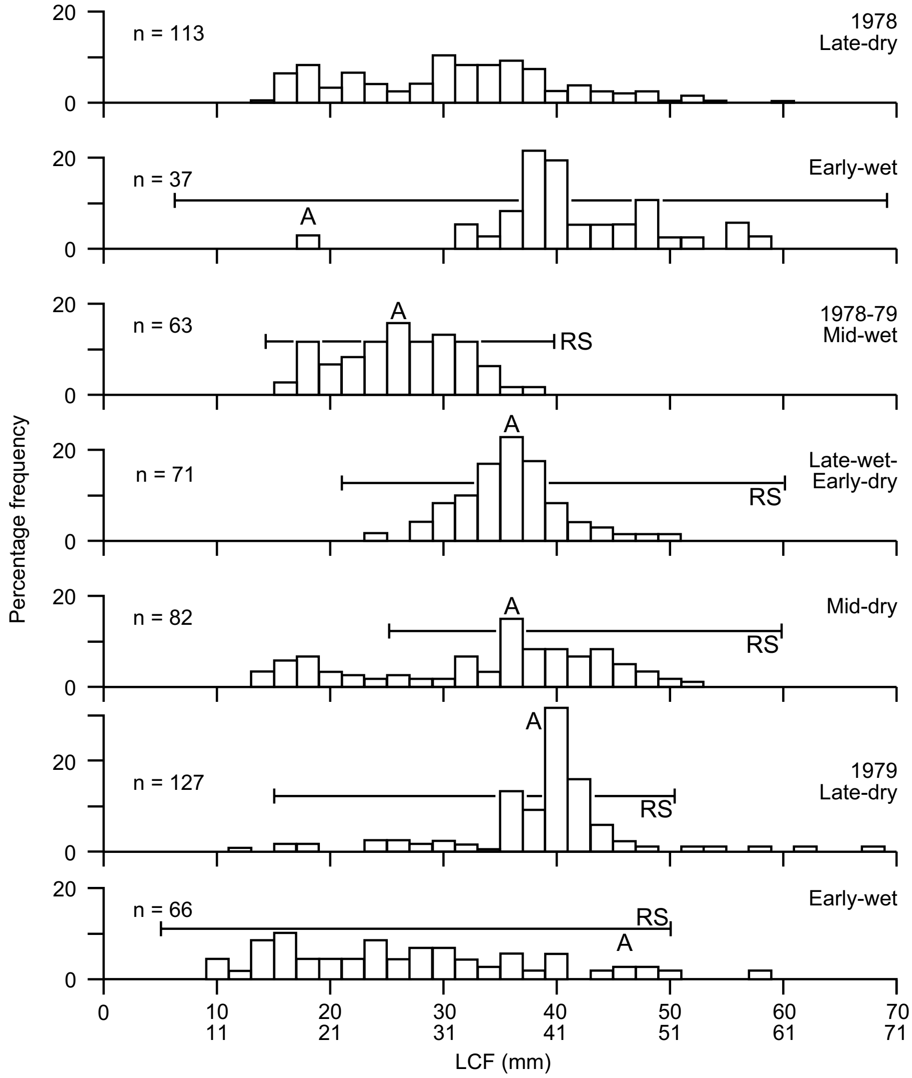


Figure 54 Seasonal length-frequency distribution of all *M. nigrans* captured during the study period. Size range at Radon Springs (RS) is shown.

The length-frequency distribution in the Mid-dry season had a smaller peak of intermediate-sized juveniles, with an additional juvenile peak. By the 1979 Late-dry season the former peak had increased to near the length at first maturity for males; there was a wide size range of specimens in this sample, with the most notable feature being the reappearance of large adults. During the 1979–80 Early-wet season the major peak of the previous season had almost disappeared, along with the larger specimens; additionally, and in contrast to the same season in 1978–79, there were more juveniles and intermediate-sized specimens.

Juveniles therefore appeared to recruit in all seasons except perhaps the Late-wet–Early-dry; the most intense recruitment was in the Mid-wet and Mid-dry seasons. Recruitment appeared to be stronger in the 1978 Late-dry than the 1979 Late-dry season, and in the 1979–80 Early-wet than the 1978–79 Early-wet season (many juveniles were observed, but not captured, in this season). Mortality of large specimens appeared to be highest between the Late-dry and Mid-wet seasons.

Growth rate

No published information on the growth of *M. nigrans* was found. Estimation of growth rate from seasonal length-frequency distributions was difficult due to the frequency with which juveniles were recruited to the populations and the range of habitats sampled. However, modal progressions were apparent for juveniles from the 1978–79 Early-wet season (A on fig 54) (modal length 18–19 mm LCF) until the 1979–80 Early-wet season (median length 48 mm LCF). *Melanotaenia splendida inornata* apparently grew the same amount in the same period of time. Growth appeared to be fastest in the Early-wet to Mid-wet season, by which time the juveniles measured about 33 mm LCF. This indicates that juvenile females present in the 1978–79 Early-wet season could attain the LFM by the Mid-wet season and juvenile males by the following Dry season (assuming the apparent growth rates are not complicated by sex differences in growth).[82]

Habitat differences in distribution

Length-frequency distributions showing the habitat preferences of *M. nigrans* captured in regular sampling sites in the Magela catchment are given in fig 55.

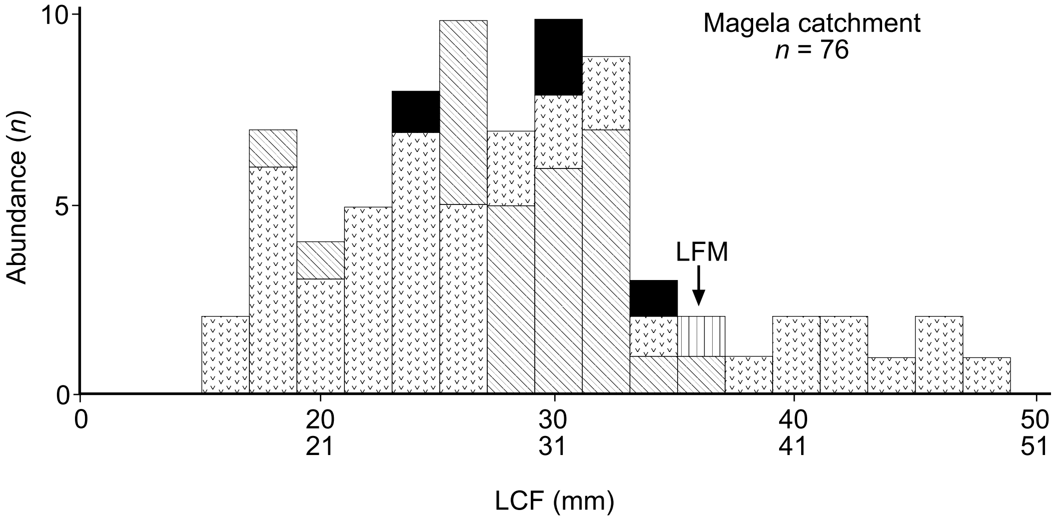


Figure 55 Length-frequency distributions and habitat preferences of *M. nigrans* captured at regular sampling sites in the Magela catchment (see appendix 5 for key to the habitats)

It was difficult to delineate juvenile–adult boundaries on length-frequency distributions for combined sexes, as the LFM for males and females was very different; the male and female components of these distributions should therefore be analysed separately in any future studies.

The habitat preferences of this species will be presented in terms of small specimens (less than the mean length [36–37 mm LCF] of all specimens examined) and large specimens (greater than the mean length). Specimens under 25 mm LCF are considered to be juveniles. Length-frequency distributions for specimens caught in escarpment perennial streams were not available for this report; however, many sizes of *M. nigrans* were abundant in such streams.

The smallest specimens were captured in lowland sandy creekbeds upstream of RUPA towards the escarpment zone; most of the small specimens were caught in these pools, though many of the larger ones were found in escarpment mainchannel waterbodies. A few specimens were caught in floodplain billabongs, which are fed in the Mid-wet season by waters from the escarpment seasonal streams in which *M. nigrans* was abundant.

---

82 Under laboratory conditions with a water temperature of 26°C, Ivantsoff et al (1988) indicated that *M. nigrans* can attain a total length of 21 mm in 52 days.

Small specimens were also common in the upper reaches of first-order streams in RUPA during the Mid-wet and Late-wet–Early-dry seasons; specimens are known to occur in the catchment of Retention Pond No. 1, and Pollard (1974) found this species in costeans in RUPA during 1972.

Most of the larger specimens were found in lowland sandy creekbeds upstream of RUPA towards the escarpment zone. A few of the smaller large specimens were found in escarpment mainchannel waterbodies and backflow billabongs.

Large specimens were captured in escarpment mainchannel waterbodies and lowland sandy creekbed habitats in the Nourlangie Creek system.

Environmental associations

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

Physico–chemical variables

Temperature

This species was captured at water temperatures between 23° and 35°C (mean = 28°C) on the surface, and between 23° and 32°C (mean = 27.5°C) on the bottom.[83] Both of these means were placed in the lower quarter (see fig 170). These ranges are slightly wider than the temperature tolerance range suggested by Allen (1978a) for melanotaeniid fishes (25–33°C). The highest surface water temperature apparently tolerated by *M. nigrans* is lower than the upper tolerance limit of 34.4°C found by Beumer (1979b) for *M. splendida splendida*. Most of the specimens of *M. nigrans* captured during this study were found in the cooler waters of the escarpment.

Dissolved oxygen

Dissolved oxygen concentration in waters in which *M. nigrans* was found ranged from 3.7 to 7.2 mg/L (mean = 5.7) on the surface, and from 5.0 to 6.8 mg/L (mean = 5.6) on the bottom. These means were ranked in the lower-middle and upper quarters respectively (see fig 171). The high bottom-water DO values are characteristic of the cool, flowing waters of the escarpment zone, in which *M. nigrans* was typically captured.

Visibility

Secchi depths for waters in which *M. nigrans* was caught ranged from 30 to 200 cm (mean = 136 cm) (see fig 172). This mean was ranked in the upper quarter, as would be expected for the clear waters and rocky or sandy substrates of the escarpment streams in which this species was mainly found.

pH

Surface and bottom water pH at sites where *M. nigrans* was found ranged from 3.9 to 6.7 (mean = 5.1) and from 3.9 to 6.2 (mean = 5.3) respectively (see fig 173). Both means were ranked at the base of the lower quarter. *M. nigrans* appears to be able to tolerate more acidic conditions than those found by Allen (1978b) for melanotaeniid fishes in general (6.5–6.9).[84]

Conductivity

Surface-water conductivities ranged from 4 to 180 µS/cm, and bottom-water conductivities from 4 to 12 µS/cm. Such low values indicate a preference for flowing waters with low levels

83 Crowley and Ivantsoff (1982) indicated that at temperatures greater than 26°C all observed pairs of *M. nigrans* spawned each day under laboratory conditions.

84 Ivantsoff et al (1988) indicated that *M. nigrans* thrived and bred well under laboratory conditions in waters of pH 7.6–7.8.

of dissolved solids. *Melanotaenia nigrans* and most other melanotaeniids generally live in freshwater (Pollard 1974). However, Beumer (1979a) found that the upper extreme of salinity tolerance of the closely related *M. splendida splendida* was 18 ppt.

Habitat–structural variables

Substrate

Melanotaenia nigrans was most frequently found over sandy substrates (upper-middle quarter), followed by boulders (upper quarter), then rocks, leaves and mud (see fig 174). Sandy and rocky bottoms are characteristic of the clear waters of the escarpment zone.

Hydrophytes

Hydrophyte abundance in waters in which *M. nigrans* was captured was low (vegetation-occurrence index 23.4%).[85] At the few sites where there were hydrophytes, submergent and emergent vegetation were almost equally dominant (34 and 32%).

Reproduction

From a total of 579 fish captured, 211 were examined for reproductive condition: 72 males (length range 24–66 mm LCF), 81 females (23–50 mm LCF), and 58 that were sexually indistinguishable.[86]

Length at first maturity

The LFM for females was 27 mm LCF (4 mm greater than the length at which ovaries could be identified). Except for one small (24 mm LCF) ripe male, no others under 38 mm LCF were found (fig 56); the LFM was 39 mm LCF for the males. In other melanotaeniid species males and females have been recorded as maturing at almost the same lengths (Beumer 1979b; see also the section on *M. splendida inornata*). The large apparent difference found in this study may be an artefact of the very small number of maturing male *M. nigrans* captured.

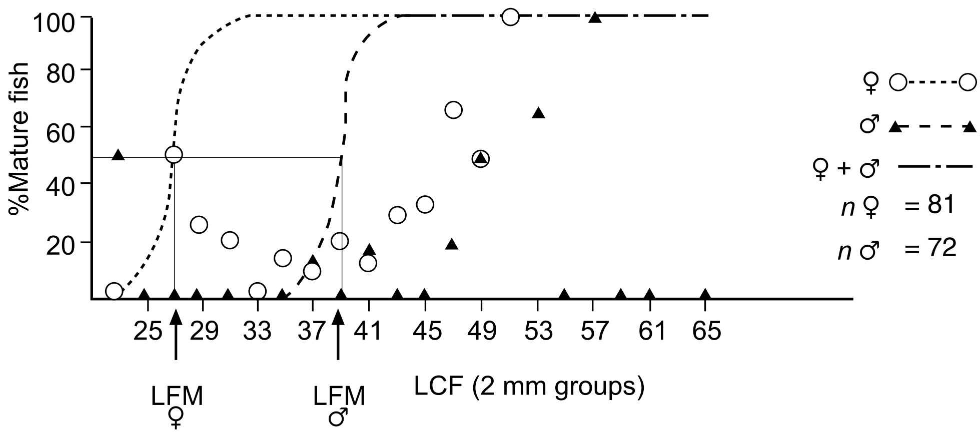


Figure 56 Estimated length at first maturity (LFM) of male and female *M. nigrans*

85 In contrast to this finding, Herbert and Peeters (1995) indicated that *M. nigrans* in streams of Cape York Peninsula prefer areas with dense aquatic vegetation.

86 Ivantsoff et al (1988) indicated that *M. nigrans* is sexually dimorphic and dichromatic. In males, the spines of the first dorsal are usually extended and may lie well past the origin of the second dorsal when not erect. The posterior rays of the second dorsal and anal fins are extended caudally and may extend past the origin of the caudal fin. In females, the first dorsal spines are short, not reaching the origin of the second dorsal. The posterior rays of the anal and second dorsal fin are not extended. The spines and outer rays of the ventral fins of some males are also extended and may reach past the vent and the origin of the anal fin.

Sex ratio

A 1:1 ratio was found for all seasons over the total sample; however, the proportion of males was significantly less in nearly all seasons when only adult fish were analysed (table 48). This was due to the small number of maturing males caught or identified (either because of difficulty in assessing the true maturation stage of the testes or possibly because of some behavioural trait of the maturing male fish).

Table 48 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *M. nigrans* 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*	3	20	5	9	10	22	12
adults	M	*n*	7	16	6	4	13	18	8
		χ^2	1.6	0.4	0.1	1.9	0.4	0.4	0.8
		P	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Adults only	F	*n*	3	20	5	8	10	19	12
	M	*n*	3	7	0	0	9	7	3
		χ^2	0.0	6.25	5.0	8.0	0.05	5.53	5.4
		P	n.s.	*	*	*	n.s.	*	*
GSI									
Adults only	F	mean	2.1	4.3	0.3	0.6	2.6	1.0	2.7
		s.d.	0.8	1.7	0.1	0.9	1.9	0.9	0.8
	M	mean	0.2	0.9	–	–	0.4	0.2	0.3
		s.d.	0.1	0.3	–	–	0.2	0.2	0.3
	F+M	mean	1.2	3.4	–	–	1.5	0.8	2.2
		s.d.	1.2	2.1	–	–	1.8	0.8	1.2
GMSI									
Adults only	F	mean	4.0	3.4	1.0	1.4	3.3	2.5	3.4
		s.d.	1.7	1.1	0.0	0.7	1.1	1.2	0.5
	M	mean	2.0	4.0	–	–	2.2	2.0	2.0
		s.d.	0.0	0.8	–	–	0.8	1.0	1.0
	F+M	mean	3.0	3.5	–	–	2.8	2.4	3.1
		s.d	1.5	1.1	–	–	1.1	1.2	0.8

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

Very few of the fish captured were mature, ripe or spent (table 49): two ripe fish were caught in the 1978 Late-dry season, three mature or spent fish in the 1978–79 Early-wet season, and one spent fish in the 1979 Late-dry season. Small (less than 20 mm) juvenile fish were caught in all seasons except the 1979 Late-wet–Early-dry season, with the smallest fish being caught in the 1979–80 Early-wet season.

The mean GSI and GMSI were relatively high for most of the year (fig 57) with a trough in the 1978–79 Mid-wet and Late-wet–Early-dry seasons. The highest peak in gonad development occurred in the 1978–79 Early-wet season, with smaller peaks in the 1979 Mid-dry and 1979–80 Early-wet seasons. Without further information, the breeding season of *M. nigrans* cannot be defined.

Table 49 Possible sites of spawning of *M. nigrans* 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
Seasonal feeder stream	–	2	–	–	1	–	9
Perennial stream	–	–	1	1	–	–	71
Lowlands							
Sandy creekbed habitats	–	–	–	–	–	–	11

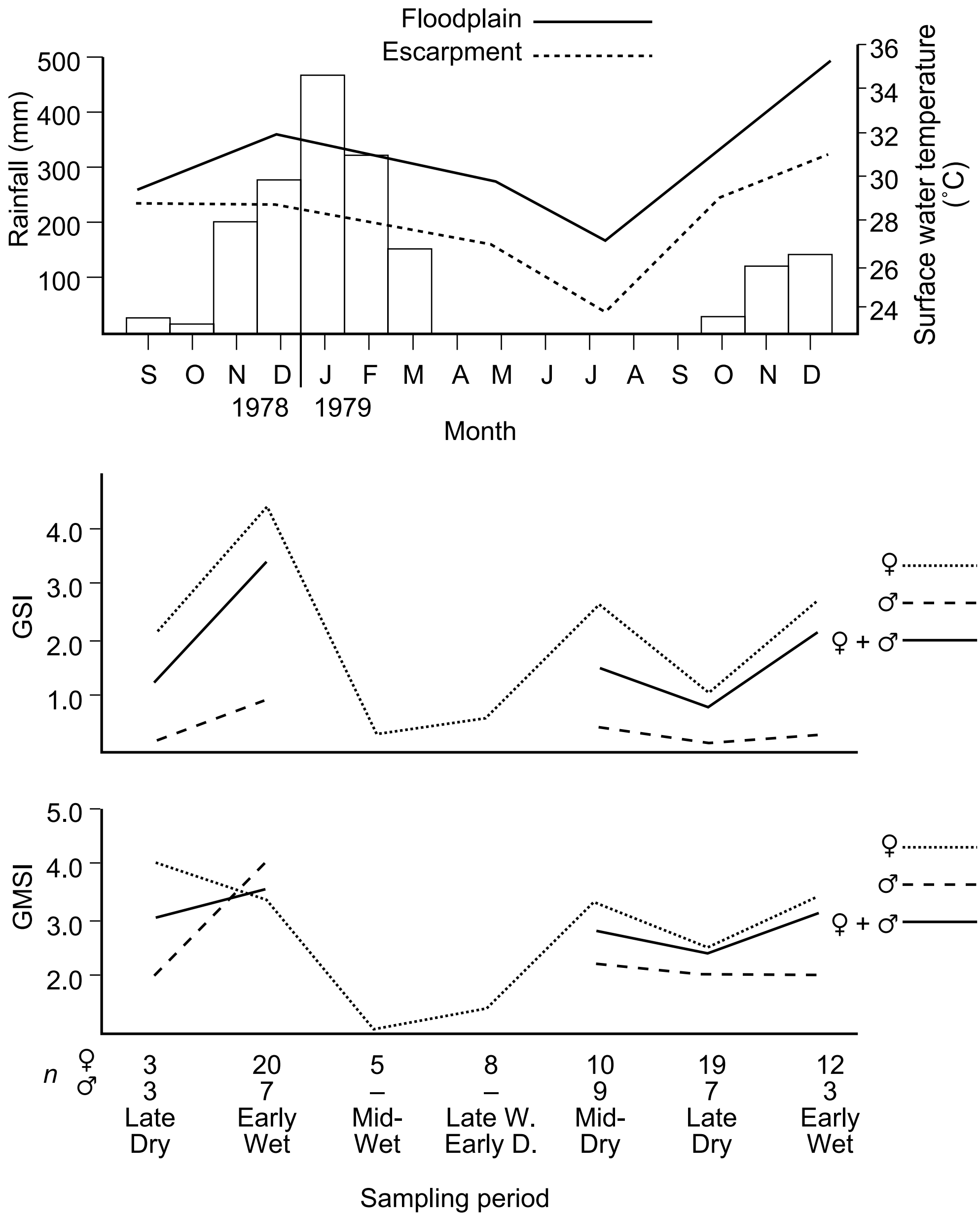


Figure 57 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *M. nigrans*

Site of spawning

The spawning sites cannot be accurately determined, as juvenile fish were only collected with seldom-used methods (2 mm mesh seine net, dipnet and poisoning). Small juveniles were observed in an escarpment perennial stream (Radon Springs) (table 49) in all sampling periods and especially in the Early-wet seasons. Mature and spent fish were found in a small escarpment seasonal stream off Hickey Creek during the 1978–79 Early-wet season. Breeding thus possibly occurs in small escarpment streams with deep pools.

Fecundity

In the ten ovaries of *M. nigrans* examined, the number of eggs ranged from 220 to 500 (mean = 344); egg diameters were not measured. These fish were not mature, so numbers only indicate developing eggs within the ovary, not how many might actually ripen during spawning.

Summary

Due to disparities in fishing methods between sites and habitats, it is difficult to define the reproductive cycle of *M. nigrans*. The LFM of males appeared to be unusually high compared with that of females, and significantly more adult female fish were identified than adult males. This suggests there was a sampling bias or gonad-staging error.[87]

Generally, *M. nigrans* appears to breed in small escarpment streams that contain deep shaded pools with roots and submerged vegetation around the edges. Eggs may be attached by threads to such vegetation. Spawning is possibly continuous, with a few eggs laid at a time, or opportunistic whenever conditions are favourable. A peak of reproductive activity occurred during the 1978–79 Early-wet season.[88]

Feeding habits

Overall diet

The stomach contents of 206 specimens were examined; 200 stomachs contained food. A summary of the diet is given in fig 58; the components are listed in table 50.

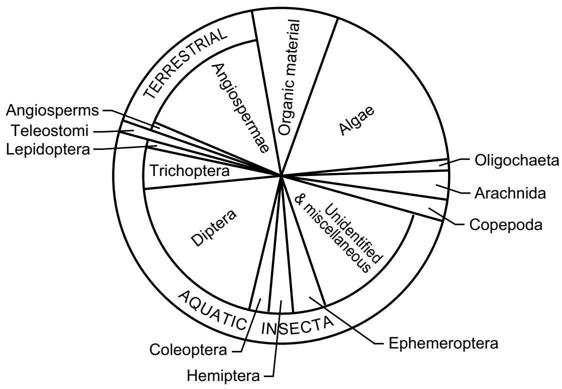


Figure 58 The main components of the diet of *M. nigrans*

87 Ivantsoff et al (1988) indicated that under stable laboratory conditions, large females (> 50 mm TL) produced more than 50 eggs per day at the peak of the spawning season. Smaller females (28–35 mm TL) which were only just sexually mature shed fewer eggs, 20–30 per day and spawning did not occur daily.

88 Ivantsoff et al (1988) has subsequently described mating behaviour, egg and embryonic development, and larval development.

Table 50 Dietary composition of *M. nigrans*

	Habitat						Season							Overall	
	Magela system				Nourlangie system		1978	1978–79	1978–79	1979	1979	1979	1979–80		
Stomach contents	Em	Ep	Ls	Fb	Ep	Ls	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Aquatic plants															
Algae															17.3
Miscellaneous	–	3.1	6.0	–	–	4.4	5.3	5.6	–	–	9.4	37.6	–	9.2	
Desmidaceae															
Closterium	–	–	–	–	–	–	5.3	–	–	–	–	–	–	0.5	
Dinophyceae	–	–	–	–	–	–	–	–	–	–	–	1.9	–	–	
Conjugatophyta															
Mougeotia	9.6	0.2	4.2	6.3	–	23.1	35.8	10.0	8.3	8.3	–	–	0.5	7.6	
Aquatic animals															
Oligochaeta	–	4.0	–	–	–	–	–	–	3.5	–	–	–	–	0.5	0.5
Arachnida															3.0
Miscellaneous	–	–	–	20.0	–	–	–	–	–	3.0	–	–	–	0.4	
Hydracarina	–	0.8	9.0	21.3	–	2.7	1.1	2.8	2.6	3.2	5.6	1.9	0.5	2.6	
Microcrustacea															2.5
Cladocera															
Miscellaneous	–	–	1.0	–	–	–	–	–	0.9	–	–	–	–	0.1	
Diaphanosoma	–	0.9	–	–	–	–	–	–	–	–	–	–	3.0	0.3	
Copepoda															
Miscellaneous	–	3.7	–	–	–	–	–	–	–	–	2.6	4.3	–	1.3	
Harpacticoida	–	–	–	–	–	–	–	–	5.2	–	–	–	–	0.8	
Insecta															49.3
Fragmented	15.8	29.0	19.2	25.0	1.5	1.1	21.1	–	10.0	8.5	32.2	7.4	40.0	14.5	
Ephemeroptera															
Baetidae	8.3	0.8	5.2	–	–	–	–	–	7.9	–	–	–	2.8	1.4	
Atalophlebia	–	3.0	–	–	2.5	6.7	–	8.3	–	1.9	–	–	10.0	2.8	
Hemiptera															
Gerridae	8.3	1.5	4.0	–	–	–	5.3	–	3.5	–	–	2.4	–	1.5	
Corixidae	–	–	0.4	–	–	–	–	–	3.5	–	0.4	–	–	0.6	
Coleoptera															
Miscellaneous	–	1.5	–	–	–	6.2	–	7.8	–	–	–	3.3	–	2.1	
Helminthidae (larvae)	–	0.1	–	–	–	–	–	–	–	–	–	–	0.3	+	
Diptera															
Chironomidae (larvae)	8.3	10.7	2.8	–	10.0	5.3	18.4	8.6	3.8	2.4	6.5	2.9	6.5	7.0	

Table 50 continued

Stomach contents	Habitat						Season							Overall	
	Magela system				Nourlangie system		1978	1978–79	1978–79	1979	1979	1979	1979–80		
	Em	Ep	Ls	Fb	Ep	Es	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Chironomidae (pupae)	8.3	6.3	7.8	–	62.5	2.2	–	2.8	10.2	46.2	4.1	7.4	–	10.3	
Ceratopogonidae	1.7	0.7	0.4	–	–	–	–	–	0.7	–	0.4	–	2.3	0.4	
Simuliidae	–	5.2	–	–	–	–	–	–	–	–	11.7	–	1.5	1.7	
Tabanidae	8.3	0.9	–	–	–	–	–	–	–	–	2.2	2.4	–	0.8	
Trichoptera															
Leptoceridae	–	11.6	6.8	–	5.0	–	–	–	3.5	3.7	13.5	10.0	3.3	5.3	
Lepidoptera															
Pyralidae	–	2.5	–	–	–	–	–	–	–	–	2.6	–	5.0	0.9	
Teleostomi															0.5
M. nigrans	–	1.5	–	–	–	–	–	–	–	–	3.7	–	–	0.5	
Terrestrial plants															
Angiospermae															0.9
Fragmented	15.0	–	–	–	–	–	–	–	6.2	–	–	–	–	0.9	
Terrestrial animals															
Insecta															15.7
Fragmented	–	0.6	4.0	–	–	9.8	–	12.2	3.5	–	–	–	2.0	2.9	
Diptera															
Miscellaneous (adults)	–	3.3	12.0	–	–	–	–	–	10.3	–	–	2.4	6.0	2.6	
Culicidae (adults)	–	3.0	–	–	–	–	–	–	–	–	–	4.8	–	1.0	
Hymenoptera															
Formicidae															
Miscellaneous	–	4.4	13.2	–	–	18.0	–	22.5	10.0	–	4.6	0.7	12.0	7.7	
Oecophylla	7.9	–	–	–	5.0	–	–	–	3.3	3.7	–	2.4	–	1.5	
Scolopendromorpha	–	1.3	–	–	–	–	–	–	–	–	–	–	4.5	0.5	0.5
Parasites															
Nematoda	–	0.2	–	5.0	–	–	–	–	–	0.7	0.4	–	–	0.2	0.2
Detrital material	–	–	–	–	3.5	–	–	–	–	2.6	–	–	–	0.4	0.4
Inorganic material	–	0.1	–	–	–	–	–	–	–	–	0.2	0.5	–	0.1	0.1
Organic material	8.3	4.5	–	22.5	10.0	18.9	7.9	19.4	3.5	10.7	–	7.1	–	9.7	7.7
Number of empty fish	–	3	2	–	–	1	2	1	2	–	1	1	1	6	6
Number of fish with food	12	67	25	4	20	45	19	36	29	27	27	42	20	200	200

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

Em = escarpment mainchannel; Ep = perennial stream; Es = escarpment seasonal stream; Ls = lowland sandy creek bed; Fb = floodplain billabongs

The main food items were aquatic insects (49%), algae (17%) and terrestrial insects (16%). The aquatic insects were mainly chironomid pupae and larvae, and leptocerid and *Atalophlebia* larvae; the identifiable algae mainly green filamentous species; and the terrestrial insects mainly ants and winged dipterans. Aquatic arachnids (3%), microcrustaceans (3%) and traces of oligochaetes, teleosts, terrestrial plant material, scolopendromorphs, detritus and inorganic material were also found in the stomachs. There were also appreciable quantities of unidentified organic material (8%). *M. nigrans* can therefore be classified as a meiophagous omnivore feeding opportunistically across substrates and in surface waters, with possibly less emphasis on mid-water areas.

Adults (Pollard 1974) sampled had eaten mainly small insects and insect larvae from the water's surface; no herbivorous component was recorded. He conjectured that juveniles ate mainly zooplankton. *M. fluviatilis* is reported to be essentially a carnivore, feeding on insects and small crustaceans, but also eating much algae (Munro [in McDowall 1980]). *M. nigrans* found in pools and riffles that drain into the Magela floodplain were primarily opportunistic surface feeders, exploiting a range of small food items such as winged dipterans and formicids, non-aquatic insects and dipteran larvae (Sanderson 1979).

Seasonal changes

In sampling periods 1–7, respectively, 21 (9% empty), 37 (3% empty), 31 (6% empty), 27 (0% empty), 28 (3% empty), 42 (0% empty) and 20 (0% empty) stomachs of *M. nigrans* were examined (all habitats combined). The highest proportion of specimens with empty stomachs was found in the 1978 Late-dry and 1978–79 Mid-wet season.

During the 1978 Late-dry season, the algal and aquatic insect components of the diet were large. By the 1978–79 Early-wet season they were smaller, and terrestrial insects (particularly ants) became important in the diet. In the Mid-wet season, the fish ate a variety of items; however, aquatic and terrestrial insects appeared to be the most important. Aquatic insects (mainly chironomid larvae) became more important in the Late-wet–Early-dry season and remained so until the 1979 Late-dry when their contribution decreased. Both the aquatic and terrestrial insect components increased during the 1979–80 Early-wet season. Algae peaked in importance again during the 1979 Late-dry season but decreased, as in the previous year, in the Early-wet season.

Habitat differences

Magela catchment

A total of 113 stomachs of *M. nigrans* were examined (all seasons combined): 12 (0% empty) from escarpment mainchannel waterbodies, 70 (40% empty) from escarpment perennial streams, 27 (7% empty) from lowland sandy creekbeds, and 4 (0% empty) from floodplain billabongs. The sample from lowland sandy creekbeds had the highest proportion of specimens with empty stomachs.

The diet in the escarpment mainchannel waterbodies was based mainly on aquatic insects, with small amounts of terrestrial insects and plant material and algae. In the perennial streams, algae and terrestrial plant material were less important, while aquatic insects and, to a lesser extent, oligochaetes and microcrustaceans, were more important.

The diet in the lowland sandy creekbeds had much larger algal and terrestrial insect components, with the addition of *Hydracarina*. The few specimens examined from the floodplains were feeding mainly on aquatic arachnids (mainly *Hydracarina*) and aquatic insects, and a small amount of algae.

Nourlangie catchment

A total of 66 stomachs of *M. nigrans* were examined (all seasons combined) from escarpment streams: 20 from perennial and 46 from seasonal. Only one specimen, from a seasonal stream, had no food in its stomach.

Aquatic insects (mainly chironomid pupae) were most important in the diet in the escarpment perennial streams, as was the case in the equivalent Magela Creek habitat; green tree ants (*Oecophylla*) also appeared in the diet. In the seasonal escarpment stream, large quantities of algae and terrestrial insects (ants) and, to a much lesser extent, aquatic insects were eaten.

Fullness

A summary of mean fullness indices of *M. nigrans* for different sampling periods and habitat types is shown in table 51. These data are presented on the assumption that feeding times do not vary with habitat or season.

Seasonal changes

The mean seasonal fullness index (all habitats combined) peaked in the 1978–79 Early-wet season and then fell during the Mid-wet and Late-wet–Early-dry seasons. It rose to another high in the 1979 Mid-dry and Late-dry seasons and fell again during the 1979–80 Early-wet season.

Table 51 Mean fullness indices of *M. nigrans* in different sampling periods and habitats

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	n/s	n/s	3.1 (10)	n/s	n/s	3.5 (2)	n/s	3.2 (12)
Lowland sandy creekbed	n/s	n/s	2.3 (18)	0 (1)	3.8 (8)	n/s	n/s	2.6 (27)
Downstream of RUPA:								
Lowland shallow backflow billabong	n/s	n/s	n/s	0 (1)	n/s	n/s	n/s	0 (1)
Floodplain billabong	n/s	n/s	n/s	3.3 (4)	n/s	n/s	n/s	3.3 (4)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	n/s	n/s	3.0 (3)	n/s	n/s	n/s	n/s	3.0 (3)
Lowland sandy creekbed	0 (1)	n/s	n/s	0 (1)	n/s	n/s	n/s	0 (2)
Seasonal mean (all sites)	2.5	3.5	2.7	2.4	3.5	3.5	2.6	

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

Habitat differences

Specimens from upstream of RUPA in the escarpment mainchannel waterbodies had higher mean fullness indices than those in lowland sandy creekbeds. The mean fullness indices for specimens captured in escarpment perennial streams (where most specimens were captured) were not available when this report was being prepared.

Downstream of RUPA the single specimen captured from backflow billabongs had not been feeding. The few captured on the floodplain had high fullness indices.

The few specimens captured in the Nourlangie catchment had higher indices in the escarpment mainchannel waterbody. The mean fullness indices for specimens captured in escarpment perennial streams (where most specimens were captured) were not available when this report was being prepared.

Summary

The habitats (not including escarpment perennial streams) and periods of greatest feeding activity were:

Magela catchment

- lowland sandy creekbeds (upstream of RUPA); 1979 Mid-dry season
- escarpment mainchannel waterbody; 1979 Late-dry season

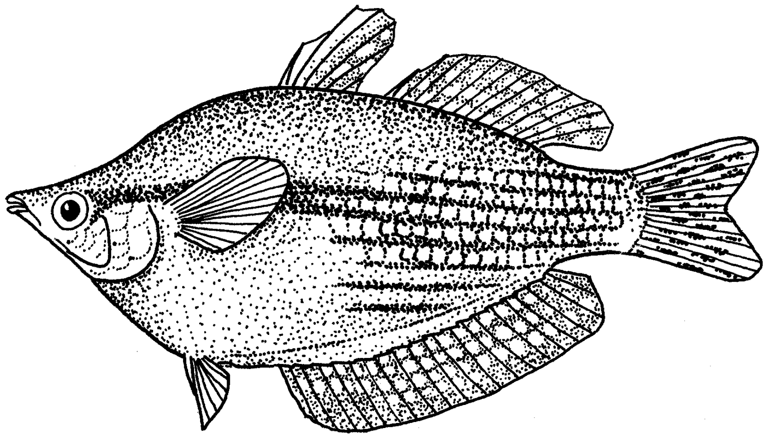
Nourlangie catchment

- escarpment mainchannel waterbody; 1978–79 Mid-wet season

Family MELANOTAENIIDAE

3.14 *Melanotaenia splendida inornata* (Castelnau)

Melanotaenia splendida inornata is commonly known as the chequered rainbow-fish. In Australia it is found in the river systems of the Northern Territory and Queensland that flow into the Arafura Sea and Gulf of Carpentaria (see map 3). The limits of its distribution appear to be the Mary River just east of Darwin, and the Jardine River near the tip of Cape York Peninsula.[89] Pollard (1974) found that large specimens were common in waterbodies of the Magela Creek system, and that juveniles occurred over shallow sandy areas together with *M. nigrans*; in the South Alligator River system, adults were observed in Sawcut Creek; and some large specimens were observed in Cooper Creek. Miller (cited in Taylor 1964) reported this species was abundant in billabongs and creeks in the Oenpelli area. A closely related subspecies is also known from southern Papua New Guinea.



Melanotaenia splendida inornata

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was moderately abundant in almost all sites and habitats examined. It was found in the fewest sites (18) in the 1978 Late-dry season (moderately abundant in lowland sandy creekbed habitats and many lowland backflow billabongs, and common in corridor and floodplain billabongs); it was found in the greatest number of sites (25) during the Mid-wet season.

Size composition

The lengths and weights of 3636 specimens were determined. Most specimens were captured by 10 mm seine net, with only the larger specimens being captured by gillnet (26 mm mesh). Mesh selectivity influenced the minimum size of specimens captured and may also have been responsible for small number of intermediate to large-sized adults captured. Very small specimens were frequently captured when the seine meshes were clogged by hydrophytes and filamentous algae.

---

89 Surveys in Cape York Peninsula by Herbert et al (1995) indicated that this subspecies extends down the east coast of the Cape to the Lockhart River. Accordingly, *M. splendida inornata* are now known to occur in the north-east coastal division.

Length–weight relationship

The length–weight relationship was described by the expression:

$$W = 1.10 \times 10^{-2} L^{3.12} \qquad r = 0.99 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 52. The seasonal condition factor decreased slightly between the 1978 Late-dry season and the 1978–79 Early-wet season, possibly due to spawning activity. It then increased to peak in the Mid-wet season and gradually declined until the 1979 Late-dry season, after which it declined more sharply; condition in the 1979–80 Early-wet season was much lower than in the same season the previous year.

Environmental conditions (including food availability) in the Wet season appeared to be more favourable to good body condition than in the Dry seasons, and the 1978 Dry season appeared to be more favourable than the 1979 Dry season.[90]

Table 52 Mean length, mean weight and condition factor of *M. splendida inornata*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	364	37.5	0.69	1.00
Early-wet (1978–79)	118	38.0	0.70	0.98
Mid-wet	826	43.4	1.10	1.02
Late-wet–Early-dry (1979)	953	45.4	1.24	1.00
Mid-dry	525	43.8	1.10	0.99
Late-dry	149	43.9	1.10	0.98
Early-wet (1979–80)	117	45.2	1.14	0.94
Overall	3052	43.2	1.06	1.00

Length-frequency distribution

The smallest specimen captured in the study was 12 mm LCF; the largest was 98 mm LCF (fig 59). Haines (1979) found that this species (*Nematocentris*, syn. *Melanotaenia*) ranged in length between 60 and 99 mm in the Purari River catchment. Pollard (1974) noted that *M. splendida inornata* reputedly grows to 120 mm LCF.

The mean and modal lengths for all specimens captured were 43.2 and 40–41 mm LCF respectively. The LFM for males was 33 mm LCF and for females 28 mm LCF, indicating that more adults than juveniles were captured. The slight negative skew apparent in the distribution was possibly caused by the reduced survival of larger specimens, and mesh selectivity resulting in no fish less than 10 mm LCF being captured. Most specimens were between 20 and 60 mm LCF.

Seasonal changes in distribution

The smallest juveniles were caught (in order of abundance) in the 1978–79 Early-wet, 1979–80 Early-wet, Mid-wet and Mid-dry seasons. The smallest specimens captured during the Late-wet–Early-dry season were much larger than the smallest specimens captured in other seasons. The largest specimen was caught (in order of abundance) in the Late-wet–Early-dry, Mid-dry, Mid-wet and 1979 Late-dry seasons. The largest specimens captured during the Early-wet seasons were much smaller than the largest specimens captured in other seasons.

90 Milton and Arthington (1984) indicated that body condition of *M. splendida fluviatilis* from south-eastern Queensland varied between seasons, peaking in May (both sexes) and lowest in April and August.

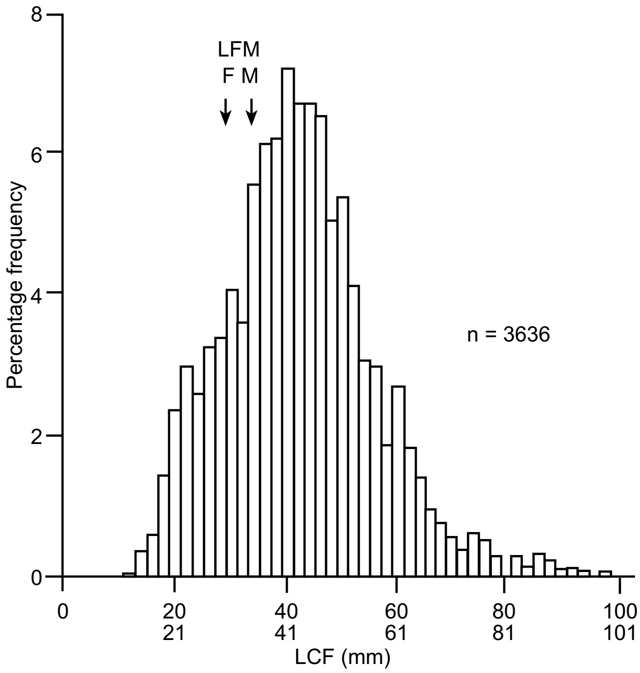


Figure 59 Length-frequency distribution of all *M. splendida inornata* captured

In the 1978 Late-dry season, the catch mainly consisted of larger juveniles and small adults, with a few larger adults (fig 60). By the 1978–79 Early-wet season there was a strong juvenile component and a slightly reduced small-adult peak; the larger adults had disappeared from the samples.

During the Mid-wet season the juvenile peak diminished considerably, with a corresponding increase in the small-adult peak; larger adults reappeared in the samples during this season. The form of the length-frequency distribution in the Late-wet–Early-dry season was similar to that recorded in the Mid-wet season with a slight overall progression to larger-sized specimens.

Another juvenile peak appeared during the Mid-dry season. The form of this distribution persisted into the 1979 Late-dry season with slight progressions and merging of the juvenile peak into the small-adult peak; the large adults comprised a smaller percentage of the samples, but had not diminished in numbers as they had in the equivalent 1978 season. By the 1979–80 Early-wet season the small-adult (to intermediate-sized by now) peak was most pronounced and all large adults had disappeared as they had by the end of the 1978 Dry season. Small numbers of juveniles were present in the 1979–80 Early-wet season, but the peak was only a trace compared with the peak recorded in the same season in 1978–79.

Juveniles apparently recruited in all seasons except the Late-wet–Early-dry. Recruitment peaked during the 1978–79 Early-wet and 1979 Mid-dry seasons; it was less intense in the 1978–79 Early-wet season, possibly because main flows had not started by the time of sampling. Adult mortality appeared to be highest at the end of the Dry season.

Growth rate

No published information on the growth of *M. splendida inornata* was found.[91] Estimation of growth rate from seasonal length-frequency distributions was difficult due to the frequent

---

91 Data given by Milton and Arthington (1984) for *M. splendida fluviatilis* from south-eastern Queensland indicate the following standard lengths for ages 1, 2, 3 and 4 years: 33/37 mm (male/female), 47/53 mm, 60/64 mm and 72 mm (female only). Under laboratory conditions with a water temperature of 26°C, Ivantsoff et al (1988) indicated that *M. splendida inornata* can attain a total length of 20 mm in 86 days.

recruitment of juveniles and the range of habitats sampled. However, modal progressions were apparent for juveniles from the 1978–79 Early-wet season (modal length 22–23 mm LCF; A on fig 60) until the 1979–80 Early-wet season (modal length 50–51 mm LCF).

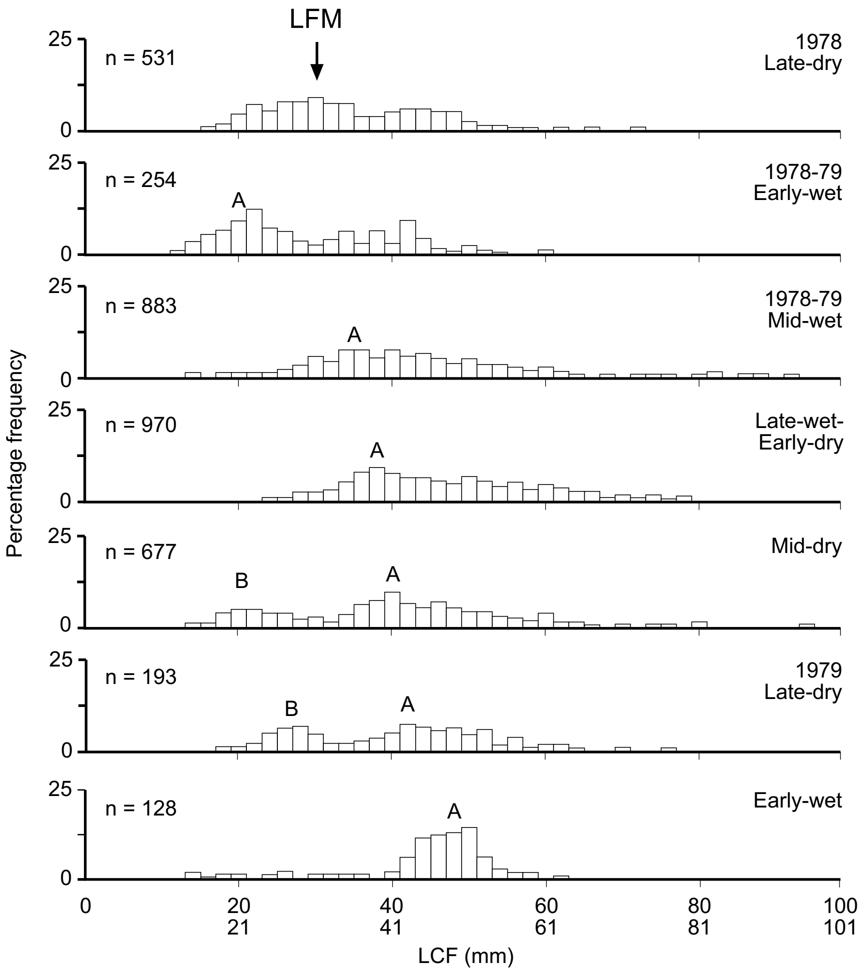


Figure 60 Seasonal length-frequency distribution of all *M. splendida inornata* captured

Over a year the mode had progressed about 30 mm LCF. Growth was fastest between the Early-wet and Mid-wet seasons when the LCF reached about 40 mm LCF, which indicates that juveniles present in the Early-wet season had reached the LFM by the Mid-wet season. The growth of juveniles present in the Mid-dry season (B on fig 60) was slower than that of those present in the Early-wet season.

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *M. splendida inornata* captured in regular sampling sites in the Magela and Nourlangie Creek catchments are given in fig 61.

Magela catchment

The smallest juveniles (12–17 mm LCF) were found in lowland sandy creekbed habitats, lowland shallow backflow billabongs and corridor waterbodies. Overall, juveniles were found in a very wide variety of habitats, though most commonly in floodplain billabongs, sandy corridor waterbodies, sandy creekbed habitats and backflow billabongs of the lowlands, and in small numbers in escarpment mainchannel waterbodies and anabranch corridor waterbodies. No juveniles were observed in escarpment perennial streams.

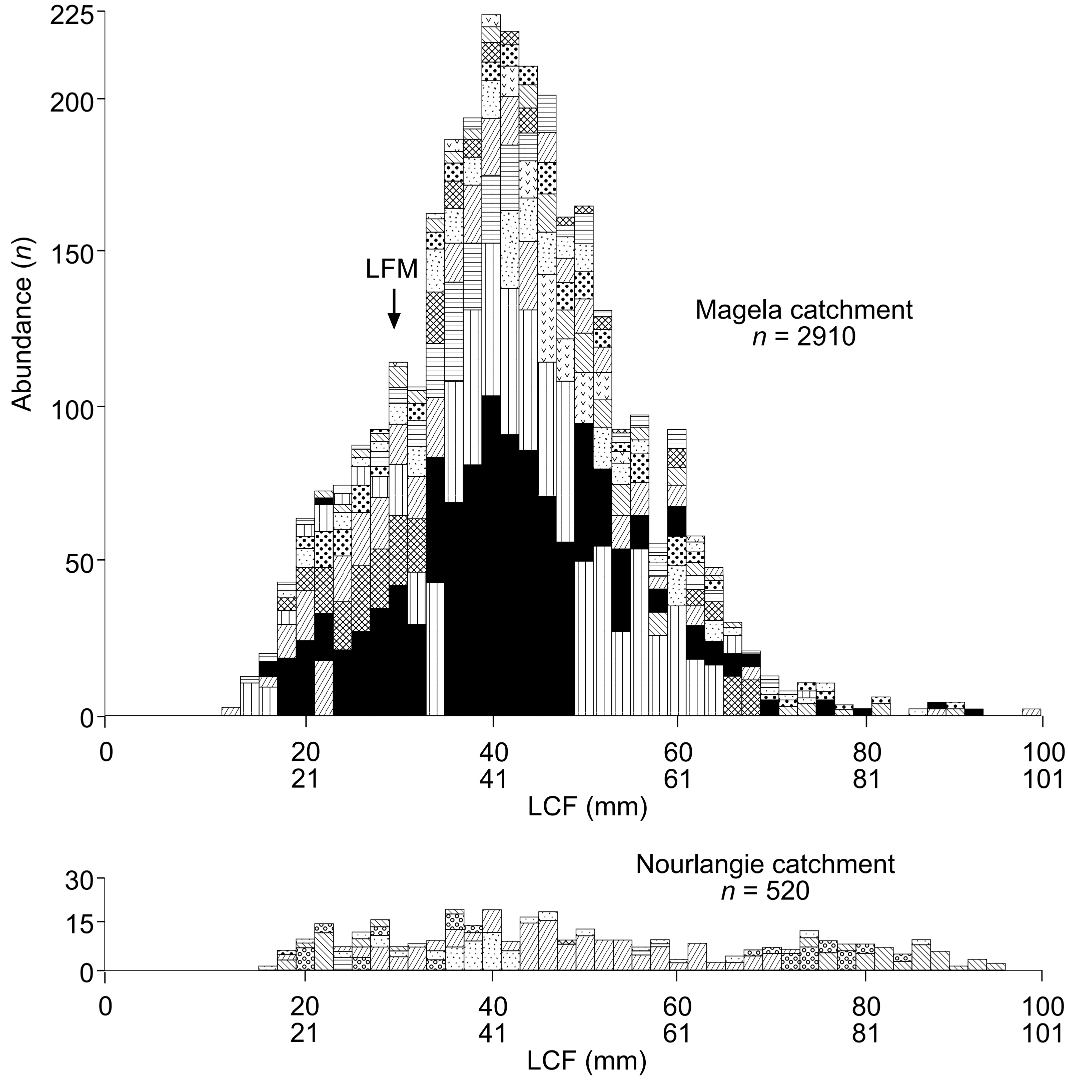


Figure 61 Length-frequency distributions and habitat preferences of *M. splendida inornata* captured at regular sampling sites (see appendix 5 for key to the habitats)

Smaller adults (30–70 mm LCF) were found most frequently in floodplain and lowland shallow backflow billabongs, and to a lesser extent in sandy creekbed habitats, lowland channel backflow billabongs, corridor anabranch billabongs and escarpment mainchannel billabongs. Small adults were noticeably less abundant in sandy corridor waterbodies than were large juveniles.

Larger adults were found in a wide variety of habitats, though mostly in escarpment mainchannel waterbodies, floodplain billabongs, lowland sandy creekbeds (in which the largest specimen was captured) and lowland backflow billabongs. During the 1978 Late-dry season, adults were found only in escarpment perennial streams.

Nourlangie catchment

Juveniles were captured in all habitats examined. The smallest juvenile was found in a channel backflow billabong. The larger juveniles were most often found in sandy creekbed habitats. Juveniles were observed in escarpment perennial streams in the Mid-wet and 1979–80 Early-wet season.

Small adults were found most frequently in sandy creekbed habitats (as were the large juveniles) and the larger adults in escarpment mainchannel waterbodies (as was the largest specimen). Adults were also found in lowland backflow billabongs, with smaller specimens found most often in channel billabongs and larger specimens in shallow backflow billabongs. Adults were observed in escarpment perennial streams in the Mid-wet, Late-wet–Early-dry and 1979–80 Early-wet seasons.

Environmental associations

Rank numbers for *M. splendida inornata* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

Surface-water temperatures ranged from 23° to 40°C (mean = 30.6°C);[92] bottom-water temperatures ranged from 23° to 36°C (mean = 29.5°C). Both of these means were ranked in the upper-middle quarters (see fig 170). This species was thus found in cool to very warm waters; indeed, *M. splendida inornata* was captured in all habitats from the escarpment area to the floodplains. As with *M. nigrans*, the observed temperature range was greater than the one proposed by Allen (1978a), and was the broadest found in the present study.

Dissolved oxygen

Dissolved oxygen concentrations in waters in which *M. splendida inornata* was captured ranged from 0.9 to 8.2 mg/L (mean = 5.8) on the surface, and from 2.0 to 6.8 mg/L (mean = 4.9) on the bottom. These means were placed in the lower-middle and upper-middle quarters respectively (see fig 171). As with *M. nigrans*, the relatively high bottom-water DO concentrations may indicate an association with moving or well-mixed waters.

Visibility

Secchi depth readings ranged from 1 to 270 cm. The mean of 44 cm was ranked in the lower-middle quarter (see fig 172).

pH

The pH of waters in which *M. splendida inornata* was found ranged from 4.6 to 8.3 (mean = 6.1) on the surface and from 4.5 to 7.3 (mean = 5.9) on the bottom. These means were both ranked in the lower-middle quarter (see fig 173). *Melanotaenia splendida inornata* was found in waters with a wider, less acidic pH range than was *M. nigrans*, again modifying Allen's (1978a) suggested range of tolerance of melanotaeniids to pH (6.5–6.9).

Conductivity

Conductivity readings for waters in which *M. splendida inornata* was found ranged from 2 to 220 µS/cm at the surface, and from 2 to 64 µS/cm in the bottom waters. This wide range of conductivities matches the wide distribution of the species, from permanent flowing escarpment streams to lower-reach billabongs.[93]

Habitat–structural variables

Substrate

The type of substrate over which *M. splendida inornata* was found varied widely, as might be expected from its distribution. Sand (upper-middle quarter) was the principal substrate,

---

92 Crowley and Ivantsoff (1982) indicated that at temperatures greater than 26°C all observed pairs of *M. splendida inornata* spawned each day under laboratory conditions.

93 Williams and Williams (1991) found that mortalities of adults of *M. splendida* from the Murray-Darling River system occurred at salinities of 22–36 ppt. A preliminary toxicity study (Williams [1987] cited in Williams and Williams [1991]) on eggs and fry indicated mortalities commence at 10 ppt salinity. The corresponding conductivities are far higher than any recorded in the Alligator Rivers Region.

followed by mud (lower-middle quarter), then clay, leaf litter and boulders (see fig 174). Allen (1978a) noted that members of the family Melanotaeniidae are found in a variety of ecological conditions, from clear, rapidly flowing waters to small muddy pools.

Hydrophytes

Melanotaenia splendida inornata was generally found in waters with moderately thick vegetation (vegetation-occurrence index 72.1%): submergent plants (42.6%), followed closely by emergent plants (34.4%). As with *M. nigrans* habitats, there was a relatively high proportion of floating vegetation.

Reproduction

A total of 1121 fish were assessed for reproductive stage and GSI; 470 of these were female, 444 male and 207 sexually indistinguishable.[94] The gonads of *M. splendida inornata* are singular and readily differentiated, even at an early stage of development. The testes are flattened, whitish, elongated and irregularly triangular; the ovaries are rounded and translucent yellowish.

Length at first maturity

The LFM for *M. splendida inornata* was estimated to be 25 mm for females and 33 mm for males (fig 62).[95] Calculations were based on 5 mm groups and only 8 mm separates the two lengths. The smallest maturing male and female were recorded at 28 and 29 mm, respectively. Both sexes of *M. splendida splendida* matured in north-eastern Queensland at between 36 and 40 mm (Beumer 1979b).

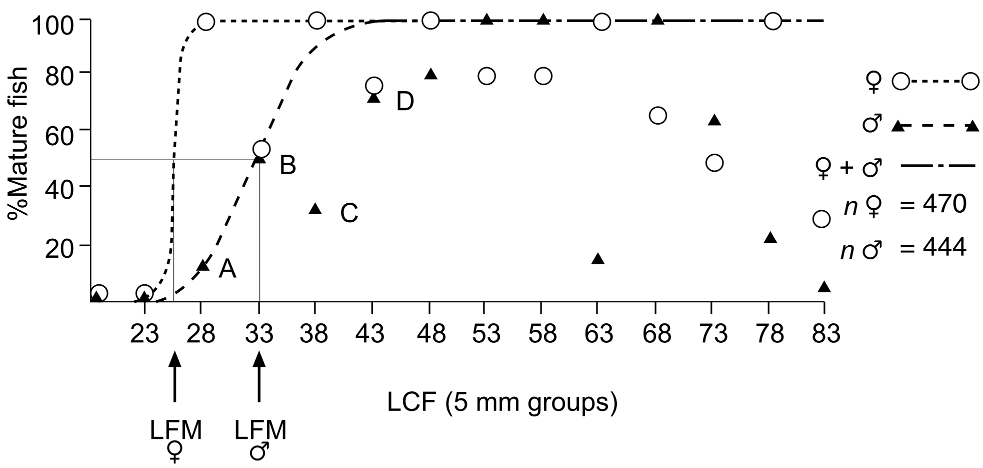


Figure 62 Estimated length at first maturity (LFM) of male and female *M. splendida inornata*

Sex ratio

There was a 1:1 ratio of males to females in all seasons (except for the 1978–79 Mid-wet sample) for both juveniles + adults and for adult fish only (table 53). During the 1978–79 Mid-wet season significantly more females were captured. It was also the period of the least gonadal development; if the male gonads had regressed to such an extent that the animals were classified as immature, this would have proportionally increased the number of females,

94 Ivantsoff et al (1988) indicated that *M. splendida inornata* is sexually dimorphic and dichromatic. Details of the sex differences are the same as given in footnotes for *M. nigrans*.

95 Milton and Arthington (1984) indicated the minimum length at spawning for *M. s. fluviatilis* from south-eastern Queensland was 30.8 mm SL.

as they remained sexually identifiable. A chi-squared test (Zar 1974) on each habitat type in the Magela system (table 54) found no significant deviation from a 1:1 ratio (at the 5% significance level) in any habitat.[96]

Table 53 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *M. splendida inornata* 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 + adults	F	*n*	60	48	147	98	65	39	13
	M	*n*	54	40	110	94	80	49	18
		χ^2	0.32	0.73	5.33	0.8	1.6	1.14	0.81
		P	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.
Adults only	F	*n*	59	39	145	98	62	32	11
	M	*n*	43	32	110	93	72	28	17
		χ^2	2.51	0.69	4.80	0.13	0.75	0.27	1.29
		P	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.
GSI									
Adults only	F	mean	2.7	3.8	0.6	1.0	1.9	1.9	3.9
		s.d.	0.6	1.2	0.4	0.4	1.0	0.7	1.1
	M	mean	0.4	0.7	0.1	0.2	0.3	0.3	0.8
		s.d.	0.1	0.1	0.1	0.1	0.2	0.1	0.2
	F+M	mean	1.5	2.1	0.4	0.6	1.0	1.2	2.3
		s.d.	1.3	1.8	0.4	0.5	1.0	0.9	1.8
GMSI									
Adults only	F	mean	3.6	3.0	2.1	2.4	3.2	3.1	3.9
		s.d.	0.5	1.0	1.0	0.7	0.8	0.6	0.6
	M	mean	3.0	3.6	1.7	2.4	3.0	2.6	3.5
		s.d.	0.5	0.5	0.6	0.9	0.7	0.8	0.8
	F+M	mean	3.3	3.3	1.9	2.4	3.1	2.9	3.7
		s.d	0.6	0.8	0.9	0.8	0.7	0.7	0.7

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.

Table 54 Sex ratio of *M. splendida inornata* found in the main habitat types during the 1978–79 Mid-wet season. None of the ratios was significantly different.

Sex ratio	Habitat
15:14	Escarpment mainchannel waterbody
22:36	Shallow backflow billabong
13:22	Lowland sandy creekbed pool
14:21	Shallow channel billabong
3:4	Corridor sandy billabong
10:3	Corridor anabranch billabong
13:23	Floodplain billabong

96 Milton and Arthington (1984) indicated that the sex ratio for all *M. s. fluviatilis* collected from south-eastern Queensland significantly differed from the expected 1:1 ratio (more females were present).

Breeding season

Melanotaeniids generally do not reproduce seasonally (Roberts 1978; Beumer 1979b; Fisher 1955), although *M. fluviatilis* is reported to breed in the Murray–Darling system during summer, depositing a few eggs at a time over many days (Lake 1978).

Melanotaenia splendida inornata has a relatively high GSI and GMSI throughout the year (fig 63, table 53), with peaks of reproductive development around the Early-wet season and a low in the Mid-wet season, when a high proportion of spent fish were found. Only four ripe specimens were found during the 1978 Late-dry and 1978–79 Early-wet seasons. All spent fish were captured during the 1978–79 Mid-wet season and 1979 Late-wet–Early-dry seasons. Juveniles (less than 20 mm LCF) were captured during all seasons except the 1979 Late-wet–Early-dry.

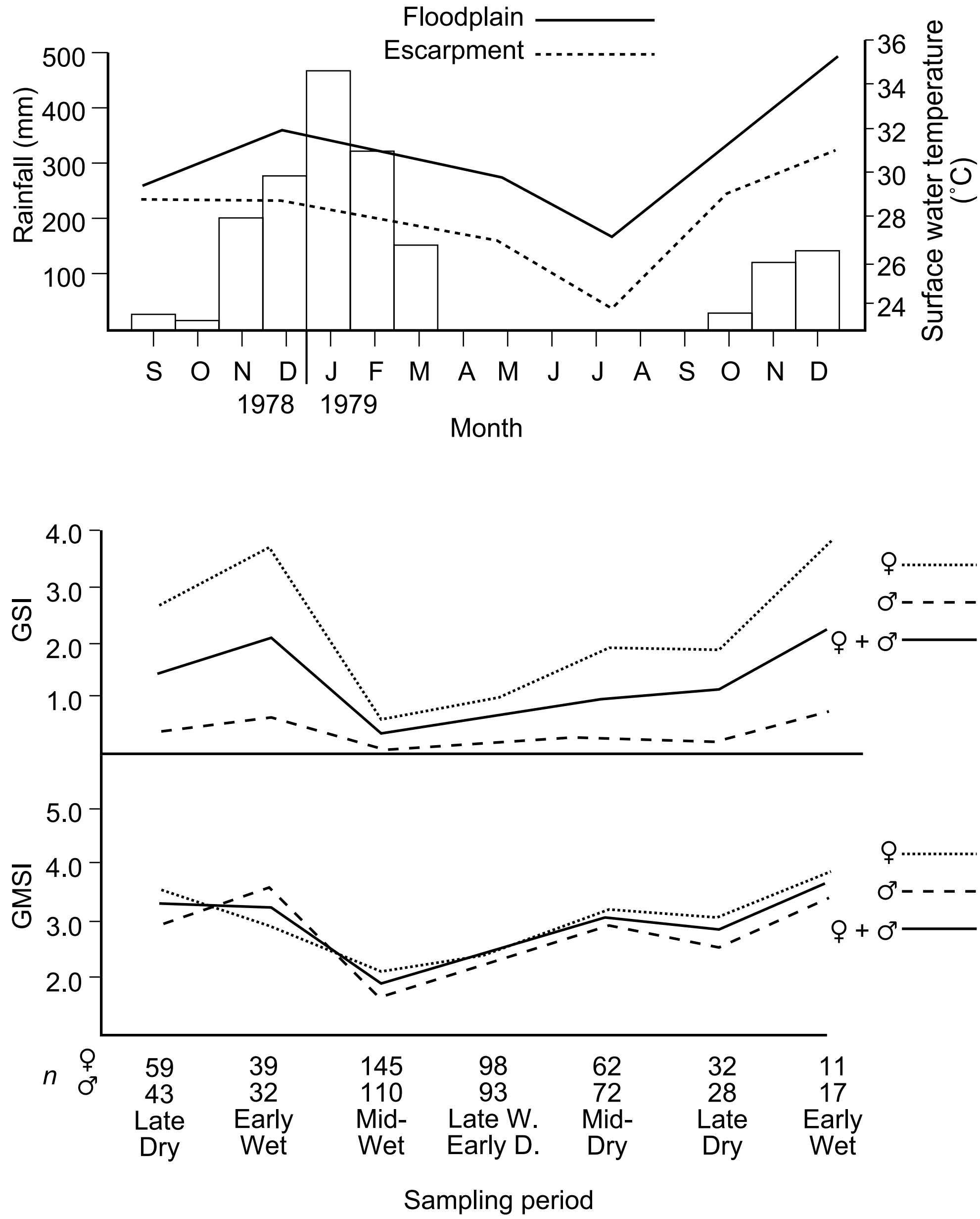


Figure 63 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *M. splendida inornata*

The presence of ripe and spent fish, together with the high GSI and GMSI values, suggests that *M. splendida inornata* spawns for an extended period during the Early-wet seasons, and that its gonads are developing for the next year's spawning by the Late-wet–Early-dry season. These results correspond closely to those of Beumer (1979b) for northern specimens of *M. splendida splendida*. Beumer also recorded juveniles throughout the year and suggested that this species spawned throughout the year with a peak before and during flood periods.

Site of spawning

Running-ripe fish were found only in the lowland sandy creekbeds; however, four fish at this stage were captured. Spent fish and juveniles were captured in all habitats sampled in both the Magela and Nourlangie systems (see table 55).

Table 55 Possible sites of spawning of *M. splendida inornata* as indicated by the abundance (*n*) of ripe, spent and juvenile fish

	Gonad stage				
	Ripe (VI)		Spent (VII)		Juveniles
Habitat	F	M	F	M	
Escarpment					
Mainchannel waterbody	–	–	2	4	5
Lowlands					
Sandy creekbed	3	1	8	–	63
Backflow billabong	–	–	4	–	52
Corridor	–	–	2	1	19
Floodplain billabong					
Upper	–	–	1	–	40

Melanotaenia splendida inornata is a ubiquitous spawner, as is *M. splendida splendida,* which spawns in both slow-flowing waters and in backwaters of flood waters (Beumer 1979b). Both species are reported (*M. splendida splendida* by Beumer 1979b; and *M. splendida inornata* by Midgley 1980) to migrate upstream at the onset of the Wet season.

Fecundity

In the eight gonads examined, the number of eggs ranged from 70 to 370 (mean = 171). The diameters ranged from 0.5 to 0.72 mm (mean = 0.6 mm). Tendrils were observed on the eggs. Beumer (1979b) did not calculate the fecundity of *M. splendida splendida,* as that species has a long spawning period and ripe oocytes were continuously spawned; however, he stated that the fecundity was low, and that the eggs were large (0.25–0.60 mm).[97]

Summary

Melanotaenia splendida inornata maintains a relatively high GSI and GMSI throughout the year. Although juveniles are present throughout the year, the occurrence of running-ripe and spent fish, and the higher values of GSI and GMSI, suggest this species mainly spawns at the onset of the Wet season. *Melanotaenia splendida inornata* is sexually dimorphic, with males having longer and more brightly coloured fins, especially during the breeding season.

97 Ivantsoff et al (1988) indicated that under stable laboratory conditions, large females (> 50 mm TL) produced possibly more than 100 eggs per day at the peak of the spawning season. Smaller females (28–35 mm TL) which were only just sexually mature shed fewer eggs, 20–30 per day and spawning did not occur daily. Milton and Arthington (1984) indicated that *M. s. fluviatilis* from south-eastern Queensland had fecundities which varied considerably: 35–333 (mean = 132) eggs per individual.

Both *M. splendida splendida* and *M. splendida inornata* are reported to migrate upstream at the onset of the breeding season (Beumer 1979b; Midgley 1980), which corresponds to the start of creek flow after the Dry season. They appear to breed throughout the system and lay a small number of relatively large eggs at a time; these are attached to aquatic vegetation by fine threads from the egg membrane.[98] Observations of *M. fluviatilis* in the Murray–Darling system suggest the incubation period is nine days at 20°C (Lake 1971) and the newly hatched larvae are at an advanced stage of development.

Feeding habits

Overall diet

The stomachs of 1109 specimens were examined; 1072 contained food. The diet is summarised in fig 64; components of the diet are given in table 56.

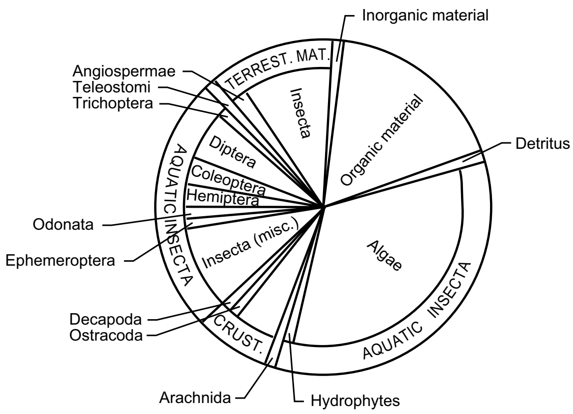


Figure 64 The main components of the diet of *M. splendida inornata*

The main components were algae (29%), aquatic insects (25%), terrestrial insects (15%) and microcrustaceans (7%). The algal component consisted mainly of green filamentous species. A variety of aquatic insects was eaten; the main identifiable species were chironomid larvae and pupae, and coleopterans. The main terrestrial insects were formicids (ants) and the main microcrustaceans were cladocerans. Traces of hydrophytes, oligochaetes, gastropods, arachnids, macrocrustaceans, teleosts, terrestrial plants, detritus and inorganic material were also found in the stomachs. Large quantities of unidentified organic material (15%) were also found. *Melanotaenia splendida inornata* can therefore be classified as a meiophagous omnivore feeding opportunistically throughout the waterbodies.

Pollard (1974) suggested this species probably eats small insects and, as with *M. nigrans*, does not mention any herbivorous component of its diet. Haines (1979) classified *M. splendida inornata* as an insectivore/detritophage in the Purari River catchment. Sanderson (1979) noted that *M. splendida inornata* in Magela floodplain billabongs ate a variety of food items — chiefly aquatic insects, vegetable matter (algae) and organic detritus. In the pools and riffles that enter the floodplain in the Wet season, *M. splendida inornata* fed mainly on non-aquatic insect forms such as winged diptera and ants. Sanderson concluded that this species was predominantly a mid-water/surface-feeder in the littoral zone of the floodplain billabongs and an opportunistic surface feeder in pools and riffles.[99]

98 Ivantsoff et al (1988) has subsequently described mating behaviour, egg and embryonic development, and larval development.

99 Pusey et al (1995b) found *M. splendida splendida* to consume large quantities of terrestrial insects in two rivers of the Australian wet tropics, north-eastern Queensland.

Table 56 Dietary composition of *M. splendida inornata*

	Habitat								Season							Overall	
	Magela system					Nourlangie system			1978	1978–79	1978–79	1979	1979	1979	1979–80		
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																	29.3
Miscellaneous	–	4.0	4.3	0.3	5.8	–	0.7	2.4	6.4	0.4	–	3.3	4.8	10.4	–	3.0	
Closterium	–	–	–	–	–	–	3.8	–	1.5	–	–	–	–	–	–	0.2	
Dinophyceae	–	1.0	0.1	–	0.1	–	–	–	–	–	–	0.6	0.1	–	–	0.1	
Cyanophyta	–	–	0.2	–	0.4	–	–	–	1.7	–	0.2	–	–	–	–	0.3	
Conjugatophyta																	
Mougeotia	13.4	8.9	18.9	28.6	32.5	34.6	66.2	16.8	3.1	5.9	20.3	48.6	40.7	18.0	3.1	23.3	
Spirogyra	–	1.2	3.1	7.3	1.1	4.0	–	–	–	–	7.0	1.2	–	–	–	2.4	
Hydrophytes																	0.9
Eriocaulon	–	0.1	–	–	–	–	–	–	–	–	+	–	–	–	–	+	
Najas	–	1.0	1.3	–	0.6	–	–	2.5	–	–	0.3	–	4.7	–	–	0.7	
Vallisneria	1.1	–	–	0.6	–	–	–	–	–	–	0.2	–	0.7	–	–	0.2	
Aquatic animals																	
Oligochaeta	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	0.1	0.1
Gastropoda																	0.1
Amerianna	–	–	–	–	0.6	–	–	–	–	–	–	–	0.7	–	–	0.1	
Arachnida																	0.8
Araenae	–	–	0.8	–	–	0.6	–	–	–	–	0.8	–	–	–	–	0.3	
Porohalacaridae	–	+	–	–	–	–	–	–	–	–	–	–	–	0.1	–	+	
Hydracarina	–	0.6	0.3	0.8	0.7	–	–	–	1.4	1.3	0.2	0.1	0.8	0.2	–	0.5	
Microcrustacea																	7.2
Conchostraca	–	–	+	–	–	–	–	–	0.4	–	–	–	–	–	–	0.1	
Cladocera																	
Miscellaneous	–	–	2.2	0.6	0.6	–	–	0.1	3.2	1.5	1.8	+	+	–	–	1.2	
Diaphanosoma	–	9.8	7.5	3.8	1.9	–	–	–	–	17.3	–	1.5	1.0	3.5	48.6	4.3	
Ostracoda	–	1.6	1.2	0.1	0.6	–	–	–	–	1.2	0.9	0.6	0.6	–	–	0.6	
Copepoda	–	–	–	–	–	–	–	1.4	0.8	–	0.3	–	–	1.2	–	0.3	
Macrocrustacea																	1.0
Macrobrachium (juveniles)	–	–	0.7	–	0.6	–	–	–	–	2.2	–	–	–	–	–	0. 3	
Macrobrachium (adults)	1.8	–	0.9	0.6	0.6	–	–	1.4	3.3	0.7	–	0.5	0.7	–	–	0.7	

Table 56 continued

	Habitat								Season							Overall	
	Magela system					Nourlangie system			1978	1978–79	1978–79	1979	1979	1979	1979–80		
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
Insecta																	25.3
Fragmented	11.7	10.7	10.8	5.0	8.0	14.1	0.8	14.6	14.2	8.6	14.2	3.0	6.9	6.4	4.4	9.6	
Ephemeroptera																	
Baetidae	0.6	1.0	1.7	0.1	–	–	–	–	1.5	2.2	0.7	–	0.1	–	–	0.7	
Atalophlebia	–	–	–	–	–	–	–	–	–	0.6	–	–	–	–	–	0.1	
Odonata																	
Coenagrionidae	1.8	–	–	–	–	–	–	–	–	–	0.3	–	–	–	–	0.1	
I. heterosticta	–	–	0.7	–	–	–	–	–	–	–	–	–	1.4	–	–	0.2	
Gomphidae	–	–	0.3	–	–	–	–	1.4	1.7	–	–	–	–	–	–	0.2	
Libellulidae	–	–	1.0	–	–	–	–	–	0.4	–	–	1.5	–	–	–	0.3	
Hemiptera																	
Naucoridae	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	0.1	
Gerridae	1.3	0.8	0.5	0.8	1.2	–	–	1.9	0.9	0.7	1.4	0.5	–	0.4	–	0.8	
Viliidae	–	1.0	1.2	–	0.4	–	–	–	1.1	–	1.1	–	–	–	–	0.5	
Anisops	–	0.1	–	–	–	–	–	–	0.3	1.2	–	–	–	–	–	0.2	
Corixidae	0.1	2.0	0.5	1.8	1.6	–	–	0.3	2.4	2.6	0.3	0.5	0.3	5.1	–	1.3	
Megaloptera																	
Austrosialis	–	–	0.1	–	–	–	–	–	–	–	0.1	–	–	–	–	+	
Coleoptera																	
Miscellaneous (adults)	6.3	4.3	3.4	2.1	0.3	4.7	1.8	1.8	10.0	0.4	2.2	–	3.3	4.0	0.7	2.8	
Miscellaneous (larvae)	–	–	0.4	–	0.6	–	–	–	0.4	–	0.7	–	–	–	–	0.3	
Diptera																	
Chaoborinae	–	–	–	–	1.2	–	–	–	–	–	0.6	–	–	–	–	0.2	
Chironomidae (larvae)	0.2	2.9	1.3	4.3	4.4	6.5	1.3	11.1	2.1	8.6	1.7	1.1	1.6	14.4	0.3	3.4	
Chironomidae (pupae)	–	1.0	3.0	2.2	0.7	4.3	–	9.4	3.1	3.3	1.7	3.1	2.9	5.4	–	2.8	
Ceratopogonidae	–	0.6	0.4	–	–	–	0.4	–	1.2	0.6	–	–	–	–	–	0.2	
Simuliidae	1.8	–	–	–	0.6	–	–	–	–	–	0.3	–	0.7	–	–	0.2	
Trichoptera																	
Leptoceridae	2.6	0.7	1.3	0.7	1.2	–	3.0	0.3	2.5	0.2	1.1	0.5	0.2	2.4	–	0.9	
Miscellaneous (pup.)	–	–	1.3	–	–	–	–	–	–	–	1.2	–	–	–	–	0.4	
Teleostomi																	1.3
Fragmented	1.8	1.1	0.4	1.3	0.6	–	0.2	–	0.8	0.7	1.2	0.6	–	–	–	0.7	
Scales	–	0.3	–	–	–	–	–	–	–	–	0.1	–	–	–	–	+	

Table 56 continued

Stomach contents	Habitat: Magela system Em	Ls	Bb	Cb	Fb	Nourlangie system Em	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
Egg material	–	–	0.9	1.9	–	–	–	1.3	–	–	2.0	–	–	–	–	0.6	
Terrestrial plants																	
Angiospermae																	2.2
Fragmented	0.9	–	–	0.6	–	–	–	–	–	0.5	0.7	2.5	4.8	–	–	1.4	
Miscellaneous	–	0.9	2.5	0.1	3.6	–	–	–	0.7	–	0.2	–	–	–	–	0.1	
Seed material	–	–	2.2	0.7	–	–	–	–	–	–	0.6	0.5	3.3	–	–	0.7	
Terrestrial animals																	
Arachnida	1.1	–	–	–	–	1.1	–	–	–	–	0.2	–	0.4	–	–	0.1	0.1
Insecta																	15.0
Fragmented	14.3	6.3	2.3	2.8	1.4	18.3	1.9	10.0	6.7	–	4.7	1.0	7.6	–	11.9	5.0	
Odonata																	
Zygopteran (adults)	–	–	–	1.9	–	–	–	–	2.1	–	–	–	–	–	–	0.3	
Anisopteran (adults)	–	0.4	0.3	–	0.6	–	–	–	–	–	0.7	–	–	–	–	0.2	
Coleopteran																	
Miscellaneous	–	–	1.0	–	0.5	1.9	–	–	0.6	–	1.2	–	–	–	–	0.4	
Dipteran																	
Miscellaneous	1.8	3.9	–	–	–	–	–	–	–	–	1.5	–	–	–	–	0.5	
Chironomidae (adults)	–	–	0.2	–	–	–	–	–	–	–	0.2	–	–	–	–	0.1	
Culicidae (adults)	1.8	–	–	–	–	–	–	–	–	–	–	–	–	1.2	0.7	0.1	
Trichoptera	–	–	–	–	0.6	–	–	–	–	–	0.3	–	–	–	–	0.1	
Hymenoptera																	
Formicidae																	
Miscellaneous	17.3	14.7	5.1	3.6	1.3	4.9	–	0.6	1.2	7.8	10.4	–	1.5	5.8	30.5	6.5	
Oecophylla	13.6	1.0	0.8	0.5	6.2	–	7.1	–	1.9	1.0	4.1	–	1.0	–	–	1.8	
Parasites																	
Cestoda	–	–	0.3	–	–	–	–	–	–	–	0.3	–	–	–	–	0.1	0.1
Nematoda	–	–	0.4	0.2	0.1	–	–	0.8	0.8	–	0.3	–	–	0.1	–	0.2	0.2
Detrital material	–	–	1.2	4.3	–	–	–	–	–	–	–	1.0	5.1	1.2	–	1.0	1.0
Inorganic material	0.3	3.1	2.0	0.5	–	1.4	–	–	2.7	0.9	0.8	–	0.1	3.9	–	1.1	1.1
Organic material	4.9	15.5	12.0	22.4	18.4	3.5	13.0	20.6	18.7	17.7	10.9	27.7	4.1	16.5	–	15.1	15.1
Number of empty fish	–	4	10	12	7	–	–	2	5	8	3	10	2	9	–	37	37
Number of fish with food	55	102	305	160	171	51	56	72	144	138	336	195	145	83	31	1072	1072

Figures represent the mean percentage volume determined by the estimated volumetric method.
Em = escarpment mainchannel; Ls = lowland sandy creek bed; Bb = lowland backflow billabongs; Cb = corridor billabongs; Fb = floodplain billabongs

Seasonal changes

In sampling periods 1–7, respectively, 149 (3% empty), 146 (5% empty), 339 (1% empty), 205 (5% empty), 147 (1% empty), 92 (10% empty) and 31 (0% empty) stomachs of *M. splendida inornata* were examined (all habitats combined). The highest proportions of specimens with empty stomachs were found in the Late-dry and Late-wet–Early-dry seasons.

The algal component of the diet increased in importance during the Mid-wet season and remained the most important food item during the Late-wet–Early-dry and 1979 Mid-dry seasons. It became less important during the 1979 Late-dry season and reached a low in the Early-wet season, as it had in the previous year.

Aquatic insects were a large component throughout the study; Chironomid larvae and pupae were most important; in the 1978–79 Early-wet and 1979 Late-dry seasons, coleopterans and corixids were most important in the Late-dry seasons. The greatest variety of aquatic insects was eaten in the Mid-wet season. Terrestrial insects became important in the diet during the Early-wet and Mid-wet seasons; the greatest variety was found in the latter season.

Microcrustaceans were found most commonly in the stomachs during the Early-wet seasons. Unidentified organic material comprised large portions of the stomach contents in all seasons other than the 1979 Mid-dry and the 1979–80 Early-wet.

Habitat differences

Magela catchment

The stomachs of 826 *M. splendida inornata* (all seasons combined) were examined: 55 (0% empty) from escarpment mainchannel waterbodies, 106 (4% empty) from lowland sandy creekbeds, 315 (3% empty) from lowland backflow billabongs, 172 (7% empty) from corridor waterbodies, and 178 (4% empty) from floodplain billabongs, caught in the Magela Creek catchment. The highest proportions of specimens with empty stomachs were found in the corridor waterbodies and the lowest proportions in the escarpment mainchannel waterbodies.

In the escarpment mainchannel waterbodies, terrestrial insects were most abundant in the stomachs, followed by aquatic insects and green filamentous algae (*Mougeotia*). In the lowland sandy creekbeds, terrestrial insects were slightly less important and microcrustaceans were also eaten. The diet in the backflow billabongs encompassed a variety of food items, including algae, microcrustacea and aquatic insects.

In the corridor waterbodies the diet consisted mainly of algae and aquatic insects; there was also a large unidentified organic material component. In the floodplain billabongs the algal component was large, aquatic insects were of secondary importance, and there was a large unidentified organic material component. Terrestrial insects also appeared in the diet but microcrustaceans were of minor importance.

Nourlangie catchment

The stomachs of 181 *M. splendida inornata* (all seasons combined) from Nourlangie Creek catchment were examined: 51 (0% empty) from escarpment mainchannel waterbodies, 56 (0% empty) from lowland sandy creekbeds, and 74 (2% empty) from backflow billabongs. Few specimens had empty stomachs.

In the escarpment mainchannel waterbodies, algae were the main food, with smaller portions of terrestrial and aquatic insects; in equivalent habitats in the Magela Creek catchment the algal component was smaller. In the sandy creekbeds, the algal component in the diet was higher and terrestrial and aquatic insects were even less important. In the backflow billabongs, larger quantities of aquatic insects (mainly chironomid larvae and pupae) were eaten along with terrestrial insects and much less algae; traces of microcrustaceans were also found in the stomachs.

Fullness

The mean fullness indices of *M. splendida inornata* for different sampling periods and habitat types are shown in table 57. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 57 Mean fullness indices for *M. splendida inornata* in different sampling periods and habitats

	Sampling period							
Habitat	Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80	Habitat mean
Magela Creek catchment (regular sites only)								
Upstream of RUPA								
Escarpment main-channel waterbody	2.0	n/s	3.3 (36)	n/s	3.5	4.0 (3)	3.7 (10)	3.4 (49)
Lowland shallow backflow billabong	4.2 (10)	n/s	3.0 (12)	n/s	3.5 (10)	2.6 (11)	n/s	3.3 (43)
Lowland sandy creekbed	n/s	3.0 (2)	3.4 (14)	n/s	n/s	n/s	3.5 (10)	3.4 (26)
Downstream of RUPA								
Lowland sandy creekbed	3.5 (17)	2.9 (24)	3.1 (36)	3.3 (8)	n/s	2.2 (5)	n/s	3.1 (90)
Lowland channel backflow billabong	2.0 (4)	3.3 (12)	3.6 (45)	3.4 (31)	0 (1)	1.3 (4)	0 (1)	3.3 (97)
Lowland shallow backflow billabong	2.9 (13)	2.5 (28)	3.4 (67)	3.4 (51)	3.4 (24)	2.7 (3)	n/s	3.2 (186)
Corridor sandy billabong	1.5 (2)	2.1 (2)	3.7 (1)	0.6 (10)	3.9 (10)	2.9 (10)	n/s	2.5 (35)
Corridor anabranch billabong	3.5 (12)	2.3 (4)	3.7 (16)	3.9 (10)	3.9 (10)	2.4 (10)	n/s	3.4 (62)
Floodplain billabong	3.5 (26)	2.8 (22)	2.8 (56)	2.8 (53)	3.6 (50)	3.2 (30)	n/s	3.1 (237)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	n/s	2.6 (11)	3.3 (22)	n/s	3.3 (18)	n/s	n/s	3.1 (51)
Lowland channel backflow billabong	4.0 (2)	2.6 (5)	2.8 (8)	3.1 (10)	3.6 (10)	4.0 (2)	n/s	3.2 (37)
Lowland shallow backflow billabong	2.2 (6)	3.5 (3)	3.0 (2)	2.6 (10)	4.0 (6)	3.4 (9)	n/s	3.1 (36)
Lowland sandy creekbed	3.0 (10)	0 (1)	0.7 (11)	3.6 (20)	3.2 (10)	4.0 (4)	n/s	2.8 (56)
Seasonal mean (all sites)	3.1	2.7	3.2	3.1	3.5	3.0	3.5	

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

Seasonal changes

The mean seasonal index (all seasons combined) fell slightly during the 1978–79 Early-wet season and then returned to a higher level for the remainder of the study. Peaks occurred during the 1979 Mid-dry and 1979–80 Early-wet seasons (unlike in the previous year).

Habitat differences

In the Magela catchment, mean fullness indices were much the same in all habitats (indicating opportunistic feeding habits), the possible exception being the corridor sandy billabong, where a slightly lower index was recorded.

In the Nourlangie catchment, mean fullness indices were similar in all habitats and comparable with the Magela Creek catchment; the possible exception was the lowland sandy creekbed pool where a slightly lower index was recorded.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

- lowland shallow backflow billabong (upstream of RUPA); 1978 Late-dry season
- corridor sandy billabong; 1979 Mid-dry season
- corridor anabranch billabong; 1979 Late-wet–Early-dry season, 1979 Mid-dry season

Nourlangie catchment

- lowland channel backflow billabong; 1978 Late-dry season, 1979 Late-dry season
- lowland shallow backflow billabong; 1979 Mid-dry season
- lowland sandy creekbed pool; 1979 Late-dry season.

Family MELANOTAENIIDAE

3.15 *Melanotaenia splendida australis* (Castelnau)

Melanotaenia splendida australis is commonly known as the red-tailed or western rainbowfish. Only a few specimens of this species were collected in the escarpment mainchannel waterbodies of the Jim Jim Creek system (South Alligator River system). *Melanotaenia splendida australis* and *M. splendida inornata* are so closely related that Allen (1978a) was tempted to consider the latter a subspecies of *australis*. During the breeding season, *M. splendida australis* is fairly easily distinguished from *M. splendida inornata* by the red colouration of the caudal fin.[100]

Melanotaenia splendida australis occurs in river systems of north-western Australia; the Ashburton River forms the western and southern limit of its distribution. It is common in most streams of the Kimberley region and the northwestern Northern Territory from the Fitzroy River to the Adelaide River, just east of Darwin. The *solata* variety (Allen considered that *M. solata* [Taylor 1964] falls within the range of *M. splendida australis* with regard to colour pattern, morphometrics and meristics) has been reported from several localities east of Darwin, including the upper South Alligator River and Yirrkala, Groote Eylandt, and Bickerton Island.

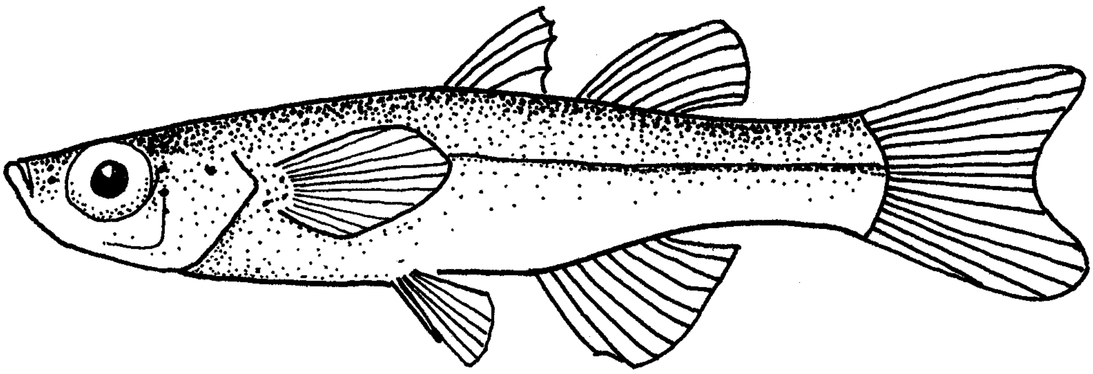
---

100 Ivantsoff et al (1988) has subsequently described aspects of the mating behaviour, egg and embryonic development, and larval development. Under laboratory conditions with a water temperature of 26°C, Ivantsoff et al (1988) indicated that *M. s. australis* can attain a total length of 25 mm in 78 days.

Family PSEUDOMUGILIDAE

3.16 *Pseudomugil tenellus* (Taylor)

Pseudomugil tenellus is commonly known as the Arnhem Land blue-eye or the delicate blue-eye. Members of this genus usually inhabit coastal brackish or fresh waters, and are not usually found very far inland. This species has so far been recorded only from the East Alligator River catchment. It was originally described by Taylor (1964) from specimens collected by R. Miller in 1948 from the Oenpelli area; it is fairly closely related to *P. gertrudae* (Weber), which occurs in the north-east coast and Gulf of Carpentaria drainage systems (see map 3).[101] It is also found in southern Papua New Guinea and the Aru Islands.



Pseudomugil tenellus

Midgley (1973) collected this species in the Magela Creek near Jabiru, where they were rare, and in lower riverine floodplain billabongs, where they were common. Miller (cited in Taylor 1964) reported it was abundant in large billabongs and creeks below escarpment waterfalls in the Oenpelli area.

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 floodplain billabongs and in some corridor and lowland backflow billabongs and in one escarpment perennial stream. It was also found in a vegetated lowland sandy creekbed habitat of the Nourlangie Creek system. It was found in the greatest number of sites during the Mid-wet season, and in the fewest during the 1978 Late-dry and the Late-wet–Early-dry seasons.

Size composition

The lengths and weights of 232 specimens were recorded. Small juveniles were captured most frequently in the 10 mm mesh seine net when it was clogged by hydrophytes and filamentous algae.

Length–weight relationship

As many specimens weighed less than 0.1 g (thus being classified as zero weight) an expression for the length–weight relationship could not be calculated.

---

101 *P. gertrudae* was recorded in the Alligator Rivers Region in the early 1980s (K Bishop, pers obs).

Seasonal mean lengths, weights and condition factors are shown in table 58 (note small sample size). Similar condition factors (near unity) were recorded for specimens collected in 1978–79 Early-wet and Mid-wet seasons. The single specimen examined in the Late-wet–Early-dry season had exceptionally high body condition.

Table 58 Mean length and weight, and condition factor of *P. tenellus*

	n	Mean length (mm)	Mean weight (g)	Condition factor (K)
Early-wet (1978–79)	10	28.2	0.31	0.99
Mid-wet	3	29.3	0.30	0.98
Late-wet–Early-dry (1979)	1	22.0	0.40	1.14
Overall	14	27.9	0.31	1.00

Length-frequency distribution

The smallest specimen captured was 14 mm LCF; the largest was 31 mm LCF (fig 65). *Pseudomugil tenellus* reputedly grows to 40 mm (Pollard 1974). The closely related diadromous *P. signifer* grows to 65 mm but is found most commonly at lengths between 25 and 45 mm (Ivantsoff 1980).

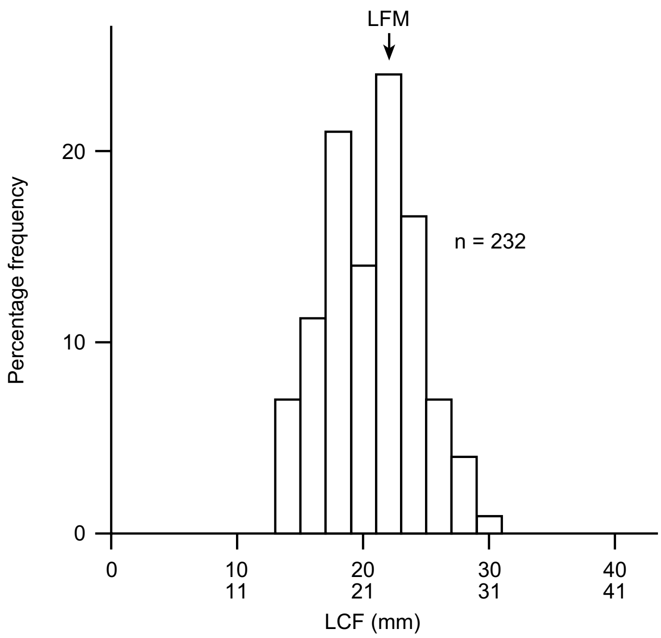


Figure 65 Length-frequency distribution of all *P. tenellus* captured

The mean and modal lengths of all specimens captured were, respectively, 22.5 and 22–23 mm LCF; based on mean length, *P. tenellus* was the smallest species found in the study area. A secondary mode occurred at 18–20 mm LCF. The LFM was 23 mm LCF for both sexes, indicating fairly equal proportions of adults and juveniles were captured during the study.

Seasonal changes in distribution

The smallest juveniles were found between the 1978–79 Mid-wet and the 1979 Late-dry seasons. Very few juveniles were found in the 1978–79 Early-wet season. The largest adults were found in the 1978–79 Early-wet and the Mid-wet seasons.

The length-frequency distributions in the 1979 Late-dry and the Mid-wet seasons (as well as the overall distribution) have two modes, separated by only 2 mm (fig 66). These modes may be a result of sexual differences in growth rates (a possibility that merits verification).

Juveniles and smaller adults dominated the samples in the 1978 Late-dry season. Juvenile recruitment appeared very weak in the 1978–79 Early-wet season, when adults were most common. No specimens of *P. tenellus* were captured in the 1979–80 Early-wet season; however, in the 1979 Late-dry season juveniles dominated the samples more completely than they had in the equivalent 1978 season.

There were many juveniles and fewer adults in the Mid-wet season. By the Late-wet–Early-dry season there a strong juvenile component and a stronger small-adult component, resulting in a clear bimodal distribution with modes separated by 6 mm.

In summary, juvenile recruits were found in all seasons except the 1978–79 and 1979–80 Early-wet seasons; recruitment appeared to peak in the Late-wet–Early-dry season.

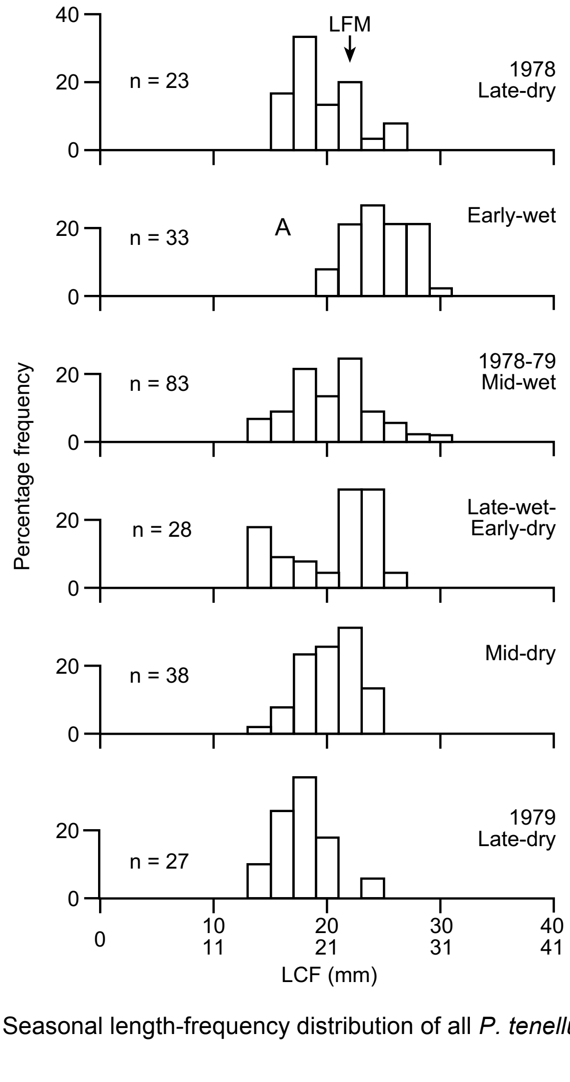


Figure 66 Seasonal length-frequency distribution of all *P. tenellus* captured

Growth rate

No published information on the growth of *P. tenellus* was found. Estimation of growth rate from the seasonal length-frequency distribution is difficult due to frequency with which juveniles were recruited to the populations, and the wide range of habitats sampled. However, during the two months between the 1978 Late-dry season and the 1978–79 Early-wet season (when juvenile recruitment was minimal; A on fig 66), the length-frequency distribution shifted approximately 5 mm. If this is a true growth effect, then this species could attain LFM within its first year of life.[102]

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *P. tenellus* caught in regular sampling sites in the Magela and Nourlangie Creek catchments are given in figure 67.

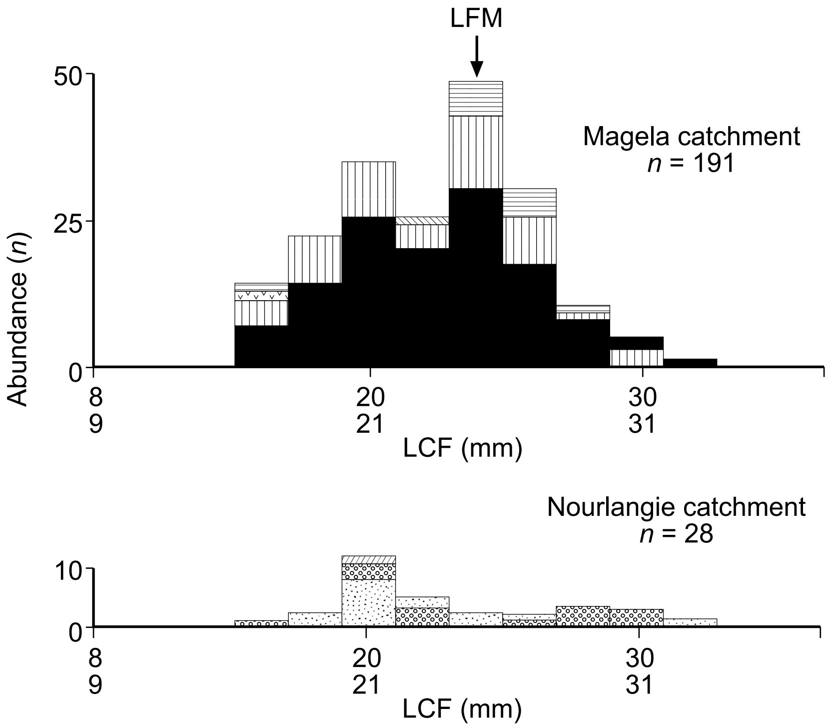


Figure 67 Length–frequency distributions and habitat preferences of *P. tenellus* captured at regular sampling sites (see appendix 5 for key to the habitats)

Magela catchment

Juveniles were mainly found in floodplain billabongs and, to a lesser extent, in lowland shallow backflow billabongs downstream of RUPA. The smallest juveniles were caught in the latter habitats as well as in corridor anabranch and lowland sandy creekbed habitats upstream of RUPA. Some larger juveniles were found in escarpment mainchannel waterbodies.

Adults were found in essentially the same habitats as the juveniles; however, higher proportions of adults were found in corridor anabranch billabongs. Some adults were found in the upper reaches of first-order streams in RUPA during the Mid-wet and Late-wet–Early-dry seasons. The largest adults were found in floodplain billabongs.

Nourlangie catchment

Juveniles and adults were found in backflow billabongs in this system. A few juveniles were found in sandy creekbed habitats and in escarpment perennial streams (in tree-root-entangled side pools of the main stream) during the Mid-wet season. The smallest juvenile was caught in a shallow backflow billabong; the largest adult in a channel backflow billabong.

102 Under laboratory conditions with a water temperature of 26°C, Ivantsoff et al (1988) indicated that *P. tenellus* can attain a total length of 19–28 mm in 144 days. By 13 months, 3 males attained a total length of 40–43 mm.

Environmental associations

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

Physico–chemical variables

Temperature

Pseudomugil tenellus was found in water temperatures from 27° to 38°C (mean = 31.4°C) on the surface, and 25° to 36°C (mean = 30.1°C) on the bottom (see fig 170). Both of these means ranked at the base of the upper quarter, indicating this species has an apparent preference for warmer waters, which accords with its distribution in lowland and floodplain habitats.

Dissolved oxygen

Dissolved oxygen concentrations ranged from 5.0 to 7.8 mg/L (mean = 6.6 mg/L) on the surface and from 5.2 to 5.9 mg/L (mean = 5.5 mg/L) on the bottom. Both means were ranked in the upper quarter (see fig 171).

Visibility

Secchi depths ranged between 3 and 360 cm. The mean depth of 50 cm ranked in the lower-middle quarter (see fig 172).

pH

The pH values of surface waters ranged from 5.0 to 7.1 with a mean of 6.0, which ranked in the lower quarter. This relatively narrow range may be a function of the small number of readings (n = 12) taken for this species (see fig 173). No bottom-water pH readings were taken in these waters.

Conductivity

Surface-conductivity values ranged from 6 to 120 µS/cm; the only bottom-water value measured was 12 µS/cm. The narrowness of this range is probably largely an artefact of the small number of readings taken.

Habitat–structural variables

Substrate

Pseudomugil tenellus was captured over the entire range of substrates defined in this study: most often clay (upper quarter), followed by mud (lower-middle quarter), sand, rocks, gravel, leaves and boulders (see fig 174).

Hydrophytes

Pseudomugil tenellus was caught in the most heavily vegetated waters (vegetation-occurrence index 91.8%) in this study: the most dominant vegetation type was submergent, followed closely by emergent, then floating attached hydrophytes.[103] This association with abundant vegetation may be related to the species' observed behaviour of laying eggs in strings amongst aquatic vegetation (Pollard 1974).

Reproduction

The gonads of 188 specimens were examined: 35 males (length range 17–30 mm LCF), 69 females (16–31 mm LCF) and 84 sexually indistinguishable (14–27 mm LCF). No gonads developed beyond stage V were found in females or beyond stage IV in males.

---

[103] Herbert and Peeters (1995) indicated that they usually found *P. tenellus* amongst dense aquatic vegetation in gently flowing waters of streams draining Cape York Peninsula.

Length at first maturity

An 18 mm LCF female was found maturing, but no others were found until 24 mm LCF. The males were first found maturing at 23 mm LCF, the estimated LFM for both sexes (fig 68). The samples were too small, especially of the males, to accurately estimate the LFM; however, it was obvious that at 23 mm LCF significant numbers of fish were capable of maturing.

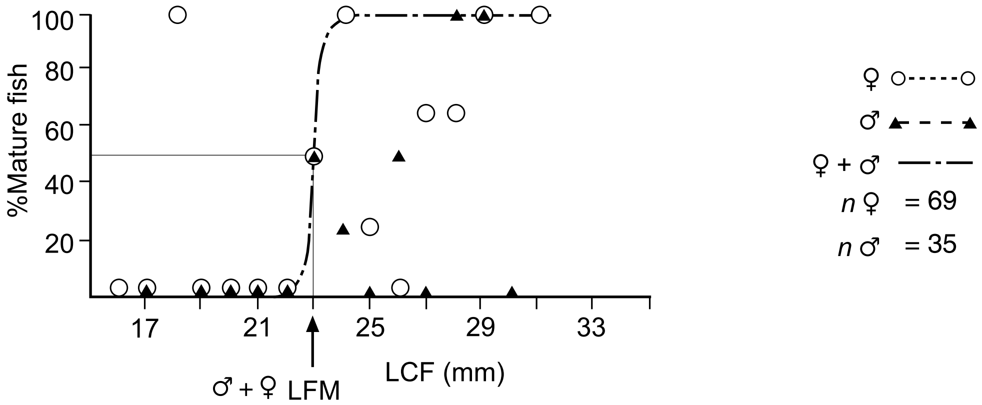


Figure 68 Estimated length at first maturity (LFM) of male and female *P. tenellus*

Sex ratio

The ratio of males to females was not significantly different from 1:1 in any season, except the 1978–79 Mid-wet (when $P < 0.001$ for juvenile + adult fish and $0.001 < P < 0.01$ for adult fish only), and the 1979 Late-wet–Early-dry (when a slight ($0.01 < P < 0.05$) difference was found in the adult + juvenile group).

When the ratio was unequal, there were more females than males (table 59). Misidentification of male gonads was unlikely to be the cause, as equal ratios were found in other seasons (eg Mid-dry season) when the mean GSI and GMSI were also low.

A significant number of females in the 1979 Late-wet–Early-dry season were juveniles; thus the sex ratio differed from 1:1 in the juveniles + adults sample but the ratio was not significantly different from 1:1 for the adult group. In the Mid-wet season sample there was also a discrepancy between the number of juvenile and adult females. Possibly females grow faster than the males and are recruited earlier into the breeding population (ie develop identifiable ovaries).

Breeding season

The GSI and GMSI for females indicated a significant peak in gonad development in the 1978–79 Early-wet season. Fewer males were captured, but their GSI and GMSI also declined after the 1978–79 Early-wet season (fig 69). No running-ripe fish were found; however, nearly all maturing males and females, and mature females were collected in the 1978–79 Early-wet season, with some maturing females collected in the 1978–79 Mid-wet season. The highest GSI readings were also found during the 1978–79 Early-wet and juvenile fish were generally captured in the three subsequent seasons. The data, although sparse, suggest that spawning most likely occurred during the 1978–79 Early-wet season, although spawning may be aseasonal, with peaks of activity during the Early-wet season.[104]

104 Under laboratory conditions, Howe (1987) found that *P. tenellus* spawning occurred mainly in summer months. Spawning did not follow a daily pattern, but continued over several days followed by a period of 1–2 weeks inactivity. A water change, which frequently lowered the temperature, or the introduction of new plants sometimes induced spawning after a period of inactivity.

Table 59 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *P. tenellus* 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*	1	13	34	11	9	1	0
adults	M	*n*	1	16	6	2	10	0	0
		χ^2	0	0.3	19.6	6.2	0.05	1.0	–
		P	n.s.	n.s.	***	*	n.s.	n.s.	–
Adults only	F	*n*	1	12	19	6	7	1	0
	M	*n*	0	15	4	2	4	0	0
		χ^2	1	0.3	9.8	2	0.8	1	–
		P	n.s.	n.s.	**	n.s.	n.s.	n.s.	–
GSI									
Adults only	F	mean	1.0	5.7	2.8	2.1	1.2	2.0	–
		s.d.	–	4.0	1.1	1.7	0.8	–	–
	M	mean	–	1.6	1.0	6.5	0.8	–	–
		s.d.	–	1.0	0.8	0	0.3	–	–
	F+M	mean	–	3.5	2.4	1.7	1.0	–	–
		s.d.	–	3.4	1.2	1.6	0.7	–	–
GMSI									
Adults only	F	mean	2.0	3.8	2.6	2.2	1.6	2.0	–
		s.d.	–	1.3	0.9	1.0	0.8	–	–
	M	mean	–	3.1	1.8	1.0	1.8	–	–
		s.d.	–	1.0	0.5	0.0	0.5	–	–
	F+M	mean	–	3.4	2.4	1.9	1.6	–	–
		s.d	–	1.2	0.9	1.0	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 < 0.01; *** = P < 0.001; s.d. = standard deviation.

Site of spawning

There is no direct evidence (eg running-ripe fish or significant numbers of mature fish) that *P. tenellus* actually breeds in the Magela Creek system (table 60). However, the presence of juveniles in the Magela system and adults up as far as the escarpment area suggests that it may do so.

Pseudomugil signifer, a closely related species from south-eastern Australia, prefers a weedy environment in flowing brackish water, close to the shore, where it lays large eggs separately on aquatic plants or on sand just below the surface. Ivantsoff (in McDowall 1980) found that a saline environment was essential for breeding.[105]

Fecundity

The two ovaries examined contained 33 and 45 eggs, with a mean oocyte diameter of 1.0 mm.[106]

105 Under laboratory conditions, Howe (1987) found that *P. tenellus* spawned in the roots of a floating water plant.

106 Under laboratory conditions, Howe (1987) found that *P. tenellus* released the largest number of eggs (3–15) in one day compared with three other *Pseudomugil* species studied (1–8).

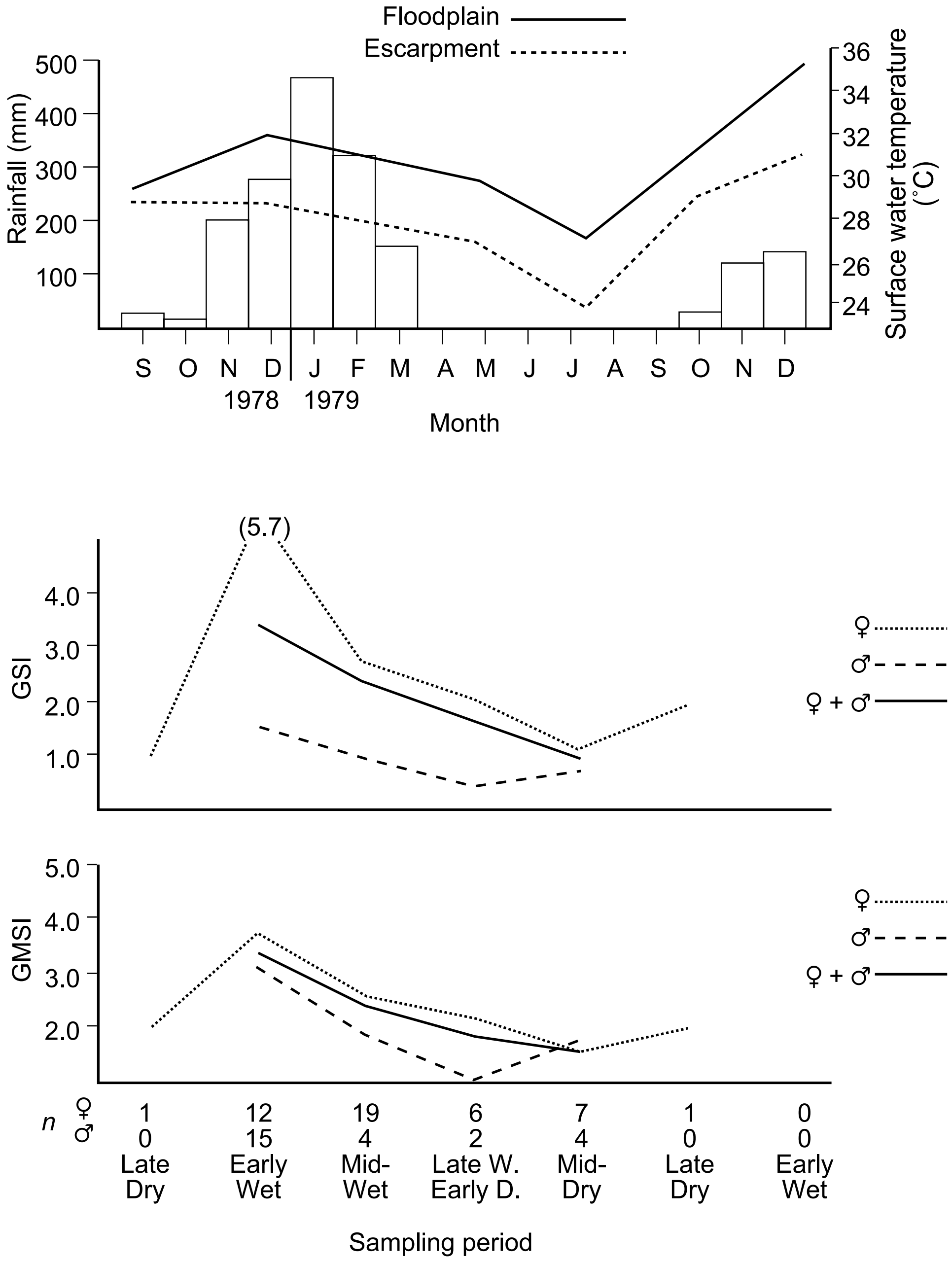


Figure 69 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *P. tenellus*

The eggs of atherinid species that have been studied are large and are normally laid in strings amongst aquatic vegetation. They are reported to take about two weeks to hatch at 21–26°C. The young mature at 12 months (Pollard 1974; Lake 1978).

Summary

Maturing *P. tenellus* were found in floodplain billabongs, and, occasionally, backflow billabongs but the area of spawning is not known. *Pseudomugil signifer*, from south-east Australia, requires a saline environment for breeding. The large eggs of *P. tenellus* are laid in strings amongst aquatic vegetation. Related species have a two-week incubation, after which the young move back up the river system, where they mature within 12 months.[107]

107 Howe (1987) and Ivantsoff et al (1988) have subsequently described spawning behaviour, egg surface morphology and embryonic development of *P. tenellus*.

Table 60 Possible sites of spawning of *P. tenellus* as indicated by the abundance (*n*) of mature, ripe and juvenile fish

	Gonad stage				
	Mature (V)		Ripe (VI)		Juveniles
Habitat	F	M	F	M	
Lowlands					
Sandy creekbed habitat	–	–	–	–	2
Backflow billabong	6	4	–	–	5
Corridor	3	2	–	–	1
Floodplain billabong					
Upper	1	1	–	–	6

Sexual dimorphism has been reported in other species of *Pseudomugil*, although it was not observed in this study (most likely because specimens were not captured in breeding condition).[108] The males of *P. signifer* have filamentous extensions to pelvic, anal and both dorsal fins (Ivantsoff, in McDowall 1980).

Feeding habits

Overall diet

The stomach contents of 189 specimens were examined; 180 contained food. The diet of *P. tenellus* is summarised in fig 70; the components are detailed in table 61.

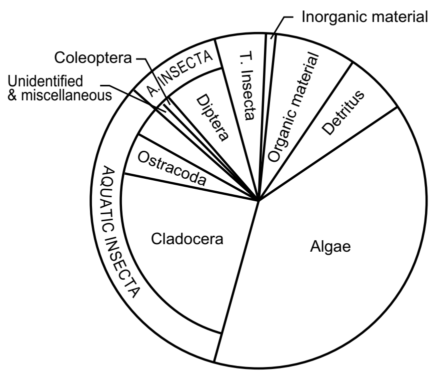


Figure 70 The main components of the diet of *P. tenellus*

108 Ivantsoff et al (1988) indicated that differences in colour of the body and especially fins make the sexes of *P. tenellus* easily distinguishable. The larger size of the fins in males, especially the second dorsal and the anal, make the distinction unequivocal.

Table 61 Dietary composition of *P. tenellus*

	Habitat				Season						Overall	
	Magela system			Nourlangie system	1978	1978–79	1978–79	1979	1979	1979		
Stomach contents	Bb	Cb	Fb	Bb	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Sub-mean	Main-mean
Aquatic plants												
Algae												38.7
Miscellaneous	–	29.3	22.7	–	–	–	–	37.3	–	99.5	16.2	
Dinophyceae	17.9	–	–	–	–	–	3.3	–	9.1	–	2.8	
Cyanophyta												
Miscellaneous	–	–	0.3	5.3	1.8	–	1.7	–	–	–	0.7	
Lyngbiya	–	–	3.3	–	–	11.1	–	–	–	–	1.7	
Conjugatophyta												
Mougeotia	8.2	17.1	22.8	15.8	4.4	–	7.1	27.7	60.6	–	17.3	
Aquatic animals												
Microcrustacea												31.9
Cladocera												
Miscellaneous	3.6	1.4	24.2	–	–	3.7	40.5	1.8	–	–	14.3	
Diaphanosoma	10.7	30.7	–	15.8	–	21.1	5.4	1.4	26.1	–	9.9	
Ostracoda	3.2	–	–	45.8	–	7.4	11.5	3.2	–	–	5.3	
Copepoda	3.6	1.4	–	–	–	–	6.7	6.4	–	–	3.0	
Insecta												8.8
Fragmented	3.6	1.8	–	5.0	–	9.3	–	–	–	–	1.4	
Coleoptera												
Miscellaneous	3.6	–	–	–	–	3.7	–	–	–	–	0.6	
Diptera												
Chironomidae (larvae)	1.1	8.6	6.1	1.6	5.9	14.8	5.7	4.6	4.2	0.5	6.1	
Chironomidae (pupae)	–	–	1.0	–	5.6	–	–	–	–	–	0.5	
Terrestrial animals												
Insecta												5.0
Egg material	32.1	–	–	–	–	–	15.0	–	–	–	5.0	
Parasites												
Trematoda	3.6	–	0.2	–	1.2	–	0.7	4.6	–	–	0.9	0.9
Detrital material	5.4	–	10.7	–	5.8	7.4	0.8	–	–	–	6.3	6.3
Inorganic material	–	–	1.1	–	–	3.7	–	–	–	–	0.6	0.6
Organic material	3.6	9.6	7.6	10.5	29.4	17.8	1.7	13.2	–	–	7.6	7.6
Number of empty fish	–	–	3	6	3	4	2	–	–	–	9	9
Number of fish with food	28	28	92	19	17	27	60	22	33	21	180	180

Figures represent the mean percentage volume determined by the estimated volumetric method. Bb = lowland backflow billabongs Cb = corridor billabongs; Fb = floodplain billabongs

The main items were algae (39%), microcrustaceans (32%) and aquatic insects (9%). The identifiable algae were green filamentous and blue-green algae and dinoflagellates. The microcrustaceans were mainly cladocerans, ostracods and copepods. Chironomid larvae were the main aquatic insects eaten. Other food items found in the stomachs were terrestrial insects (5%) and detritus (6%). *Pseudomugil tenellus* can therefore be classified as a microphagous omnivore feeding opportunistically from the benthos and mid-water areas of the waterbodies.

Pollard (1974) noted that the diet of this species was unknown, though other members of the genus, eg *P. signifer*, are thought to be essentially plankton feeders; in freshwaters *P. signifer* feeds on mosquito larvae at the very margins of the water (Ivantsoff, in McDowall 1980). The algal component of the diet of *P. tenellus* appears to be only slightly less important than the aquatic animal component.

Seasonal changes

In sampling periods 1–6, respectively, 20 (15% empty), 31 (13% empty), 62 (3% empty), 22 (0% empty), 33 (0% empty), 21 (0% empty) stomachs of *P. tenellus* were examined (all habitats combined). The highest proportions of specimens with empty stomachs were found in the 1978 Late-dry and 1978–79 Early-wet seasons.

The diet in the 1978 Late-dry season was mainly based on detritus (with associated unidentified organic material) and small quantities of chironomid larvae and pupae, and algae; no microcrustaceans were eaten. In the 1978–79 Early-wet microcrustaceans appeared in the diet and detritus decreased in importance; aquatic insects also appeared in the diet during this season. In the Mid-wet season *P. tenellus* ate mainly microcrustaceans (particularly cladocerans) with smaller amounts of terrestrial and aquatic insects.

By the Late-wet–Early-dry season algae were the main component of the diet and remained so until the 1979 Late-dry season, when they were essentially the only food item, which is in contrast to the diet in the 1978 Late-dry season.

Habitat differences

Magela catchment

A total of 151 combined stomachs of *P. tenellus* were examined (all seasons combined): 28 (0% empty) from backflow billabongs, 28 (0% empty) from corridor waterbodies and 95 (3% empty) from floodplain billabongs.

The diet in the backflow billabongs was made up of fairly equal portions of algae and microcrustaceans (a wide variety) and a large terrestrial insect (mainly egg material) component (which was not present in the other two habitats). In the floodplain billabongs, *P. tenellus* ate substantial quantities of detritus.

Nourlangie catchment

In all, 25 stomachs of *P. tenellus* were examined (all seasons combined) from backflow billabongs. A high proportion (24%) of the stomachs were empty. The diet was based mainly on ostracods, cladocerans (*Diaphanosoma*), and green filamentous and blue-green algae.

Fullness

The mean fullness indices of *P. tenellus* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments are summarised in table 62. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 62 Mean fullness indices of *P. tenellus* for 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 sandy creekbed pool	n/s	n/s	3.0 (2)	n/s	n/s	n/s	3.0 (2)
Downstream of RUPA:							
Lowland shallow backflow billabong	0 (1)	3.0 (2)	2.4 (14)	2.8 (5)	3.3 (6)	n/s	2.6 (28)
Corridor anabranch billabong	n/s	n/s	n/s	3.6 (10)	1.7 (3)	n/s	3.2 (13)
Floodplain billabong	2.4 (19)	3.0 (21)	2.4 (23)	2.5 (6)	3.3 (20)	2.8 (20)	2.8 (109)
Nourlangie Creek catchment (regular sites only)							
Lowland channel backflow billabong	n/s	0 (1)	1.5 (12)	n/s	n/s	n/s	1.4 (13)
Lowland shallow backflow billabong	n/s	0.7 (7)	n/s	0 (1)	2.7 (3)	n/s	1.2 (11)
Lowland sandy creekbed pool	n/s	n/s	n/s	n/s	0 (1)	n/s	0 (1)
Seasonal mean (all sites)	2.5	2.4	2.3	3.1	3.1	2.8	

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

Seasonal changes

The mean seasonal fullness index (all habitats combined) remained fairly stable between the 1978 Late-dry and the 1978–79 Mid-wet seasons; it then rose to a higher level and remained stable to the end of the study.

Habitat differences

In the Magela catchment the few specimens found upstream of RUPA in lowland sandy creekbeds had fullness indices comparable with downstream habitats. In the Nourlangie catchment the mean fullness indices were generally much lower than in the Magela catchment.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

- corridor anabranch billabong; 1979 Late-wet–Early-dry season
- lowland shallow backflow billabong; 1979 Mid-dry season
- floodplain billabong; 1979 Mid-dry season

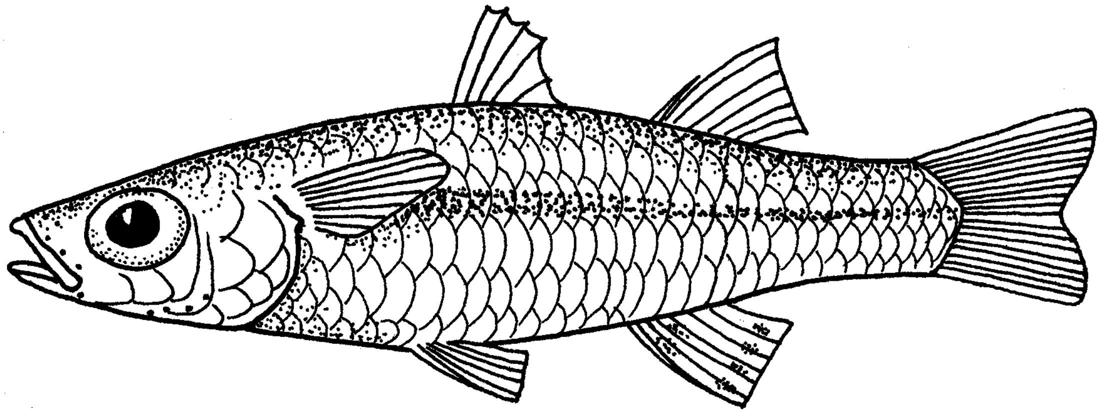
Nourlangie catchment

- lowland shallow backflow billabong; 1979 Mid-dry season.

Family ATHERINIDAE

3.17 *Craterocephalus marianae* (Ivantsoff, Crowley & Allen)

Craterocephalus marianae is commonly known as Mariana's freshwater hardyhead. It belongs to a mainly freshwater genus, with some estuarine and marine species. *Craterocephalus marianae* is found only in the Timor Sea drainage (see map 3). Pollard (1974) found this species (then identified as *C. marjoriae*) in very large schools over shallow, sandy areas. It was one of the most plentiful species in Magela Creek and its associated sandy-bottomed waterbodies.



Craterocephalus marianae

Details of the catches at each site and in each season are given in volume 2. In summary, this species was abundant in all escarpment mainchannel waterbodies, moderately abundant in most lowland sandy creekbed habitats and rare in some lowland backflow billabongs. It was found in the greatest number of sites in the 1978 Late-dry season (mainly escarpment mainchannel and lowland sandy creekbed habitats); it was found in the fewest sites during the Mid-wet season (mainly escarpment mainchannel waterbodies).

Size composition

The lengths and weights of 1730 specimens were determined. All specimens were captured by 10 mm mesh seine net. Very small specimens were frequently captured when filamentous algae clogged the mesh.

Length–weight relationship

The mean length–weight relationship was described by the expression:

$$W = 1.43 \times 10^{-2} L^{2.95} \qquad r = 0.98 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 63. The seasonal condition factor was stable (near unity) between the 1978 Late-dry and Mid-wet seasons. It rose dramatically in the Late-wet–Early-dry season to a record level, only to fall to its lowest by the Mid-dry season. This rise and fall may have been associated with spawning activity, as evidenced by the presence of large numbers of juveniles in the Mid-dry season. By the 1979 Late-dry season the condition factor had returned to a level close to that recorded in the 1978 Late-dry season.

Table 63 Mean length, mean weight and condition factor of *C. marianae*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late-dry (1978)	372	34.6	0.57	1.02
Early-wet (1978–79)	39	38.9	0.79	1.01
Mid wet	139	41.4	0.95	1.01
Late-wet–Early-dry (1979)	32	39.1	0.91	1.15
Mid-dry	152	42.8	1.00	0.96
Late-dry	192	32.1	0.45	1.01
Early-wet (1979–80)	74	37.3	0.61	0.88
Overall	1000	36.6	0.66	1.00

The condition factor fell to a very low level in the 1979–80 Early-wet season. Most specimens were captured during the first flow of the Wet season, which went as far downstream as Georgetown Billabong in the Magela Creek bed and then began to recede. Extreme water temperatures (> 40°C) and limited food availability (eg harpacticoid copepods would not have established in interstitial substrate waters) may have caused the poor body condition in this season.[109]

Length-frequency distribution

The smallest specimen captured in the study was 12 mm LCF; the largest was 72 mm LCF (fig 71). Ivantsoff (in McDowall 1980) reported that this species grows to 80 mm LCF.

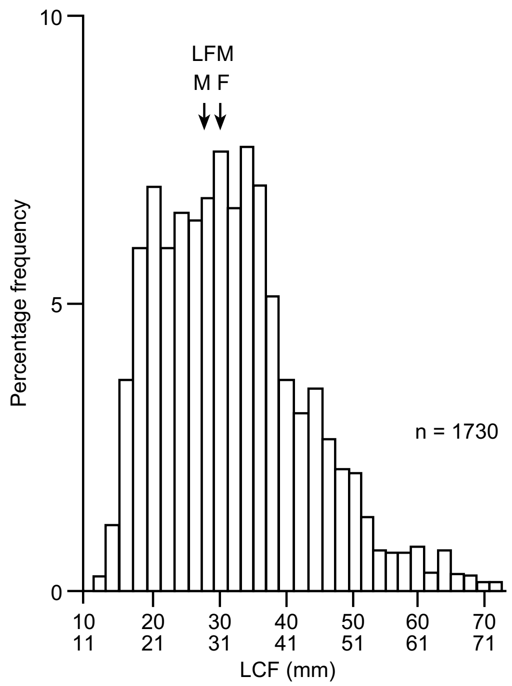


Figure 71 Length-frequency distribution of all *C. marianae* captured

109 Ward (1982) investigated the causes of dry-season mortality of *C. marianae* dwelling in pools within the lowland sandy creek habitat of Magela Creek.

The mean and modal lengths of all specimens captured were 32.5 and 34–35 mm LCF, respectively. A secondary mode occurred at 30–31 mm LCF. The LFM was 29 mm LCF for males and 32 mm LCF for females, indicating that slightly more adults than juveniles were captured. Most specimens were between 18 and 39 mm LCF; a slight negative skew was apparent in the distribution, indicating lower survival rates for larger-sized specimens.

Seasonal changes in distribution

The smallest juveniles were caught during the 1978 Late-dry, Late-wet–Early-dry and the 1979 Mid-dry seasons. The smallest specimen caught in the 1978–79 Mid-wet season was a large 29 mm LCF. The largest adults were caught in the Mid-wet and Mid-dry seasons.

Juveniles and small adults dominated the samples during the 1978 Late-dry season and larger adults were fewer (fig 72). By the 1978–79 Early-wet season there were noticeably fewer specimens near the LFM; the numbers of small to intermediate-sized adults increased dramatically at 36–37 mm LCF. The length-frequency distribution in the 1979 Late-dry season resembled that recorded in the 1978–79 Early-wet season, with differences caused by a narrower size range of specimens and a general shift to small adult specimens, leaving a noticeable gap in the numbers of large juveniles.

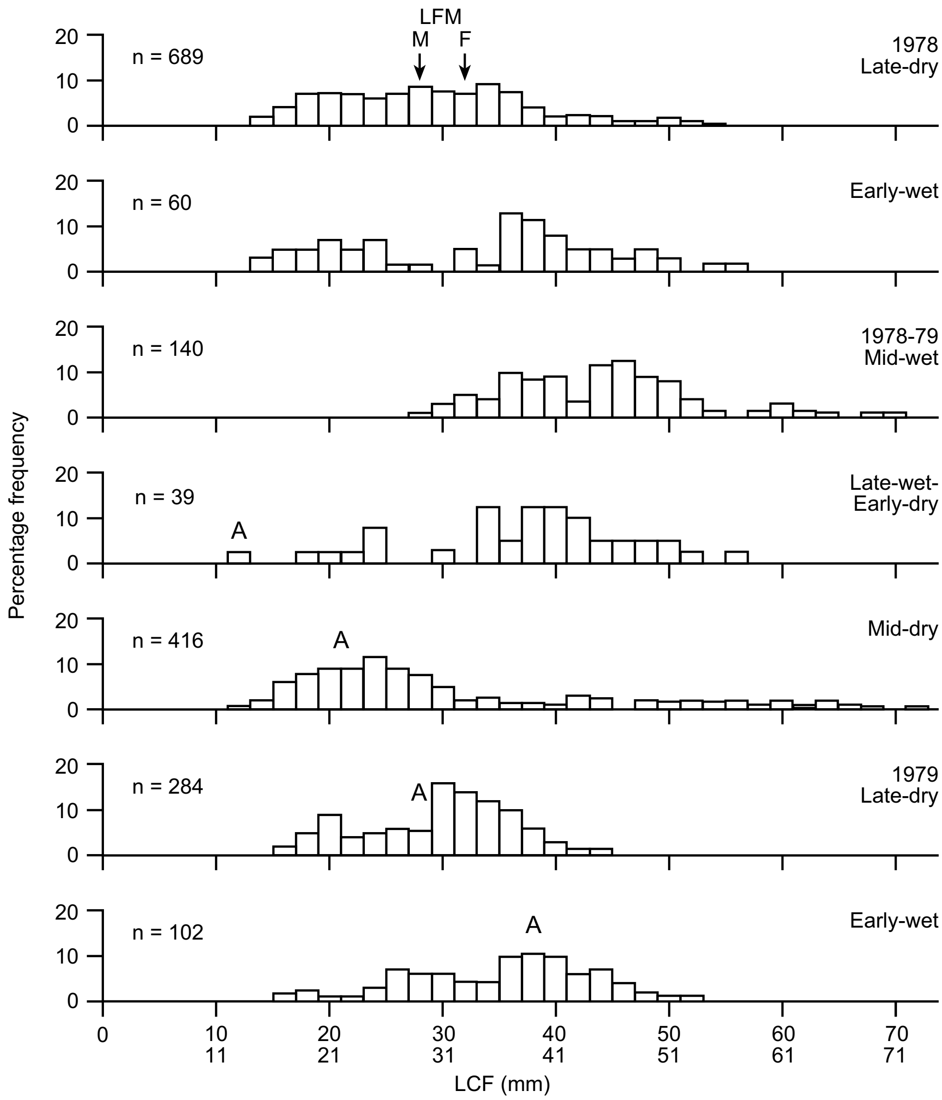


Figure 72 Seasonal length-distribution of all *C. marianae* captured

The 1979–80 Early-wet season length-frequency distribution was dominated by intermediate-sized adults and, to a lesser extent, by large juveniles and small adults; few small juveniles were captured in this season.

Very few large adults were found in the Late-dry and Early-wet seasons. Virtually no juveniles were found in the Mid-wet season, when samples were dominated by small to intermediate-sized adults and a few large adults. By the Late-wet–Early-dry season there were a few juveniles and many small and intermediate-sized adults in the samples, but few large adults. During the Mid-dry season a wide size-range of adults (though few in number) were captured together with very large numbers of juveniles.

Juveniles therefore recruited in all seasons except the Mid-wet (although this may have been an artefact of the difficulty of sampling flood-swollen creeks), and recruitment peaked in the Mid-dry and Late-dry seasons. Recruitment appeared to be most successful in the 1978 season.

Growth rate

Estimation of growth rate from seasonal length-frequency distributions was difficult due to frequency with which juveniles are recruited and the range of habitats sampled. However, modal progressions were apparent for juveniles from the Mid-dry season (24–25 mm LCF) until they reached the size of small adults (38–39 mm LCF) in the 1978–79 Early-wet season (about four months later).

If this apparent growth is real, then the LFM may be attained in less than eight months.[110] The closely related *C. fluviatilis* takes about eight months to grow from 25 to 33 mm in more temperate freshwater habitats (Llewellyn 1979).

Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *C. marianae* captured in regular sampling sites in the Magela and Nourlangie Creek catchments are given in figure 73.

Magela catchment

The smallest juveniles were found in lowland sandy creekbeds and escarpment mainchannel waterbodies; most of the juveniles were found in these habitats (especially the former). A few larger juveniles were found in corridor waterbodies and lowland backflow billabongs (mainly channel types). No juveniles were found in escarpment perennial streams.

The adults were captured in essentially the same habitats as the juveniles (ie mainly lowland sandy creekbeds where the largest specimen was found) and escarpment mainchannel waterbodies. Larger numbers of adults than juveniles were found in sandy creekbed habitats upstream of RUPA. No adults were found in escarpment mainchannel waterbodies.

Nourlangie catchment

Most juvenile and adult *C. marianae* were captured in escarpment mainchannel waters, and a few in lowland sandy creekbed sites and even lowland shallow backflow billabongs. *C. marianae* was also abundant in occasionally sampled sandy corridor waterbodies and the lower reaches of escarpment perennial streams. The adults captured in the Nourlangie catchment were larger than those in the Magela catchment.

Environmental associations

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

---

110 Under laboratory conditions with a water temperature of 26°C, Ivantsoff et al (1988) indicated that *C. marianae* can attain a total length of 21–28 mm in 127 days, and 43–44 mm in 245 days.

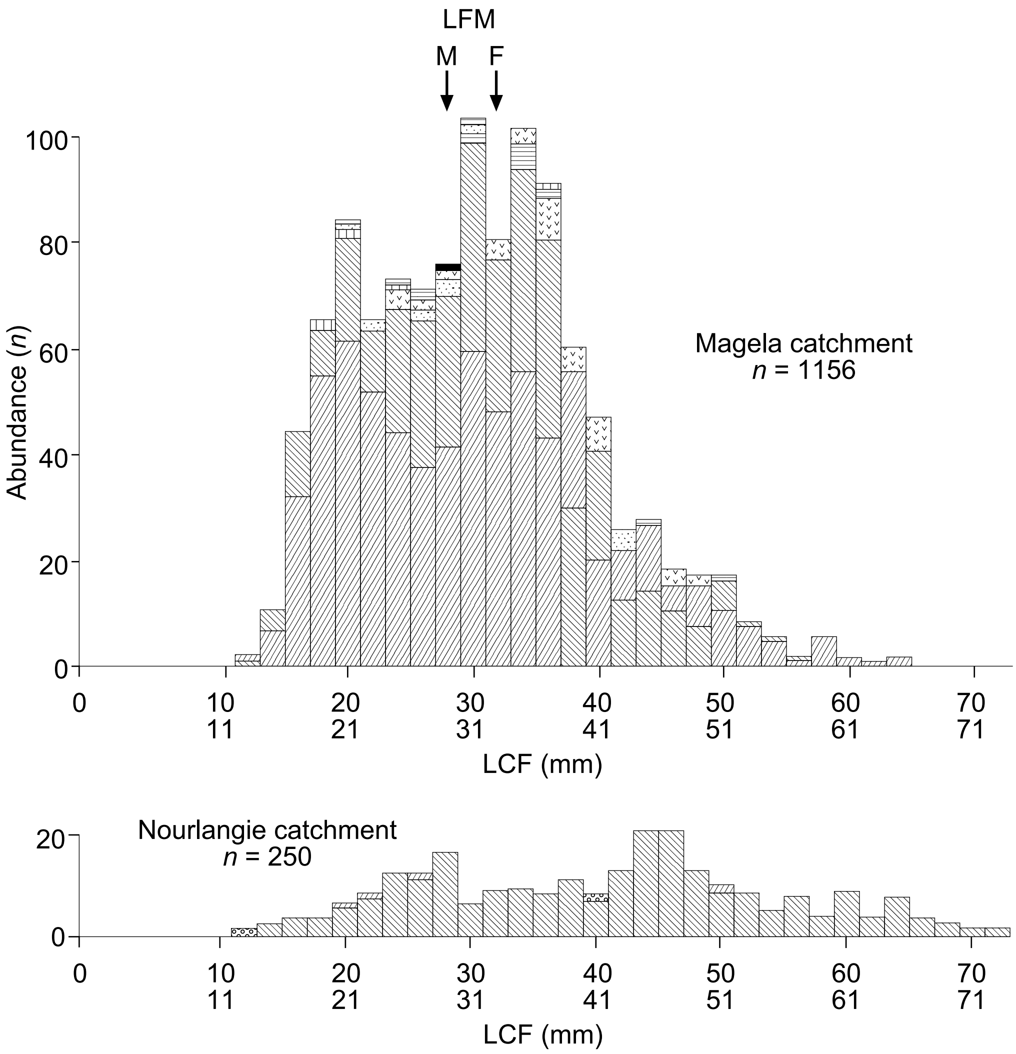


Figure 73 Length-frequency distributions and habitat preference of *C. marianae* captured at regular sampling sites (see appendix 5 for key to habitats)

Physico–chemical variables

Temperature

Surface-water temperatures ranged between 25° and 40°C (mean = 30.6°C), and bottom-water temperatures from 23° and 35°C (mean = 29.6°C). These means ranked in the lower-middle and upper-middle quarters, respectively (see fig 170). *Craterocephalus marianae* appears to tolerate a wide range of temperatures, as it was captured in both escarpment and lowland waters. The related *C. dalhousiensis* can also tolerate a range of temperatures, from 20° to 38.8°C, in natural conditions (Ivantsoff & Glover 1974). Llewellyn (1979) found that *C. fluviatilis* spawned when the water temperature exceeded 24°C, so water temperature may not be of significance to the breeding patterns of *C. marianae*.

Dissolved oxygen

Dissolved oxygen concentrations ranged from 3.2 to 8.2 mg/L (mean = 6.2) at the surface, and from 5.2 to 6.8 mg/L (mean = 6.2) at the bottom. These means ranked in the upper-middle and upper quarters, respectively (see fig 171). Such high bottom DO concentrations might be expected for a species that was commonly found in shallow waters (see Pollard 1974).

Visibility
Secchi depth readings ranged from 1 to 130 cm (mean = 44 cm). This mean ranked in the lower-middle quarter (see fig 172). Since *C. marianae* is usually found in shallow, sandy watercourses, the low Secchi depth values are caused more by the shallowness of the water at many habitats than by the lack of clarity of the water.

pH
The pH values ranged from 4.3 to 8.3 (mean = 6.3) on the surface, and from 5.4 to 7.0 (mean = 6.2) on the bottom. These means both ranked in the upper-middle quarter. Tolerance to a wide range of pH values is indicated (see fig 173).

Conductivity
Water conductivities ranged from 4 to 160 µS/cm on the surface, and from 2 to 64 µS/cm on the bottom. Such low values may be a function of this species' preference for waters with sandy substrates and possible underground seepage. *Craterocephalus* spp. are thought to be primarily freshwater dwellers (Pollard 1974); however, the closely related *C. eyresii* has been found living in inland waters of 39 ppt salinity (Ruello 1976).

Habitat–structural variables

Substrate
Craterocephalus marianae was most commonly found in waters with sandy substrates (upper quarter), followed by leaf litter (upper quarter) then rocks and mud (see fig 174). Both *C. marianae* and *C. stercusmuscarum* were often found in sandy-bottomed waterbodies of the Magela Creek system (Pollard 1974).

Hydrophytes
Craterocephalus marianae was found not commonly found in vegetated waters (vegetation-occurrence index 46.3%): submergent hydrophytes (50.8%), emergent (34.4%) and floating-attached vegetation. *Craterocephalus stercusmuscarum* was found in similarly vegetated habitats.

Reproduction

The reproductive state of the 374 specimens was assessed: 186 females (length range 20–70 mm LCF), 137 males (22–67 mm LCF) and 51 sexually indistinguishable (13–44 mm LCF).[111]

Length at first maturity
The smallest sexually maturing males and females were 22 and 28 mm LCF, respectively. The LFM, estimated from 2 mm groupings, was 29 mm LCF for males and 32 mm LCF for females (fig 74).

Sex ratio
The sex ratio was 1:1 for both juveniles + adults and adults only in all seasons, except during the 1978 Late-dry and 1979 Mid-dry seasons, when there were significantly more females than males in the juveniles + adults sample. In the 1978 Late-dry season there were also more females amongst the adult fish (table 64).

A further breakdown of the sex ratios for each site in the 1978 Late-dry and 1979 Mid-dry seasons revealed that in most cases there were more females present but the differences were not significant at the 5% level except at a small sandy creekbed pool.

111 Semple (1986) indicated that females over 30 mm SL had more convex dorsal profiles than the males, making them appear deeper anteriorly. Gravid females developed distended bellies. No colour changes associated with spawning were observed in either sex.

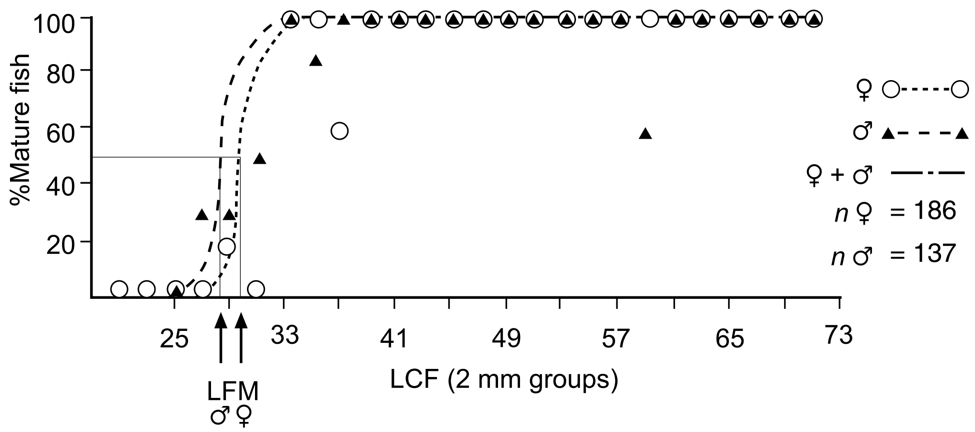


Figure 74 Estimated length at first maturity (LFM) of male and female *C. marianae*

The predominance of females suggests a behavioural characteristic of the fish at a particular time of the year, as conditions in the 1978 Late-dry and the 1979 Mid-dry seasons were very similar, and fish were unable to migrate between pools. Misidentification of male fish as sexually indistinguishable was unlikely, as the sex ratios recorded differed in only two seasons and such misidentification is most likely in the earliest stages of gonad development (which was generally only in the Mid-wet season, when a 1:1 ratio was recorded).

Breeding season

Both GMSI and GSI were high throughout the year, with a peak in gonad development around the Early-wet seasons and a trough in the 1978–79 Mid-wet season (fig 75, table 64).[112] Juveniles were present, and the gonads appeared to be well developed, throughout most of the year. Stage V and stage VI gonads were found in male fish in almost all seasons, while mature and ripe female fish were more common in the 1978 Late-dry and both Early-wet seasons.

Both males and females had well-developed gonads throughout the year, and there may have been occasional spawning, but the main spawning appears to have occurred in the 1978–79 Early-wet season, with gonads starting to develop again after the Mid-wet season.

Site of spawning

C. marianae appears to spawn in the escarpment mainchannel waterbodies and lowland sandy creekbed streams or pools (table 65). Some juveniles and mature specimens were captured in other areas such as lower riverine floodplain billabongs and tidal billabongs. *Craterocephalus marianae* has not to date been bred successfully in still water ponds (H. Midgley, pers. comm.).[113]

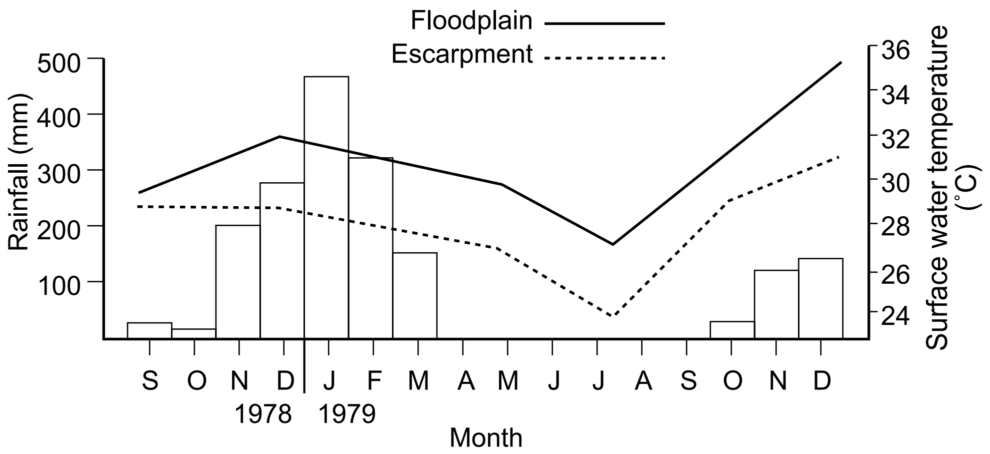
Fecundity

The egg counts of three ovaries were 380, 388 and 429. In two of the ovaries the egg diameters were 0.73 ± 0.05 mm ($n = 10$) and 0.75 ± 0.07 mm ($n = 10$). The ovaries contained eggs of different sizes, indicating progressive development. Thus *C. marianae* appears to have a medium to large store of relatively large eggs, although it is not known how many eggs are spawned at a time.[114] The family Atherinidae typically produce relatively large eggs with adhesive filaments, which attach them to vegetation, gravel or other objects in the water (Lake 1971).

112 Under laboratory conditions, Semple (1986) found that males displayed spawning behaviour when water temperature exceeded 25.5°C. The female spawned during 3–5 days and each spawning period was followed by a rest period of 3–5 days.

113 Under laboratory conditions, Semple (1986) found that *C. marianae* spawned within beds of aquatic plants.

114 Under laboratory conditions, Semple (1986) found that *C. marianae* released 30–250 eggs in spawning periods lasting 3–5 days.



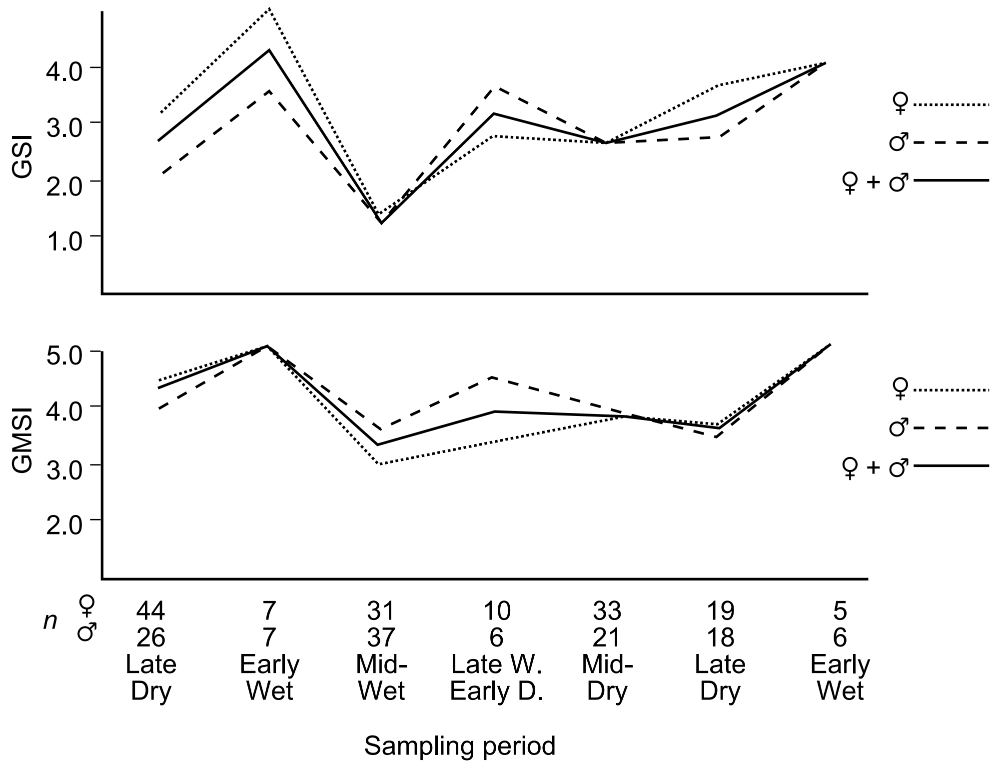


Figure 75 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *C. marianae*

Summary

Craterocephalus marianae most likely breeds in the larger escarpment pools and lowland sandy creekbed streams and pools, producing a medium to large clutch of large eggs that attach by filaments to aquatic vegetation, gravel or other objects in the water. Spawning appears to be aseasonal, with a peak in gonad development at the start of the Wet season.[115] The gonads are not paired and the ovary is covered by a distinctive black mesovarium that, unlike in *C. stercusmuscarum,* does not adhere closely to the ovary.

115 Semple (1986) and Ivantsoff et al (1988) have subsequently described spawning behaviour, egg surface morphology and embryonic development of *C. marianae*.

Table 64 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *C. marianae* 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*	56	8	39	11	46	21	5
+ adults	M	*n*	37	7	37	6	26	18	6
	χ^2	3.9	0.07	0.05	1.5	5.6	0.2	0.09	
		P	*	n.s.	n.s.	n.s.	*	n.s.	n.s.
Adults only	F	*n*	44	7	31	10	33	19	5
	M	*n*	26	7	37	6	21	18	6
	χ^2	4.6	0.0	0.5	1.0	2.7	0.03	0.09	
		P	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
GSI									
(Adults only)	F	mean	3.2	5.1	1.4	2.8	2.6	3.7	4.1
		s.d.	1.0	1.1	0.6	0.7	0.9	1.1	1.9
	M	mean	2.1	3.6	1.2	3.7	2.7	2.8	4.1
		s.d.	1.3	2.0	0.5	1.5	1.5	1.6	1.8
	F+M	mean	2.7	4.3	1.3	3.2	2.7	32	4.1
		s.d.	1.3	1.8	0.6	1.2	1.2	1.4	1.7
GMSI									
(Adults only)	F	mean	4.5	5.0	3.0	3.4	3.8	3.7	5.0
		s.d.	0.7	0.0	0.9	0.5	0.5	0.4	0.8
	M	mean	4.0	5.1	3.6	4.5	4.0	3.5	5.1
		s.d.	0.9	1.6	1.1	0.5	0.8	1.0	0.9
	F+M	mean	4.3	5.1	3.3	3.9	3.9	3.6	5.0
		s.d	0.8	1.2	1.0	0.8	0.7	0.7	0.8

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.

Table 65 Possible sites of spawning of *C. marianae* as indicated by the abundance (*n*) of ripe and spent fish and juveniles

	Gonad stage				
	Ripe (VI)		Spent (VII)		Juveniles
Habitat	F	M	F	M	
Escarpment					
Mainchannel waterbody	5	15	1	2	30
Lowlands					
Sandy creekbed habitat	13	7	5	8	55
Backflow billabong	7	–	–	–	–
Floodplain billabong					
Lower	–	–	–	–	2
Estuarine habitat					
Upper reaches	–	3	–	–	–

Feeding habits

Overall diet

The stomachs of 373 specimens were examined; 365 contained food. The diet is summarised in fig 76; the components of the diet are given in table 66. The main components of the diet were aquatic insects (41%), microcrustaceans (34%) and algae (7%). The aquatic insects were mainly chironomids, leptocerids and ceratopogonid larvae. The main identifiable microcrustaceans were harpacticoid copepods and cladocerans. The identifiable algae were mainly green filamentous species. Inorganic material (4%) and unidentified organic material (13%) were also found in the stomachs, as well as traces of oligochaetes, aquatic arachnids, macrocrustaceans, teleosts, anuran larvae, and detritus. *Craterocephalus marianae* can thus be classified as a microphagous carnivore (perhaps occasionally an omnivore, unless it ingests plant material incidentally) feeding opportunistically, primarily on the bottom and secondarily in mid-water.

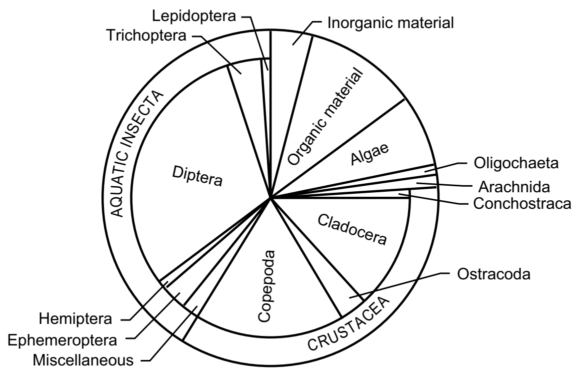


Figure 76 The main components of the diet of *C. marianae*

Pollard (1974) speculated that the diet of *C. marianae* probably included insect larvae and small insects from the water's surface and that the young might eat zooplanktonic crustaceans (eg copepods). However, in the present study, although aquatic insects were common, no surface-dwelling or terrestrial insects were found in the diet, and all size groups of *C. marianae* were eating copepods and other zooplankton.

The presence in the diet of inorganic material and a large component of chironomid larvae and harpacticoid copepods (some species of which are found in the interstices of substrate material [Williams 1968]) indicates that *C. marianae* is generally a benthic feeder. This diet is in accord with its modified protrusible jaws (premaxillary process long and slender [Ivantsoff, in McDowall 1980]), which enable it to direct the mouth obliquely downwards to feed across mainly sand substrates (pers. obs.).

Seasonal changes

In sampling periods 1–7, respectively, 117 (4% empty), 25 (0% empty), 79 (0% empty), 20 (5% empty), 80 (3% empty), 40 (0% empty) and 12 (0% empty) stomachs of *C. marianae* were examined (all seasons combined). The proportion of specimens with empty stomachs was low throughout the study.

Aquatic insects were important in the diet throughout the study. Chironomid larvae were most important in the Early-wet seasons and the Late-wet–Early-dry season. Chironomid pupae were most important in the 1978–79 Early-wet and Mid-wet seasons. Baetids were most common in the stomachs in the 1978–79 Early-wet and the Late-wet–Early-dry season. Leptocerids were very important in the diet during the 1979 Late-dry season.

Table 66 Dietary composition of *C. marianae*

	Habitat						Season								
	Magela system				Nourlangie system		1978	1978–79	1978–79	1979	1979	1979	1979–80	Overall	
Stomach contents	Em	Ls	Bb	Cb	Em	Ls	Late-dry	Early-wet	Mid-wet	Late-wet–Early-dry	Mid-dry	Late-dry	Early-wet	Sub-mean	Main-mean
Aquatic plants															
Algae															6.7
Miscellaneous	4.8	2.4	–	–	0.8	–	4.7	–	–	–	5.3	–	–	2.6	
Chlorophyceae															
Desmidaceae	0.1	–	–	–	–	–	–	–	0.1	–	–	–	–	+	
Closterium	–	–	–	0.7	–	–	–	–	–	–	–	–	–	+	
Conjugatophyta															
Mougeotia	0.1	1.1	–	–	10.8	–	–	4.8	8.0	7.9	0.3	–	–	2.6	
Spirogyra	–	–	–	–	7.8	–	–	–	7.1	–	–	–	–	1.5	
Aquatic animals															
Oligochaeta	–	0.6	–	7.9	–	–	0.8	–	1.9	–	–	–	–	0.6	0.6
Arachnida															1.0
Porohalacaridae	0.1	–	–	–	–	–	0.1	–	–	–	–	–	–	+	
Hydracarina	0.3	–	–	–	0.1	–	–	–	–	–	0.3	–	–	1.0	
Microcrustacea															34.2
Conchostraca	–	–	–	–	–	–	3.2	–	–	–	–	–	–	1.0	
Cladocera															
Miscellaneous	12.6	3.2	70.0	–	6.3	22.5	23.6	–	1.1	2.1	15.0	2.3	–	11.1	
Diaphanosoma	1.5	3.2	–	–	1.7	–	–	4.0	1.2	8.4	0.5	2.5	16.7	1.9	
Ostracoda	12.6	–	–	–	–	–	–	–	11.7	–	–	0.3	–	2.6	
Copepoda															
Miscellaneous	1.4	–	20.0	47.9	–	–	8.6	–	0.6	–	–	–	–	2.8	
Harpacticoida	10.0	23.5	–	–	18.1	–	–	–	14.3	–	19.4	63.5	16.7	14.8	
Macrocrustacea															0.2
Macrobrachium (juv)	–	0.4	–	–	–	–	0.5	–	–	–	–	–	–	0.2	
Insecta															40.5
Fragmented	0.1	1.5	–	–	5.1	–	0.8	7.2	5.1	–	0.1	–	–	1.9	
Ephemeroptera															
Baetidae	1.1	1.6	–	28.7	1.1	–	3.0	8.0	1.0	11.6	–	–	–	2.3	
Tasmanocoenis	–	3.1	–	–	–	–	–	–	–	–	5.7	–	–	1.2	

Table 66 continued

Stomach contents	Habitat: Magela system Em	Ls	Bb	Cb	Nourlangie system Em	Ls	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
Hemiptera															
Corixidae	0.5	1.7	–	–	1.4	–	0.4	–	1.3	–	3.1	–	–	1.0	
Coleoptera															
Miscellaneous (larvae)	0.3	–	–	–	–	–	0.8	–	–	–	–	–	–	0.2	
Diptera															
Culicidae	–	–	–	–	0.1	–	–	–	0.1	–	–	–	–	+	
Chironomidae (larvae)	29.9	30.0	–	–	23.4	–	20.0	47.6	10.5	63.7	33.7	1.5	66.7	24.5	
Chironomidae (pupae)	–	2.1	–	–	1.4	–	–	4.0	3.8	–	–	–	–	1.1	
Ceratopogonidae	2.8	3.0	–	–	4.8	–	4.3	4.8	–	1.1	9.2	–	–	3.7	
Trichoptera															
Leptoceridae	17.6	1.1	–	–	0.4	–	1.0	–	1.4	–	1.0	29.8	–	4.1	
Lepidoptera															
Pyralidae	2.6	–	–	–	–	–	–	–	–	–	2.5	–	–	0.5	
Teleostomi															+
Scales	0.1	–	–	–	–	–	–	–	–	–	–	0.3	–	+	
Anura													0.3		
Miscellaneous (larvae)	–	–	–	–	–	25.0	–	4.0	–	–	–	–	–	0.3	
Parasites															
Nematoda	–	–	–	0.7	0.5	–	0.1	–	0.4	–	–	–	–	0.1	0.1
Detrital material	–	1.1	–	–	–	–	1.4	–	–	–	–	–	–	0.4	0.4
Inorganic material	1.6	7.5	–	–	2.4	–	1.5	0.8	14.2	–	2.6	–	–	4.1	4.1
Organic material	–	12.9	10.0	14.3	13.8	52.5	25.3	14.8	16.1	5.3	1.3	–	–	12.8	12.8
Number of empty fish	–	4	2	–	–	–	5	–	–	1	2	–	–	8	8
Number of fish with food	74	142	10	7	72	4	112	25	79	19	78	40	12	365	365

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

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

Microcrustaceans were common in the diet throughout the study; harpacticoid copepods were most important during the 1979 Late-dry season; cladocerans were important in the 1978 Late-dry season and then again after the Wet season, and also in the 1979–80 Early-wet season; ostracods were most important during the Mid-wet season.

Algae were most common in the stomachs between the 1978–79 Mid-wet and Late-wet–Early-dry seasons, after which they became less common.

Habitat differences

Magela catchment

A total of 239 stomachs of *C. marianae* were examined (all seasons combined) in the Magela Creek catchment: 74 (0% empty) from escarpment mainchannel waterbodies; 146 (3% empty) from lowland sandy creekbeds; 12 (17% empty) from backflow billabongs; and 7 (0% empty) from floodplain billabongs. The highest proportion of specimens with empty stomachs was found in backflow billabongs.

The diet in the escarpment mainchannel waterbodies was based primarily on aquatic insects (chironomid and leptocerid larvae) and microcrustaceans (cladocerans, ostracods and harpacticoid copepods). In the lowland sandy creekbeds, harpacticoid copepods were eaten more intensively; inorganic material and unidentified organic material were also more common in the stomachs. The few specimens examined from the lowland backflow billabongs were eating only microcrustaceans (cladocerans). Copepods, along with baetid larvae and oligochaetes, were the main food items in the corridor waterbodies.

Nourlangie catchment

A total of 76 stomachs of *C. marianae* were examined (all seasons combined) from the Nourlangie Creek catchment: 72 from the escarpment mainchannel waterbody and 4 from lowland sandy creekbeds.

Mainly aquatic microcrustaceans (harpacticoid copepods and cladocerans), aquatic insects (chironomid and ceratopogonid larvae) and green filamentous algae were eaten in the escarpment mainchannel waterbody. The proportions of algae eaten in the escarpment habitat were larger in the Nourlangie Creek catchment than in the Magela Creek catchment. The few specimens from lowland sandy creekbeds were feeding on equal amounts of cladocerans and anuran larvae; there was also a large amount of unidentified organic material in their stomachs.

Fullness

A summary of mean fullness indices of *C. marianae* in different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments is shown in table 67.

Seasonal changes

After the 1978 Late-dry season the mean seasonal fullness index (all habitats combined) rose slightly through the 1978–79 Early-wet season to peak in the Mid-wet season. In the Late-wet–Early-dry season the index fell slightly and then rose to peak by the 1979 Late-dry season.

Habitat differences

In the Magela catchment, upstream of RUPA, the highest mean fullness indices were found in fish from the escarpment mainchannel waterbody and the lowest in the few specimens from the shallow backflow billabong.

Downstream of RUPA, the highest mean indices (equivalent to those found upstream of RUPA) were found in lowland sandy creekbed sites and corridor anabranch billabongs; the lowest indices were found in channel backflow billabongs.

Table 67 Mean fullness indices of *C. marianae* in different sampling periods and habitats

Habitat	Sampling period: Late-dry 1978	Early-wet 1978–79	Mid-wet	Late-wet–Early-dry 1979	Mid-dry	Late-dry	Early-wet 1979–80	Habitat mean
Magela Creek catchment (regular sites only)								
Upstream of RUPA:								
Escarpment main-channel waterbody	3.4 (10)	n/s	3.9 (14)	n/s	3.9 (20)	4.0 (20)	3.5 (10)	3.8 (74)
Lowland shallow backflow billabong	2.3 (3)	n/s	n/s	n/s	n/s	n/s	n/s	2.3 (3)
Lowland sandy creekbed pool	n/s	n/s	3.1 (15)	2.5 (10)	3.7 (16)	n/s	3.0 (2)	3.2 (43)
Downstream of RUPA:								
Lowland sandy creekbed pool	2.8 (30)	3.6 (11)	3.6 (9)	3.6 (10)	3.0 (30)	3.9 (20)	n/s	3.3 (110)
Lowland channel backflow billabong	1.4 (9)	n/s	n/s	n/s	n/s	n/s	n/s	1.4 (9)
Lowland shallow backflow billabong	2.7 (3)	n/s	n/s	n/s	n/s	n/s	n/s	2.7 (3)
Corridor sandy billabong	n/s	2.5 (2)	n/s	n/s	n/s	n/s	n/s	2.5 (2)
Corridor anabranch billabong	3.0 (3)	n/s	n/s	n/s	n/s	n/s	n/s	3.0 (3)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	4.6 (5)	2.9 (11)	3.2 (36)	n/s	3.3 (18)	n/s	n/s	3.3 (70)
Lowland sandy creekbed pool	2.3 (3)	0 (1)	n/s	n/s	n/s	n/s	n/s	1.7 (4)
Seasonal mean (all sites)	2.9	3.2	3.4	3.1	3.5	4.0	3.4	

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

In the Nourlangie catchment, the mean indices recorded in the escarpment mainchannel waterbody were slightly lower than those recorded in equivalent Magela Creek habitats. The few specimens examined from the lowland sandy creekbed pool had very much lower indices than those recorded in the Magela catchment.

Summary

The habitats and periods of greatest feeding activity were:

Magela catchment

- escarpment mainchannel waterbody; 1979 Late-dry season, 1978–79 Mid-wet season, 1979 Mid-dry season
- lowland sandy creekbeds (downstream of RUPA); 1979 Late-dry season

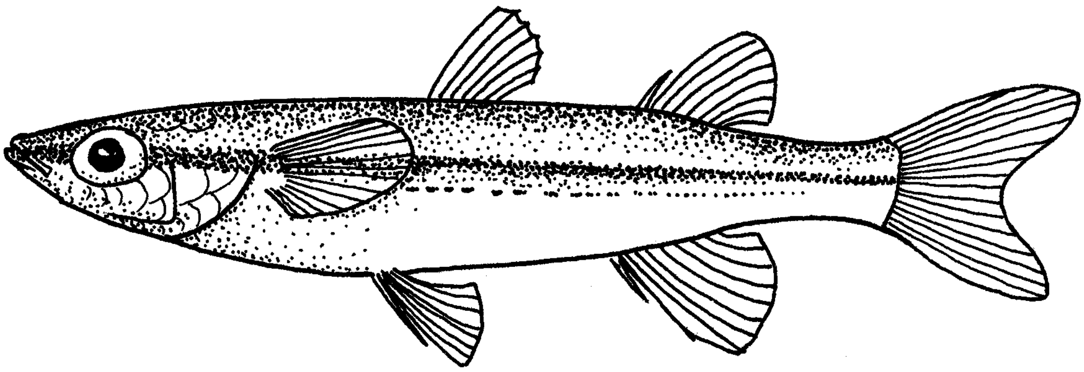
Nourlangie catchment

- escarpment mainchannel waterbody; 1978 Late-dry season, 1979 Mid-dry season

Family ATHERINIDAE

3.18 *Craterocephalus stercusmuscarum* (Gunther)

Craterocephalus stercusmuscarum is commonly known as the fly-specked hardyhead, Worrel's hardyhead or (in the Murray–Darling system) the Mitchellian freshwater hardyhead. It is found in the drainage systems of the north-east coast, Gulf of Carpentaria and Timor Sea (see map 3). Subspecies have been found in the northern rivers of the Murray–Darling system (where it has been known as *C. fluviatilis*), in freshwater lakes on Fraser Island, and in the rivers of southern Queensland. Pollard (1974) found that larger specimens of this species were relatively uncommon, compared with *C. marianae,* in shallow sandy habitats of the Magela Creek system. In contrast, Miller (cited in Taylor 1964) found this species to be abundant in large billabongs in the Oenpelli area. This species belongs to a mainly freshwater genus, but it also has representatives in estuarine and marine waters.



Craterocephalus stercusmuscarum

Craterocephalus stercusmuscarum was relatively abundant at the sites examined in the present study; detailed information on catches at each site and in each season is given in volume 2. In summary, this species was moderately abundant in all corridor waterbodies, lowland sandy creekbed sites and most floodplain billabongs. It was also common in lowland backflow billabongs (in contrast to *C. marianae*) and escarpment mainchannel waterbodies; it was rare in perennial streams. It was found in the greatest number of sites during the Mid-wet season, and in the least number of sites during the 1978 Late-dry season.

Size composition

The lengths and weights of a total of 1976 specimens were determined. The smallest juveniles were captured most frequently in the 10 mm mesh seine net when the meshes were clogged by filamentous algae.

Length–weight relationship

The length–weight relationship was described by the expression:

$$W = 1.10 \times 10^{-2} L^{2.88} \qquad r = 0.97 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 68. The seasonal condition factor was stable (near unity) between the 1978 Late-dry season and the Mid-wet season and dropped slightly in the Late-wet–Early-dry season. This fall in condition may be attributed to spawning activity, the anoxic conditions recorded in most backflow billabongs during this season, or both. The condition factor rose in the Mid-dry season, only to drop dramatically in the 1979 Late-dry season (well below that recorded in the equivalent 1978 season) and remain low in the 1979–80 Early-wet season. This drop in condition may have been associated with adverse environmental conditions in the 1979 Dry season.

Table 68 Mean length, mean weight and condition factor of *C. stercusmuscarum*

Sampling period	*n*	Mean length (mm)	Mean weight (g)	Condition factor (K)
Late dry (1978)	138	37.7	0.50	1.00
Early-wet (1978–79)	165	36.8	0.48	1.01
Mid-wet (1979)	228	42.2	0.71	1.02
Late-wet–Early-dry (1979)	46	42.0	0.65	0.96
Mid-dry	89	35.3	0.41	0.99
Late-dry	22	36.5	0.42	0.91
Early-wet (1979–80)	23	41.9	0.63	0.93
Overall	711	38.9	0.55	1.00

Length-frequency distribution

The smallest specimen captured in the study was 12 mm LCF; the largest was 68 mm LCF (fig 77). Ivantsoff (in McDowall 1980) reported that this species grows to 90 mm LCF, while Pollard (1974) noted that it reputedly grew to only 70 mm LCF.

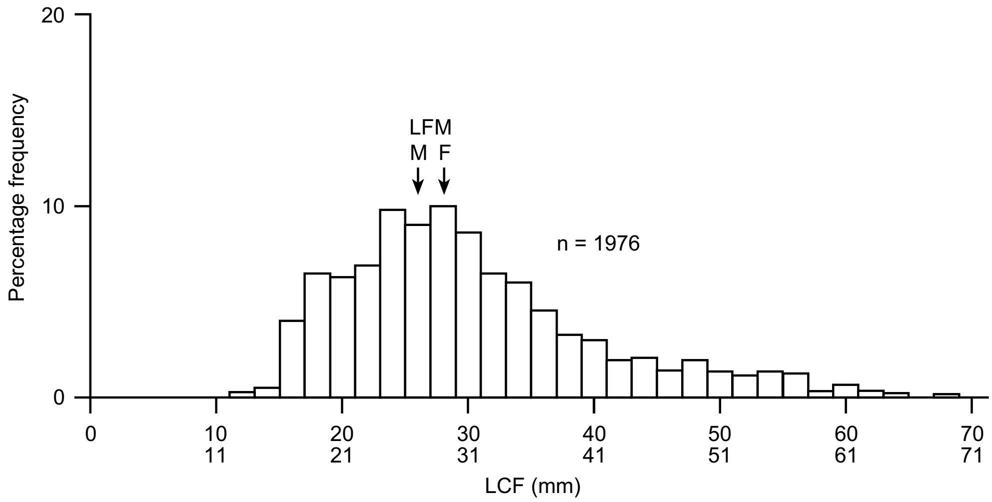


Figure 77 Length-frequency distribution of all *C. stercusmuscarum* captured

The mean and modal lengths of all specimens captured were 30.4 and 28–29 mm LCF, respectively. The LFM for males was 27 mm and for females 29 mm, which indicates that slightly more adults than juveniles were captured. Most specimens were between 15 and 40 mm LCF. The noticeable negative skew in the distribution indicated lower survival rates for larger fish.

Seasonal changes in distribution

The smallest juveniles were found between the 1979 Late-wet–Early-dry and Late-dry seasons. The largest adults were found in the Late-wet–Early-dry season, followed closely by the Mid-wet season (fig 78).

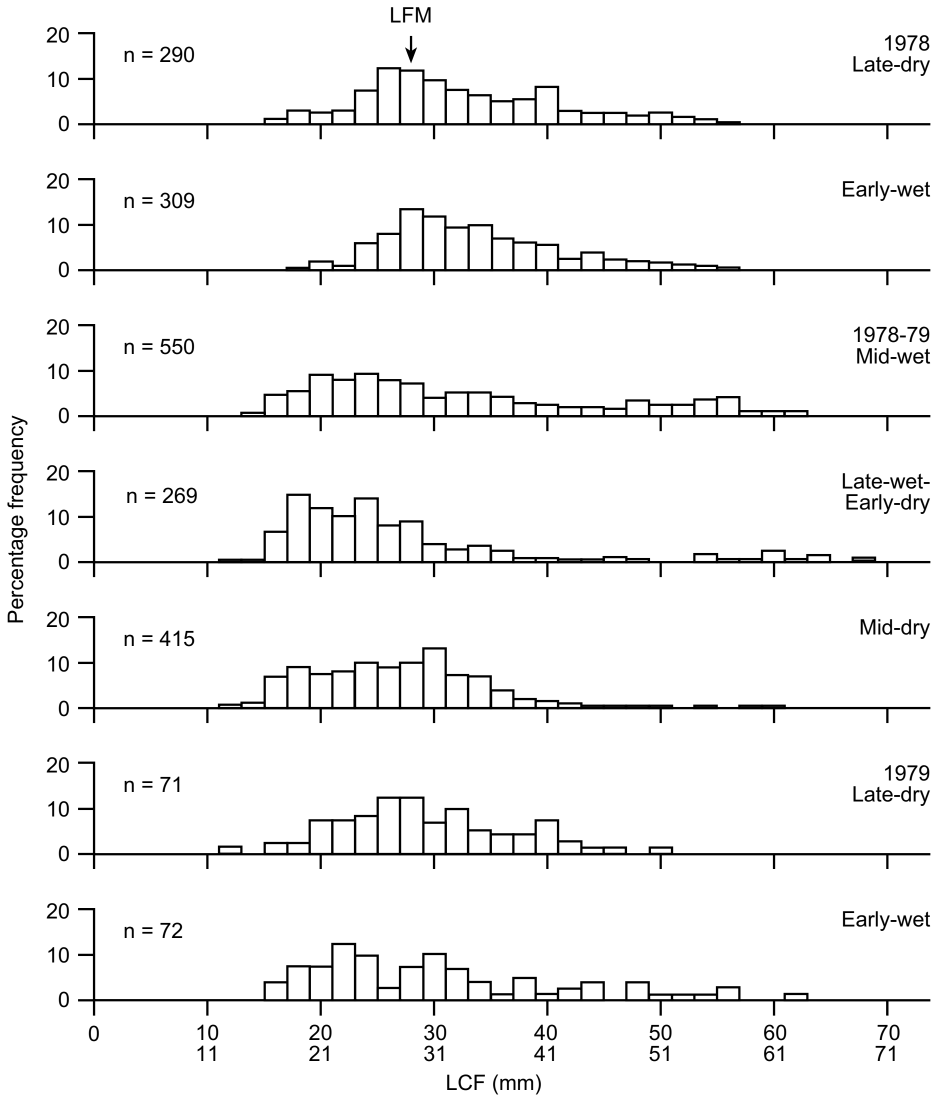


Figure 78 Seasonal length-frequency distribution of all *C. stercusmuscarum* captured

In the 1978 Late-dry season, most specimens were large juveniles and small adults, with smaller numbers of large adults. By the 1978–79 Early-wet season, there were more small adults than large juveniles, as the latter had grown over this period. The length-frequency distribution in the 1979 Late-dry season was essentially similar in form to that in the equivalent 1978 season; however, there was a juvenile peak during the Early-wet season of 1979–80, unlike the previous year.

By the 1978–79 Mid-wet season a strong and wide juvenile peak appeared in the distribution, and the small adults from the previous season had survived and grown, resulting in a continuous size-range of adults (which were abundant) during this season. In the Late-wet–Early-dry season there was another strong and wide juvenile peak, but a much reduced — and discontinuous — size-range of adults. By the Mid-dry season the juveniles still dominated the samples, with a slight shift towards larger specimens and small adults; the larger adults that were present in the Mid-wet season had almost disappeared.

Juveniles recruited at all seasons, especially perhaps between the Mid-wet and Mid-dry seasons. The survival rate of large adults appeared to be highest in the Mid-wet season, declining into the 1979 Dry season.

Growth rate

Estimation of growth from the seasonal length-frequency distributions is very difficult due to the frequency with which juveniles recruited and the wide range of habitats sampled.

Llewellyn (1979) noted that the southern subspecies (as *C. fluviatilis*) attains 25 mm in four months, 35 mm in one year, and 45 mm in two years, in temperate waters of New South Wales. If the growth rates of the two forms are similar, then *C. stercusmuscarum* may attain its LFM by 4–5 months (ie juveniles present in the Mid-wet season may be spawning by the Mid-dry season).[116]

Habitat differences in distribution

Length-frequency distributions showing the habitat preferences of *C. stercusmuscarum* caught in regular sampling sites in the Magela and Nourlangie Creek catchments are given in fig 79.

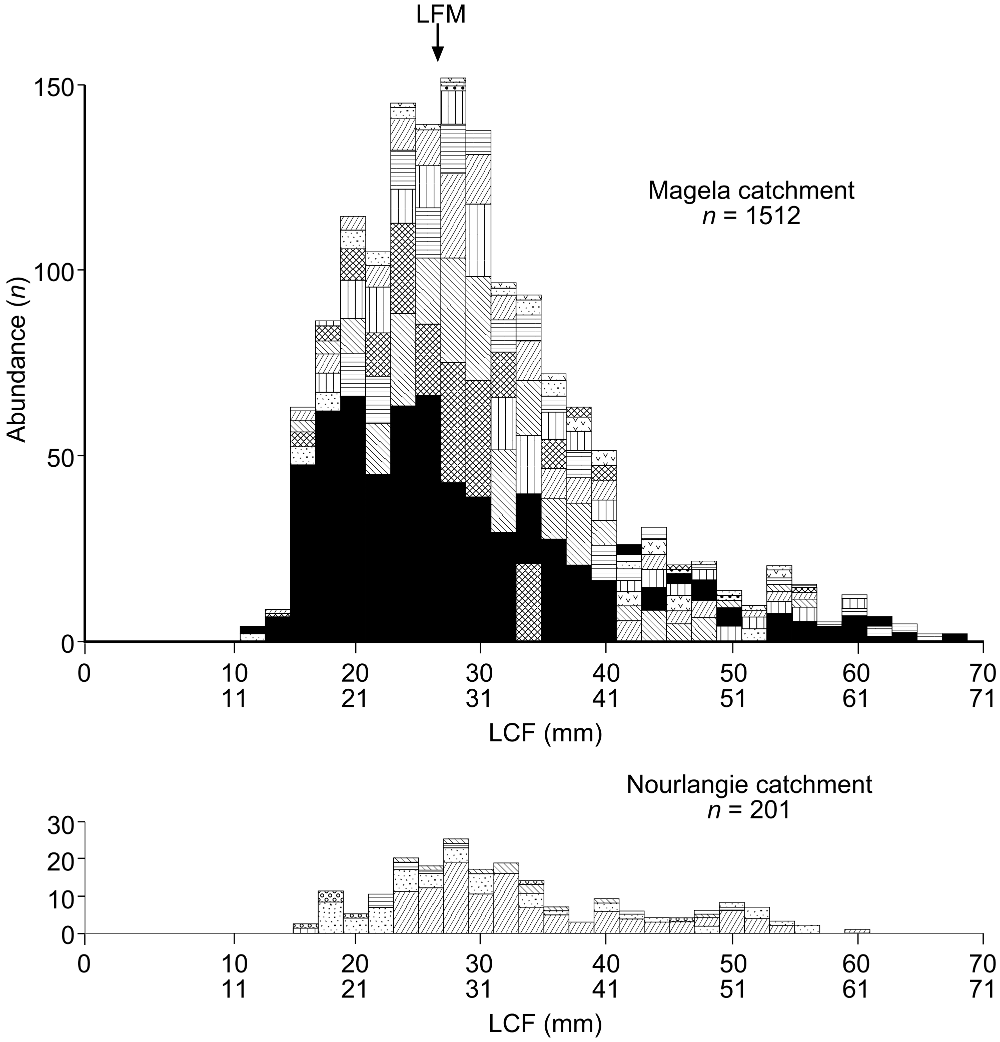


Figure 79 Length-frequency distributions and habitat preferences of *C. stercusmuscarum* captured at regular sampling sites (see appendix 5 for key to the habitats)

116 Under laboratory conditions with a water temperature of 26°C, Ivantsoff et al (1988) indicated that *C. stercusmuscarum* can attain a total length of 29–32 mm in 127 days, and 46–57 mm in 14 months. Milton and Arthington (1983) presented data that indicated that *C. stercusmuscarum* in a stream in south-eastern Queensland can attain a standard length of 33 mm within its first year of life.

Magela catchment

The smallest juveniles (12–13 mm LCF) were captured in sandy corridor waterbodies, lowland sandy creekbeds and lowland channel backflow billabongs. The juveniles were found most often in floodplain billabongs, followed by corridor and escarpment mainchannel waterbodies; smaller numbers were found in backflow billabongs and sandy creekbed habitats (in contrast to *C. marianae*). Juveniles appeared in escarpment perennial streams during the 1979 Late-dry season.

Small adults were found in the same habitats as the large juveniles, with slightly more in sandy creekbed habitats. Large adults were found fairly evenly across a wide range of habitats, especially escarpment mainchannel billabongs, lowland sandy creekbeds and lowland backflow billabongs. Slightly fewer were found in floodplain billabongs (although the largest specimen was captured from one).

Nourlangie catchment

Small juveniles were most frequently captured in backflow billabongs (especially channel types); larger juveniles were captured mainly in lowland sandy creekbed habitats, although a few were found in escarpment mainchannel waterbodies.

Adult *C. stercusmuscarum* were mainly captured in sandy creekbed habitats (as was the largest specimen recorded in the catchment). Smaller numbers were recorded in backflow billabongs (again especially channel types) and escarpment mainchannel billabongs. A few small adults were recorded in escarpment perennial streams during the Mid-wet season.

Environmental associations

The rank numbers for *C. stercusmuscarum* for the physico–chemical and habitat–structural variables are shown in table 155.

Physico–chemical variables

Temperature

Surface-water temperatures ranged from 25° to 43°C (mean = 30.9°C), bottom-water temperatures ranged from 24° to 36°C (mean = 29.7°C). These means both ranked in the upper-middle quarter (see fig 170). This range is wider than that of *C. marianae,* which is less widely distributed than *C. stercusmuscarum*.

Dissolved oxygen

Dissolved oxygen concentrations in waters where *C. stercusmuscarum* was found ranged from 0.9 to 8.2 mg/L (mean = 5.7 mg/L) on the surface, and from 2.5 to 6.8 mg/L (mean = 5.3 mg/L) on the bottom (see fig 171). It appears that *C. stercusmuscarum* can tolerate lower DO concentrations than *C. marianae* can; this may explain why *C. stercusmuscarum* is not found only in the sandy shallows preferred by *C. marianae*.

Visibility

Secchi depths ranged from 2 to 190 cm (mean = 48 cm) (see fig 172). This mean ranked in the lower-middle quarter. The values are close to those recorded for *C. marianae*. Although the two species were typically found together in sandy, shallow watercourses by Pollard (1974), *C. stercusmuscarum* is also often found in other habitats, which may account for the slightly wider range of Secchi depths recorded for its habitats.

pH

The pH values of surface waters ranged from 4.0 to 8.1 (mean = 6.1), and of bottom waters from 5.1 to 7.0 (mean = 6.1). These means ranked in the lower-middle and upper-middle quarters, respectively (see fig 173). The similarity between the two species of *Craterocephalus* in their ranges of pH tolerance is notable.

Conductivity

Craterocephalus stercusmuscarum was found in waters with conductivities ranging from 4 to 220 µS/cm on the surface, and from 2 to 110 µS/cm on the bottom. These ranges are wider than the corresponding ranges for *C. marianae* and may indicate a tolerance of higher levels of dissolved solids.[117]

Habitat–structural variables

Substrate

Craterocephalus stercusmuscarum was typically found over sand (upper-middle quarter), followed closely by mud (lower-middle quarter), clay, and then leaf litter. Apart from the common preference for sandy substrates (which was less marked in *C. stercusmuscarum*), the two species of *Craterocephalus* differ in their preference for other substrates; there is a higher incidence of clay and mud in waters where *C. stercusmuscarum* was found.

Hydrophytes

This species was found in moderately to heavily vegetated waters (vegetation-occurrence index 78.8%). The order of dominance of hydrophyte types was the same as for *C. marianae:* normally submergent (44.5%) followed by emergent (34.1%) and floating-attached hydrophytes. *Craterocephalus stercusmuscarum*, which has a wider distribution, was often found in more heavily vegetated waters than was *C. marianae* (Pollard 1974).

Reproduction

From a total of 764 gonads, 429 females (18–67 mm LCF), 274 males (18–60 mm LCF) and 61 sexually indistinguishable fish (15–58 mm LCF) were identified.

Length at first maturity

Both sexes were found to be maturing at 22 mm LCF; however, the LFM was 29 mm LCF for females and 27 mm LCF for males (fig 80).[118]

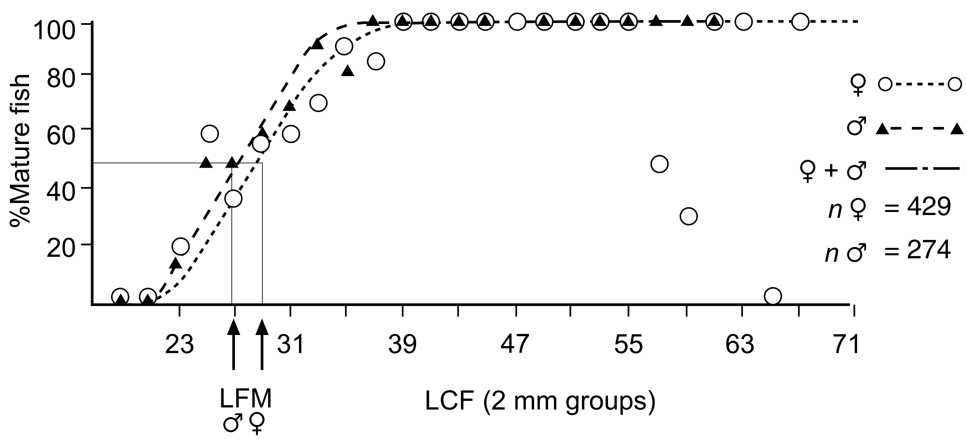


Figure 80 Estimated length at first maturity (LFM) of male and female *C. stercusmuscarum*

117 Williams and Williams (1991) found that mortalities of adults of *C. stercusmuscarum* from the Murray-Darling River system occurred at salinities of 36–50 ppt. The corresponding conductivities are far higher than any recorded in the Alligator Rivers Region.

118 Milton and Arthington (1983) indicated that the minimum size at maturity for *C. stercusmuscarum* in a stream in south-eastern Queensland was 31 mm standard length.

In the Murray–Darling system, Ivantsoff (pers. comm.) found mature males and females of *C. fluviatilis* at 40 and 45.4 mm LCF, respectively. Growth estimates for *C. fluviatilis* suggested that they could mature at one years old in favourable conditions (the largest size observed was 104 mm, cf. 67 mm for *C. stercusmuscarum*).

Sex ratio

Significantly more females than males were caught during the 1978 Late-dry and 1979 Mid-dry seasons (P < 0.001) (table 69), and also in the 1978–79 Early-wet (P < 0.05). Ratios were not significantly different from 1:1 in the other seasons.[119] The sex ratios were almost identical to those for *C. marianae*. Although determining the sex of males was difficult, it is unlikely that this affected the results, as 1:1 ratios were found in seasons when male gonads were least developed (eg 1979–80 Early-wet season). Movements of fish between habitats was not generally possible during the Mid- and Late-dry seasons, so it is likely that a behavioural characteristic of one of the sexes at the sampling sites may have resulted in more females than males being collected. Conditions during the 1978 Late-dry and 1979 Mid-dry seasons were very similar; however, it is interesting to note that the sex ratio returned to around 1:1 by the 1979 Late-dry season.

Table 69 Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *C. stercusmuscarum* 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*	77	99	84	52	70	34	13
+ adults	M	*n*	39	71	68	37	33	20	6
		χ^2	12.4	4.6	1.7	2.5	13.29	3.6	2.6
		P	***	*	n.s.	n.s.	***	n.s.	n.s.
Adults only	F	*n*	61	81	65	32	55	21	13
	M	*n*	32	64	62	24	25	11	6
		χ^2	9.0	2.0	0.1	1.1	11.25	3.1	2.6
		P	**	n.s.	n.s.	n.s.	***	n.s.	n.s.
GSI									
(Adults only)	F	mean	3.1	6.2	3.5	3.0	5.3	4.1	2.7
		s.d.	1.4	0.7	1.0	1.6	1.2	1.0	0.8
	M	mean	1.3	2.0	1.0	1.1	1.3	1.2	0.9
		s.d.	0.5	0.6	0.4	0.6	0.4	0.6	0.3
	F+M	mean	2.3	4.2	2.3	1.9	2.9	3.0	2.1
		s.d.	1.4	2.3	1.5	1.5	2.2	1.7	1.2
GMSI									
(Adults only)	F	mean	3.4	4.6	3.1	2.9	4.0	3.2	3.8
		s.d.	0.6	0.7	0.7	0.7	0.6	0.7	0.6
	M	mean	3.1	4.2	2.9	2.5	3.4	3.0	4.2
		s.d.	0.6	0.5	0.8	0.7	0.9	1.8	1.1
	F+M	mean	3.3	4.4	3.0	2.7	3.7	3.1	3.9
		s.d	0.6	0.6	0.7	0.7	0.8	1.2	0.6

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

119 Milton and Arthington (1983) indicated that sex ratios for *C. stercusmuscarum* in a stream in south-eastern Queensland did not vary significantly from the expected 1:1 ratio.

Breeding season

As for *C. marianae*, the GSI and GMSI were high for most of the year; the means for the females were significantly higher than those for the males in all seasons. There were peaks in reproductive development in the 1978 Early-wet and the 1979 Mid-dry seasons; in the latter, the female peak was greater than the male (fig 81, table 69). The highest GSI recorded was 6.2 for females and 2.00 for males (both in 1978–79 Early-wet season).

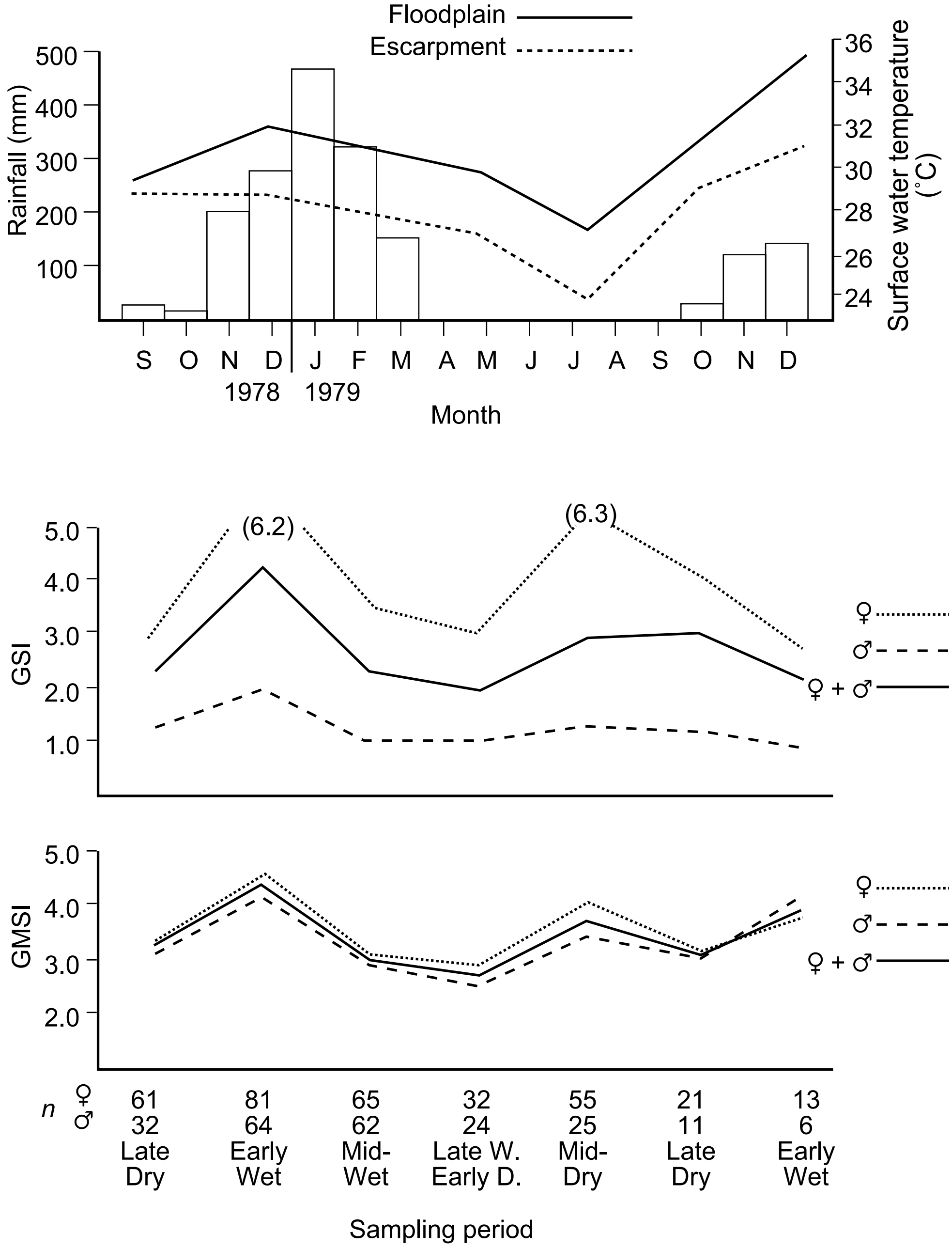


Figure 81 Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) for male and female *C. stercusmuscarum*

The gonads of the closely related *C. fluviatilis* start developing in August for an extended breeding season from mid-October to mid-February; they spawn only when temperatures throughout the water column are above 23.6°C and there is some water flow. The highest GSI recorded for *C. fluviatilis* are 13.1 for females and 7.2 for males. However, the environmental conditions in the two seasons when the gonadal development of *C. stercusmuscarum* peaked were not alike: in the 1978–79 Early-wet season, water temperatures were above 28°C and flows were substantial; in the 1979 Mid-dry temperatures were below 25°C and there was no water flow. Spawning in this species may not necessarily be so dependent on the water temperature or presence of water flow.

Mature and ripe gonads were most common during the 1978–79 Early-wet season and, although no running ripe fish were captured during the 1979 Mid-dry season, maturing fish were found.

Maturing and running-ripe fish (both sexes) were caught from the 1978 Late-dry season through the next two seasons (ie until the 1979–80 Mid-wet season), which indicates a very extended breeding season. Although there was a peak in GSI (particularly female) in the 1979 Mid-dry season, and maturing males and females were collected then, no running-ripe fish were collected until the following two seasons (1979 Late-dry and 1979–80 Early-wet); all were males. This may also be due to the extended breeding season. The breeding season for *C. stercusmuscarum* appeared to start in the 1978 Late-dry season and extend through to the Mid-wet season, with gonads being well developed by the 1979 Mid-dry season. Juvenile fish (less than 20 mm) were captured in all but one season (1978–79 Early-wet), with the smallest being collected in the 1979 Late-wet–Early-dry and Mid-dry seasons.[120]

Site of spawning

During the 1978 Late-dry season, lowland sandy creekbeds contained specimens in spawning condition (83% of all females and 50% of males captured were running-ripe). In the 1978–79 Early-wet season, running-ripe fish were found in lowland sandy creekbeds, lowland shallow backflow billabongs and in a floodplain billabong (table 70). Running-ripe fish were also caught in lowland shallow backflow billabongs (1978–79 Mid-wet season), escarpment mainchannel waterbodies (1979 Late-dry season), and lowland sandy creekbeds (1979–80 Early-wet season).

Table 70 Possible sites of spawning of *C. stercusmuscarum* 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	–	2	–	1	15
Seasonal feeder stream	–	–	–	–	–	–	11
Lowlands							
Sandy creekbed	14	4	10	4	–	–	18
Backflow billabong	5	5	4	–	–	–	1
Corridor	9	11	5	2	–	–	6
Floodplain billabong							
Upper	2	1	–	1	–	–	4

Small juveniles were caught in almost all habitats in the Magela Creek system, from escarpment mainchannel waterbodies through to floodplain billabongs. In the Nourlangie

120 Under laboratory conditions, Ivantsoff et al (1988) found that spawning becomes infrequent after spring and summer. The most common pattern for spawning was fish to spawn for several days, followed by variable periods of rest.

system maturing fish were caught in an escarpment mainchannel waterbody and in lowland sandy creekbeds; small juveniles (< 14 mm LCF) were collected from an escarpment spring-fed stream, a mainchannel waterbody and a lowland sandy creekbed.[121]

Fecundity

The gonads of *C. stercusmuscarum* are single and the ovary is covered by a black mesovarium. Nine gonads were examined. The mean number of eggs was 71 (range = 55–90). The mean egg diameter was 1.0 mm (n = 20) (range = 0.9–1.1 mm). There were two size-classes of eggs (the smaller was about 0.4 mm in diameter) and some eggs of intermediate sizes.[122]

The ova of *C. fluviatilis* in the Murray–Darling system develop progressively during an individual's spawning period, which appears to last for well over a month. Three size-classes of oocytes were found (0.04–0.10, 0.11–0.90 and above 0.90 mm diameter); the largest oocyte had a diameter of 1.52 mm. The fecundity range for *C. fluviatilis,* counting the largest eggs only, was between 20 and 107, and no correlation between the number of ova present in the ovary and the size of the fish was found (Llewellyn 1979).

The eggs of *C. stercusmuscarum* are spherical, transparent and demersal with a thick, sticky shell (Ivantsoff, in McDowall 1980). Adhesive filaments on the eggs are reported to be a general characteristic of the Atherinidae (Breder & Rosen 1966; Llewellyn 1979). The filaments attach the eggs to submerged objects.

Llewellyn (1979) recorded that the prolarvae of *C. fluviatilis* are about 3.4 mm in length and are well developed at hatching. He thought it unlikely that *C. fluviatilis* provided parental care because the spawning season was long, and the eggs are randomly dispersed throughout weedy areas; the same most likely applies to *C. stercusmuscarum*. Ivantsoff (1980) reported that *C. stercusmuscarum* spawned randomly, dispersing the eggs by spreading them over rocks or in crevices. The females rub against rocks and the males usually wait immediately behind to fertilise the eggs.

Summary

The sexes of *C. stercusmuscarum* have some characteristic markings. The females have a distinctive black mesovarium surrounding the singular ovary while the males are yellower on the ventral surface of their body; the yellow becomes stronger as the breeding season approaches.[123]

The breeding season extended from the 1978 Late-dry season through to the 1978–79 Mid-wet season. After a short quiescent period, the gonads developed again, ready for further breeding by the 1979 Mid-dry season. There was at least some spawning in the 1979 Late-dry and 1979–80 Early-wet seasons.

Craterocephalus stercusmuscarum bred in a wide range of habitats, from the larger escarpment area streams, the lowland sandy creekbeds and streams and shallow backflow billabongs to corridor waterbodies. Small specimens were most abundant in the escarpment area and lowland sandy streams and pools.

---

121 Under laboratory conditions, Ivantsoff et al (1988) found that *C. stercusmuscarum* spawned within beds of aquatic plants.

122 Ivantsoff et al (1988) indicated that under stable laboratory conditions, females shed about 20 eggs per spawning. Milton and Arthington (1983) indicated that the mean fecundity for *C. stercusmuscarum* in a stream in south-eastern Queensland was 70 eggs/individual (range 5–126).

123 Milton and Arthington (1983) found that male specimens in Queensland waters became more intensely golden below the mid-lateral stripe.

Craterocephalus stercusmuscarum probably uses similar breeding strategies to *C. fluviatilis* (Llewellyn 1979): progressive development of ova within the ovary while spasmodic spawning takes place, leading to an extended breeding season for each individual; a relatively small number of large demersal eggs, with adhesive filaments scattered randomly amongst the aquatic vegetation; an unknown length of incubation period, but are well developed prolarvae at hatching.[124]

Feeding habits

Overall diet

The stomachs of 766 specimens were examined; 731 contained food. The diet is summarised in fig 82; the components are listed in table 71. The main components of the diet were aquatic insects (38%), microcrustaceans (37%) and algae (9%).

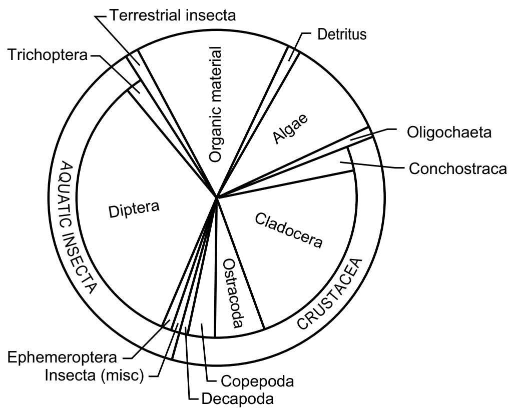


Figure 82 The main components of the diet of *C. stercusmuscarum*

The aquatic insect component consisted mainly of chironomid larvae and pupae. The main microcrustaceans were cladocerans, ostracods and copepods. The algae were mainly green filamentous types and many phytoplankton species. Traces of hydrophytes, aquatic arachnids, macrocrustaceans, terrestrial insects and plant material, detritus and inorganic material were also found in the stomachs. *Craterocephalus stercusmuscarum* can therefore be classified as a microphagous carnivore (occasionally an omnivore), feeding opportunistically on the bottom and mid-water.[125]

Pollard (1974) noted that the diet of this species was unknown, but that it might include mosquito larvae. Ivantsoff (in McDowall 1980) suggested this species was carnivorous and fed on small insects, which would help regulate local insect populations. The microcrustacean and algal components of the diet had not previously been recorded by research workers. Sanderson (1979) noted that *C. stercusmuscarum* from the Magela floodplain fed mainly upon cladocerans, ostracods, algae (single cell and filamentous green species) and organic detritus.

---

124 Ivantsoff et al (1988) has subsequently described mating behaviour, egg and embryonic development, and larval development.

125 Pusey et al (1995b) found *C. stercusmuscarum* to consume large quantities of aquatic insects in two rivers of the Australian wet tropics, north-eastern Queensland.

Table 71 Dietary composition of *C. stercusmuscarum*

	Habitat								Season							Overall	
	Magela system					Nourlangie system			1978	1978–79	1978–79	1979	1979	1979	1979–80		
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																	8.6
Miscellaneous	1.5	3.4	0.2	0.1	1.1	–	2.8	–	2.4	–	–	2.2	0.9	2.2	–	1.0	
Chrysophyta																	
Volvox	–	–	–	–	0.3	–	–	–	–	–	–	–	–	0.5	–	+	
Chlorophyceae																	
Desmidaceae	0.2	–	0.3	–	–	–	–	–	–	–	0.3	–	–	–	–	0.1	
Bacillariophyceae	–	–	–	–	4.9	–	–	–	–	–	–	–	5.3	–	–	0.8	
Dinophyceae	–	1.1	0.8	1.3	0.1	–	2.6	4.6	–	–	0.1	3.8	1.0	3.5	–	0.9	
Conjugatophyta																	
Mougeotia	2.2	–	2.3	7.5	11.3	–	3.1	16.0	0.3	0.5	0.9	16.7	13.9	6.4	3.2	5.3	
Spirogyra	–	–	2.1	0.1	–	–	–	–	–	–	1.6	–	–	–	2.4	0.4	
Hydrophytes																	0.1
Najas	–	0.5	–	–	–	–	–	–	–	–	0.3	–	–	–	–	0.1	
Aquatic animals																	
Oligochaeta	–	–	–	1.5	0.2	–	–	–	0.9	0.6	0.8	–	–	–	–	0.5	0.5
Arachnida																	0.4
Porohalocaridae	0.7	–	–	–	0.6	–	–	–	0.4	–	–	–	0.6	–	–	0.2	
Hydracarina	1.7	–	+	–	0.8	–	–	2.7	1.0	–	–	–	–	–	–	0.2	
Microcrustacea																	36.5
Conchostraca																	
Miscellaneous	–	–	2.3	–	–	–	–	–	3.3	–	–	–	–	–	–	0.5	
Cyzicus	–	–	0.4	–	0.6	–	–	1.0	–	0.4	0.6	–	–	–	–	0.2	
Cladocera																	
Miscellaneous	3.9	6.8	14.4	4.3	14.7	41.7	13.9	13.2	24.6	7.1	12.9	14.6	3.5	4.1	–	11.3	
Diaphanosoma	9.0	7.4	16.6	15.8	28.2	–	5.7	2.7	–	20.8	7.1	19.5	24.6	21.4	47.1	15.4	
Ostracoda	5.8	5.4	9.1	3.9	11.2	–	–	9.3	–	0.5	21.8	2.5	3.3	–	0.3	6.1	
Copepoda																	
Miscellaneous	5.6	–	1.5	4.6	1.8	–	–	–	4.6	2.6	1.6	2.0	1.8	1.7	–	2.3	
Cyclops	–	–	–	1.6	–	–	–	–	–	–	–	–	0.9	2.4	–	0.3	
Harpacticoida	–	2.9	–	–	–	–	–	–	–	–	–	–	–	5.2	–	0.4	
Macrocrustacea																	0.5
Macrobrachium (adults)	–	0.4	–	–	–	–	–	–	0.3	–	0.6	–	–	–	–	0.2	
Macrobrachium (juv)	–	–	1.5	–	–	–	–	–	0.9	0.6	–	–	–	–	–	0. 3	
Insecta																	37.9

Table 71 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
Fragmented	1.8	2.2	0.8	0.3	–	–	–	7.0	1.5	1.9	2.2	1.0	–	–	–	1.3	
Ephemeroptera																	
Baetidae	–	1.2	2.3	0.4	1.8	–	0.8	1.6	2.5	0.8	1.2	0.9	1.7	–	–	1.2	
Hemiptera																	
Corixidae	–	0.2	–	–	0.5	–	–	2.7	0.9	0.5	–	–	0.5	–	0.5	0.3	
Coleoptera																	
Miscellaneous (larvae)	–	0.6	0.3	–	–	–	–	–	–	0.4	0.2	–	–	–	–	0.1	
Hydrophilidae	–	–	–	0.3	–	–	–	–	–	–	0.2	–	–	–	–	0.1	
Diptera																	
Culicidae	1.1	–	–	–	–	–	–	–	–	–	–	–	–	–	4.0	0.1	
Chironomidae (larvae)	31.6	36.6	27.8	29.7	9.7	33.3	42.5	22.4	22.5	35.9	29.4	22.5	17.6	20.9	35.5	26.4	
Chironomidae (pupae)	–	8.0	5.8	1.7	1.7	8.3	5.0	8.1	0.9	5.5	1.9	4.5	7.7	0.7	3.2	3.7	
Ceratopogonidae	6.8	4.2	0.7	2.3	1.1	–	6.9	0.3	3.0	1.6	2.1	–	3.2	7.9	0.3	2.4	
Simuliidae	–	–	–	–	–	–	2.8	–	–	0.6	–	–	–	–	–	0.1	
Trichoptera																	
Hydroptilidae	–	–	–	–	–	–	–	2.7	–	–	0.6	–	0.9	–	–	0.3	
Leptoceridae	13.2	0.1	0.6	0.5	–	–	2.8	2.7	–	0.5	0.2	–	2.6	16.2	–	1.8	
Lepidoptera																	
Pyralidae	–	0.8	–	–	–	–	–	–	–	–	–	–	0.7	–	–	0.1	
Terrestrial plants																	
Angiospermae																	0.3
Fragmented	–	–	–	0.1	–	–	–	–	0.2	–	–	–	–	–	–	+	
Seed material	1.5	–	0.5	0.4	–	–	–	–	–	–	0.9	0.6	–	–	–	0.3	
Terrestrial animals																	
Insecta																	0.5
Orthoptera																	
Egg material	–	3.3	–	–	–	–	–	–	–	–	2.0	–	–	–	–	0.5	
Parasites																	
Nematoda	–	–	0.4	–	–	–	–	0.3	0.3	+	0.2	0.2	–	–	–	0.1	0.1
Detrital material	0	3.3	–	–	–	–	–	–	–	1.7	–	–	0.7	–	–	0.5	0.5
Inorganic material	0.2	1.6	–	0.4	–	–	–	–	0.7	0.8	0.2	–	0.2	–	–	0.4	0.4
Organic material	12.2	9.3	9.4	23.5	9.7	16.7	11.1	2.7	29.0	16.8	10.2	9.0	6.7	6.9	–	13.3	13.3
Number of empty fish	2	3	7	8	6	–	2	1	13	15	2	2	1	2	–	35	35
Number of fish with food	68	103	131	154	120	12	36	37	115	156	172	100	111	58	19	731	731

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

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

Seasonal changes

In sampling periods 1–7, respectively, 128 (10% empty), 171 (9% empty), 174 (1% empty), 102 (2% empty), 111 (1% empty), 60 (3% empty) and 19 (0% empty) stomachs of *C. stercusmuscarum* were examined (all habitats combined). The highest proportions of specimens with empty stomachs were in the 1978 Late-dry and 1978–79 Early-wet seasons, though this pattern was not repeated in 1979–80.

Aquatic insects were important in the diet throughout the study. Chironomid larvae were most important in the Early-wet seasons and least important in the 1979 Mid-dry season; chironomid pupae were most important in the 1978–79 Early-wet and the 1979 Mid-dry seasons; ceratopogonid larvae were most import-ant in the 1979 Mid-dry and Late-dry seasons; leptocerid larvae were very important in the 1979 Late-dry season.

Microcrustaceans were also a substantial part of the diet throughout the study: cladocerans especially in the Late-wet–Early-dry and 1979 Mid-dry seasons, and also the 1979–80 Early-wet season; ostracods in the Mid-wet season; copepods in the Late-dry seasons.

The algal component was largest in the Late-wet–Early-dry season, and then gradually became smaller through the following Mid-dry and 1979 Late-dry seasons.

Habitat differences

Magela catchment

A total of 602 stomachs of *C. stercusmuscarum* were examined (all seasons combined): 70 (3% empty) from escarpment mainchannel waterbodies; 106 (3% empty) from lowland sandy creekbeds; 138 (5% empty) from lowland backflow billabongs; 162 (5% empty) from corridor waterbodies; 126 (5% empty) from floodplain billabongs. Few specimens with empty stomachs were found in any habitat examined.

The diet in the escarpment mainchannel waterbodies was based primarily on aquatic insects (chironomid, leptocerid, and ceratopogonid larvae) and to a lesser extent on microcrustaceans. The diet was similar in the lowland sandy creekbeds, with the minor difference that fewer leptocerid larvae and more chironomidae pupae were eaten. In the backflow billabongs the aquatic insect component was slightly smaller, the microcrustacean component slightly larger, and traces of algae were found in the stomachs.

In the corridor billabongs, *C. stercusmuscarum* had eaten mainly aquatic insects (chironomid larvae); in the floodplain billabongs it had eaten mainly microcrustaceans (cladocerans and ostracods). In both areas the diet had a noticeable algal component. In the corridor waterbodies, the large unidentified organic material component in the diet may have been associated with the microcrustacean component.

Nourlangie catchment

A total of 88 stomachs of *C. stercusmuscarum* were examined (all seasons combined): 12 (0% empty) from escarpment mainchannel waterbodies; 38 (5% empty) from lowland sandy creekbeds; 38 (3% empty) from backflow billabongs. Few specimens with empty stomachs were found in any habitat examined.

The diet in the escarpment mainchannel waterbodies, as in the Magela Creek catchment, was based primarily on aquatic insects (chironomid larvae and pupae) and microcrustaceans. The diets in the lowland habitats were similar in the two catchments. The algal component was more important in the sandy creekbeds and especially so in the backflow billabongs.

Fullness

A summary of mean fullness indices of *C. stercusmuscarum* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments is shown in table 72. These data are presented on the assumption that feeding times do not vary with habitat or season.

Table 72 Mean fullness indices for *C. stercusmuscarum* in different sampling periods and habitats

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	2.2 (10)	n/s	2.7 (21)	n/s	3.2 (10)	4.0 (20)	3.7 (10)	3.2 (71)
Lowland shallow backflow billabong	2.3 (3)	n/s	n/s	n/s	n/s	n/s	n/s	2.3 (3)
Lowland sandy creekbed pool	n/s	2.5 (12)	2.0 (2)	2.5 (2)	4.0 (10)	n/s	n/s	3.0 (26)
Downstream of RUPA								
Lowland sandy creekbed pool	2.8 (16)	3.0 (31)	3.3 (22)	2.6 (7)	2.0 (4)	1.8 (5)	n/s	2.9 (85)
Lowland channel backflow billabong	1.4 (9)	0 (1)	3.1 (19)	1.8 (11)	2.0 (2)	0 (1)	n/s	2.2 (43)
Lowland shallow backflow billabong	5.0 (4)	3.6 (35)	2.8 (25)	3.0 (21)	3.1 (14)	0 (1)	n/s	3.0 (100)
Corridor sandy billabong	1.1 (7)	1.6 (21)	3.3 (7)	3.2 (10)	3.5 (10)	n/s	n/s	2.0 (55)
Corridor anabranch billabong	1.8 (10)	2.5 (10)	3.4 (14)	0 (1)	2.0 (2)	3.1 (8)	n/s	3.1 (45)
Floodplain billabong	2.4 (16)	2.5 (37)	2.9 (14)	2.8 (20)	2.9 (5)	2.6 (22)	n/s	2.6 (114)
Nourlangie Creek catchment (regular sites only)								
Escarpment main-channel waterbody	n/s	2.2 (6)	0 (1)	n/s	n/s	n/s	n/s	1.9 (7)
Lowland channel backflow billabong	n/s	0 (1)	3.6 (10)	2.8 (10)	2.4 (10)	n/s	n/s	2.8 (31)
Lowland shallow backflow billabong	1.8 (5)	n/s	n/s	n/s	n/s	2.5 (2)	n/s	2.0 (7)
Lowland sandy creekbed	2.6 (10)	2.1 (15)	n/s	2.2 (11)	4.0 (2)	n/s	n/s	2.4 (38)
Seasonal mean (all sites)	2.4	2.6	3.0	2.7	3.1	3.1	3.9	

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

Seasonal changes

The mean seasonal fullness index (all habitats combined) increased slightly through the 1978–79 Early-wet season to peak in the Mid-wet season. In the Late-wet–Early-dry season the mean index fell slightly but rose again in the 1979 Mid-dry season; after the 1979 Late-dry season it rose dramatically into the 1979–80 Early-wet season.

Habitat differences

In the Magela catchment, upstream of RUPA, the mean fullness indices were highest in specimens from the escarpment mainchannel waterbody and lowland sandy creekbed sites, and lowest in the few specimens examined from the backflow billabong.

Downstream of RUPA the mean fullness indices were lower only in the channel backflow billabongs and corridor sandy billabongs, and slightly lower in the floodplain habitats.

In the Nourlangie catchment, the mean fullness indices were generally lower than in the Magela catchment. The highest mean indices were found in the channel backflow billabong and the lowest mean indices in the escarpment mainchannel waterbody.

Summary

The habitats and periods of greatest apparent feeding activity were:

Magela catchment

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

Nourlangie catchment

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