# 3 Autecology of the fishes

The extent of biological information gathered varied considerably between taxa, mainly due to their relative abundances in the Region. A list of fish taxa ranked by the numbers of specimens examined for basic biological information is shown in table 1.

Information on fish distributions beyond the Alligator Rivers Region is given in the introductory section for each taxa. This is facilitated by the provision of a map showing Australian drainage divisions (map 3).

A key to length-frequency distribution figures showing habitat preferences of the fishes studied is given in appendix 5.

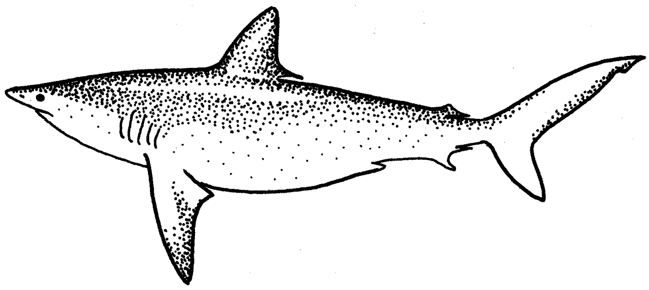

**Map 3** Australian drainage divisions (adapted from Lake 1978)

1 North-east coast
2 South-east coast
3 Tasmanian
4 Murray-Darling
5 South Australian Gulf
6 South-west coast
7 Indian Ocean
8 Timor Sea
9 Gulf of Carpentaria
10 Lake Eyre
11 Bulloo-Bancannia
12 Western Plateau

# Family CARCHARHINIDAE

## 3.1 *Carcharhinus leucas* (Muller & Henle)

*Carcharhinus leucas*, commonly known as the river whaler shark or bull shark is a euryhaline marine/freshwater carcharhinid with a worldwide distribution in tropical and warm temperate waters; it has been found in North and South America, Africa, South-East Asia, Papua New Guinea and Australia. In Australia it is found in the north-east, south-east, south-west, Indian Ocean, Timor Sea and Gulf of Carpentaria drainage divisions (see map 3).



*Carcharhinus leucas*

In South Africa and Central America, *C. leucas* is often found far upstream in freshwaters; in Australia it has been reported as far as 320 km upstream in the Fitzroy River in the Kimberley Region of Western Australia (Chubb et al 1979).[8]

Pollard (1974) found that river whaler sharks, which he identified as *C. mckaili* (syn. *C. leucas*; Chubb et al 1979), were common in tidal waterbodies of the East Alligator River system;[9] Taylor (1964) identified the head of a single specimen collected by R. Miller in the East Alligator River as being from *C. mckaili*. There are unconfirmed reports (M. Alderson, pers comm) of river whaler sharks in Yellow Water Billabong in the Jim Jim Creek drainage of the South Alligator River system.

### Size composition

The lengths and weights of 10 specimens, all taken with 150 mm mesh multi-filament gillnets from tidal waterbodies of the East Alligator River, were measured.

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8 In Papua New Guinea, bull sharks have been recorded in the Sepik River 70 km upstream from the river mouth (Kan & Taniuchi 1991). They are also reported to be very common in Lake Jamur, some 130 km inland from the Arafura Sea (Allen 1991). Herbert and Peeters (1995) indicated that bull sharks are distributed throughout all coastal streams of Cape York Peninsula and are known to penetrate great distances into freshwaters.

9 Larson (2000) indicated that *C. amboinensis* and two potential species of rare speartooth (whaler) sharks, *Glyphis* sp. A (Bizant River shark) and *Glyphis* sp. C (Northern Speartooth Shark), have recently been identified from the Alligator Rivers Region. Their specific identity could not be determined as the taxonomy and relationships of these freshwater sharks within the genus *Glyphis* are still currently being investigated. Following Last and Stevens (1994), *Glyphis* sp. A (GS) varies from *C. leucas* (CL) in the following features:

- lower teeth — CL serrated; GS not serrated, and first few anterior teeth with cutting edges confined to slightly expanded spear-like tips.
- height of the 2nd dorsal relative to the first dorsal — CL 32%; GS 60%.
- toothcount — CL 25-27/25; GS 33/32.

### Length–weight relationship

As only 10 specimens were caught, an expression for the length–weight relationship was not derived.[10] Specimens ranged in weight from 4.0 to 6.8 kg (mean = 5.3 kg) (table 2).

**Table 2** Length, weight and reproductive condition of *C. leucas*

| Sampling period | LCF (mm) | TL (mm) | Wt (kg) | Gonad stage | Gonad wt (g) | GSI |
|---|---|---|---|---|---|---|
| **Females** | | | | | | |
| Mid-dry 1978 | 670 | 825 | 5.0 | II | 15 | 0.30 |
| | 670 | 845 | 4.6 | II | 14 | 0.30 |
| | 730 | 910 | 6.2 | II | 36 | 0.53 |
| **Males** | | | | | | |
| Mid-dry 1978 | 680 | 850 | 4.9 | II | 18 | 0.36 |
| | 710 | 880 | 4.8 | II | 24 | 0.5 |
| | 710 | 880 | 5.4 | II | 20 | 0.37 |
| | 710 | 900 | 5.3 | II | 24 | 0.45 |
| Mid-wet 1978–79 | 800 | 995 | 6.8 | II | 15 | 0.22 |
| | 820 | 1025 | 6.3 | II | 21 | 0.33 |
| **Museum specimen: preserved whole** | | | | | | |
| Mid-dry 1978 | 640 | 805 | 4.0 | | | |

### Length-frequency distribution

The specimens of *C. leucas* ranged in length from 640 to 820 mm LCF (825–1025 mm TL) (table 2). The mean length was 714 mm LCF.

Specimens caught during the 1978 Mid-dry season (pilot survey) were smaller (640–730 mm LCF) than those caught in the 1978–79 Mid-wet season (800–820 mm LCF).

Bigelow and Schroeder (1948) reported that this species is 650–700 mm TL at birth.[11] Springer (1960) noted that embryos ranged in size from 680 to 700 mm TL. The specimens caught in this study are therefore probably small juveniles.[12] Thorson et al (1966) reported that this species grows up to 2060 mm TL in freshwater and 2590 mm TL in brackish

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10 The length-weight relationship given by Snelson et al (1984) for a population in mesohaline lagoons along the central east coast of Florida, USA, was:

$\log_{10}WT = -0.270 + (0.011)(TL)$; r = 0.98; P (F) < 0.0001
where WT is weight in kg, and TL is total length in cm.

11 In Florida, USA, *C. leucas* are born at a size of 600–800 mm TL, with an average of about 750 mm (Snelson et al 1984).

12 From the examination of rings on vertebral centra, Tanaka (1991) indicated that 785 to 888 mm TL bull sharks collected from Northern Australia and Papua New Guinea seemed to be in their first year. In the Lake Nicaragua–Rio San Juan system of Nicaragua and Costa Rica, Thorson and Lacy (1982) found the growth rate of bull sharks to be relatively rapid in the first two years (180 and 160 mm per year), then gradually slows to 120 to 110 mm per year, and appears to remain at 90 to 100 mm per year for the later years of life. Females reached a maximum size of 2500 mm TL in 16 years while male reached 2140 mm TL maximum size in 12 years. In marine environments from the northern Gulf of Mexico, Branstetter and Stiles (1987) found lengths at age for males and females were similar except that males did not attain as great a length/age as females. Growth was slow and varied among individuals, but in general, was estimated to be 150–200 mm per year for the first five years, 100 mm per year for years 6–10, 50–70 mm per year for years 11–16, and less than 40–50 mm per year thereafter. Males matured at 2100–2200 mm TL or 14–15 yr of age; females matured at >2250 mm TL or 18+ yr of age. The largest male (2450 mm TL) was 21.3 yr old; the largest female (2680 mm TL) was 24.2 yr old.

waters.[13] Haines (1979) reported *C. leucas* ranging in length from 1110 to 1380 mm in the Purari River, Papua New Guinea.

## Environmental associations

During this study, *C. leucas* was captured only in deep tidal waterbodies with sandy substrates, bordered by bedrock outcrops.

Studies from other areas indicate that *C. leucas* moves back and forth between fresh and salt water (Thorson 1971) and can readily tolerate both (Thorson & Gerst 1972). Osmoregulatory adaptations of this species have been examined by Oguri (1964) and Gerzeli et al (1969).

*Carcharhinus leucas* was observed in a fish kill that occurred during March 1978 in the Belmore River (Macleay River system, northern New South Wales) during rapid de-oxygenation of floodwaters (Richardson 1979, pers comm). Most specimens died when dissolved oxygen levels dropped below 20% saturation at temperatures ranging between 22° and 25°C.

*Carcharhinus leucas* can readily inhabit and navigate through areas of torrential flow. Thorson et al (1966) noted that, in Nicaragua, *C. leucas* have been observed both below and above three large rapids in the Rio San Juan, as well as actually in the rapids, mainly heading upstream into Lake Nicaragua.[14]

## Reproduction

The reproductive condition of *C. leucas* captured in this study is shown in table 2.

Like most other sharks, *C. leucas* is ovoviviparous. Studies from other areas indicate that the young are born at 600–750 mm TL, in litters of between 5 and 13 embryos (Bigelow & Schroeder 1948; Springer 1960; Clark & von Schmidt 1965; Bass et al 1973). The young are probably born during summer after a gestation period of 10–11 months (Bass et al 1973).

There is no conclusive evidence that *C. leucas* breeds in freshwater. It is believed that the young are born in estuarine areas and stay there during the early part of their lives. In South Africa the larger sharks tend to move into lake systems and then out to sea as they mature (Bass et al 1973). Bass et al (1973) found a preponderance of young male sharks in estuarine and lower river areas; in the present study, most of the specimens captured in tidal waterbodies were juvenile males (table 2).

## Feeding habits

The stomachs of nine specimens were examined; eight contained food (fig 1). The main dietary component was teleosts (85%); the remainder (15%) was unidentified organic material, most probably partially digested fish flesh. *Toxotes chatareus* (a 250 mm specimen bitten cleanly in half) was the only identifiable teleost species found in the stomachs.

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13 Snelson et al (1984) indicated that maturing and adult *C. leucas* apparently reside primarily in deeper marine waters off the coast of central Florida. Females 2400–2650 mm TL, most carrying near-term embryos, begin to appear in shallow inshore marine water during Spring, and enter coastal lagoons to give birth in late-Spring to early-Summer.

14 The voluntary swimming speeds of bull sharks in aquarium conditions was determined by Weihs (1981) to average 0.62 m/s (SE = 0.04 m/s) for a 2 m TL individual, and 0.72 m/s (SE = 0.06 m/s) for a 2.3 m TL individual.

*C. leucas* can therefore be classified as a macrophagous piscivore. Haines (1979) also classified *C. leucas* as a piscivore in the freshwater delta of the Purari River system, Papua New Guinea.[15]

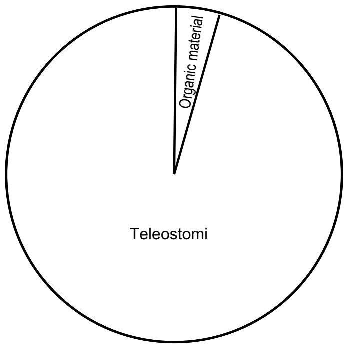



**Figure 1** The main components of the diet of *C. leucas*

Larger *C. leucas* can be aggressive and dangerous to humans: they have attacked and killed bathers off the beaches in Lake Nicaragua, Central America (Thorson et al 1966).[16] Lack of food appears to be primarily responsible for such attacks (Blegvad & Loppenthin 1944).

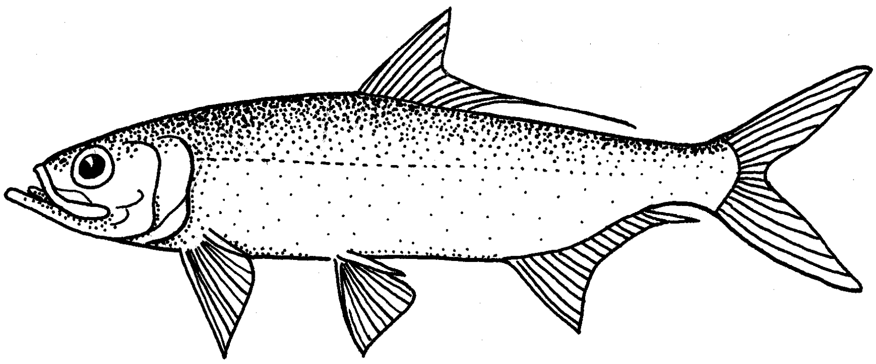
15 Juvenile bull sharks in coastal lagoons within the central coast of Florida, USA, were found by Snelson et al (1984) to feed primarily on stingrays and marine catfishes.

16 Bull sharks have been implicated in 34 unprovoked attacks (17 fatal) within freshwaters of Southern Iran from 1953 to 1985 (Coad & Papahn 1988).

# Family MEGALOPIDAE

## 3.2 *Megalops cyprinoides* (Broussonet)

*Megalops cyprinoides*, commonly known as the tarpon or ox-eye herring, is widespread in the tropics, from East Africa across the Indian Ocean to South-East Asia, Papua New Guinea and Tahiti. It is also found in temperate seas as far north as Japan. In Australian seas, it is found as far south as the coasts of northern New South Wales and south-western Western Australia. Pollard (1974) found this species in floodplain and sandy corridor waterbodies of the Magela Creek system.[17] Miller (cited in Taylor 1964) found it in billabongs and creeks of the Oenpelli area.[18]



*Megalops cyprinoides*

It is essentially a marine species, though smaller specimens inhabit estuaries and are regularly found in freshwater rivers and creeks well above tidal influence. In Australia, it is likely to be commonly found in freshwaters only in far northern Australia.[19]

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was found to be common in all floodplain and corridor waterbodies and backflow billabongs downstream of RUPA, and was occasionally found in some lowland sandy creekbeds. It was also found in escarpment habitats in the Nourlangie Creek system and lower riverine floodplain billabongs of the East Alligator River. It was most widely distributed during the Late-wet–Early-dry season (mainly in floodplain, corridor and backflow billabongs); it was found in fewest sites in the Late-dry season (mainly in floodplain billabongs).

### Size composition

The lengths and weights of all 155 specimens, which were captured in multiple-mesh gillnets, were determined. Some of the largest specimens observed in the 150 mm mesh of the gillnets at the beginning of sets during the 1978–79 Mid-wet season had struggled free by the time

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17 Herbert and Peeters (1995) indicated that tarpon are a common species in all rivers of northern Queensland. Large pools and lagoons are their preferred habitats.

18 In the Sepik River catchment of northern Papua New Guinea, Coates (1987) recorded *M. cyprinoides* in high-order rivers, ox-bow lakes and other areas of permanent water and also on the floodplain, although the latter was not a preferred habitat.

19 Allen (1991) indicated that *M. cyprinoides* penetrates at least 900 km upstream the Fly River system in Papua New Guinea.

the nets were collected an hour later, so the number of larger specimens is underestimated. Additionally, length-frequency distributions may have been affected by mesh selectivity.

#### Length–weight relationship

The length–weight relationship is described by the expression:[20]

$$W = 2.42 \times 10^{-2} L^{2.83} \qquad r = 0.84 \text{ (length in cm, weight in g)}$$

Seasonal changes in mean length, weight and condition factor are shown in table 3. The condition factor was lowest during the 1978 Late-dry season and increased markedly by the 1978–79 Early-wet season. Condition remained stable (near unity) through the Mid-wet and Late-wet–Early-dry seasons, peaked during the 1979 Mid-dry season, and then fell in the Late-dry season.[21]

**Table 3** Mean length, mean weight and condition factor of *M. cyprinoides*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| Late-dry (1978) | 13 | 297.4 | 326.6 | 0.91 |
| Early-wet (1978–79) | 4 | 295.0 | 354.8 | 1.01 |
| Mid-wet (1978–79) | 28 | 266.7 | 255.2 | 1.00 |
| Late-wet–Early-dry (1979) | 19 | 233.5 | 182.6 | 1.01 |
| Mid-dry | 20 | 247.4 | 222.5 | 1.05 |
| Late-dry | 71 | 234.1 | 177.8 | 0.98 |
| Overall | 155 | 246.2 | 209.9 | 1.00 |

#### Length-frequency distribution

The specimens captured ranged in length from 137 to 410 mm LCF (fig 2); the large minimum size is consistent with the observation that this species does not breed in freshwaters (Wade 1962).[22] The LFM was estimated to be 300 mm, which indicates that most of the specimens captured were large juveniles. Pollard (1974) suggested that this species may possibly grow to at least 1000 mm.

The mean and modal lengths of specimens captured were 246 and 250 mm LCF respectively. Approximately 80% of the total number of fish captured were between 170 and 300 mm LCF. Pollard (1974) mentioned that small specimens (usually between 200 and 500 mm in length) inhabit estuaries in northern Australia and are regularly found in freshwater rivers and creeks well above tidal influence. Haines (1979) found *M. cyprinoides* between 290 and 470 mm in length in the Purari River, Papua New Guinea.

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20 The length-weight relationship given by Coates (1987) for *M. cyprinoides* from the Sepik River catchment of northern Papua New Guinea was:

$W = 9.96 \times 10^{-6} L^{3.1}$, $r^2 = 0.95$
where L is total length in mm, W is total weight in g.

21 In the Sepik River catchment of northern Papua New Guinea, Coates (1987) found the condition of *M. cyprinoides* to be slightly, but significantly, lower during the dry season. A fat deposit index also followed this pattern, however, this index was low for the whole population indicated that surplus energy was directed to growth and not stored.

22 The size range of *M. cyprinoides* recorded in the Sepik River catchment of PNG by Coates (1987) was 103–440 mm standard length, all classed as immature stages.

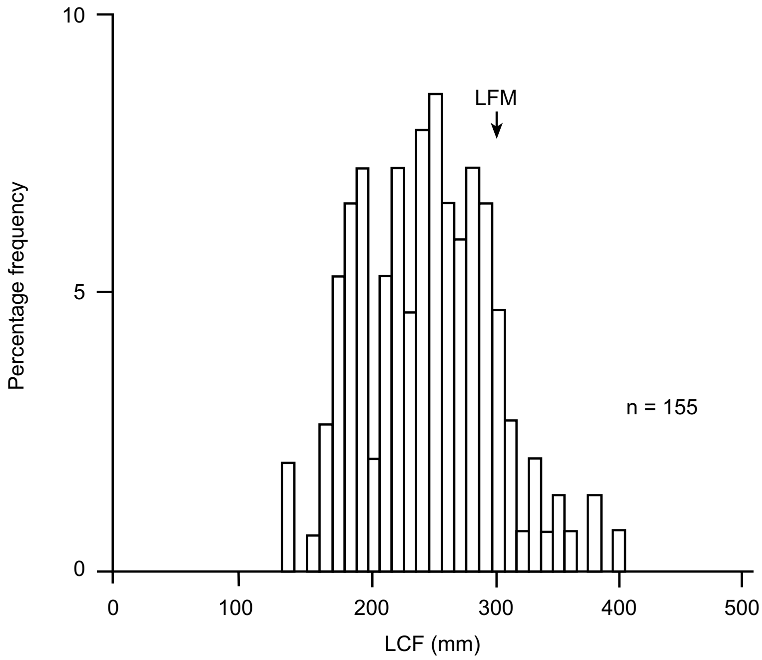


**Figure 2** Length-frequency distribution of all *M. cyprinoides* captured

### Seasonal changes in distribution

The smallest specimens were captured during the 1978–79 Mid-wet and 1979 Mid-dry seasons; the largest specimens were captured in the Mid-wet season (fig 3). The juveniles therefore recruited to the catchments during the Mid-wet season when connection was made with the estuaries. Small juveniles were present in the Nourlangie Creek catchment into the Mid-dry season and persisted in the escarpment perennial streams to the 1979 Late-dry season.

The seasonal changes in length-frequency distribution are shown in figure 3. The mean lengths (table 3) of the fish were consistently high during the 1978 Late-dry and 1978–79 Early-wet seasons and then began to decrease during the Mid-wet season as juvenile recruits became more common in the populations.[23] The mean lengths were further reduced during the Late-wet–Early-dry season and remained low until the 1979 Late-dry season. Juvenile recruitment in the catchments may, therefore, have been greater in the 1978–79 Wet season than in the 1977–78 Wet season.

### Growth rate

The growth rates could not be estimated from data gathered in the present study, as the size distribution of recruits was not well defined. If the growth rate of *M. cyprinoides* captured in this study is comparable with that of larvae reared in freshwater by Alikunhi and Rao (1951) (31.4 mm/month), then the largest specimens examined would be less than a year old, indicating that the fish may mature within their first year of life.[24]

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23 In contrast, the smallest juvenile *M. cyprinoides* entered the Sepik River of PNG in April to July, ie a period equivalent to the Early- to Mid-dry season in the Alligator Rivers Region. Russell and Garrett (1983) have recorded very small (22–25 mm) individuals in the Norman River estuary, northern Queensland, during December which is equivalent to the Early-wet season.

24 The oldest *M. cyprinoides* recorded were at least 52 years of age (Kulkarni 1992). The specimens arose from releases of fingerling tarpon made in July 1939 into an isolated freshwater lake near Bombay, India. Stunted growth was apparent as specimens averaged only 670 mm in length and weighed 3 kg. Crabtree et al (1995) indicated the closely related *M. atlanticus* has a maximum age of at least 55 years in South Florida waters, USA. Growth of *M. atlanticus* was rapid to the age of twelve years (fork lengths 1200 mm for males, and 1435 mm for females), then slowed considerably.

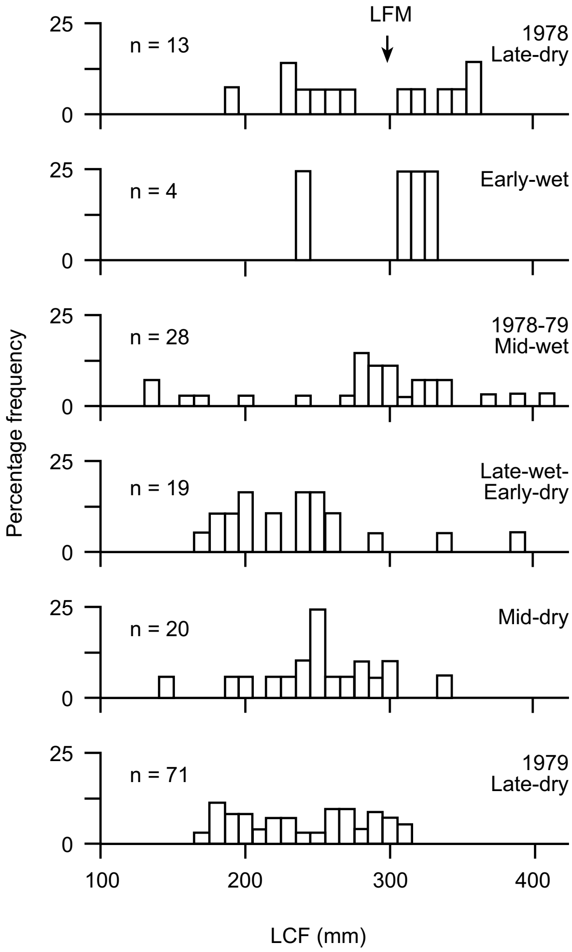


**Figure 3** Seasonal length-frequency distribution of all *M. cyprinoides* captured

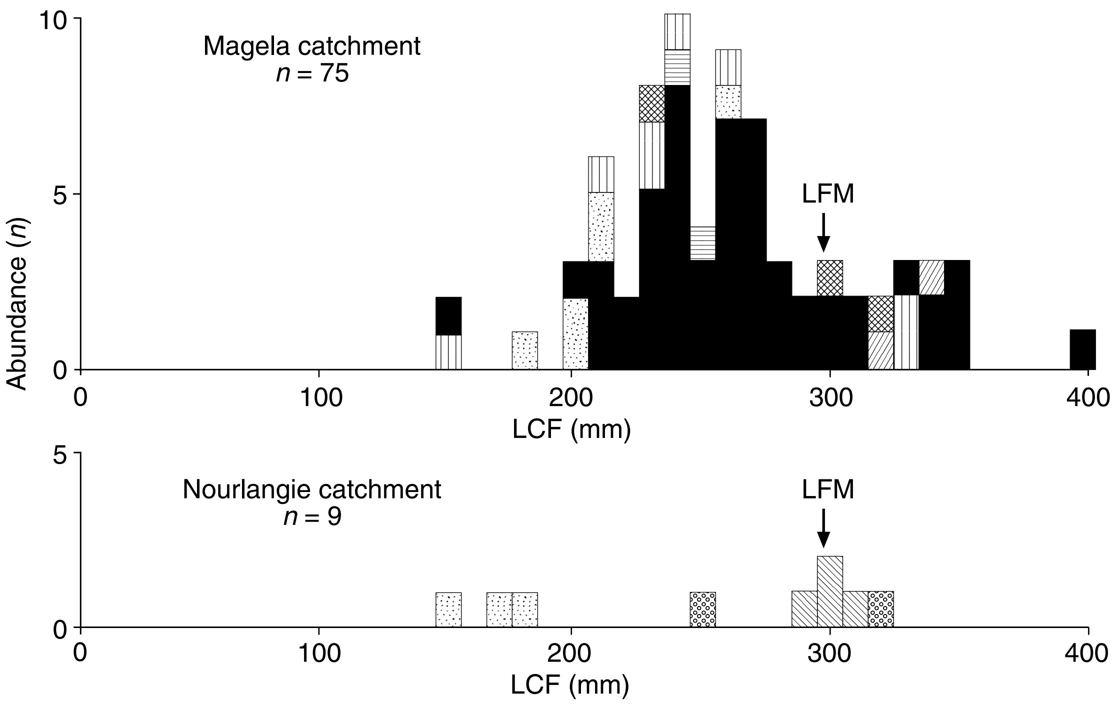


**Figure 4** Length-frequency distributions and habitat preferences of *M. cyprinoides* captured at regular sampling sites (see appendix 5 for key to the habitats)

**Habitat differences in distribution**

Length-frequency distributions showing habitat preferences of *M. cyprinoides* captured in regular sampling sites in the Magela and Nourlangie creek catchments are given in figure 4.

*Magela catchment*

The smallest juveniles were captured in floodplain billabongs and in shallow and channel backflow billabongs. The larger juveniles were captured mainly in the floodplain billabongs, with fewer in the backflow billabongs and corridor waterbodies. No juveniles were found upstream of RUPA.

Most of the specimens, including the largest adult (Jabiluka Billabong), were netted in floodplain billabongs. Smaller numbers of adults were found in corridor waterbodies and lowland sandy creekbeds and shallow backflow billabongs. No adults were found upstream from RUPA.

*Nourlangie catchment*

The few small juveniles that were captured were found in a channel backflow billabong (Baroalba Crossing) during the Mid-wet season. Small juveniles also appeared in the headwaters of Baroalba Creek during the Mid-wet season and remained there until the 1979 Late-dry season. Some larger juveniles were found in shallow backflow billabongs.

The few adults captured in this catchment were found in escarpment mainchannel waterbodies and shallow backflow billabongs. Both adults and juveniles were seen in the lower reaches of an escarpment perennial stream during the 1979 Mid-dry season. No floodplain billabongs were sampled in the Nourlangie catchment.

## Environmental associations

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

**Physico–chemical variables**[25]

*Temperature*

This species was captured in waters with surface temperatures from 23° to 34°C (mean = 29.8°C); bottom waters had the same range (mean = 28.0°C). *Megalops cyprinoides* was therefore found at some of the lowest temperatures recorded in the region. It was ranked in the lower-middle quarter for surface and bottom water temperature based on mean temperatures (see fig 170 in chapter 4).

*Dissolved oxygen*

Dissolved oxygen concentrations in waters in which this species was captured ranged from 1.9 to 9.7 mg/L (mean = 6.2) in surface waters and from 0.2 to 7.4 mg/L in bottom waters (mean = 2.8). *M. cyprinoides* was ranked in the upper-middle quarter for surface DO and at the base of the lowest quarter for bottom DO (see fig 171 in chapter 4).

Although *M. cyprinoides* was known from previous sampling to occur in the area, it was not found in a large fish kill, caused by de-oxygenation of the water (Bishop 1980), in Leichhardt Billabong during the 1978–79 Early-wet season. The closely related Atlantic tarpon *Megalops atlanticus* was not reported in a large fish kill caused by oxygen depletion in North Florida Bay during 1960 (Tabb & Jones 1962). *Megalops atlanticus* is an obligate air breather (Schlaifer

25 Chaverri (1994) found the juveniles of the closely related *M. atlanticus* to be associated with low levels of dissolved oxygen, $H_2S$ occurrence, high turbidity, and variable salinities and temperature in lagoons and creeks in the coast of Costa Rica.

1941), a characteristic that may be associated with its 'rolling' behaviour (Wade 1962). Schools of *M. cyprinoides* exhibit similar 'rolling' behaviour and are also air breathers, and thus able to survive the de-oxygenation of a billabong (Merrick & Schmida 1984, Wells et al 1997).[26] The surface rolling behaviour of *M. cyprinoides* was more noticeable in the more anoxic billabongs of the region.

*Visibility*

Secchi depths recorded at sites in which this species was captured ranged from 4 to 270 cm (mean = 86 cm). *Megalops cyprinoides* was ranked at the top of the upper-middle quarter, based on the mean Secchi depth of waters in which it was captured (see fig 172 in chapter 4).

*pH*

Surface water pH ranged from 5.3 to 9.1 (mean = 6.5) and bottom pH ranged from 5.2 to 7.1 (mean = 6.0). This species was ranked towards the top of the highest quarter of pH for surface waters and in the upper-middle quarter for bottom waters (see fig 173 in chapter 4).

*Conductivity*

The conductivity of surface waters varied between 2 and 200 µS/cm; the conductivity of bottom waters varied between 4 and 280 µS/cm.

### Habitat–structural variables

*Substrate*

The substrates over which *M. cyprinoides* was captured were mainly mud and clay, and to a lesser extent sand. Only a few specimens were captured over other substrates. The ranked positions for mud, clay and sand substrates were upper-middle, upper (near maximum) and lower-middle quarters, respectively (see fig 174 in chapter 4).

*Hydrophytes*

*Megalops cyprinoides* was typically found in vegetated waters (vegetation-occurrence index 78.5%). The dominant hydrophyte types were submergent (percentage dominance = 50.0%), floating-attached (23.6%) and emergent forms (20.9%).

## Reproduction

Over 95% of *M. cyprinoides* captured were immature, with the sexes being indistinguishable. Seven males (186–360 mm LCF) were captured during the 1978 Late-dry season, mostly in Western Red Lily Billabong on the East Alligator flood plain. Two females were captured at Magela Crossing during the 1978–79 Mid-wet season. The length, weight and reproductive condition of the males and females are given in table 4.

### Length at first maturity

As only a few sexually distinguishable fish were captured, the LFM had to be estimated: 300 mm LCF for both males and females.

### Sex ratio

Too few (nine) sexually distinguishable fish were captured to test the sex ratio (7:2) statistically. However, all the fish captured on the East Alligator flood plain during the 1978 Late-dry season were males and all those captured at Magela Crossing during the 1978–79 Mid-wet season were females.

26 Wells et al (1997) stated, without citations, that *M. cyprinoides* are facultative air breathers that use a well-vascularised swim bladder for oxygen uptake. Wells et al showed that tarpon had a high blood-oxygen carrying capacity.

**Table 4** Length, weight and reproductive condition of sexually distinguishable *M. cyprinoides*

| LCF (mm) | Weight (g) | Gonad stage | Gonad wt (g) | GSI |
|---|---|---|---|---|
| **Females** | | | | |
| 390 | 1000 | VII | 1.8 | 1.80 |
| 410 | 1150 | VII | 2.1 | 1.83 |
| **Males** | | | | |
| 186 | 100 | II | 0.1 | 0.10 |
| 225 | 152 | II | 1.0 | 0.66 |
| 235 | 170 | II | 0.4 | 0.25 |
| 245 | 275 | III | 0.4 | 0.15 |
| 270 | 325 | III | 0.7 | 0.22 |
| 353 | 725 | V | 2.4 | 0.34 |
| 360 | 775 | V | 1.5 | 1.19 |

### Breeding season

Sexually distinguishable fish were captured during only two sampling periods. Male fish showed reproductive development at the end of the Dry season and spent females were captured as they moved back upstream in the Mid-wet season, supporting previous reports (Lake 1971; Pollard 1980) that *M. cyprinoides* spawns in the summer. Wade (1962), however, cites evidence that *M. cyprinoides* breeds throughout the year.[27]

### Site of spawning

Spawning sites could not be determined from the data collected in the present study. However, *M. cyprinoides* has been reported to breed in estuarine or shallow inshore waters (Lake 1971; Pollard 1980) and in deeper offshore waters (Wade 1962).[28]

### Fecundity

No mature ovaries were collected. The fecundity of *M. cyprinoides* is most likely high, with small pelagic eggs being produced (Breder & Rosen 1966). The larvae are of the leptocephalus type: colourless, elongate, ribbon-like and translucent, with a very small head and small undeveloped fins. Although the larva takes only seven weeks to metamorphose, it does not fully attain the adult appearance until around 300 mm TL, which takes about nine months (Wade 1962).

### Summary

Published information suggests that, during the Early-wet season, *M. cyprinoides* migrates downstream to coastal or possibly offshore areas to spawn, and lays numerous small pelagic eggs. The larvae move shoreward, metamorphosing in coastal and estuarine areas, and juveniles are found in shallow coastal waters and in adjacent brackish and freshwater pools and rivers (Wade & Robins 1962, Wade 1962).

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27 Crabtree (1995) indicated that spawning of the closely related *M. atlanticus* occurs in late-Spring to early-Summer in marine waters off the Florida coast, USA. The spawning activity appeared to be associated with the lunar phase (peak hatching activity occurred 6–7 days after the full moon and 3–8 days after the new moon).

28 Spawning of *M. atlanticus* occurs in marine waters 65–511 m deep off the Florida coast, USA (Crabtree (1995). Smallest larvae were captured in surface waters over a bottom depth of 240 m.

## Feeding habits

### Overall diet

The stomachs of 151 specimens were examined; 79 contained food. The overall diet is summarised in fig 5; the dietary components are listed in table 5. The main dietary components were aquatic insects (42%) and teleosts (31%). Most of the aquatic insects were libellulid larvae, chironomid pupae, coleopterans and naucorid bugs. The identifiable teleosts were mainly *Ambassis* spp. and *M. splendida inornata,* and less abundant species were *Neosilurus* spp., *P. tenellus, D. bandata* and *H. compressa*. Macrocrustaceans (6%, only *Macrobrachium*) were also found in the stomachs, as were microcrustaceans (3%, *Cyzicus* and *Diaphanosoma*) and terrestrial insects (2%). There were also traces of terrestrial plant material, inorganic material and unidentified organic material. *Megalops cyprinoides* can be classified as a macrophagous carnivore/piscivore that feeds predominantly in surface and mid-waters.[29]

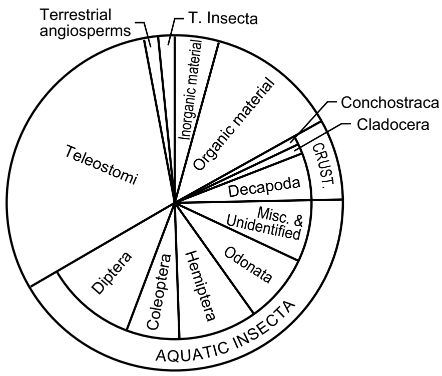



**Figure 5** The main components of the diet of *M. cyprinoides*

Pollard (1980) reported that *M. cyprinoides* adults feed on crustaceans and smaller fish, and that the young will eat insects at the water's surface, while the larvae will eat plankton. Haines (1979) classified this species as a prawn eater in coastal areas near the mouth of the Purari River, Papua New Guinea. Wade (1962) noted that information on feeding habits was scarce, but that larvae acclimatised to freshwater ate freshwater plankton, insects and young forage fish.

Adults of the closely related *M. atlanticus* are carnivorous and prey upon fish (including mullet and long toms) and crustaceans (Wade 1962). The food of larval and young *M. atlanticus* included cyclopoid copepods, fishes, shrimps and *Aedes* mosquito larvae.

### Seasonal changes

During sampling periods 1–6, respectively, 151 stomachs of *M. cyprinoides* were examined (all habitats combined): 11 (27% empty), 4 (0% empty), 27 (18% empty), 18 (28% empty), 20 (65% empty) and 71 (65% empty).

29 Based on data from the present study, Bishop and Forbes (1991) classified *M. cyprinoides* as a piscivore which uses ambush tactics, particularly in the lowland sandy creekbed habitat. In the Sepik River catchment of PNG, Coates (1987) found *M. cyprinoides* to be a meso-predator, feeding mainly on small prawns, aquatic and terrestrial insects and small fish. Catano and Garzon-Ferreira (1994) found the closely related *M. atlanticus* to consume gastropods, shrimps, insects, fishes and plant remains in an estuarine-deltaic system in the Caribbean coast of Colombia.

**Table 5** Dietary composition of *M. cyprinoides*

| | Habitat | | | | Season | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magela system | | | Nourlangie system | 1978 | 1978–79 | 1978–79 | 1979 | 1979 | 1979 | Overall | |
| 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 animals** | | | | | | | | | | | | |
| Microcrustacea | | | | | | | | | | | | 2.5 |
| Conchostraca | | | | | | | | | | | | |
| *Cyzicus* | – | – | – | 19.0 | – | 23.8 | – | – | – | – | 1.2 | |
| Cladocera | | | | | | | | | | | | |
| *Diaphanosoma* | 7.7 | – | – | – | – | – | – | – | 14.3 | – | 1.3 | |
| Macrocrustacea | | | | | | | | | | | | 5.8 |
| *Macrobrachium* | 13.9 | – | 1.3 | – | – | – | 2.5 | 6.2 | – | 13.0 | 5.8 | |
| Insecta | | | | | | | | | | | | 42.1 |
| Fragmented | – | – | 8.7 | – | 25.0 | – | 1.4 | – | – | 12.4 | 6.8 | |
| Ephemeroptera | | | | | | | | | | | | |
| Baetidae | – | – | – | – | – | – | – | – | 7.1 | – | 0.6 | |
| Odonata | | | | | | | | | | | | |
| Libellulidae | 1.5 | – | – | – | – | – | 1.8 | 1.5 | – | 21.6 | 7.6 | |
| Hemiptera | | | | | | | | | | | | |
| Naucoridae | – | – | 6.7 | – | – | – | 8.0 | – | 14.3 | 5.2 | 5.1 | |
| Gerridae | – | 16.7 | – | – | – | – | – | 7.7 | – | – | 1.3 | |
| *Anisops* | – | – | – | – | – | – | – | – | – | 1.2 | 0.4 | |
| Corixidae | – | 20.0 | – | 1.0 | – | 1.3 | – | – | 2.9 | 8.0 | 2.9 | |
| Coleoptera | | | | | | | | | | | | |
| Fragmented | 8.8 | 20.0 | – | – | – | – | 9.8 | 7.7 | 2.9 | 4.0 | 6.0 | |
| Diptera | | | | | | | | | | | | |
| Chaoborinae | 13.9 | – | – | – | – | – | – | 13.9 | – | – | 2.3 | |
| Chironomidae (larvae) | – | – | 13.0 | – | – | – | – | – | 35.7 | – | 3.2 | |
| Chironomidae (pupae) | – | 26.7 | 0.3 | – | 37.5 | – | – | – | 22.9 | 0.2 | 5.9 | |

Table 5  continued

| | Habitat | | | | Season | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magela system | | | Nourlangie system | 1978 | 1978–79 | 1978–79 | 1979 | 1979 | 1979 | Overall | |
| Stomach contents | Bb | Cb | Fb | Bb | Late-dry | Early-wet | Mid-wet | Late-wet–Early-dry | Mid-dry | Late-dry | Sub-mean | Main-mean |
| Teleostomi | | | | | | | | | | | | 31.1 |
| Fragmented | – | – | 6.7 | 20.0 | – | 25.0 | 4.3 | 7.7 | – | 6.4 | 5.8 | |
| *Neosilurus* spp. | – | – | – | – | – | – | – | – | – | 4.0 | 1.3 | |
| *M. splendida inornata* | 12.3 | – | 26.3 | – | 12.5 | – | 20.7 | 7.7 | – | – | 8.3 | |
| *P. tenellus* | – | – | 5.3 | – | – | – | – | – | – | 3.2 | 1.0 | |
| *Ambassis* spp. | 18.5 | | 18.7 | – | – | 25.0 | 10.9 | 36.9 | – | – | 10.4 | |
| *D. bandata* | – | – | – | 40.0 | – | – | 9.1 | – | – | – | 2.5 | |
| *H. compressa* | – | – | – | – | – | – | 4.6 | – | – | 1.6 | 1.8 | |
| **Terrestrial plants** | | | | | | | | | | | | |
| Angiospermae | | | | | | | | | | | | 0.9 |
| Fragmented | – | – | 1.3 | – | – | – | – | 1.5 | – | 2.0 | 0.9 | |
| **Terrestrial animals** | | | | | | | | | | | | |
| Insecta | | | | | | | | | | | | 2.4 |
| Fragmented | – | 16.7 | 0.3 | – | – | – | 4.8 | – | – | – | 1.3 | |
| Orthoptera | | | | | | | | | | | | |
| Fragmented | – | – | – | – | – | – | 4.1 | – | – | – | 1.1 | |
| **Parasites** | | | | | | | | | | | | |
| Nematoda | 0.8 | – | – | – | – | – | 0.5 | – | – | – | 0.1 | 0.1 |
| Inorganic material | – | – | – | – | – | – | – | – | – | 11.8 | 3.7 | 3.7 |
| Organic material | 22.7 | – | 11.0 | 20.0 | 25.0 | 25.0 | 17.3 | 9.2 | – | 5.4 | 12.0 | 12.0 |
| Number of empty fish | 2 | 19 | 14 | – | 3 | – | 5 | 5 | 13 | 46 | 72 | 72 |
| Number of fish with food | 13 | 6 | 15 | 5 | 8 | 4 | 22 | 13 | 7 | 25 | 79 | 79 |

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

Bb = lowland backflow billabong  Cb = corridor billabong;  Fb = floodplain billabong

The highest proportion of specimens with empty stomachs was during the 1979 Mid-dry and 1979 Late-dry seasons; the lowest in the 1978–79 Early-wet season.[30]

In the 1978 Late-dry season, mainly aquatic insects and smaller amounts of *M. splendida inornata* were eaten. In the 1978–79 Early-wet season the few specimens examined had eaten primarily teleosts (mainly *Ambassis* spp.) followed by conchostracans (*Cyzicus*). In the Mid-wet season the diet consisted mainly of teleosts (*M. splendida inornata*, *Ambassis* spp., *D. bandata* and *H. compressa*), with some aquatic (coleopterans and naucorids) and terrestrial insects. By the Late-wet–Early-dry season the teleost component of the diet (mainly *Ambassis* spp. and *M. splendida inornata*, which were migrating in this season) was still large, though aquatic insects (chaoborids, coleopterans and gerrids) were of increasing importance. During the 1979 Mid-dry season, teleosts were no longer found in the stomachs. They were replaced by aquatic insects and cladocerans (mainly chironomid larvae and pupae, and naucorids). By the 1979 Late-dry season, small quantities of teleosts (plotosids and *P. tenellus*) had reappeared, although the aquatic insects (mainly libellulid larvae and corixids) still dominated the diet, with an additional *Macrobrachium* component.

### Habitat differences

*Magela catchment*

A total of 60 stomachs of *M. cyprinoides* were examined (all seasons combined): 15 (13% empty) from backflow billabongs, 25 (24% empty) from corridor waterbodies and 29 (48% empty) from floodplain billabongs.

The diet in the backflow billabongs consisted mainly of teleosts (*Ambassis* spp. and *M. splendida inornata*), aquatic insects (chaoborids and coleopterans) and *Macrobrachium*, with smaller portions of cladocerans. During the Mid-wet season, schools of 10–20 *M. cyprinoides* established feeding stations in the Magela system sandy creekbeds, at sites where migrating *M. splendida inornata* were congregating in large numbers (within hydrophytes, which covered the upstream ends of creek islands). The specimens of *M. cyprinoides* from these areas had stomachs full of *M. splendida inornata*.

In the corridor waterbodies *M. cyprinoides* was feeding only on aquatic insects (mainly chironomid pupae, corixids, coleopterans and gerrids). On the floodplain, it was eating mainly teleosts (*M. splendida inornata*, *Ambassis* spp. and *P. tenellus*) and, to a lesser extent, aquatic insects.[31]

*Nourlangie catchment*

The stomach contents of five specimens from backflow billabongs were examined. All had teleost fish (mainly *D. bandata*) in their stomachs, with only traces of aquatic insects.

### Fullness

Mean fullness indices of *M. cyprinoides* are summarised in table 6. These data are presented on the assumption that feeding times within the day do not vary with habitat or season.

30 Coates (1987) found no major seasonal changes in the diet of *M. cyprinoides* from the Sepik River catchment of PNG. Catano and Garzon-Ferreira (1994) found the diet of the closely related *M. atlanticus* to vary considerably with the seasons, particularly in relation to the availability of juvenile mullet which entered the studied estuarine-deltaic system in mass migrations in March to July. Larger *M. atlanticus* were more piscivorous.

31 Catano and Garzon-Ferreira (1994) found the diet of the closely related *M. atlanticus* to vary considerably between habitats, particularly in relation to both the greater diversity and insect-component of the diet in swamps as opposed to river mouths where environmental changes were stronger and more frequent.

**Table 6** Mean fullness indices of *M. cyprinoides* 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 | Habitat mean |
|---|---|---|---|---|---|---|---|
| **Magela Creek catchment** (regular sites only) | | | | | | | |
| Downstream of RUPA: | | | | | | | |
| Lowland sandy creekbed | n/s | 1.0 (1) | 1.0 (1) | n/s | n/s | n/s | 1.0 (2) |
| Lowland channel backflow billabong | n/s | n/s | n/s | 1.2 (5) | n/s | 1.0 (1) | 1.2 (6) |
| Lowland shallow backflow billabong | n/s | 1.0 (1) | 1.5 (2) | 0.8 (4) | 1.0 (2) | n/s | 1.0 (9) |
| Corridor sandy billabong | n/s | n/s | n/s | 0 (1) | n/s | 0 (2) | 0 (3) |
| Corridor anabranch billabong | n/s | n/s | n/s | 1.0 (1) | n/s | 1.0 (1) | 1.0 (2) |
| Floodplain billabong | 3.0 (2) | n/s | 1.3 (6) | 1.3 (7) | 0.5 (15) | 0.2 (20) | 0.7 (50) |
| **Nourlangie Creek catchment** (regular sites only) | | | | | | | |
| Escarpment main-channel waterbody | n/s | n/s | 0 (1) | n/s | 0.3 (3) | n/s | 0.2 (4) |
| Lowland channel backflow billabong | n/s | n/s | 1.7 (3) | n/s | n/s | n/s | 1.7 (3) |
| Lowland shallow backflow billabong | n/s | 2.5 (2) | n/s | n/s | n/s | n/s | 2.5 (2) |
| **Seasonal mean (all sites)** | 2.5 | 2.0 | 2.7 | 1.1 | 0.6 | 0.5 | |

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

*Seasonal changes*

The mean seasonal fullness index (all habitats combined) fell during the 1978–79 Early-wet season and then rose to a peak in the Mid-wet season. The index decreased suddenly to the Late-wet–Early-dry season and remained low for the remainder of the Dry season.

*Habitat differences*

In the Magela catchment, *M. cyprinoides* was found only downstream of RUPA. The mean fullness indices were highest in the lowland and corridor anabranch habitats, and lowest in the sandy corridor habitats.

In the Nourlangie catchment, the mean fullness indices were highest in the lowland habitats, but sample sizes were very small.

*Summary*

The habitats and periods of greatest apparent feeding activity were:

**Magela catchment**

- floodplain billabong; 1978 Late-dry, 1978–79 Mid-wet and 1979 Late-wet–Early-dry seasons
- lowland shallow backflow billabong; 1978–79 Mid-wet season

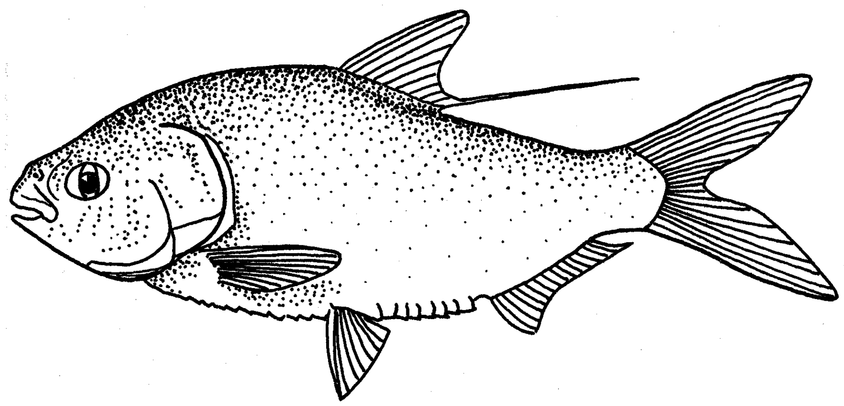
**Nourlangie catchment**

- lowland shallow backflow billabong; 1978–79 Early-wet season
- lowland channel backflow billabong; 1978–79 Mid-wet season

# Family CLUPEIDAE

## 3.3 *Nematalosa erebi* (Gunther)

*Nematalosa erebi* is commonly known as the bony bream or freshwater herring. It is found in the Indian Ocean, Timor Sea and Gulf of Carpentaria drainage divisions; in Papua New Guinea, and throughout the Murray–Darling River, Lake Eyre and Bulloo drainage divisions (map 3). Pollard (1974) found this species to be common in a variety of habitats in the Magela Creek system. Miller (cited in Taylor 1964) captured this species in billabongs in the Oenpelli area and on the riverine flood plains of the East Alligator River. Other members of the genus *Nematalosa* generally occur in estuarine or marine environments.



*Nematalosa erebi*

P. Kailola identified *Hilsa kelee* (Cuvier) (syn. *Macrura brevis* Bleeker) from samples collected during extensive fish sampling by R. Tait (pers comm) in Magela Creek floodplain billabongs; on closer examination of these specimens the authors found them to be juvenile *Nematolosa* rather than *Hilsa.*

Detailed information on catches at each site and in each season is given in volume 2. In summary, *N. erebi* was found commonly in all floodplain, corridor and escarpment mainchannel waterbodies and in some lowland sandy creekbeds; it was also moderately abundant in most backflow billabongs. In the Late-dry season it was found mainly in escarpment mainchannel and in some backflow billabongs; during the Mid-wet and Late-wet–Early-dry seasons it was found mainly in backflow billabongs.

### Size composition

The lengths and weights of 677 specimens were determined; only the lengths of a further 168 specimens were determined. The smallest *N. erebi* were caught with 10 mm mesh seine nets and the largest with monofilament gillnets of multiple-sized mesh. All sizes of fish appeared to be effectively sampled; however, the number of large adults may be underestimated, as some specimens were observed to struggle free from the gillnets. Some of the smallest juveniles captured in the seine nets were caught because hydrophytes clogged the net, effectively reducing the mesh size.

#### Length–weight relationship

The length–weight relationship is described by the expression:

$W = 1.22 \times 10^{-2} L^{3.12}$ r = 1.00 (length in cm, weight in g)

Seasonal mean length, weight and condition factor are shown in table 7. The condition factor was high during the 1978 Late-dry season, then fell dramatically during the 1978–79 Early-wet season, probably because of spawning activity. It then improved through the Mid-wet season to peak by the Late-wet–Early-dry season; this corresponds to the period of highest estimated rate of growth. The condition factor fell markedly during the Mid-dry season and remained at a stable low level for the remainder of the study. Condition in the 1979 Late-dry season was poorer than that recorded in the 1978 Late-dry season, indicating a difference in the environmental conditions.

**Table 7** Mean length, mean weight and condition factor of *N. erebi*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| Late-dry (1978) | 88 | 139.9 | 49.1 | 1.06 |
| Early-wet (1978–79) | 154 | 110.3 | 20.4 | 0.93 |
| Mid-wet | 114 | 76.4 | 7.0 | 1.00 |
| Late-wet–Early-dry (1979) | 147 | 124.9 | 34.7 | 1.09 |
| Mid-dry | 93 | 144.2 | 49.8 | 0.98 |
| Late-dry | 73 | 167.2 | 77.6 | 0.96 |
| Early-wet (1979–80) | 8 | 216.6 | 173.2 | 0.96 |
| Overall | 677 | 120.2 | 28.7 | 1.00 |

### Length-frequency distribution

Specimens ranged in length from 16 mm to 340 mm LCF (fig 6). *N. erebi* is reputed to grow to 400 mm (Pollard 1974). The LFM was estimated to lie between 130 and 140 mm; the overall mean length at capture was 120 mm, indicating that more juveniles than adults were captured. Large numbers of very small juveniles were captured. Peaks in abundance of larger specimens (between 110–160 mm and 240–270 mm) may be due to mesh-size selectivity.

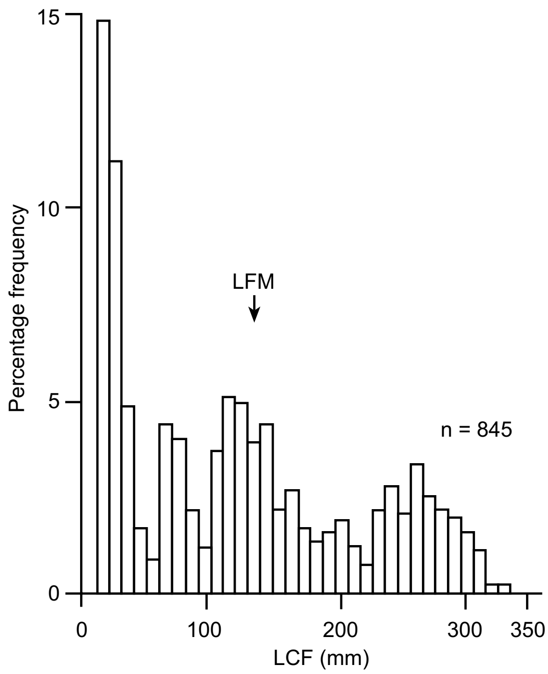



**Figure 6** Length-frequency distribution of all *N. erebi* captured

**Seasonal changes in distribution**

Seasonal length-frequency distributions of all *N. erebi* captured are given in fig 7. The largest number of small juveniles was captured during the 1978–79 Early-wet season, and the second largest in the Mid-wet season. Small numbers were present during the other seasons, except for the 1979–80 Early-wet season when the sample size was small. There were more small juveniles in the 1978 Late-dry than the 1979 Late-dry season. Large adults were caught every season, with the largest being caught in the 1979 Late-dry and 1979–80 Early-wet seasons.

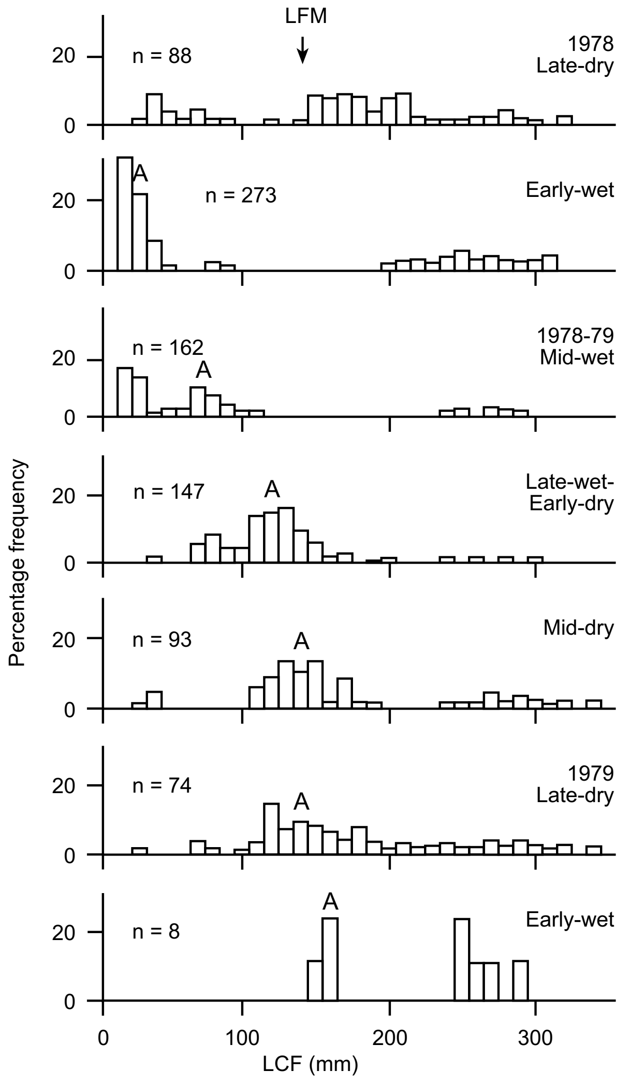



**Figure 7** Seasonal length-frequency distribution of all *N. erebi* captured

The seasonal changes in the mean lengths of specimens that were both weighed and measured are shown in table 7. Mean length fell to its lowest between the 1978 Late-dry and the 1978–79 Mid-wet season, when large numbers of juveniles recruited to the populations. After recruitment had eased, mean lengths increased throughout the remainder of the study. The mean length achieved by the 1979 Late-dry and 1979–80 Early-wet seasons was much greater than the previous year, as few juvenile recruits appeared in the population (possibly due to the extreme nature of the 1979 Dry season).

Specimens captured during the 1978 Late-dry season had a nearly continuous size range, with peaks in the numbers of small adults and small juveniles. By the Early-wet season small adults had virtually disappeared, while the number of small juveniles and large adults had increased. The length-frequency distribution in the Mid-wet season was similar to that of the previous season, the only differences being there were fewer large adults and more larger juveniles. By the Late-wet–Early-dry season the number of large juveniles peaked, corresponding to the loss of the small-juvenile component; the large-adult component remained stable. During the 1979 Mid-dry season the large-juvenile component consolidated and remained strong and the large-adult component remained stable; some small juveniles appeared in the population during this season, giving evidence of some breeding activity in the billabongs.

During the 1979 Late-dry season a near-continuous size range of specimens was captured, with a distribution similar to that of the 1978 Late-dry season; however, fewer small juveniles, and more large juveniles than small adults, were captured during the 1979 Late-dry season. In the 1979–80 Early-wet season only eight specimens (small and large adults) were captured.

#### Growth rate

The growth rate of small juveniles spawned in the 1978–79 Early-wet season can be tentatively followed by examining the progression of this size group (A on fig 7) during the study. They appeared to grow fastest over the Wet season, and some attained 100–130 mm LCF by the Late-wet–Early-dry season (ie in about six months). Growth appeared to slow down in the Dry season, as only a further 30–50 mm increase in length was noted up to the 1979–80 Early-wet season. Yearly growth appeared to be around 140–170 mm LCF, indicating that *N. erebi* may reach sexual maturity in the region during its first year.

Ruello (1976) noted a 40 mm shift (130 to 170 mm) in modal size of this species over two months in Lake Eyre, South Australia.[32]

#### Habitat differences in distribution

Length-frequency distributions showing habitat preferences of *N. erebi* captured in regular sampling sites of the Magela and Nourlangie creek catchments are shown in figure 8.

##### *Magela catchment*

The smallest juveniles were most frequently caught in sandy corridor waterbodies, channel backflow billabongs and, less often, in floodplain and corridor anabranch billabongs and sandy creekbeds. Larger juveniles appeared to be dispersed in the lowlands and were most frequently caught in channel and shallow backflow billabongs and sandy creekbeds. Very few juveniles were found upstream of RUPA.

Adults were found in a wide variety of habitats: the smaller ones most often in channel and shallow backflow billabongs and sandy creekbeds and to a lesser extent in sandy corridor waterbodies, and the larger most often in corridor and floodplain billabongs as well as backflow billabongs. Few adults were found upstream of RUPA; only larger specimens were found in escarpment mainchannel waterbodies, and no specimens were seen in, or collected from, escarpment seasonal or perennial streams.

##### *Nourlangie catchment*

Length-frequency distributions in the Nourlangie and Magela catchments were markedly different (fig 8); few juveniles and very few small adults were caught in the former.

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32 Data from Puckeridge and Walker (1990) on the growth of *N. erebi* in the River Murray, South Australia, indicate that total lengths at ages 1, 2 and 3 were ~110, 170 and 265 mm respectively. Median lengths at first maturity were given as 159 and 180 mm respectively for males and females respectively, indicating that the species matures in its second or third year, considerably later than that apparent in the Alligator Rivers Region.

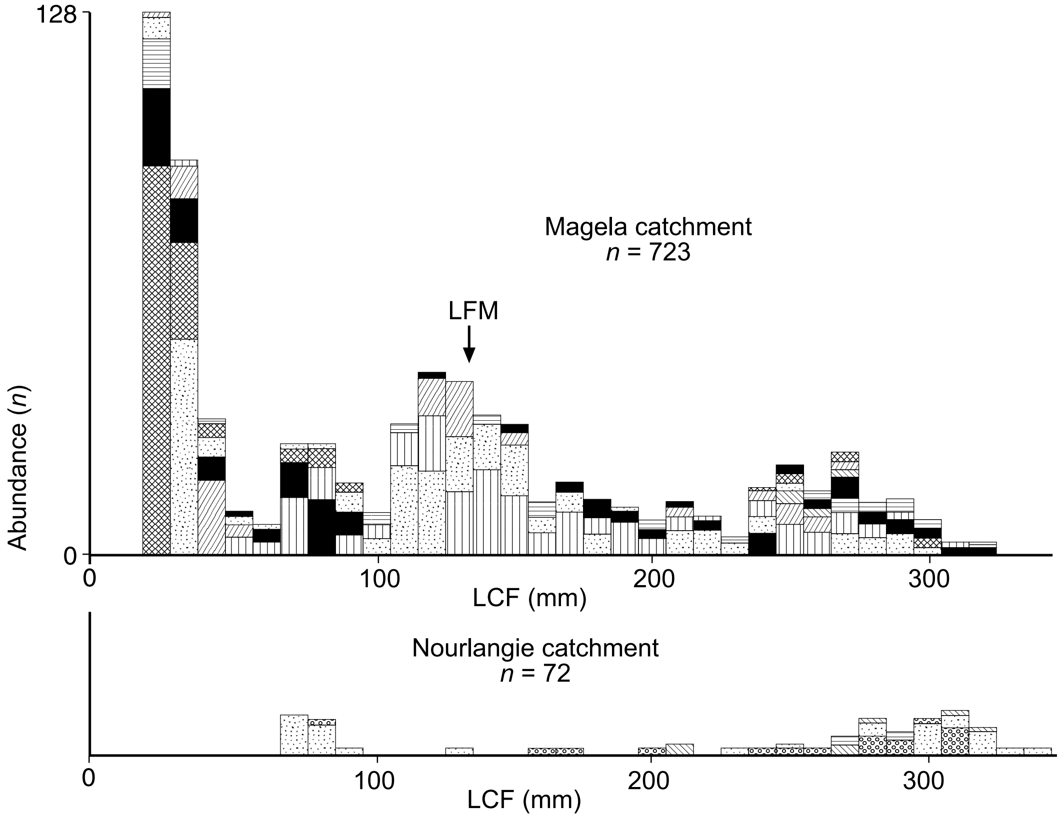


**Figure 8** Length-frequency distributions and habitat preferences of *N. erebi* captured at regular sampling sites (see appendix 5 for key to the habitats)

The few juveniles that were caught were found mainly in channel and shallow backflow billabongs; none were found in escarpment habitats.

Small adults were caught mainly in backflow billabongs, while the larger adults were caught mainly in channel backflow and in shallow backflow billabongs. A few large adults were found in escarpment mainchannel waterbodies.

## Environmental associations

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

### Physico–chemical variables

*Temperature*

The surface temperature range was 23–38°C (mean = 31.0°C); the bottom temperature range was 23–35°C (mean = 28.8°C). Although this species was found at some of the lowest temperatures recorded in the region, it was ranked in the highest and lower-middle quarters for mean surface and bottom temperatures respectively (see fig 170).

*Nematalosa erebi* is also found in the cooler temperate freshwaters of Australia; however, Lake (1971) noted that rapid drops in water temperature during winter in New South Wales frequently resulted in kills. The species is now rare in the Murrumbidgee and Murray rivers for several hundred kilometres below Burrinjuck and Hume dams, probably because cold hypolimnetic discharges reduce average summer water temperatures (22–24°C) by approximately 6°C.[33]

33 Puckeridge and Walker (1990) indicated that *N. erebi* in the River Murray, South Australia, spawn at temperatures 21–23°C, independently of flooding.

*Dissolved oxygen*

Dissolved oxygen concentrations ranged from 2.7 to 9.7 mg/L (mean = 6.3) in surface waters and from 0.2 to 9.5 mg/L (mean = 3.9) in bottom waters. *Nematalosa erebi* was ranked in the highest and lower-middle quarters for surface and bottom mean DO levels, respectively (see fig 171).

Small numbers of *N. erebi* were observed in a fish kill at Leichhardt Billabong during the 1978–79 Early-wet season when surface DO levels dropped below 0.1 mg/L.[34]

*Visibility*

Secchi depths ranged from 1 to 360 cm, with a mean of 65 cm (ie this species was found in both the clearest and most turbid waters in the region). *Nematalosa erebi* was ranked in the upper-middle quarter based on mean Secchi depths (see fig 172).

*pH*

Surface water pH ranged from 5.1 to 8.6 (mean = 6.2) and bottom pH ranged from 4.8 to 6.8 (mean = 5.9) at the capture sites, which placed it into the upper-middle and lower-middle quarters respectively (see fig 173).

*Conductivity*

Surface and bottom conductivities ranged between 2 and 498 µS/cm and between 6 and 478 µS/cm respectively. Ruello (1976) recorded a large kill of *N. erebi* in Lake Eyre during 1976, which he attributed to high salinity (50–300 ppt); he found *N. erebi* surviving in 39 ppt salinity.

### Habitat–structural variables

*Substrate*

The main substrates over which *N. erebi* was captured were mud and clay, followed by sand. Specimens were also found over gravel and leaf litter substrates, but rarely over rocks and boulders. The ranked positions for mud, clay and sand substrates were upper-middle, highest and lower-middle quarters respectively (see fig 174).

*Hydrophytes*

*Nematalosa erebi* was typically found in vegetated waters (vegetation-occurrence index 73.9%). The hydrophyte types amongst which *N. erebi* was captured were submergent (45.4%), floating-attached (25.6%) and emergent forms (24.6%).

## Reproduction

The gonads of 565 *N. erebi* were examined: 241 fish were sexually indistinguishable, 167 were females and 157 males.

### Length at first maturity

Males and females reached LFM at 130 and 140 mm respectively (fig 9). Briggs (1980) suggests that *N. erebi* probably reaches maturity at about 80 mm LCF, but mature individuals below 130 mm were not found in the present study.

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34 Herbert and Peeters (1995) noted that *N. erebi* is highly susceptible to low oxygen levels, and is one of the first species to show distress when oxygen levels are reduced. Mortalities in *Nematalosa* have been recorded at the following DO concentrations: 0.2 mg/L (Hogan & Graham 1994), 0.5 mg/L (Townsend et al 1992) and 0.74 mg/L (Bishop 1994).

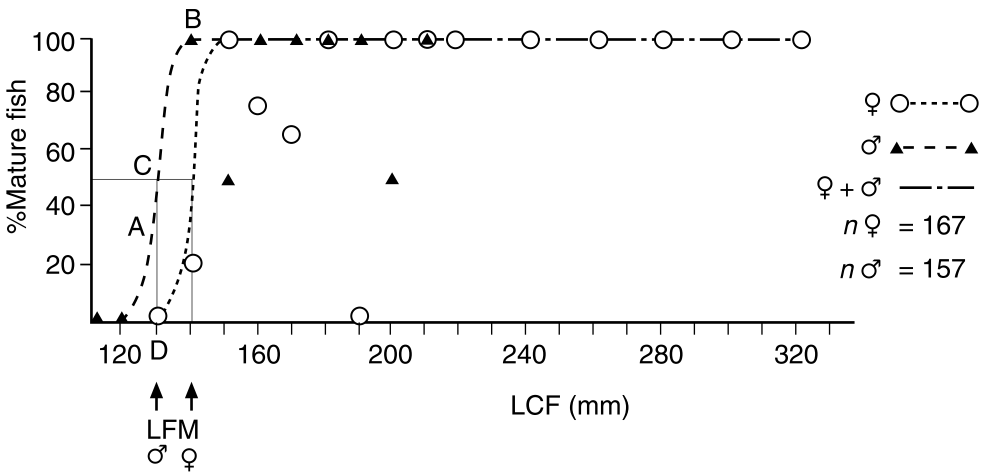


**Figure 9** Estimated length at first maturity (LFM) of male and female *N. erebi*

**Sex ratio**

The sex ratio was 157 males to 167 females, and of these 154 males and 150 females were adults. A chi-squared test was carried out to test the sex ratio at each season on both the entire sample and the adult portion of the sample only (table 8); these ratios were not significantly different from 1:1 in any season.[35]

**Breeding season**

*Nematalosa erebi* maintained a relatively high GSI and GMSI throughout the year, with minor and major peaks around the Early-wet seasons of 1978 and 1979 (fig 10; table 8). An analysis of the percentage frequency of occurrence of gonad stages V, VI and VII indicated that some fish were maturing in the 1978 Late-dry season. More ripe fish, together with some spent specimens, were found during the 1978–79 Early-wet season. By the Mid-wet season most of the fish were spent. By the 1979 Mid-dry season both males and females were maturing and 4% of the male fish captured were running-ripe. Spent males were captured in the following Late-dry. Spent females were captured during the 1979 Mid-dry season, although no running ripe females were identified at any time after the 1978–79 Early-wet season. The data indicate that there was no reproductive activity at all in the 1979–80 Early-wet season (although this may have been an artefact of small sample size).

Small juveniles were captured in large numbers only during the 1978–79 Early-wet and 1978–79 Mid-wet seasons. The one juvenile in the 1979 Late-dry season sample was possibly the progeny from some Mid-dry season breeding (table 9).

It appears that *N. erebi* may have reproduced throughout the year but had a peak in reproductive activity during the 1978–79 Early-wet season. *Nematalosa erebi* are aseasonal spawners in Papua New Guinea (Roberts 1978) and the same species breeds in spring–early summer in the Murray–Darling system (Lake 1978; Briggs 1980). These variations may be due to the differences in environmental and physico–chemical conditions.[36]

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35 This was in contrast to the finding of Puckeridge and Walker (1990) for *N. erebi* in the River Murray, South Australia, that the male:female sex ratio there was 0.86:1.

36 Herbert and Peeters (1995) indicated that bony bream breed in October to December in the middle of Cape York Peninsula, but stated it is possible that they could breed all year round where temperatures are high enough.

### Site of spawning

The habitats in which fish with gonads at stages V to VII (table 10) were captured, and those in which the smallest juveniles were captured (table 9), suggest that *N. erebi* was breeding in the corridor backflow billabongs — this species can breed in still waters such as dams and other isolated waterbodies (Midgley, pers comm; Lake 1978).

Spent fish and juveniles were also caught in corridor waterbodies; however, no ripe fish were caught at these sites. Juvenile fish were also collected in the Magela Creek near Gulungul Billabong in the 1978–79 Early-wet season.

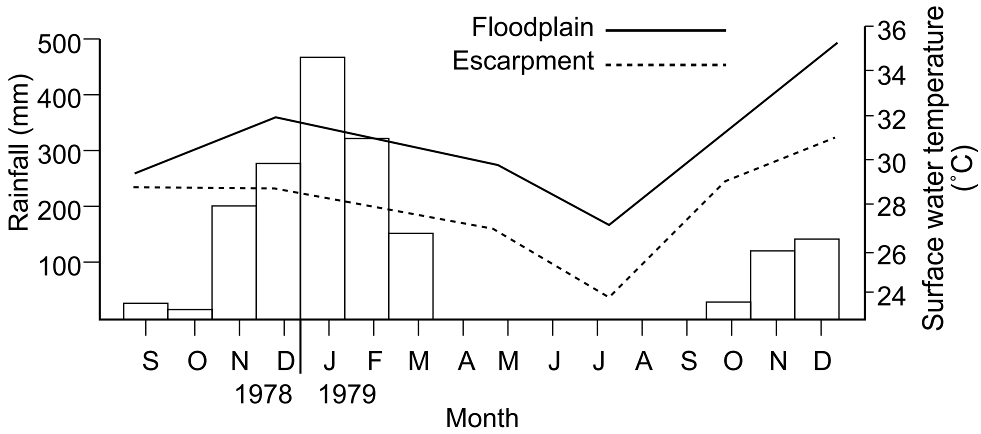
**Table 8** Seasonal changes over all habitats in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI), and the percentage frequency of *N. erebi* captured with gonad stages V–VII

| | | | 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* | 32 | 45 | 8 | 24 | 32 | 23 | 4 |
| adults | M | *n* | 35 | 41 | 15 | 21 | 24 | 17 | 4 |
| | | $\chi^2$ | 0.24 | 0.19 | 2.13 | 0.2 | 1.4 | 0.9 | 0 |
| | | P | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| Adults only | F | *n* | 30 | 45 | 8 | 18 | 28 | 17 | 4 |
| | M | *n* | 35 | 41 | 15 | 21 | 23 | 15 | 4 |
| | | $\chi^2$ | 0.38 | 0.19 | 2.13 | 0.23 | 0.49 | 0.13 | 0 |
| | | P | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| **GSI** | | | | | | | | | |
| Adults only | F | mean | 3.1 | 3.6 | 1.4 | 1.7 | 1.7 | 1.9 | 5.4 |
| | | s.d. | 1.3 | 2.6 | 1.0 | 1.3 | 1.2 | 1.2 | 1.6 |
| | M | mean | 1.1 | 1.8 | 0.9 | 0.4 | 1.9 | 1.3 | 3.7 |
| | | s.d. | 0.9 | 1.3 | 0.9 | 0.3 | 1.0 | 0.9 | 1.9 |
| | F+M | mean | 2.1 | 2.8 | 1.1 | 1.1 | 1.8 | 1.6 | 4.6 |
| | | s.d. | 1.4 | 1.3 | 1.0 | 1.1 | 1.1 | 1.1 | 1.9 |
| **GMSI** | | | | | | | | | |
| Adults only | F | mean | 4.3 | 4.1 | 2.7 | 2.8 | 3.0 | 2.9 | 4.0 |
| | | s.d. | 0.5 | 0.5 | 1.3 | 0.6 | 0.9 | 1.1 | 0.0 |
| | M | mean | 4.1 | 4.5 | 2.5 | 2.2 | 4.0 | 3.9 | 4.0 |
| | | s.d. | 0.7 | 0.6 | 0.7 | 0.8 | 0.7 | 1.5 | 0.0 |
| | F+M | mean | 4.2 | 4.3 | 2.6 | 2.5 | 3.5 | 3.4 | 4.0 |
| | | s.d | 0.6 | 0.6 | 0.9 | 0.7 | 1.0 | 1.3 | 0.0 |
| **Gonad stage** | | | | | | | | | |
| Mature, V | F | % | 31 | 31 | 13 | 0 | 13 | 9 | 0 |
| Ripe, VI | | % | 3 | 4 | 0 | 0 | 0 | 0 | 0 |
| Spent, VII | | % | 0 | 7 | 75 | 4 | 3 | 0 | 0 |
| | | Total *n* | 32 | 45 | 8 | 24 | 32 | 23 | 4 |
| Mature, V | M | % | 26 | 32 | 7 | 0 | 42 | 41 | 0 |
| Ripe, VI | | % | 6 | 10 | 7 | 0 | 4 | 0 | 0 |
| Spent, VII | | % | 0 | 0 | 60 | 10 | 0 | 6 | 0 |
| | | Total *n* | 35 | 41 | 15 | 21 | 24 | 17 | 4 |

*n* = number; $\chi^2$ = Chi-squared value; n.s. = not significant (P > 0.05); s.d. = standard deviation.

**Table 9** Abundance ($n$) of juvenile *N. erebi* (< 30 mm)

| Habitat | Sampling period | | |
|---|---|---|---|
| | Early-wet | Mid-wet | Late-dry |
| **20–29 mm juveniles** | | | |
| Lowland sandy creekbed | 6 | 1 | – |
| Upper floodplain billabong | 19 | – | – |
| Corridor billabong | 66 | 42 | – |
| Backflow billabong | 21 | 17 | 1 |
| **10–19 mm juveniles** | | | |
| Corridor billabong | 11 | 2 | – |



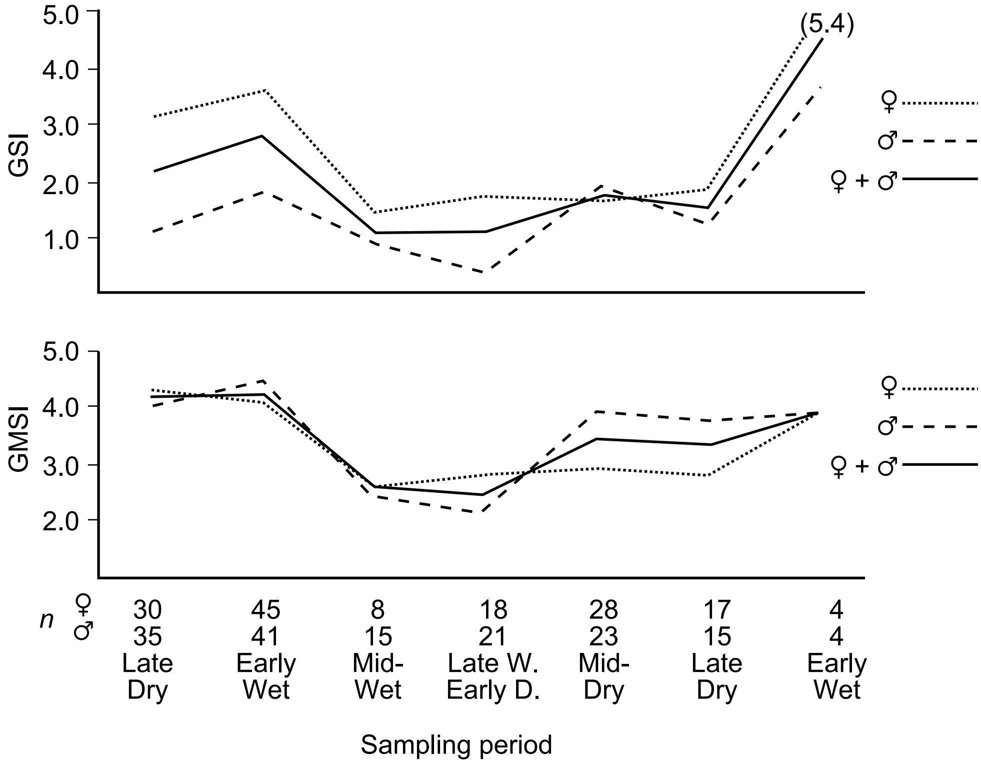




**Figure 10** Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *N. erebi*

**Table 10** Possible sites of spawning of *N. erebi* as indicated by the abundance (*n*) of mature, ripe and spent fish

| | Gonad stage | | | | | |
|---|---|---|---|---|---|---|
| | Mature (V) | | Ripe (VI) | | Spent (VII) | |
| Habitat | F | M | F | M | F | M |
| **Escarpment** | | | | | | |
| Mainchannel waterbody | 3 | 1 | – | – | – | – |
| **Lowlands** | | | | | | |
| Sandy creekbed | 2 | 1 | – | – | – | – |
| Backflow billabong | 20 | 29 | 3 | 6 | 9 | 11 |
| **Corridor** | 2 | 6 | – | – | 2 | 3 |
| **Floodplain billabong** | | | | | | |
| Upper | 1 | 2 | 2 | – | – | – |
| **Artificial** | 3 | – | – | – | – | – |

### Fecundity

Examination of three ovaries of *N. erebi* indicated fecundities of 80 000, 85 500 and 230 000 (mean = 132 000).[37] Mean diameters of oocytes in two ovaries were 0.43 ± 0.04 mm and 0.41 ± 0.05 mm. These results confirm an observation (Briggs 1980) that *N. erebi* had a very high fecundity and very small eggs.

### Summary

*Nematalosa erebi* first matures around 130–140 mm, possibly at one year old, and shows a peak of reproductive development around the Early-wet season. The sex ratio was 1:1 throughout all seasons. The fish spawns many thousands of tiny eggs, probably in backflow billabongs and possibly also in corridor waterbodies. Many species of Clupeidae spawn in large aggregations (Lake 1971).

## Feeding habits

### Overall diet

The stomach contents of 493 specimens were examined; 471 stomachs contained food. The diet of *N. erebi* is summarised in figure 11; the dietary components are listed in table 11. The main dietary components were algae (37%), detritus (38%) and microcrustaceans (4%).[38] The identifiable algal component consisted mainly of planktonic-sized taxa such as Desmidaceae and Dinophyceae. Microcrustaceans (mainly cladocerans) were frequently eaten by juvenile *N. erebi*. Aquatic insects, inorganic material and traces of *Hydracarina* and terrestrial plant material were also found in the stomachs of various-sized specimens. *Nematalosa erebi* can therefore be classified as a microphagic omnivore. The smaller fish were the most omnivorous, while the larger fish were mainly detritivorous and planktivorous (mainly phytoplankton).

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37 Puckeridge and Walker (1990) presented a range of relationships between fecundity and body-size variables for *N. erebi* in the River Murray, South Australia. They indicated that fecundity ranged from 33 000 for a fish of 199 mm TL (body weight 88.9 g) to 880 000 for a fish of 403 mm TL (595.4 g). Puckeridge and Walker also described egg and larval development.

38 Pusey et al (1995b) found *N. erebi* to primarily consume detritus in two rivers of the Australian wet tropics, northeastern Queensland. Smith (1998) indicated that the two closely-related species *N. papuensis* and *N. flyensis* in the Fly River system of Papua New Guinea appear to be largely planktonivorous, never grazing over bottom substrates. Hydro-acoustic sampling had demonstrated that these species form large schools that are present throughout the water column at all times of the day.

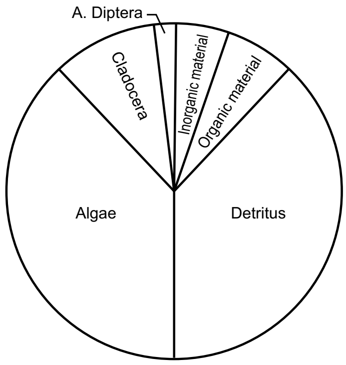



**Figure 11** The main components of the diet of *N. erebi*

From the few specimens he examined, Pollard (1974) noted that *N. erebi* ate predominantly detritus and mud (ie it was iliophagous). It was also known to eat algae, other aquatic plants and sometimes small insects. The diet of specimens collected during the present study appeared to have a larger algal component than that noted by Pollard.

### Seasonal changes

In sampling periods 1–7 respectively, 80 (0% empty), 100 (13% empty), 82 (4% empty), 93 (0% empty), 73 (5% empty), 57 (4% empty) and 8 (0% empty) stomachs of *N. erebi* were examined (all habitats combined). The proportion of specimens with empty stomachs was generally low—the highest proportion was in the 1978–79 Early-wet season.

The diet in the 1978 Late-dry season was based primarily on detritus with a large, unidentified component of organic material. A large microcrustacean component appeared in the diet during the 1978–79 Early-wet season when many small fish were captured. This component was very small for the remainder of the study, except in the 1979 Mid-dry season, because *N. erebi* was feeding extensively on other planktonic forms.

The algal component of the diet increased in importance from the 1978–79 Mid-wet. During the Late-wet–Early-dry season, it peaked and then gradually decreased to its lowest point in the few specimens examined in the 1979–80 Early-wet season. The levels of algae recorded in the stomach contents during the 1979 Late-dry and 1979–80 Early-wet seasons were much higher than in the previous year.

The detrital component of the diet was large throughout most of the study. However, during the Late-wet–Early-dry it dropped dramatically and remained at a low level, increasing after the 1979 Mid-dry. The decrease in the detrital component may have resulted from anoxic conditions at the bottom, ie *N. erebi* filter-fed on phytoplankton from the mid-water zone of the billabongs rather than entering anoxic bottom waters to feed on the substrate.

### Habitat differences

#### *Magela catchment*

The totals of stomachs of *N. erebi* examined (all seasons combined) were: 7 (0% empty) from the Magela Creek catchment escarpment mainchannel waterbodies; 32 (0% empty) from lowland sandy creekbeds; 239 (5% empty) from backflow billabongs; 91 (7% empty) from corridor waterbodies and 51 (2% empty) from floodplain billabongs. Generally, few specimens had empty stomachs; however, slightly more fish with empty stomachs were found in corridor and backflow billabongs.

**Table 11** Dietary composition of *N. erebi*

| | Habitat | | | | | | | Season | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magela system | | | | | Nourlangie system | | 1978 | 1978–79 | 1978–79 | 1979 | 1979 | 1979 | 1979–80 | Overall | |
| Stomach contents | Em | Ls | Bb | Cb | Fb | Em | Bb | Late-dry | Early-wet | Mid-wet | Late-wet–Early-dry | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean |
| **Aquatic plants** | | | | | | | | | | | | | | | | |
| Algae | | | | | | | | | | | | | | | | 36.5 |
| Miscellaneous | 71.4 | 22.2 | 23.2 | 12.7 | 6.4 | 24.0 | 60.7 | 3.0 | – | – | 28.0 | 58.8 | 45.5 | 37.5 | 20.6 | |
| Desmidaceae | – | – | 8.3 | 17.5 | 4.0 | – | – | – | 2.3 | 19.0 | 18.2 | 4.6 | – | – | 7.9 | |
| Dinophyceae | – | 2.8 | 14.3 | – | 2.0 | – | 3.6 | – | – | – | 35.1 | 3.9 | – | – | 7.5 | |
| Conjugatophyta | | | | | | | | | | | | | | | | |
| *Mougeotia* | – | – | + | 2.8 | – | – | – | – | 1.2 | 1.8 | – | – | – | – | 0.5 | |
| **Aquatic animals** | | | | | | | | | | | | | | | | |
| Arachnida | | | | | | | | | | | | | | | | 0.2 |
| Hydracarina | – | – | – | 1.2 | – | – | – | – | – | 1.3 | – | – | – | – | 0.2 | |
| Microcrustacea | | | | | | | | | | | | | | | | 11.0 |
| Fragmented | – | – | 0.4 | – | – | – | – | – | 1.2 | – | – | – | – | – | 0.2 | |
| Conchostraca | | | | | | | | | | | | | | | | |
| *Cyzicus* | – | – | | 0.7 | – | – | – | – | – | 0.8 | – | – | – | – | 0.1 | |
| Cladocera | | | | | | | | | | | | | | | | |
| Miscellaneous | – | – | 3.2 | 0.9 | 0.4 | – | – | 1.3 | 0.9 | – | 1.1 | 9.0 | 0.4 | – | 2.0 | |
| *Diaphanosoma* | – | 37.5 | 2.8 | 17.9 | 11.9 | – | – | – | 45.3 | – | – | – | – | – | 8.4 | |
| Ostracoda | – | 0.9 | – | 1.1 | – | – | – | – | – | 1.5 | – | – | – | – | 0.3 | |
| Copepoda | | | | | | | | | | | | | | | | |
| *Cyclops* | – | – | – | 0.2 | – | – | – | – | 0.1 | – | – | – | – | – | + | |

Table 11 continued

| Stomach contents | Habitat | | | | | | | Season | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magela system | | | | | Nourlangie system | | 1978 | 1978–79 | 1978–79 | 1979 | 1979 | 1979 | 1979–80 | Overall | |
| | Em | Ls | Bb | Cb | Fb | Em | Bb | Late-dry | Early-wet | Mid-wet | Late-wet–Early-dry | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean |
| Insecta | | | | | | | | | | | | | | | | 2.2 |
| Ephemeroptera | | | | | | | | | | | | | | | | |
| Baetidae | – | – | – | – | 0.8 | – | – | – | 0.3 | – | – | – | 0.7 | – | 0.2 | |
| Hemiptera | | | | | | | | | | | | | | | | |
| Corixidae | – | – | 0.1 | – | – | – | – | 0.3 | – | – | – | – | – | – | + | |
| Diptera | | | | | | | | | | | | | | | | |
| Chironomidae (larvae) | – | 2.2 | 0.9 | 5.5 | – | – | – | – | 5.3 | 3.0 | – | 0.3 | 1.8 | – | 1.7 | |
| Ceratopogonidae (larvae) | – | – | – | 1.7 | – | – | – | – | – | 1.8 | – | – | – | – | 0.3 | |
| **Terrestrial plants** | | | | | | | | | | | | | | | | + |
| Miscellaneous seeds | – | – | + | – | – | – | – | – | 0.1 | – | – | – | – | – | + | |
| **Parasites** | | | | | | | | | | | | | | | | |
| Nematoda | – | – | + | 3.8 | 0.1 | – | – | – | 3.6 | 0.3 | – | – | – | – | 0.7 | 0.7 |
| Detrital material | 17.9 | 18.9 | 37.7 | 23.9 | 49.9 | 15.0 | 32.1 | 63.5 | 28.5 | 63.8 | 14.5 | 11.3 | 44.6 | 59.4 | 37.5 | 37.5 |
| Inorganic material | 10.7 | 15.2 | 3.2 | 2.8 | 0.9 | 60.0 | – | 11.0 | 1.2 | 2.5 | 3.3 | 3.0 | 7.1 | 3.1 | 4.5 | 4.5 |
| Organic material | – | – | 5.4 | 5.9 | 23.4 | – | 3.6 | 21.0 | 10.1 | 2.5 | – | 9.1 | – | – | 7.2 | 7.2 |
| Number of empty fish | – | – | 12 | 6 | 1 | – | 3 | – | 13 | 3 | – | 4 | 2 | | 22 | 22 |
| Number of fish with food | 7 | 32 | 227 | 85 | 50 | 5 | 28 | 80 | 87 | 79 | 93 | 69 | 55 | 8 | 471 | 471 |

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

Em = escarpment mainchannel; Ls = lowland sandy creekbed; Bb = lowland backflow billabong; Cb = corridor billabong; Fb = floodplain billabong

In escarpment mainchannel waterbodies, the fish ate mainly algae, together with detritus and incidental organic material. The algae contained large numbers of diatoms (mainly *Melesira granulata*, *Pinnularia* and *Eunotia* [D. Thomas, pers comm]), which were possibly present as a sludge over sandy substrates in these habitats. *N. erebi* was frequently observed ‘pecking’ at the sand substrate and then spitting out the sand it had incidentally ingested.

The diet in the lowland sandy creekbeds consisted of smaller proportions of algae and detritus and a large component of microcrustaceans (mainly the cladoceran *Diaphanosoma*). This finding reflected the high proportion of juvenile fish, which frequently ate microcrustaceans, collected at this habitat. In the backflow billabongs fairly equal proportions of algae and detritus were eaten, and only a few cladocerans. The algae were mainly desmids (genera included *Micrasterias, Xanthidium, Staurastrum, Phymatodocis* and *Cosmarium*). One specimen captured in Gulungul Billabong in the Mid-wet season had 90 different forms of desmids in its stomach (H. Ling, pers comm), including dinoflagellates (mainly *Peridinium*), euglenophytes (*Euglena, Trachelomonas* and *Phacus*), chrysophytes (*Volvox, Dimorphococcus lunatis*), and cyanophytes (*Spirulina* and *Microcystis*).

In the corridor waterbodies there was a larger cladoceran component in the diet which, however, still had algal and detrital components. The algal component was mainly made up of desmids (*Staurastrum*) and diatoms (mainly *Melosira, Eunotia, Pinnularia, Cymbella* and *Cyclotella* [D. Thomas, pers comm]), and traces of dinoflagellates (*Peridinium*), chlorophytes (*Tetraedrom, Scenedesmus, Mougetia*) and euglenophytes (*Trachelomonas* and *Phacus*).

The diets in the floodplain billabongs and in the lowland backflow billabongs were similar: large quantities of algae (mainly phytoplankton) and detritus.

*Nourlangie catchment*

Totals of 5 (0% empty) and 31 (10% empty) stomachs of *N. erebi* were examined (all seasons combined) from escarpment mainchannel waterbodies and backflow billabongs, respectively, in the Nourlangie Creek catchment.

The diet in the escarpment mainchannel waterbodies consisted of algae (mainly diatoms) and detritus, with a large inorganic material component. In the backflow billabongs the diet was primarily algae and, to a lesser extent, detritus. The algae included dinoflagellates (*Peridinium*), desmids (*Closterium, Desmidium swartzi* and *Phymatodocis*) and euglenophytes (*Trachelomonas oblongata* var. *australica*). The diet in the backflow billabongs was thus similar to that observed in the equivalent habitats of the Magela catchment.

**Fullness**

Mean fullness indices of *N. erebi* for different sampling periods and habitat types are shown in table 12. The data are presented on the assumption that feeding times within the day do not vary with habitat or season.

*Seasonal changes*

The mean fullness indices (all habitats combined) peaked in the 1978–79 Mid-wet season and then fell to lower levels in all subsequent seasons.

*Habitat differences*

In the Magela catchment the highest mean fullness indices were recorded in habitats with sandy substrates — escarpment mainchannel waterbodies, corridor waterbodies and lowland sandy creekbeds. The lowest indices were recorded in the shallow backflow billabongs and the floodplain billabongs.

In the Nourlangie catchment, specimens from escarpment mainchannel waterbodies had the highest fullness indices.

**Table 12** Mean fullness indices of *N. erebi* 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 | 4 (1) | n/s | n/s | n/s | n/s | 3.5 (2) | 4.0 (4) | 3.9 (7) |
| Downstream of RUPA: | | | | | | | | |
| Lowland sandy creekbeds | n/s | 2.8 (16) | 1.0 (1) | 3.5 (4) | 3.6 (9) | 3.0 (3) | n/s | 3.0 (33) |
| Lowland channel backflow billabong | 3.3 (8) | 2.1 (13) | 2.8 (20) | 2.6 (27) | 2.8 (19) | 1.6 (12) | 1.0 (1) | 2.5 (100) |
| Lowland shallow backflow billabong | 2.4 (14) | 1.7 (12) | 2.6 (24) | 2.3 (46) | 2.0 (29) | 1.2 (14) | n/s | 2.1 (139) |
| Corridor sandy billabong | n/s | 2.5 (28) | 2.5 (16) | 3.6 (2) | 3.3 (3) | 2.5 (2) | n/s | 3.6 (51) |
| Corridor anabranch billabong | 4 (1) | 0 (1) | n/s | 3.3 (3) | 3.0 (2) | 3.2 (5) | n/s | 3.0 (12) |
| Floodplain billabong | 1.9 (13) | 1.7 (26) | 3.1 (17) | 4 (1) | 1.4 (8) | 2.4 (14) | n/s | 2.1 (79) |
| **Nourlangie Creek catchment** (regular sites only) | | | | | | | | |
| Escarpment main-channel waterbody | 3.2 (5) | n/s | n/s | n/s | n/s | n/s | n/s | 3.2 (5) |
| Lowland channel backflow billabong | 1.5 (4) | n/s | 1.5 (2) | 1.6 (11) | 0.7 (3) | 2.2 (5) | n/s | 1.6 (25) |
| Lowland shallow backflow billabong | 3.5 (2) | 2.7 (3) | n/s | 3 (1) | n/s | n/s | n/s | 3.1 (6) |
| **Seasonal mean (all sites)** | 2.5 | 2.2 | 2.7 | 2.4 | 2.4 | 2.0 | 2.0 | |

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**

- escarpment mainchannel waterbody; 1979–80 Early-wet season
- lowland sandy creekbeds; 1979 Mid-dry season
- corridor sandy billabong; 1979 Late-wet–Early-dry season

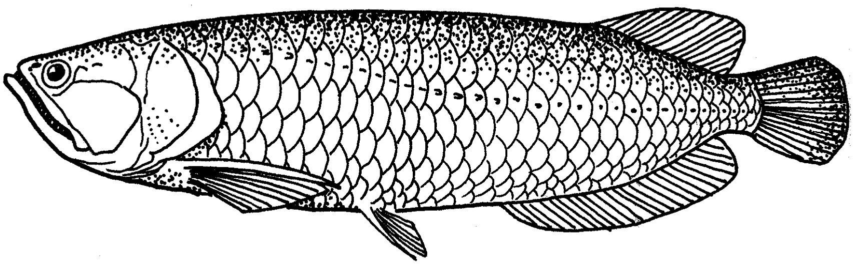
**Nourlangie catchment**

- lowland shallow backflow billabong; 1978 Late-dry season
- escarpment mainchannel waterbody; 1978 Late-dry season

# Family OSTEOGLOSSIDAE

## 3.4 *Scleropages jardinii* (Saville-Kent)

*Scleropages jardinii*, commonly known as the northern spotted barramundi or saratoga, is a primary division or true freshwater fish (Darlington 1957) belonging to a family that dates back to Eocene times (50 million years BP). Several genera of this group occur in the Indo-Malayan area, Brazil and in the Nile. It had previously been regarded as a subspecies of *S. leichardti* (Castelnau) which is found in the Fitzroy River system in eastern Queensland.



*Scleropages jardinii*

*Scleropages jardinii* is found in the Gulf of Carpentaria and Timor Sea drainage divisions (see map 3).[39] Pollard (1974) found this species in still-water billabongs and larger waterholes, and occasionally in the main channels of rivers in the Alligator Rivers Region. It appeared to be more plentiful in upstream areas of clean water in escarpment country bordering the Arnhem Land Plateau, where it lurks by day under overhanging vegetation and other cover. This species was not captured during Miller's survey in the Oenpelli area (Taylor 1964). It is also found in some southward-flowing rivers in Papua New Guinea.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was collected (but rarely) in all escarpment perennial streams and mainchannel waterbodies, corridor waterbodies, some floodplain billabongs, backflow billabongs and lowland sandy creekbeds.

### Size composition

#### Length–weight relationship

The lengths and weights of 16 specimens were determined. The length–weight relationship was described by the expression:[40]

$$W = 0.21 \times 10^{-2} L^{3.40} \qquad r = 0.99 \text{ (length in cm, weight in g)}$$

39 Herbert and Peeters (1995) and Herbert et al (1995) indicated they are also found within some eastern-flowing Cape York Peninsula streams (Olive River and Harmer Creek) within the north-east coastal division.

40 Length-weight relationships given by Merrick et al (1983) for *S. jardinii* and the closely related *S. leichardti* were as follows (W= weight in g; L= total length in mm):

*S. jardinii*:

Females: $W = 3.357 \times 10^{-6} \times L^{3.175}$

Males: $W = 3.133 \times 10^{-6} \times L^{3.175}$

*S. leichardti*:

Females: $W = 5.649 \times 10^{-7} \times L^{3.432}$

Males: $W = 5.272 \times 10^{-6} \times L^{3.432}$

Seasonal mean lengths, weights and condition factors are shown in table 13. As the sample size was small, little can be said about seasonal changes in condition factors other than that the highest was recorded late in the 1978 Late-dry season and the lowest in the 1979–80 Early-wet season. (See table 14 for data on individual fish.)

**Table 13** Mean length, mean weight and condition factor of *S. jardinii*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| Late-dry (1978) | 6 | 507.0 | 1382.2 | 1.08 |
| Mid-wet (1978–79) | 1 | 380.9 | 429.8 | 0.89 |
| Late-wet–Early-dry (1979) | 2 | 323.9 | 283.8 | 1.02 |
| Mid-dry | 4 | 444.1 | 772.3 | 0.95 |
| Late-dry | 2 | 485.0 | 1096.5 | 1.00 |
| Early-wet (1979–80) | 1 | 515.2 | 1164.9 | 0.86 |
| Overall | 16 | 453.5 | 876.2 | 1.00 |

### Length-frequency distribution

Specimens ranged in length from 198 mm to 690 mm TL (fig 12). Lake (1971) reported that both *S. jardinii* and the closely related *S. leichardti* grow to around 900 mm.

The smallest specimen was captured by seine net in the Late-wet–Early-dry season. The largest specimens were captured by gillnet (150 mm mesh) in the Mid-dry. Specimens up to 800 mm in length were observed in escarpment mainchannel waterbodies and perennial streams; such specimens may have struggled free from enmeshing gillnets in the lower reaches.

Most fish captured were either 420 to 440 mm or 500 to 530 mm in length. If *S. jardinii* matures sexually at around the same size as *S. leichardti* (ie 560 mm, Lake & Midgley 1970b), then most of the specimens captured in the study were large juveniles.

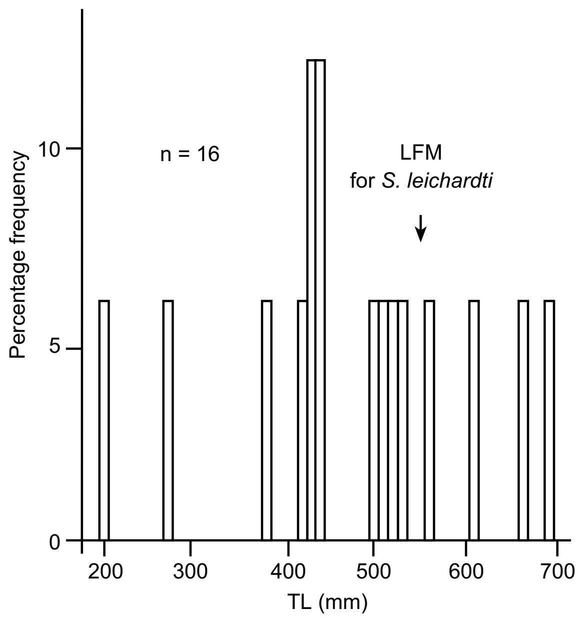



**Figure 12** Length-frequency distribution of all *S. jardinii* captured

### Seasonal changes in distribution

The smallest specimen was captured in the Late-wet–Early-dry season; the second smallest specimen and the largest specimen were both captured in the Mid-dry season.

### Growth rate

No estimate of the growth rate of *S. jardinii* could be made, as only 16 fish were captured during the study. There is no published information on its growth rate, but the closely related *S. leichardti* grows to 270, 430 and 560 mm TL at one, two and three years old respectively (Lake & Midgley 1970a).

### Habitat differences in distribution

In the Magela catchment the few small juveniles captured were found in lowland shallow billabongs. Larger juveniles were found in escarpment mainchannel waterbodies and perennial streams, and corridor and floodplain billabongs. Adults were captured only in floodplain billabongs but were observed in escarpment mainchannel waterbodies and perennial streams.

In the Nourlangie catchment the few specimens that were captured were in escarpment habitats. Juveniles and adults of all sizes were frequently seen in escarpment mainchannel waterbodies.

## Environmental associations

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

### Physico–chemical variables

*Temperature*

This species was captured in waters with surface temperatures from 23° to 33°C (mean = 28.2°C) and bottom temperatures from 23° to 31°C (mean = 27.3°C). It was placed at the base of the lowest quarter for both surface and bottom temperatures (see fig 170).

*Scleropages jardinii* is reported to require temperatures above 15°C for survival, and temperature may be a limiting factor in its distribution (Pollard 1974). *Scleropages leichardti* tolerates lower temperatures (range 7–40°C, Lake 1971).[41]

*Scleropages leichardti* spawns only above 23°C (Lake & Midgley 1970b). As this was the lowest temperature recorded in the Alligator Rivers Region, the temperature at which *S. jardinii* spawns may be somewhat higher.

*Dissolved oxygen*

Dissolved oxygen concentrations in waters in which this species was captured ranged from 3.0 to 6.8 mg/L (mean = 5.8) for surface waters and from 1.7 to 6.8 mg/L (mean = 3.8) for bottom waters. *Scleropages jardinii* was placed in the lower-middle quarter for both means (see fig 171).[42]

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41 Merrick and Green (1982) indicated that as surface water temperatures reach 31°C, *S. leichardti* cease cruising on the surface and remain in deeper cooler areas.

42 Merrick and Schmida (1984) indicated that *S. jardinii* was a suspected facultative air breather. However, Wells et al (1997) stated, without citations, that *S. jardinii* is not an air breather. Wells et al showed that the saratoga has fewer erythrocytes, lower haemoglobin concentration and hence lower oxygen carrying capacity, and higher blood oxygen affinity than either the facultative air breathing tarpon, or the obligate water breathing silver barramundi (*Lates calcarifer*). Herbert and Peeters (1995) indicated that northern saratoga are tolerant of low oxygen levels and are suspected to use their swim bladders as auxiliary lungs.

Lake and Midgley (1970b) noted that, under conditions of thermal stratification and oxygen depletion in the Dawson River, Queensland, *S. leichardti* remained in the top one metre of water and could be seen just under or breaking the surface to obtain oxygen.

*Visibility*

Secchi depths recorded at sites in which this species was captured ranged from 4 to 360 cm (mean = 130 cm). *Scleropages jardinii* was therefore ranked in the highest (greatest visibility) quarter (see fig 172). Lake (1971) noted that the closely related *S. leichardti* can also tolerate highly turbid waters with Secchi depths as low as 3.8 cm.[43]

*pH*

At sites where *S. jardinii* were observed or collected, the pH of surface waters ranged from 4.1 to 6.8 (mean = 5.9), and that of bottom waters from 4.5 to 6.5 (mean = 5.8). The species was placed in the lowest quarter for both waters (see fig 173).

*Conductivity*

Conductivities at sites where *S. jardinii* were captured were generally very low: from 6 to 80 µS/cm for surface waters and from 6 to 58 µS/cm for bottom waters.

*Scleropages jardinii* is a primary division freshwater fish. It has not been tested for salinity tolerance. The only osteoglossid that has been tested is the South-East Asian species *Scleropages formosus* (Muller & Schlegel); Roberts (1978) concluded that it may be more tolerant of salinity than might be expected for a primary division freshwater fish.

### Habitat–structural variables

*Substrate*

*Scleropages jardinii* was found most frequently over sandy substrates, followed by boulders/bedrock, rocks, clay and mud. The ranked positions for this species for sand, boulders and rocks were the highest quarters; for clay the lower-middle; for mud the lowest quarter (see fig 174). Lake (1971) reported that *S. jardinii* was frequently captured over clay substrates.

*Hydrophytes*

*Scleropages jardinii* was typically found in vegetated habitats (vegetation-occurrence index 62.2%).[44] The main hydrophyte types were submergent (44.7%) and floating-attached forms (28.9%). Lake (1971) records that this species was most frequently caught in billabongs with abundant water lilies.

## Reproduction

Of the 16 fish captured, one (265 mm TL) was not dissected. Of the others, 7 were female (420–560 mm TL), 3 were male (440–660 mm TL) and 5 were sexually indistinguishable (198–690 mm TL). Table 14 gives the site and season of capture, and the length, weight and reproductive condition of these 16 fish.

### Length at first maturity

The small number of fish captured did not provide enough information to estimate the LFM; however, the smallest maturing fish captured was 435 mm TL. *Scleropages leichardti* can spawn at three years of age (about 560 mm) in the Fitzroy River system, but most do not spawn until four years old (Lake & Midgley 1970b).

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43 Higher turbidity for *S. leichardti* was considered desirable by Merrick and Green (1982) as it was considered to enable individuals to move into preferred cooler areas at depths unlikely to become deficient in oxygen.

44 Allen (1991) indicated that *S. jardinii* is frequently seen near the surface or near shore among aquatic vegetation in Papua New Guinea.

**Table 14** Site and season of capture, and length, weight and reproductive condition of *S. jardinii*

| Sampling period | Site | TL (mm) | Wt (g) | Gonad stage | Gonad wt (g) | GSI |
|---|---|---|---|---|---|---|
| **Females** | | | | | | |
| Late-dry 1978 | Corridor billabong | 435 | 785 | IV | – | – |
| " | Corridor billabong | 510 | 1550 | V | 46.6 | 2.98 |
| Mid-wet 1978–79 | Sandy creekbed | 515 | 1165 | III | 9.0 | 0.78 |
| Late-wet 1978–79 | Corridor billabong | 530 | 1550 | IV | 10.8 | 0.70 |
| Mid-dry 1979 | Floodplain billabong | 495 | 1130 | III | 5.2 | 0.46 |
| Late-dry 1979 | Mainchannel waterbody | 420 | 633 | III | 3.8 | 0.61 |
| " | Floodplain billabong | 560 | 1900 | IV | 70.3 | 3.70 |
| **Males** | | | | | | |
| Late-dry 1978 | Corridor billabong | 610 | 2100 | II | 0.8 | 0.04 |
| " | Mainchannel waterbody | 440 | 800 | IV | 10.1 | 1.26 |
| " | Perennial stream | 660 | 3900 | II | 0.9 | 0.02 |
| **Reference collection** | | | | | | |
| Mid-dry 1979 | Backflow billabong | 265 | 140 | | | |
| **Juveniles** | | | | | | |
| Late-dry 1978 | Perennial stream | 432 | 875 | I | 0.5 | 0.6 |
| Mid-wet 1978–79 | Mainchannel waterbody | 381 | 430 | I | – | – |
| Late-wet 1978–79 | Backflow billabong | 198 | 52 | I | 0.001 | 0.02 |
| Mid-dry 1979 | Corridor billabong | 430 | 750 | I | 0.14 | 0.19 |
| " | Corridor billabong | 690 | 3000 | I | 0.4 | 0.13 |

### Sex ratio

Seven females were captured from seven sites over five seasons, while three males were captured from three sites in one season (1978 Late-dry). There may be more females present in the population in all seasons; however, the sample is too small to draw conclusions.

### Breeding season

Sexually maturing fish were captured during the 1978 and 1979 Late-dry and the 1979 Late-wet–Early-dry seasons. The GSI values suggested an error in the gonad staging of the Late-wet–Early-dry season specimen. Although the data are sparse, they indicate that spawning may have occurred during the Early-wet season (when no fish were captured).

Midgley (pers comm) states that *S. jardinii* breeds from October to November.[45] *Scleropages leichardti* breeds in spring when temperatures rise above 23°C (Lake & Midgley 1970b; Lake 1971).

### Site of spawning

As no ripe or spent fish, or females incubating eggs in their mouths, were captured, no spawning site could be identified; however, maturing fish were found in corridor and floodplain billabongs and in an escarpment mainchannel waterbody. Lake and Midgley (1970b) found that *S. leichardti* can breed in small, shallow, turbid pools as well as in rivers.

45 Herbert and Peeters (1995) indicated the breeding season extends from September to November.

**Fecundity**

*Scleropages jardinii* has a single, naked ovary with eggs generally developing on the left side of the body cavity. A preserved ovary examined contained two size-classes of eggs with mean diameters of 8.4 ± 0.3 mm ($n$ = 90) and 1.7 ± 0.78 mm ($n$ = 10). Ten eggs from a fresh ovary were measured; the mean diameter was 10.5 mm. The mature ova of *S. leichardti* have a similar mean diameter (10 mm) and fecundity (range 75 to 173) (Lake & Midgley 1970b).[46]

**Summary**

The data, although sparse, indicate that *S. jardinii* and *S. leichardti* have similar reproductive strategies. *Scleropages jardinii* may spawn in the Early-wet season, most likely in corridor and floodplain billabongs and escarpment mainchannel waterbodies. A small number of large eggs develop in the single, naked ovary and the female carries the eggs and larvae in her mouth until absorption of the yolk sac (Sanderson, pers comm). The eggs of *S. leichardti* take an estimated 10–14 days to hatch at water temperatures between 23 and 30°C; the larvae are well developed at hatching and average 36 mm total length. No external sexual dimorphism is evident, although mature males have been found with fine scratch marks over the operculars and along the sides of the body. Lake and Midgley (1970b) suggested that these scratches were inflicted by teeth during the spawning period; scratches have been observed around the vent area of the body of females (about two years old) .

## Feeding habits

The stomach contents of 14 specimens were examined; all stomachs contained food. A summary of the overall diet of *S. jardinii* is given in fig 13; the components are detailed in table 15.

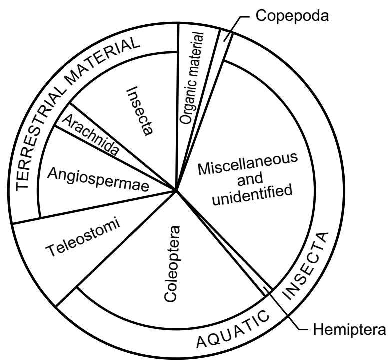



**Figure 13** The main components of the diet of *S. jardinii*

The main dietary items were aquatic insects (54%), terrestrial insects (12%), terrestrial plant material (10%) and teleosts (9%).[47] The identifiable aquatic insects were mainly *Macrogyrus* coleopteran adults. The identifiable terrestrial insects also were mainly coleopterans, with traces of zygopteran adults. The terrestrial plant material may have been eaten incidentally when *S. jardinii* was preying upon forage species. The main identifiable teleost was

46 Herbert and Peeters (1995) indicated that female *S. jardinii* incubate 30–130 fertilised eggs in their mouths for one to two weeks. Newly hatched larvae continue to reside in or around the mouth for a further four to five weeks.

47 Smith (1998) indicated that in the Fly River system of Papua New Guinea, *S. jardinii* primarily consumed terrestrial insects, fish, aquatic insects, detritus/mud, and crustaceans in that order. Other vertebrates, aquatic and terrestrial plants and worms were also consumed.

*N. hyrtlii*. Traces of *Macrobrachium* and terrestrial arachnids were also found in the stomachs. *Scleropages jardinii* can therefore be classified as a macrophagous carnivore/insectivore that feeds opportunistically in mid- and surface waters.

Pollard (1974) noted that this species was predatory, mainly feeding on crustaceans, smaller fishes and frogs, but also to some extent on insects; he appears to have underestimated the importance of insects in the diet. Lake (1978) considered this species ate more fish and crustaceans than the spotted barramundi (*S. leichardti*) of eastern Queensland.

**Table 15** Dietary composition of *S. jardinii*

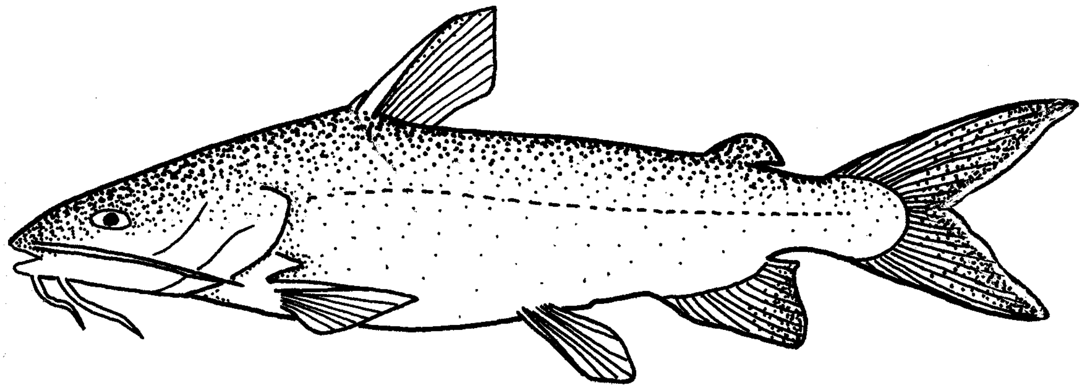
| Stomach contents | % Composition | |
|---|---|---|
| | Sub-mean | Main-mean |
| **Aquatic animals** | | |
| Macrocrustacea | | 1.4 |
| *Macrobrachium* | 1.4 | |
| Insecta | | 53.5 |
| Fragmented | 30.0 | |
| Hemiptera | | |
| Naucoridae | 1.4 | |
| Coleoptera | | |
| Fragmented | 2.1 | |
| *Macrogyrus* | 20.0 | |
| Teleostomi | | 8.9 |
| Fragmented | 1.4 | |
| Fish scales | 0.4 | |
| *N. hyrtlii* | 7.1 | |
| **Terrestrial plants** | | |
| Angiospermae | | 9.7 |
| Fragmented | 9.7 | |
| **Terrestrial animals** | | |
| Arachnida | | 2.9 |
| Fragmented | 2.9 | |
| Insecta | | 11.7 |
| Fragmented | 7.1 | |
| Odonata | | |
| Zygopteran (adults) | + | |
| Coleoptera | | |
| Fragmented | 4.6 | |
| **Parasites** | | |
| Nematoda | 8.2 | 8.2 |
| Organic material | 3.6 | 3.6 |
| Number of empty fish | – | – |
| Number of fish with food | 14 | 14 |

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

# Family ARIIDAE[48]

## 3.5 *Arius leptaspis* (Bleeker)

*Arius leptaspis* is commonly known as the lesser salmon catfish or fork-tailed catfish. It (or closely related species) is found in coastal drainages of northern Australia from northern New South Wales through Queensland and the Northern Territory to the far west of Western Australia. Pollard (1974) found this species in floodplain and channel backflow billabongs of the Alligator Rivers Region. It is also found in Papua New Guinea.



*Arius leptaspis*

*Arius leptaspis* belongs to a predominantly marine family of catfishes, members of which are often caught in brackish waters, especially in river estuaries.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was common to moderately abundant in all floodplain and corridor waterbodies and in most backflow billabongs; it was found only occasionally in escarpment mainchannel waterbodies and lowland sandy creekbeds. It was found in the greatest number of sites in the 1978 Late-dry season (mainly floodplain and corridor waterbodies and escarpment mainchannel billabongs), and was found least often in the Mid-wet (lowland sandy creekbeds and backflow billabongs) and the Late-wet–Early-dry seasons.

### Size composition

The lengths and weights of 740 specimens were determined. Most specimens were captured in gillnets, so the number of adults may be underestimated, as larger specimens could have struggled free of the nets. Some of the peaks in the length-frequency distribution may be due to mesh selectivity.

#### Length–weight relationship

The length–weight relationship was described by the expression:

$$W = 1.46 \times 10^{-2} L^{3.1} \qquad r = 0.98 \text{ (length in cm, weight in g)}$$

48 An additional species of ariid catfish, the shovel-nosed catfish (*Arius midgleyi*), was recorded in the region in May 1988.

Tait (1979) found that the length–weight equations for males and females captured in Magela Creek floodplain habitats were not significantly different.

Seasonal mean lengths, weights and condition factors are shown in table 16. Condition went down after the 1978 Late-dry season to reach a low during the 1978–79 Early-wet season; this change may have been a result of spawning activity in the former season and buccal incubation of eggs by males during the latter season. During the Mid-wet season, condition improved to reach a peak by the 1979 Mid-dry season. The condition factor then fell to a level close to that of the same season in 1978. During the 1979–80 Early-wet season, condition fell to its lowest level, possibly as a result of spawning or the severe 1979 Dry season, or both.

**Table 16** Mean length, mean weight and condition factor of *A. leptaspis*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| Late-dry (1978) | 129 | 328.7 | 754.9 | 1.04 |
| Early-wet (1978–79) | 211 | 336.6 | 704.5 | 0.91 |
| Mid-wet | 66 | 362.5 | 975.8 | 1.00 |
| Late-wet–Early-dry (1979) | 78 | 253.0 | 335.0 | 1.04 |
| Mid-dry | 139 | 281.2 | 492.4 | 1.10 |
| Late-dry | 89 | 325.6 | 711.9 | 1.02 |
| Early-wet (1979–80) | 12 | 317.6 | 532.8 | 0.82 |
| Overall | 724 | 314.5 | 631.0 | 1.00 |

#### Length-frequency distribution

The smallest specimen captured was 108 mm LCF; the largest was 600 mm LCF (fig 14). This (or a closely related) species is reputed to grow to a length of 1000 mm and weight of over 10 kg (Pollard 1974).

The mean length of all specimens was 314 mm LCF and the modal length was 330 mm LCF. The length at first sexual maturity (LFM) was 270 mm for males and 300 mm for females, so most of the fish captured were adults. Few juveniles were sampled, possibly due to mesh, site or time selectivity — or all three. Specimens up to 60 mm LCF have been found in the mouths of adult males. Most of the specimens captured were small adults (the main peak had a modal value of 330 mm).

#### Seasonal changes in distribution

A few small juveniles (less than 130 mm LCF) first appeared in the samples during the Mid-wet season. They increased in number during the following Late-wet–Early-dry and Mid-dry seasons (fig 15).

During the Early-wet seasons the smallest fish captured were about 200 mm LCF. The largest fish were captured during the Early-wet seasons and the 1978 Late-dry season.

The seasonal mean lengths of all specimens captured are shown in table 16.

The mean lengths gradually increased from the 1978 Late-dry season to peak in the 1978–79 Mid-wet season. The mean lengths then fell to their lowest during the Late-wet–Early-dry season when juveniles were recruited into the populations. They gradually increased again until the 1979 Late-dry season and then fell slightly in the 1979–80 Early-wet season (in contrast to the same season the previous year).

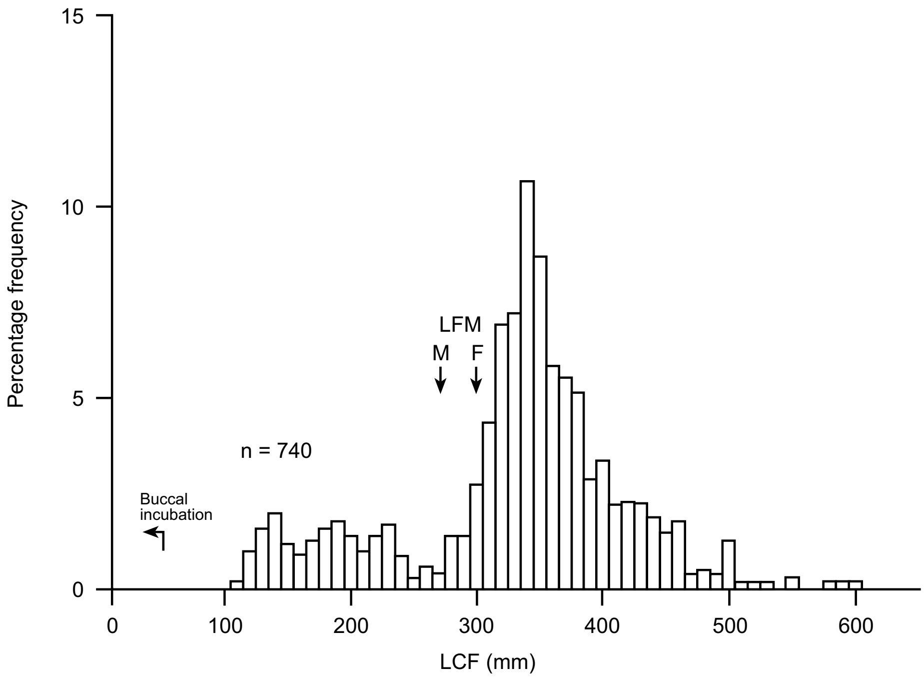



**Figure 14** Length-frequency distribution of all *A. leptaspis* captured

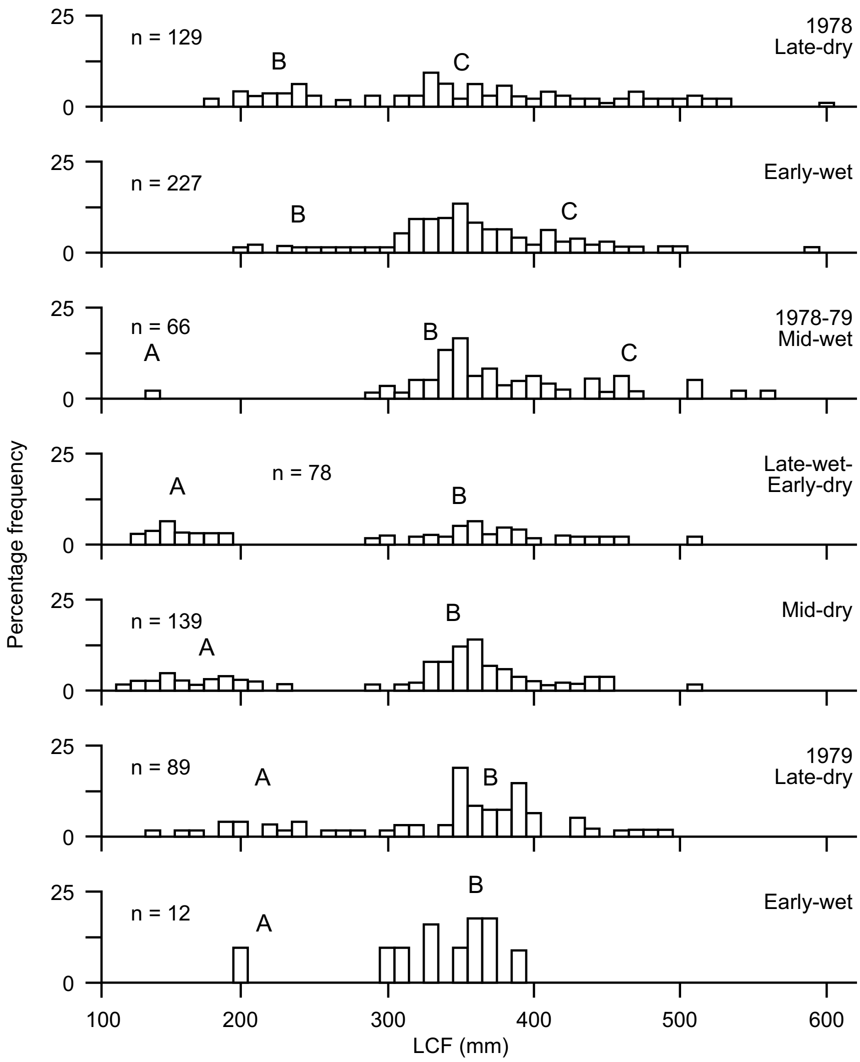



**Figure 15** Seasonal length-frequency distribution of all *A. leptaspis* captured

A near-continuous size-range of specimens was captured during the 1978 Late-dry season, with peaks in the numbers of larger juveniles and small adults; there were few specimens with lengths around the LFM in the population. During the 1978–79 Early-wet season the length-frequency distribution was similar, though with fewer of the larger juveniles. Very few large adults were found in these seasons.

By the Mid-wet season there were virtually no large juveniles in the population, which consisted mainly of smaller adults. Growth was also apparent in larger adults, and the first juvenile recruits appeared during this season. The small juvenile component increased by the Late-wet–Early-dry season while the length-frequency of adults remained essentially unchanged. By the 1979 Mid-dry season the juvenile component was reinforced by larger-sized specimens; small adults dominated the population and only a few large adults were present. The gap between the juveniles spawned in the 1978–79 Early-wet season and the small adults closed during the 1979 Late-dry season (as in the 1978 season) as a nearly continuous size-range of specimens was captured; small to medium-sized adults dominated the population. Juveniles appeared to be more common during the 1979 Late-dry season than the 1978 Late-dry season. In the small sample captured in the 1979–80 Early-wet season, most were small adults; only a few were juveniles.

### Growth rate

There is no published information on the growth of *A. leptaspis*. Tait (1979) distinguished five age classes in samples collected from the Magela Creek flood plain during June 1979. Estimation of growth rates from the seasonal length-frequency distributions is difficult due to mesh selectivity, the times at which the juveniles were recruited, and the variety of habitats examined.

The growth rate of small juveniles spawned in the 1978–79 Early-wet season can be tentatively followed by examining the progression of this size group (A in fig 15). The same may apply for juveniles spawned in the 1977–78 and 1976–77 Early-wet seasons (B and C, respectively, in fig 15). The growth rate appeared to be fastest over the Wet season and specimens had attained 120–190 mm LCF by the Late-wet–Early-dry season (about 5 months later). By the 1979 Late-dry season most specimens could be considered to be large juveniles (190–250 mm LCF) and a few specimens may have attained the LFM. Most recruits may be ready to spawn by the end of their second year.

### Habitat differences in distribution

#### *Magela catchment*

Length-frequency distributions showing habitat preferences of *A. leptaspis* captured in regular sampling sites in the Magela Creek catchment are shown in fig 16.

The smallest juveniles were found in backflow billabongs. The medium-sized juveniles were found most often in floodplain billabongs and, to a lesser extent, in backflow billabongs. The larger juveniles were found more often in corridor and backflow billabongs than in the floodplain billabongs.

The smaller adults were found mainly in floodplain billabongs and, to a lesser extent, in corridor and backflow billabongs. Only a few small adults were found in escarpment mainchannel waterbodies and lowland sandy creekbeds. The largest adults were found in floodplain and channel backflow billabongs. The presence of the smallest adults in corridor waterbodies indicates that these billabongs are used as migration routes before the spawning season.

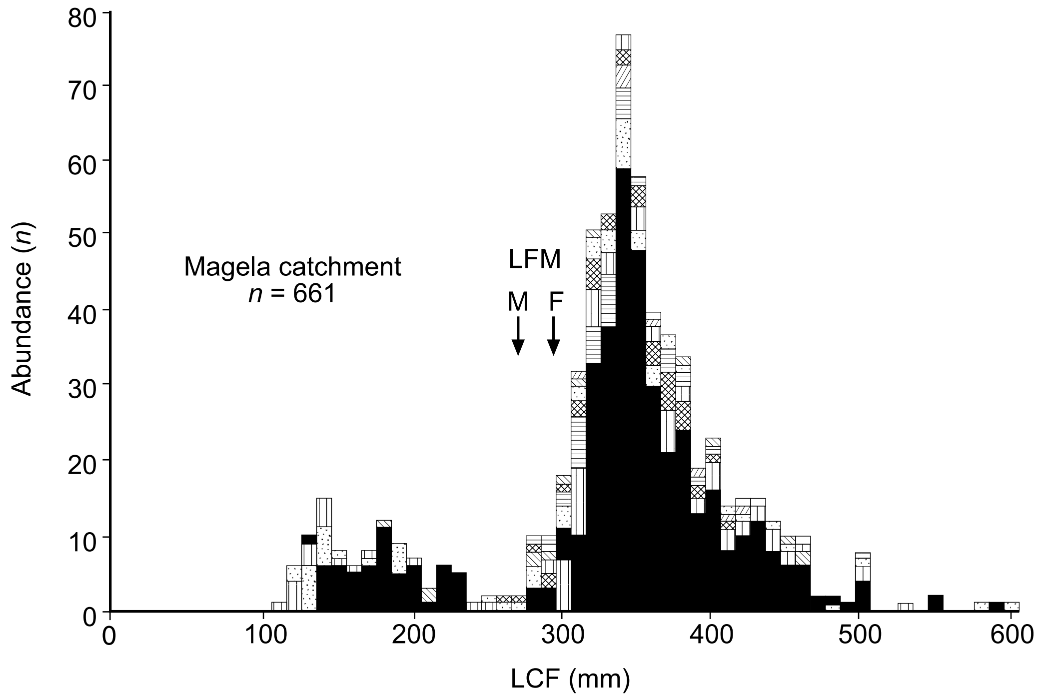



**Figure 16** Length-frequency distributions and habitat preferences of *A. leptaspis* captured at regular sampling sites in the Magela catchment (see appendix 5 for key to the habitats)

*Nourlangie catchment*

Few specimens were found in the Nourlangie catchment. Adults were found in escarpment mainchannel waterbodies and perennial streams as well as in lowland habitats in this system.

## Environmental associations

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

### Physico–chemical variables

*Temperature*

This species was captured at water temperatures ranging on the surface from 26° to 34°C (mean = 30.3°C) and on the bottom from 23° to 32°C (mean = 28.3°C). *Arius leptaspis* was placed in the lower-middle quarters for both waters (see fig 170).

This (or a closely related) species is found in cool temperate waters as far south as the Hunter River in New South Wales.

*Dissolved oxygen*

Dissolved oxygen concentrations in waters in which this species was captured ranged from 0.1 to 9.7 mg/L (mean = 5.8) for surface waters and from 0.2 to 7.4 mg/L (mean = 2.9) for bottom waters. Specimens captured in almost anoxic waters were usually very inactive when handled and had apparently not been feeding. *Arius leptaspis* was ranked in the lower-middle and lowest quarters for surface and bottom waters respectively (see fig 171).

This species was present in a fish kill in Leichhardt Billabong when surface DO levels fell to 0.1 mg/L during the 1978–79 Early-wet season (Bishop 1980).

*Visibility*
Secchi depths recorded at sites in which this species was captured ranged from 1 to 360 cm; ie from the clearest to the most turbid waters. The mean Secchi depth was 76 cm, and *A. leptaspis* was ranked in the upper-middle quarter (see fig 172).

*pH*
The pH of surface waters ranged from 4.8 to 9.1 (mean = 6.1) and of bottom waters from 4.3 to 7.1, (mean = 5.8). *Arius leptaspis* ranked in the lower-middle and lowest quarters for this parameter (see fig 173).

*Conductivity*
Surface and bottom conductivities ranged from 2 to 750 µS/cm and from 4 to 478 µS/cm respectively.

Pollard (1974) noted that this fish belongs to a predominantly marine family and it and its close relatives are often captured in brackish or marine (35 ppt salinity) waters.

**Habitat–structural variables**

*Substrate*
*Arius leptaspis* was found most often over mud and clay substrates, and next often over sand. Only a few specimens were found over other substrates. The ranked positions for mud, clay and sand substrates were in the highest, highest and lowest quarters respectively (see fig 174).

*Hydrophytes*
*Arius leptaspis* was typically found in moderately vegetated waters (vegetation-occurrence index 79.5%). The main hydrophyte types were submergent (44.6%), floating-attached (25.3%) and emergent (24%) forms.

## Reproduction

The gonads of 721 specimens were examined, resulting in the identification of 364 females (length range 190–600 mm LCF) and 273 males (length range 118–460 mm LCF), with 84 fish being sexually indistinguishable. Males were generally smaller than females.

**Length at first maturity**

The LFM (fig 17) was 270 mm LCF for males and 300 mm for females; however, a few precocious males (240 and 187 mm LCF) and females (270 and 290 mm LCF) were also maturing.

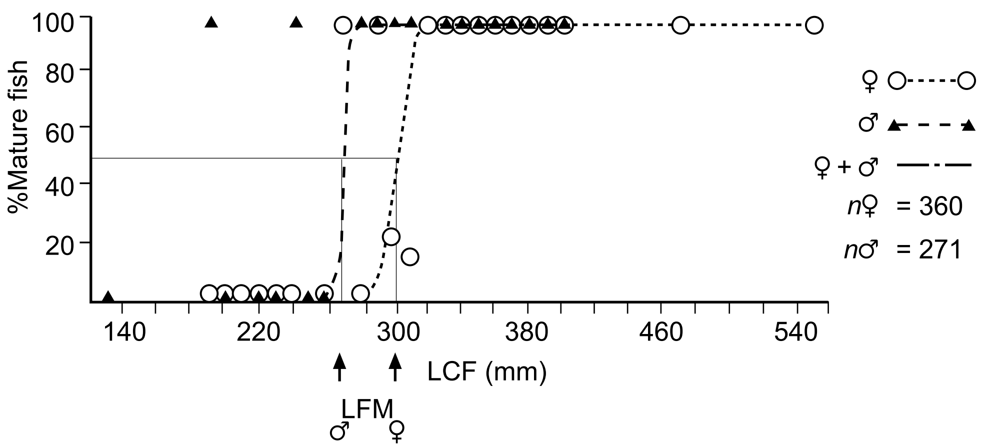



**Figure 17** Estimated length at first maturity (LFM) of male and female *A. leptaspis*

### Sex ratio

There were significantly (P < 0.001) more females in both the entire sample and among the adult fish during the 1978 Late-dry season (table 17). This may reflect our initial difficulty in differentiating between immature and male gonads even in the larger fish, thus reducing the number of males recorded in this season. The sex ratio of adult fish was 1:1 during all other seasons; however, in total samples there were significantly (P < 0.05) more females during the 1978–79 Mid-wet season and significantly (P < 0.05) more males during the 1979 Mid-dry season. This could reflect a true situation (due to movement or behaviour), a sampling bias, or a bias in sexual determination.

**Table 17** Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI), over all habitats and the percentage frequency of spent (stage VII) *A. leptaspis* captured

| 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* | 91 | 111 | 41 | 28 | 42 | 44 | 7 |
| adults | M | *n* | 21 | 92 | 24 | 19 | 72 | 40 | 5 |
| | | $\chi^2$ | 43.75 | 1.78 | 4.45 | 1.72 | 7.89 | 0.19 | 0.33 |
| | | P | *** | n.s. | * | n.s. | ** | n.s. | n.s. |
| Adults only | F | *n* | 74 | 105 | 40 | 27 | 42 | 41 | 7 |
| | M | *n* | 15 | 86 | 24 | 19 | 57 | 30 | 4 |
| | | $\chi^2$ | 39.11 | 1.89 | 2.0 | 1.39 | 2.0 | 2.05 | 0.82 |
| | | P | *** | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| **GSI** | | | | | | | | | |
| Adults only | F | mean | 1.9 | 3.0 | 0.3 | 0.3 | 0.5 | 4.3 | 1.3 |
| | | s.d. | 2.7 | 2.0 | 0.1 | 0.1 | 0.07 | 2.6 | 0.9 |
| | M | mean | 0.06 | 0.08 | 0.01 | 0.01 | 0.001 | 0.01 | 0.01 |
| | | s.d. | 0.05 | 0.04 | 0.03 | 0.04 | 0.04 | 0.1 | 0.0 |
| | F+M | mean | 1.4 | 1.6 | 0.2 | 0.2 | 0.2 | 2.4 | 0.9 |
| | | s.d. | 2.4 | 2.0 | 0.2 | 0.2 | 0.3 | 2.9 | 1.1 |
| **GMSI** | | | | | | | | | |
| Adults only | F | mean | 2.90 | 3.0 | 2.0 | 2.0 | 2.7 | 3.9 | 2.5 |
| | | s.d. | 1.24 | 0.82 | 0.0 | 0.1 | 0.3 | 0.8 | 1.0 |
| | M | mean | 2.00 | 3.9 | 2.0 | 1.9 | 2.1 | 4.0 | 2.3 |
| | | s.d. | 0.9 | 0.8 | 0.0 | 0.2 | 0.7 | 1.0 | 0.6 |
| | F+M | mean | 2.7 | 3.4 | 2.0 | 2.0 | 2.4 | 3.9 | 2.4 |
| | | s.d | 1.2 | 0.9 | 0.0 | 0.2 | 0.6 | 0.9 | 0.8 |
| **Spent fish** | F | % | 8 | 38 | 98 | 52 | 2 | 2 | 86 |
| (stage VII) | M | % | 0 | 67 | 83 | 68 | 2 | 3 | 50 |

*n* = number; $\chi^2$ = 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.

**Breeding season**

Seasonal GSI (fig 18) indicated that reproductive activity peaked during the 1978–79 Early-wet and 1979 Late-dry seasons. While females showed significant changes in GSI at the peaks, the GSI of the males hardly varied throughout the year. The testes were elongated, roundish straps and, apart from a slightly swollen appearance and the presence of liquid internally, their appearance did not change appreciably throughout the year.

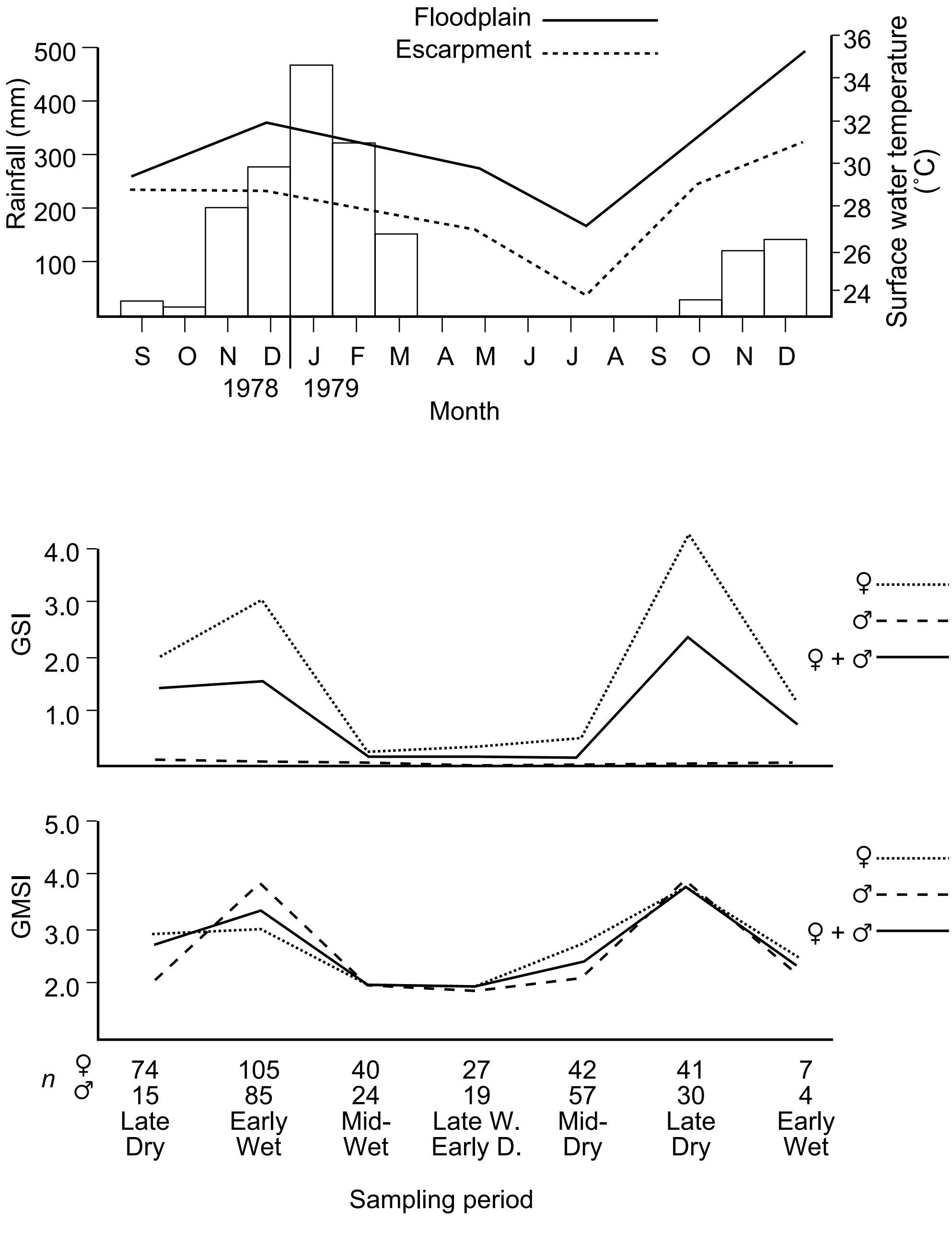



**Figure 18** Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *A. leptaspis*

Adult male fish were found incubating eggs in their mouths during the 1978–79 Early-wet (27 fish, 31%), 1979 Late-wet–Early-dry (1 fish, 2%), and the 1979–80 Early-wet (1 fish, 25%) seasons. Therefore the fish probably spawn during the Early-wet. Although the GSI was high during the 1979 Late-dry season, no eggs and only a few spent fish were found, which indicates that spawning was limited.

The single record of eggs being incubated during the 1979 Late-wet–Early-dry season may have been a result of a late spawning — the embryos were at the free-swimming/yolk-sac resorption stage.

*Arius leptaspis* exhibits seasonal reproduction (as also recorded by Roberts 1978), spawning around the Early-wet season (table 17) before the main floods. The spawning period may be quite extended and the spent gonads may have a long recovery period; thus, spent fish were present throughout the year (table 17).

Lake (1978) found *A. leptaspis* breeding when water temperatures were over 26°C.

### Site of spawning

Mature, ripe or spent fish, or fish buccally incubating eggs, were found in almost all habitats where *A. leptaspis* was caught in the Magela Creek system (table 18). Although the main concentration of apparently spawning fish was in floodplain billabongs, corridor waterbodies and backflow billabongs (where the highest catches of *A. leptaspis* were recorded), spawning may also have taken place in the higher reaches of the river system where few fish were captured. Spent fish were present in an escarpment mainchannel waterbody (Sawcut Gorge) in the South Alligator system, and in a sandy creekbed in the escarpment area of Magela Creek.

Although sampled infrequently, the East Alligator lower floodplain billabongs also appeared to be spawning areas for this species; both spent fish, and fish incubating eggs, were captured in Cannon Hill Billabong.

**Table 18** Possible sites of spawning of *A. leptaspis,* as indicated by the abundance of mature, ripe and spent fish and fish incubating eggs

| | Gonad stage | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mature (V) | | Ripe (VI) | | Spent (VII) | | Incubating eggs |
| Habitat | F | M | F | M | F | M | M |
| **Escarpment** | | | | | | | |
| Mainchannel waterbody | 2 | – | – | – | 1 | – | – |
| **Lowlands** | | | | | | | |
| Sandy creekbed | 1 | – | – | – | – | 3 | – |
| Backflow billabong | 2 | 2 | 1 | – | 37 | 13 | 6 |
| **Corridor** | 11 | 20 | – | – | 16 | 9 | 3 |
| **Floodplain billabong** | | | | | | | |
| Upper | 9 | 30 | – | 1 | 48 | 21 | 20 |

### Fecundity

Egg counts of 20 ovaries gave a fecundity range of 26–70 large yolky eggs, with an average of 42 eggs per ovary. The oocyte diameters ranged from 11.9 to 15.7 mm with a mean of 13.8 mm ($n$ = 200).[49] A large number of medium-sized eggs (4 mm diam.) were not included in the fecundity estimates, as they were most likely eggs developing for the next breeding season.

49 Data from Coates (1988) suggest that mature egg size is positively correlated to female parent length in five species of ariid catfish studied in the Sepik River of Papua New Guinea.

Eggs found in the buccal cavities of male catfish and eggs swallowed in the stress of capture were also counted, although it was impossible to estimate how many eggs were lost into the water when the parent fish was captured. The number of eggs in the mouths of incubating fish ranged from 1 to 62, although the smallest numbers were obviously remnants of larger clutches. The mean number of eggs was 28 (standard deviation = 17) for 29 clutches. Lake and Midgley (1970a) recorded a 55 cm, 8 kg *A. leptaspis* from the Dawson River, Queensland, carrying in its mouth 123 well-developed eggs with an average oocyte diameter of 14 mm. In the Alligator Rivers Region, the largest fishes carrying eggs were four males measuring 420 mm LCF and weighing between 1.4 and 1.5 kg; they carried between 44 and 62 eggs each. Although the diameters of the fresh eggs were not measured, the preserved oocyte diameter was 14 mm, which is comparable with the Dawson River specimens.

#### Summary

*Arius leptaspis* exhibited external sexual dimorphism. The most obvious differences were the pelvic fins of mature females — which were large and fleshy, particularly in the breeding season — and the generally larger size of the females. Only the males incubated the large yolky eggs in their mouths. *Arius leptaspis* began breeding when the temperatures increased before the onset of the Wet season. They bred mainly in floodplain billabongs, corridor waterbodies and backflow billabongs, where the fish were caught in the greatest numbers.

Well-developed prolarvae hatched after about four weeks' incubation in the buccal cavity of the male; the male holds them either in his mouth or close by until their yolk sacs are resorbed, which takes a further four weeks (Midgley 1980). Plate 1 shows the stages of egg, embryonic and prolarvae development of *A. leptaspis*.[50]

### Feeding habits

#### Overall diet

The stomach contents of 706 specimens were examined; 633 contained food. The overall diet is summarised in fig 19; the components are listed in table 19.

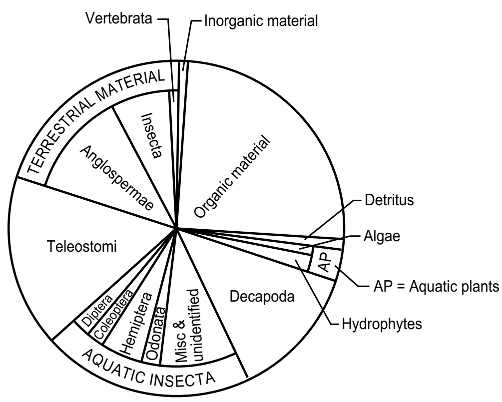



**Figure 19** The main components of the diet of *A. leptaspis*

50 Data from Coates (1988) suggest that embryo size is positively correlated with the length of the male mouth brooding parent in four species of ariid catfish studied in the Sepik River of Papua New Guinea.

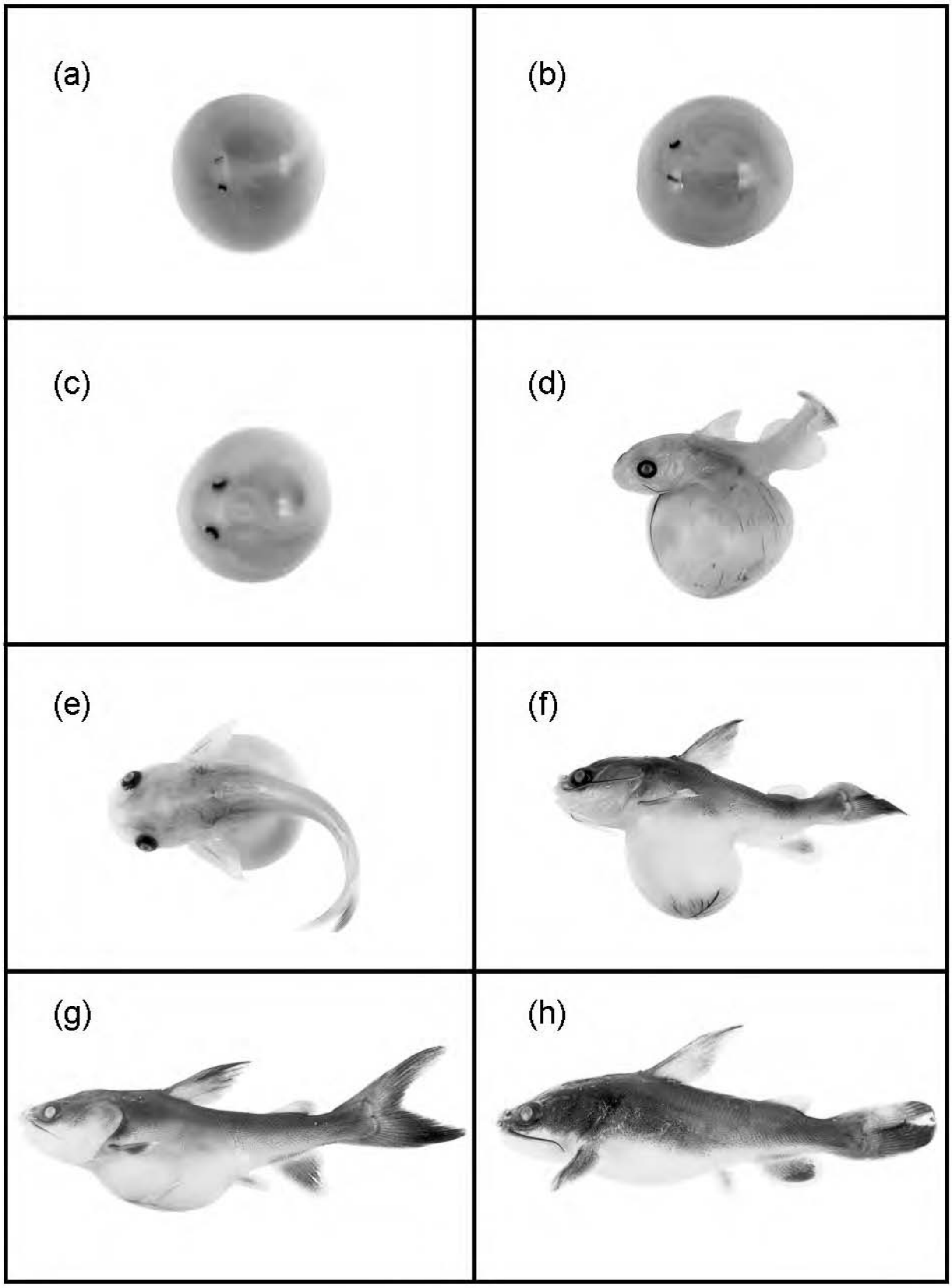



**Plate 1** Stages of egg, embryonic and prolarval development of *A. leptaspis*: (a) Egg from mouth (1.2 cm diam.); (b) 11 days after removal (a.r.) (1.3 cm diam.); (c) 17 days a.r. (1.4 cm diam., 2.4 cm LCF); (d) 23 days a.r. (1.5 cm diam., 2.4 cm LCF; (e) 28 days a.r. (1.5 cm diam., 2.4 cm LCF); (f) 38 days a.r. (4.0 cm LCF); (g) 49 days a.r.(egg sac absorbing, 5.0 cm LCF); (h) 62 days a.r. (6.0 cm LCF)

**Table 19** Dietary composition of *A. leptaspis*

| | Habitat | | | | | | | Season | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magela system | | | | | Nourlangie system | | 1978 | 1978–79 | 1978–79 | 1979 | 1979 | 1979 | 1979–80 | Overall | |
| Stomach contents | Em | Ls | Bb | Cb | Fb | Em | Bb | Late-dry | Early-wet | Mid-wet | Late-wet–Early-dry | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean |
| **Aquatic plants** | | | | | | | | | | | | | | | | |
| Algae | | | | | | | | | | | | | | | | |
| Conjugatophyta | | | | | | | | | | | | | | | | 1.0 |
| Miscellaneous | 2.0 | – | 0.4 | 1.7 | 0.8 | – | – | 3.7 | 0.1 | – | – | 0.2 | 1.6 | – | 1.0 | |
| Hydrophytes | | | | | | | | | | | | | | | | 2.4 |
| *Hymenachne* | – | – | – | – | 0.6 | – | – | – | – | – | – | 1.1 | – | – | 0.2 | |
| *Najas* | – | – | – | – | 0.4 | – | – | – | – | – | – | 0.8 | – | – | 0.2 | |
| *Pseudoraphis* | – | – | 4.4 | 0.2 | 2.2 | – | 2.0 | – | 1.3 | 14.8 | – | 0.9 | – | – | 1.9 | |
| *Vallisneria* | – | – | – | – | – | – | – | 0.7 | – | – | – | – | – | – | 0.1 | |
| **Aquatic animals** | | | | | | | | | | | | | | | | |
| Bivalvia | | | | | | | | | | | | | | | | 0.4 |
| *V. angasi* | – | – | 1.8 | – | – | – | – | – | – | – | – | – | 2.7 | – | 0.4 | |
| Microcrustacea | | | | | | | | | | | | | | | | 0.2 |
| Cladocera | – | – | 0.2 | – | – | – | – | 0.3 | – | – | – | – | – | – | 0.1 | |
| Isopoda | – | – | 0.2 | – | – | – | – | 0.3 | – | – | – | – | – | – | 0.1 | |
| Macrocrustacea | | | | | | | | | | | | | | | | 13.2 |
| *Macrobrachium* adults | 42.0 | – | 9.5 | 12.5 | 8.3 | – | 1.0 | 11.9 | 5.2 | 9.6 | 22.1 | 11.5 | 8.4 | – | 10.2 | |
| Macrobrachium (juveniles) | – | – | – | 0.6 | – | – | – | 0.7 | – | – | – | – | – | – | 0.1 | |
| Parastacidae | | | | | | | | | | | | | | | | |
| Fragmented | – | – | – | 0.1 | – | – | – | 0.7 | 0.1 | – | – | – | – | – | 0.2 | |
| *Euastacoides* | – | – | 0.2 | – | – | – | – | – | 0.1 | 0.1 | – | – | – | – | + | |
| Hymenosomatidae | | | | | | | | | | | | | | | | |
| *P. transversa* | – | 16.9 | 11.3 | – | 0.4 | – | – | – | 3.7 | 10.5 | 8.1 | 0.1 | – | – | 2.7 | |
| **Insecta** | | | | | | | | | | | | | | | | 19.9 |
| Fragmented | 11.0 | 21.3 | 9.8 | 10.2 | 6.7 | 4.0 | 22.0 | 3.5 | 12.1 | 6.9 | 11.3 | 8.3 | 4.8 | 7.3 | 8.0 | |
| Miscellaneous | 2.0 | – | – | 0.1 | + | – | – | 3.7 | – | – | – | – | – | – | 0.7 | |
| Ephemeroptera | | | | | | | | | | | | | | | | |
| Baetidae | – | – | 0.1 | – | – | – | – | – | – | – | – | 0.1 | – | – | + | |
| *Atalophlebia* | – | – | 0.1 | – | – | – | – | – | 0.1 | – | – | – | – | – | + | |
| Odonata | | | | | | | | | | | | | | | | |
| *I. heterosticta* | – | – | – | – | 0.1 | – | – | – | – | – | – | 0.2 | – | – | + | |
| Libellulidae | – | – | 1.1 | 1.0 | 3.0 | – | – | – | – | 5.5 | 1.4 | 4.8 | 0.1 | 2.7 | 1.7 | |
| Aeshnidae | – | – | – | 0.4 | 0.1 | – | – | – | – | 0.3 | 0.9 | – | – | – | 0.1 | |

Table 19 continued

| Stomach contents | Habitat: Magela system Em | Ls | Bb | Cb | Fb | Nourlangie system Em | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hemiptera | | | | | | | | | | | | | | | | |
| Miscellaneous | – | – | 0.6 | – | – | – | – | – | 0.1 | – | – | 0.4 | – | – | 1.0 | |
| Naucoridae | – | – | 3.5 | 5.0 | 4.0 | – | 10.0 | 1.5 | 3.3 | 0.7 | 6.9 | 9.3 | 0.6 | 9.1 | 4.1 | |
| Gerridae | – | – | – | 0.2 | – | – | – | – | – | – | 0.3 | 1.0 | – | – | 0.1 | |
| Veliidae | 1.0 | – | – | – | – | – | – | 0.1 | – | – | – | – | – | – | + | |
| Hydrometridae | – | – | 0.1 | – | + | – | – | 0.4 | 0.1 | – | – | – | – | – | 0.1 | |
| *Anisops* | – | – | 0.1 | – | + | – | – | – | – | – | – | – | 0.1 | – | 0.1 | |
| Coleoptera | | | | | | | | | | | | | | | | |
| Miscellaneous (adults) | 1.0 | – | 0.8 | 1.0 | 0.7 | – | 2.0 | 0.1 | 2.1 | 0.4 | – | 0.4 | 0.4 | 1.8 | 0.7 | |
| Miscellaneous (larvae) | – | – | 0.2 | – | – | – | – | – | – | 0.5 | – | – | – | – | 0.1 | |
| Dytiscidae (adults) | – | – | + | – | – | – | – | – | – | 0.1 | – | – | 0.1 | – | + | |
| Dytiscidae (larvae) | – | – | – | – | 0.4 | – | – | – | – | 1.7 | – | – | – | – | 0.2 | |
| *Macrogyrus* | – | – | 0.9 | – | 0.7 | 0.6 | – | 0.9 | 0.6 | 1.1 | 1.6 | 0.9 | – | – | 0.8 | |
| Diptera | | | | | | | | | | | | | | | | |
| Miscellaneous (adults) | – | – | – | – | 0.1 | – | – | 0.2 | 0.2 | – | – | – | – | – | 0.1 | |
| Miscellaneous (larvae) | – | – | 1.0 | + | 0.2 | – | – | – | 0.3 | 0.5 | 1.6 | – | – | – | 0.3 | |
| Chaoborinae | – | – | 0.7 | – | 0.9 | – | – | – | – | – | – | 1.2 | 2.1 | – | 0.5 | |
| Chironomidae (larvae) | 3.0 | – | 0.4 | 0.6 | 0.8 | – | – | 1.1 | 0.2 | – | 0.2 | 0.9 | 1.9 | – | 0.7 | |
| Chironomidae (pupae) | – | – | – | 0.1 | – | – | – | 0.1 | – | – | – | 0.1 | 0.2 | – | 0.1 | |
| Ceratopogonidae | – | – | – | – | – | – | – | – | + | – | – | – | – | – | + | |
| Tabanidae | – | – | – | – | – | – | – | – | – | – | – | + | – | – | + | |
| Trichoptera | | | | | | | | | | | | | | | | |
| Egg case | – | – | – | – | – | – | – | 0.1 | – | – | – | – | – | – | + | |
| Leptoceridae | – | – | – | 0.3 | + | – | – | 0.2 | 0.3 | – | – | – | – | – | 0.1 | |
| Teleostomi | | | | | | | | | | | | | | | | 14.7 |
| Fragmented | – | 10.0 | 6.8 | 3.6 | 4.8 | 34.0 | 6.0 | 5.6 | 4.3 | 6.8 | 7.9 | 8.2 | 1.0 | – | 5.4 | |
| Fish scales | 1.0 | – | 4.1 | 9.5 | 3.4 | 16.0 | 4.0 | 9.9 | 10.6 | 0.9 | – | 0.5 | 3.6 | 10.9 | 5.4 | |
| *N. erebi* | – | – | 0.7 | – | – | – | – | – | 0.6 | – | – | – | – | – | 0.2 | |
| *S. jardinii* | – | – | – | 0.7 | – | – | – | – | – | – | 1.6 | – | – | – | 0.2 | |
| *A. leptaspis* | – | – | – | 0.7 | – | – | – | – | – | 1.6 | – | – | – | – | 0.2 | |
| *Neosilurus* spp. | – | 12.5 | 1.5 | – | 0.4 | – | – | – | 0.6 | 1.1 | 1.4 | 1.0 | – | – | 0.6 | |
| *P. rendahli* | – | – | – | – | 0.3 | – | – | – | – | – | – | 0.6 | – | – | 0.1 | |
| *N. ater* | – | – | – | – | 0.4 | – | – | – | – | – | – | 0.8 | – | – | 0.2 | |

Table 19 continued

| | Habitat | | | | | | | Season | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magela system | | | | | Nourlangie system | | 1978 | 1978–79 | 1978–79 | 1979 | 1979 | 1979 | 1979–80 | Overall | |
| Stomach contents | Em | Ls | Bb | Cb | Fb | Em | Bb | Late-dry | Early-wet | Mid-wet | Late-wet–Early-dry | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean |
| *M. spendida inornata* | – | – | 0.5 | – | 0.2 | – | – | – | – | 1.0 | 0.2 | 0.2 | – | – | 0.2 | |
| *Ambassis* spp. | – | – | – | 1.3 | 0.4 | – | 12.0 | – | – | 1.0 | 3.0 | 0.8 | – | – | 0.6 | |
| *L. unicolor* | – | – | – | – | 0.3 | – | – | – | – | 1.4 | – | – | – | – | 0.1 | |
| *T. chatareus* | – | – | – | 1.3 | – | – | – | – | – | – | 3.1 | – | – | – | 0.3 | |
| *G. giuris* | – | – | 0.4 | 1.0 | – | – | – | – | – | 0.9 | 3.4 | – | – | – | 0.4 | |
| *H. compressa* | – | – | – | – | – | – | – | 1.2 | – | – | – | – | – | – | 0.2 | |
| *O. lineolata* | – | – | 0.2 | – | 1.1 | – | – | – | – | 2.5 | – | 1.2 | – | – | 0.5 | |
| *S. krefftii* | 9.0 | – | – | – | – | – | – | 0.8 | – | – | – | – | – | – | 0.1 | |
| Egg material | | | | | | | | | | | | | | | | |
| Miscellaneous | – | – | + | 0.5 | 1.0 | – | – | 0.6 | 0.9 | – | 0.2 | – | 1.3 | – | 0.5 | |
| *A. leptaspis* | – | – | 0.8 | 2.7 | 2.3 | – | – | 1.7 | 5.5 | – | – | 0.3 | 2.2 | – | 2.1 | |
| Leptodactylidae | – | – | – | – | + | – | – | – | 0.1 | – | – | – | – | – | + | |
| **Terrestrial plants** | | | | | | | | | | | | | | | | |
| Angiospermae | | | | | | | | | | | | | | | | 12.1 |
| Miscellaneous | 1.0 | – | 3.4 | 8.8 | 5.0 | – | 4 | 20.3 | 9.4 | 5.3 | 9.2 | 16.1 | 4.5 | – | 11.6 | |
| Miscellaneous seeds | – | – | – | – | 0.4 | – | – | – | – | 1.5 | – | 0.1 | – | – | 0.2 | |
| *Pandanus* seeds | – | – | – | 0.9 | 0.1 | – | – | 0.4 | 0.3 | – | – | 0.5 | – | – | 0.3 | |
| **Terrestrial animals** | | | | | | | | | | | | | | | | |
| Arachnida | | | | | | | | | | | | | | | | 0.1 |
| Fragmented | – | – | – | – | 0.2 | – | – | – | – | – | 0.8 | – | – | – | 0.1 | |
| Insecta | | | | | | | | | | | | | | | | 5.8 |
| Fragmented | – | 0.6 | 0.3 | 2.9 | 0.9 | – | – | 0.2 | 3.7 | 0.9 | – | – | 0.6 | – | 1.1 | |
| Odonata | | | | | | | | | | | | | | | | |
| Zypopteran (adults) | – | – | 0.2 | – | 0.4 | – | 1 | + | + | 0.7 | – | 0.3 | 0.5 | – | 0.2 | |
| Anisopteran (adults) | – | – | 0.6 | – | – | – | – | – | – | 1.2 | 1.6 | – | – | – | 0.3 | |
| Orthoptera | | | | | | | | | | | | | | | | |
| Miscellaneous | – | 25.0 | 5.3 | 2.1 | 2.4 | – | – | – | 8.1 | 4.2 | 3.3 | 0.6 | – | – | 2.9 | |
| Egg material | – | – | – | – | + | – | – | – | – | – | 0.1 | – | – | – | + | |
| Hemiptera | – | – | 0.2 | – | 0.6 | – | – | – | – | 3.3 | – | – | – | – | 0.3 | |
| Coleoptera | | | | | | | | | | | | | | | | |
| Miscellaneous | – | 3.8 | 0.2 | 0.6 | 0.1 | 26.0 | 20.0 | 0.1 | 1.9 | 0.4 | – | – | 0.9 | – | 0.7 | |
| Diptera | | | | | | | | | | | | | | | | |
| Larvae | – | – | – | – | – | – | – | – | + | – | – | – | – | – | + | |

Table 19 continued

| | Habitat | | | | | | | Season | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magela system | | | | | Nourlangie system | | 1978 | 1978–79 | 1978–79 | 1979 | 1979 | 1979 | 1979–80 | Overall | |
| Stomach contents | Em | Ls | Bb | Cb | Fb | Em | Bb | Late-dry | Early-wet | Mid-wet | Late-wet–Early-dry | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean |
| Lepidoptera | | | | | | | | | | | | | | | | |
| Larvae | – | – | 0.2 | – | – | – | – | – | – | – | – | 0.5 | – | – | 0.1 | |
| Adults | – | – | – | 0.5 | – | – | – | – | 0.2 | – | – | – | – | – | 0.1 | |
| Hymenoptera | | | | | | | | | | | | | | | | |
| *Oecophylla* | – | – | – | – | 0.3 | – | – | – | – | 1.2 | – | – | – | – | 0.1 | |
| Scolopendromorpha | – | – | – | – | – | 12 | – | – | 0.4 | – | – | – | – | – | 0.1 | 0.1 |
| Vertebrata | | | | | | | | | | | | | | | | 1.3 |
| Fragmented | 10.0 | – | 0.4 | 0.8 | – | – | 14.0 | 1.7 | 0.8 | – | – | – | – | – | 0.5 | |
| Reptillia | | | | | | | | | | | | | | | | |
| Skin (*Acrocaudis*) | – | – | 0.5 | – | 0.3 | – | – | 0.7 | 0.9 | – | – | – | – | – | 0.4 | |
| Scincidae | – | – | – | – | – | 4.0 | – | – | 0.1 | – | – | – | – | – | + | |
| Aves | | | | | | | | | | | | | | | | |
| Feathers | – | – | – | 1.0 | 0.2 | – | – | 1.5 | – | – | – | – | 0.2 | – | 0.3 | |
| Mammalia | | | | | | | | | | | | | | | | |
| Fragmented | – | – | 0.2 | – | + | – | – | – | 0.2 | – | 0.2 | – | – | – | 0.1 | |
| **Parasites** | | | | | | | | | | | | | | | | 1.6 |
| Cestoda | – | – | – | – | + | – | – | – | – | 1.7 | – | 0.8 | – | – | 0.3 | |
| Nematoda | 3.0 | – | 0.2 | 1.3 | 1.6 | – | 2.0 | 2.5 | 0.9 | 0.7 | 3.4 | 2.1 | – | – | 1.3 | |
| Detrital material | 3.5 | – | – | 2.0 | 0.6 | – | – | 2.6 | 1.4 | – | – | – | 0.4 | – | 0.9 | 0.9 |
| Inorganic material | 1.5 | – | 0.5 | 1.0 | 5.0 | – | – | 0.3 | 0.8 | 1.7 | – | 0.2 | 1.2 | – | 0.9 | 0.9 |
| Organic material | 9.0 | 10.0 | 22.9 | 20.3 | 35.4 | 4.0 | – | 18.4 | 19.7 | 5.4 | 5.9 | 22.4 | 61.2 | 68.2 | 24.9 | 24.9 |
| Number of empty fish | – | – | 11 | 26 | 28 | 1 | 0 | 5 | 47 | 6 | 11 | 3 | – | 1 | 73 | |
| Number of fish with food | 10 | 8 | 131 | 147 | 272 | 5 | 5 | 117 | 161 | 59 | 64 | 134 | 87 | 11 | 633 | |

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

Em = escarpment mainchannel; Ls = lowland sandy creekbed; Bb = lowland backflow billabong; Cb = corridor billabongs; Fb = flood plain billabongs

The main components of the diet were aquatic insects (20%), teleosts (15%), macrocrustaceans (13%), terrestrial plant material (12%) and terrestrial insects (6%). Large quantities of unidentified organic material (25%) were also found in the stomachs. The identifiable portion of the aquatic insects consisted mainly of naucorids and libellulid larvae. Fish scales were common. The identifiable teleosts were *N. erebi, A. leptaspis, Neosilurus* sp., *P. rendahli, N. ater, M. splendida inornata, Ambassis* spp., *L. unicolor, T. chatareus, G. giuris, H. compressa, O. lineolata* and *S. krefftii*. The macrocrustaceans were *Macrobrachium* and *Paratelphusa transversa*. Most of the terrestrial plant material consisted of leaves, twigs, bark and grass. The main terrestrial insects were orthopterans and coleopterans. Traces of green filamentous algae, hydrophytes, bivalves, microcrustaceans, terrestrial arachnids, scolopendromorphs, unidentified vertebrates, and detritus were also found in the stomachs. *Arius leptaspis* can therefore be classified as an opportunistic macrophagous omnivore.

Little published information on the diet of this species was found. Haines (1979) considered it to be an omnivore in the Purari River catchment.[51] Pollard (1974) noted that the stomachs of specimens caught in billabongs of the Magela Creek system in 1972 contained the remains of plotosid catfishes.

During the Dry season in the Magela flood plain *A. leptaspis*'s diet was restricted to items obtained by scavenging around the bottom and edges of the billabong—mainly terrestrial plant material, bird bones and feathers and fish scales. Tait (1979) noted that, in the Wet season, after breeding, the catfish can move over the flood plain and seek out fish and macroinvertebrates as food.

**Seasonal changes**

In sampling periods 1–7 respectively, 122 (4% empty), 208 (23% empty), 65 (9% empty), 75 (15% empty), 137 (2% empty), 87 (0% empty) and 12 (8% empty) stomachs of *A. leptaspis* were examined (all habitats combined). The highest proportions of specimens with empty stomachs were found in the 1978–79 Early-wet and Late-wet–Early-dry seasons.

The diet in the 1978 Late-dry season was based mainly on terrestrial plant material and teleosts (mainly scales), followed by macrocrustaceans and aquatic insects. During the 1978–79 Early-wet season the terrestrial insects increased in the diet and terrestrial plants decreased, while the teleost component (again mainly fish scales) and aquatic insects remained much the same.

During the 1978–79 Mid-wet season, hydrophytes (mainly *Pseudoraphis*) and macrocrustaceans (*Macrobrachium* and *P. transversa*) became more important in the diet. Aquatic insects were still common (libellulid larvae displaced naucorids in importance), as were the teleosts, though in greater variety (*A. leptaspis*, plotosids, *M. splendida inornata, Ambassis* spp., *L. unicolor, G. giuris* and *O. lineolata*). Fish scales were much less important, but terrestrial insects remained important.

By the Late-wet–Early-dry season, hydrophytes had disappeared from the diet and there was a large macrocrustacean component (*Macrobrachium* and *P. transversa*). Aquatic insects (mainly naucorids) and teleosts (mainly *Ambassis* spp., *T. chatareus, G. giuris*, with a few plotosids and *M. splendida inornata*) remained important. Terrestrial plant material and insects decreased in importance.

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51 Rimmer and Midgley (1985) indicated that larvae which had almost completed yolk absorption showed feeding habits similar to those of adults, which are opportunistic omnivores. Coates (1991) found all 5 species of ariid catfish studied in the Sepik River in Papua New Guinea to be omnivorous, but diets varied according to morphology and habitat preferences.

Aquatic insects (mainly naucorids and libellulids) and terrestrial plant material increased in importance in the diet during the 1979 Mid-dry season, and all other components became less common; terrestrial insects almost disappeared. During the 1979 Late-dry season there was a very large unidentified organic material component (this component was lowest in the Wet season and increased through the Dry season to peak in the Late-dry and Early-wet seasons). Macrocrustaceans (mainly *Macrobrachium*), aquatic insects, and to a lesser extent naucorids and terrestrial plant material, were also important. The few specimens examined in the 1979–80 Early-wet season had eaten mainly aquatic insects (naucorids and libellulid larvae) and fish scales. The fish scale component of the diet appeared to be lowest in the Wet season and gradually increased into the Dry season (large numbers of dead fish, mainly *L. calcarifer*, were found around the edges of the billabongs towards the end of the Dry seasons).

**Habitat differences**

*Magela catchment*

The totals of stomachs of *A. leptaspis* examined (all seasons combined) were: 10 (0% empty) from escarpment mainchannel waterbodies; 8 (0% empty) from lowland sandy creekbeds; 142 (8% empty) from backflow billabongs; 173 (15% empty) from corridor billabongs, and 300 (9% empty) from floodplain billabongs.

The diet in the escarpment mainchannel waterbodies consisted mainly of *Macrobrachium*, with aquatic insects and miscellaneous vertebrates of lesser importance. In the lowland creekbeds the diet was mainly of terrestrial orthopterans, miscellaneous aquatic insects, fish (mainly *Neosilurus* sp.), macrocrustaceans (*P. transversa*), and terrestrial coleopterans.

In the backflow billabongs, the fish had eaten mainly macrocrustaceans (*Macrobrachium* and *P. transversa*), aquatic insects, teleosts (including *N. erebi*, plotosids, *M. splendida inornata, G. giuris* and *O. lineolata*), fish scales, and traces of hydrophytes and terrestrial plant material. Large quantities of unidentified organic material were found in the stomachs in this habitat; this material was thought to be mainly fish flesh.

In the corridor waterbodies, macrocrustaceans (mainly *Macrobrachium*), aquatic insects, teleosts (including *A. leptaspis, Ambassis* spp., *T. chatareus* and *G. giuris*), fish scales and terrestrial plant material, featured in the diet. Partly digested *A. leptaspis* eggs, which were presumably accidentally swallowed during buccal incubation, were present in some of the stomachs from corridor and floodplain billabongs. In the floodplain billabongs *A. leptaspis* had eaten a variety of food items, including macrocrustaceans, aquatic insects, teleosts (including fish scales; the identifiable species were *Neosilurus* sp., *P. rendahli*, *N. ater*, *M. splendida inornata*, *Ambassis* spp., *L. unicolor* and *O. lineolata*) and terrestrial plant material.

*Nourlangie catchment*

Six (17% empty) stomachs of *A. leptaspis* were examined (all seasons combined) from Nourlangie Creek escarpment mainchannel waterbodies and five (0% empty) from backflow billabongs. Generally, higher proportions of specimens in this catchment had empty stomachs.

In the escarpment mainchannel habitat, the diet was different from that recorded in the equivalent Magela Creek habitat: here it was mainly teleosts and terrestrial animals (especially coleopterans and scolopendromorphs), with only a trace of aquatic insects. In the backflow billabongs, the fish ate mainly aquatic insects (naucorids were the main identifiable component); however, teleosts (mainly *Ambassis* spp.) and terrestrial vertebrates and insects (mainly coleopterans) were also part of the diet.

### Fullness

A summary of mean fullness indices of *A. leptaspis* at different sampling periods and habitats in the Magela Creek and Nourlangie Creek catchments is given in table 20. It is assumed that feeding times do not vary with habitat or season.

**Table 20** Mean fullness indices of *A. leptaspis* 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 | 1.9 (9) | n/s | n/s | n/s | n/s | 0 (1) | n/s | 1.7 (10) |
| Downstream of RUPA: | | | | | | | | |
| Lowland sandy creekbed | n/s | 3.7 (3) | 3.4 (5) | n/s | n/s | n/s | n/s | 3.5 (8) |
| Lowland channel backflow billabong | 3.6 (5) | n/s | 3.3 (6) | 2.3 (9) | 3.3 (11) | 2.2 (19) | 1 (10) | 3.4 (60) |
| Lowland shallow backflow billabong | n/s | 2.6 (47) | 2.3 (18) | 2.3 (6) | 3.5 (12) | n/s | n/s | 2.6 (83) |
| Corridor sandy billabong | 1.3 (4) | 1.5 (25) | 1 (1) | 1.3 (6) | 10.0 (2) | n/s | n/s | 1.5 (38) |
| Corridor anabranch billabong | 2.9 (9) | 1.9 (23) | n/s | 2.0 (4) | n/s | n/s | n/s | 2.2 (36) |
| Floodplain billabong | 2.6 (36) | 1.8 (106) | 2.0 (38) | 2.5 (47) | 2.2 (114) | 1.7 (69) | n/s | 2.1 (410) |
| **Nourlangie Creek catchment** (regular sites only) | | | | | | | | |
| Escarpment main-channel waterbody | 1 (2) | 1.8 (4) | n/s | n/s | n/s | n/s | n/s | 1.5 (6) |
| Lowland channel backflow billabong | 4 (1) | 3 (1) | 5 (1) | n/s | n/s | n/s | n/s | 4 (3) |
| Lowland shallow backflow billabong | n/s | 4 (1) | n/s | 3 (1) | n/s | n/s | n/s | 3.5 (2) |
| Seasonal mean (all sites) | 2.5 | 2.0 | 2.3 | 2.3 | 2.4 | 1.8 | 0.96 | |

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

*Seasonal changes*

The mean seasonal fullness index (all habitats combined) decreased during the 1978–79 Early-wet season, which possibly corresponded to an increased number of males buccally incubating eggs. The index increased during the Mid-wet season and remained at a higher level till the 1979 Mid-dry season. The index then decreased during the 1979 Late-dry season and reached its lowest during the 1979–80 Early-wet season.

*Habitat differences*

In the Magela catchment the mean fullness indices of *A. leptaspis* were lowest in corridor sandy billabongs and escarpment mainchannel waterbodies, and highest in the lowland sandy creekbeds and channel backflow billabongs.

In the Nourlangie catchment the specimens examined in the escarpment mainchannel waterbodies and lowland habitats had fullness indices comparable with specimens in the equivalent Magela Creek habitat.

*Summary*

The habitats and periods of greatest apparent feeding activity were:

**Magela catchment**

- lowland sandy creekbeds; 1978–79 Early-wet and Mid-wet seasons
- lowland shallow backflow billabong; 1979 Mid-dry season
- lowland channel backflow billabong; 1978 Late-dry season, 1978–79 Mid-wet season and 1979 Mid-dry season

**Nourlangie catchment**

- lowland channel backflow billabong; 1978–79 Mid-wet season

# Family ARIIDAE

## 3.6 *Arius proximus* (Ogilby)

*Arius proximus* (identified by P Kailola[52]) is commonly known as the grey catfish. It belongs to a predominantly marine family. It has been collected near Darwin and in the waters of the Arafura Sea around Aru, Pellew and Melville islands. Pollard (1974) tentatively identified this species from tidal waters of the East Alligator River. It has also been tentatively identified by Haines (1979) in the Purari-Kikori delta in Papua New Guinea, where it was found in very brackish and marine waters of the lower estuary and coastal zones.

Detailed information on catches at each site and in each season is given in volume 2. In summary, this species was found (but only rarely) in backflow billabongs and corridor waterbodies of the Nourlangie Creek system.

### Size composition

#### Length–weight relationship

The lengths and weights of nine specimens were determined. The length–weight relationship was described by the expression:

$$W = 6.25 \times 10^{-3} L^{3.33} \qquad r = 1.00 \text{ (length in cm, weight in g)}$$

The mean weight of specimens captured was 450 g.

#### Length-frequency distribution

The length-frequency distribution is shown in fig 20. The smallest specimen (captured during the Mid-wet season) was 85 mm LCF and the largest specimen (captured during the 1978 Late-dry season) was 400 mm LCF. The mean length of all specimens captured was 289 mm LCF.

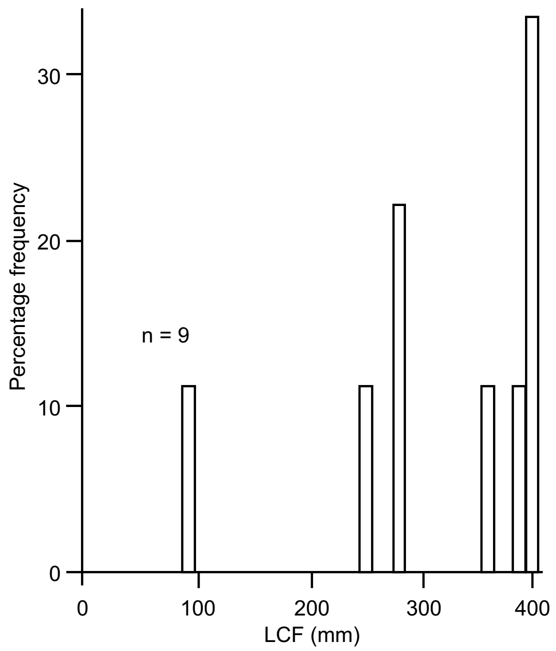



**Figure 20** Length-frequency distribution of all *A. proximus* captured

52 In Kailola's PhD thesis (Kailola 1990) it is stated that a sample of distinct specimens of an 'Arius', identified in the late 1970s as *A. proximus*, is suspected in hindsight to be *A. graeffei*.

## Environmental associations

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

### Physico–chemical variables

*Temperature*

*Arius proximus* was captured in waters with surface temperatures from 29° to 34°C (mean = 30.0°C), and with bottom temperatures from 26° to 31°C (mean = 26.7°C). These means were placed in the lower-middle and lower quarters respectively (see fig 170). This range of water temperatures is quite wide despite the small number ($n$ = 7) of temperature readings taken.

*Dissolved oxygen*

Dissolved oxygen concentrations in waters in which *A. proximus* was captured ranged from 5.3 to 7.8 mg/L (mean = 6.7) on the surface, and from 2.0 to 4.9 mg/L (mean = 3.5) on the bottom. The means ranked in the upper and lower quarters respectively (see fig 171). The narrow ranges and large differences between mean concentrations are probably artefacts of the small number of readings taken.

*Visibility*

Secchi depths recorded at sites in which *A. proximus* was captured ranged from 90 to 210 cm (mean = 130 cm) (fig 172). This mean depth ranked in the upper quarter, indicating an apparent preference for clearer waters, although the small number of readings must be taken into account.

*pH*

The pH of waters from which *A. proximus* was captured ranged from 5.7 to 6.3 (mean = 6.2) on the surface and from 5.2 to 5.9 (mean = 5.7) on the bottom. These means were ranked in the lower-middle and lower quarters respectively (see fig 173).

*Conductivity*

Surface-water conductivities at sites where *A. proximus* was found ranged from 10 to 70 µS/cm; corresponding bottom-water conductivities ranged from 10 to 58 µS/cm. *Arius proximus* is reputedly found in estuarine waters (Pollard 1974), so its presence in waters of such low conductivities is of interest.

### Habitat–structural variables

*Substrate*

*Arius proximus* was captured only over mud and clay substrates. The percentage dominance means for mud and clay substrates thus ranked high in the upper quarter.

*Hydrophytes*

*Arius proximus* was found exclusively in vegetated waters (vegetation-occurrence index 100%). The main vegetation type was submergent (60.7%), followed by floating attached (21.4%).

## Reproduction

Of the nine specimens captured, two were not examined for reproductive condition and one (85 mm LCF) was sexually indistinguishable. The remainder were four females (length range 360–400 mm LCF) and two males (245–395 mm LCF).

All fish were immature, except for one female (400 mm LCF), which had spent gonads. Two of the large females from a corridor waterbody had eggs at a very early stage of development.

Haines (1979) found breeding individuals only in lower estuarine and coastal zones.

## Feeding habits

The stomach contents of nine specimens were examined; eight contained food. A summary of the diet of *A. proximus* is given in fig 21; details of the components are given in table 21.

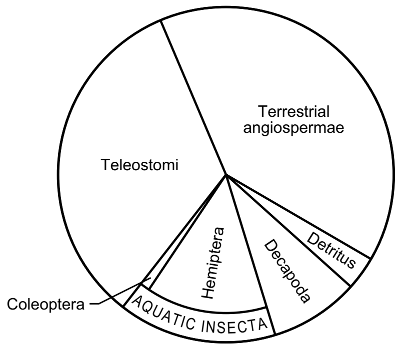



**Figure 21** The main components of the diet of *A. proximus*

**Table 21** Dietary composition of *A. proximus*

| | % composition | |
|---|---|---|
| Stomach contents | Sub-mean | Main-mean |
| **Aquatic animals** | | |
| Macrocrustacea | | 9.4 |
| *Macrobrachium* | 9.4 | |
| Insecta | | 16.2 |
| Fragmented | 14.4 | |
| Hemiptera | | |
| Naucoridae | 0.6 | |
| Coleoptera | | |
| *Macrogyrus* | 1.2 | |
| Teleostomi | | 35.0 |
| Scales | 35.0 | |
| **Terrestrial plants** | | |
| Angiospermae | | 36.3 |
| Fragmented | 34.4 | |
| *Pandanus* (seed) | 1.9 | |
| **Terrestrial animals** | | |
| Insecta | | + |
| Coleoptera | + | |
| **Parasite** | | |
| Nematoda | 0.6 | 0.6 |
| Detrital material | 2.5 | 2.5 |
| Number of empty fish | 1 | 1 |
| Number of fish with food | 8 | 8 |

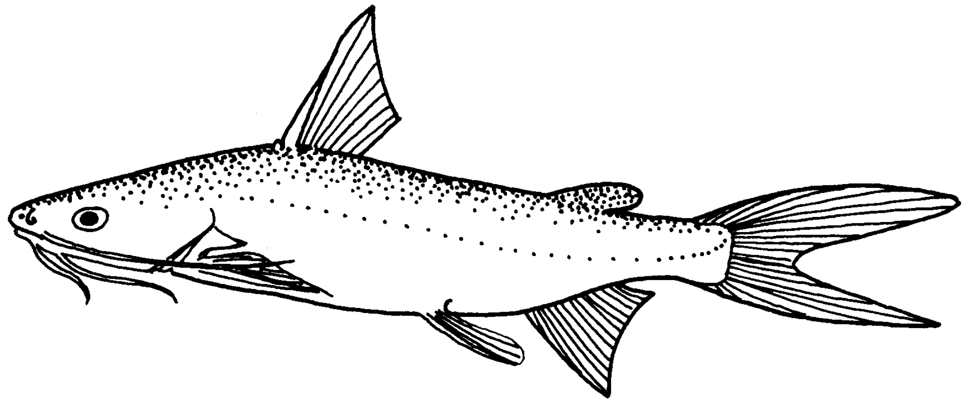
The main components of the diet were terrestrial plant material (36%), teleost scales (35%), aquatic insects (16%) and macrocrustaceans (*Macrobrachium*) (9%). As most of the specimens were captured in the 1979 Late-dry season, it is not known whether there are habitat differences and seasonal changes in the diet. The high proportion of fish scales (mainly from *L. calcarifer*) in the diet is notable. *Arius proximus* can be tentatively classified as a macrophagous omnivore.

Little published information on the diet of this species was found; Haines (1979), however, noted that this species is partly omnivorous in the estuarine waters of the Purari-Kikori delta, where it feeds mainly on prawns and crabs.

# Family ARIIDAE

## 3.7 *Arius graeffei* (Kner & Steindacher)

*Arius graeffei* is commonly known as the blue catfish, ridged-back catfish, shark catfish and occasionally also as the forktailed catfish. It is mainly found in tropical waters (Haines 1979). In Australia it is found in the Gulf of Carpentaria, Timor Sea, Indian Ocean and the south-east and north-east coast drainage divisions (see map 3). Miller (cited in Taylor 1964) collected *A. graeffei* from billabongs in the Oenpelli area and in the East Alligator River near Cahills Crossing. It has also been found in the coastal zone off the Purari River delta.



*Arius graeffei*

*Arius graeffei* belongs to a predominantly marine family and is very common in estuaries and rivers, ascending above the tidal limit into freshwater.

Information on catches at each site and in each season is presented in volume 2. In summary, this species was found only in occasionally sampled sites (backflow billabongs and corridor waterbodies) in the Nourlangie Creek system.

### Size composition

#### Length–weight relationship

The lengths and weights of 41 specimens were determined. The length–weight relationship was described by the expression:[53]

$$W = 9.21 \times 10^{-3} L^{3.19} \qquad r = 0.99 \text{ (length in cm, weight in g)}$$

Seasonal mean lengths, weights and condition factors are shown in table 22. The condition factors during the 1978 Late-dry and 1979 Late-wet–Early-dry seasons were almost identical.[54]

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53 The length-weight relationship given by Rimmer (1985a) for *A. graeffei* from the Clarence River upper estuary in north-eastern NSW was:

Females: $W = 1.515 \times 10^{-6} L^{3.45}$, $r^2 = 0.97$

Males: $W = 2.761 \times 10^{-6} L^{3.34}$, $r^2 = 0.95$

where L is standard length in mm, W is total weight in g.

54 Rimmer (1985a) indicated that the relative condition of *A. graeffei* decreased in winter when water temperatures dropped to a minimum in the upper estuary of the Clarence River.

**Table 22** Mean length, mean weight and condition factor of *A. graeffei*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| Late-dry (1978) | 21 | 237.0 | 223.4 | 1.00 |
| Late-wet–Early-dry (1979) | 20 | 291.2 | 426.5 | 0.99 |
| Overall | 41 | 262.0 | 306.2 | 1.00 |

**Length-frequency distribution**

Lengths ranged from 113 mm to 395 mm LCF (fig 22);[55] the mean length was 262 mm LCF. There are two distinct peaks in the length-frequency distribution, with modes at 180 and 260 mm LCF. They can be attributed to the mesh selectivity of the gillnets used to collect specimens. As this species was not sampled continuously, there are discontinuities in the distribution.

Both the smallest and largest specimens were captured in the Late-wet–Early-dry season.

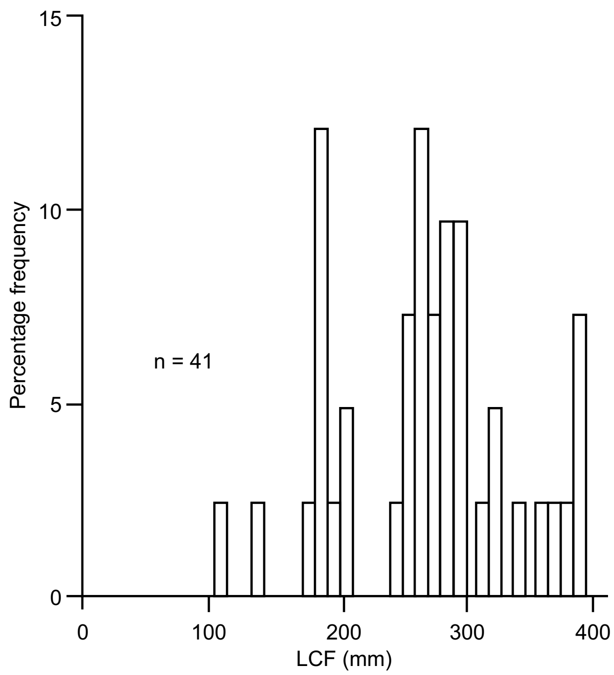



**Figure 22** Length-frequency distribution of all *A. graeffei* captured

## Environmental associations

Rank numbers for *A. graeffei* for the physico–chemical and habitat–structural variables recorded during the study are shown in table 155.

55 The largest specimens of *A. graeffei* collected by Rimmer (1985a) from the Clarence River upper estuary in north-eastern NSW were 494 mm standard length (SL) and 2900 g weight for females, and 453 mm standard length (SL) and 2250 g weight for males.

**Physico–chemical variables**

*Temperature*

*Arius graeffei* was captured in waters with surface temperatures ranging from 28° to 31°C (mean = 29.3°) and bottom temperatures ranging from 27° to 31°C (mean = 28.7°C). These means ranked in the lower and lower-middle quarters, respectively (see fig 170).[56]

*Dissolved oxygen*

Dissolved oxygen concentrations in waters from which *A. graeffei* was captured ranged from 4.4 to 6.5 mg/L (mean = 5.6) on the surface, and from 0.6 to 4.9 mg/L (mean = 3.2) on the bottom. These means ranked in the lower quarter (see fig 171). A tolerance of low DO concentrations on the bottom is indicated, although the small number of readings must be taken into account.

*Visibility*

Secchi depths in waters from which this species was captured ranged from 15 to 190 cm, with a mean depth of 117 cm. This mean ranked in the upper-middle quarter (see fig 172).

*pH*

Both surface and bottom water pH levels ranged from 6.1 to 7.0 (mean = 6.6), (see fig 173).

*Conductivity*

Conductivity ranged from 10 to 160 µS/cm for both surface and bottom waters.

**Habitat–structural variables**

*Substrate*

*Arius graeffei* was predominantly found over sandy substrates (upper quarter), followed by clay, then mud. No specimens were captured over other substrates.

*Hydrophytes*

*Arius graeffei* was infrequently found in vegetated waters (vegetation-occurrence index 20%). Submergent hydrophytes (42.9%) were most often associated with this species, followed by emergent hydrophytes (28.5%) and floating vegetation (28.6%).

## Reproduction

In all, 27 sexually distinguishable fish were caught, in the 1978 Late-dry and 1979 Late-wet–Early-dry seasons. The sex ratio was 10 males (191–395 mm LCF) to 17 females (186–395 mm LCF). The LFM could not be calculated due to the small sample size; however, the smallest maturing specimens were a 270 mm LCF female and a 285 mm LCF male.[57]

During the Late-dry season five females were captured. Two (186 and 257 mm LCF) were immature, two (265 and 365 mm LCF) had developing eggs, and one (270 mm) had well-developed ovaries. All females caught during the Late-wet–Early-dry season had either spent or recovering-spent gonads. They had probably spawned some time between the Late-dry and the end of the Wet season.

All six males caught during the 1978 Late-dry season were recorded as immature; however, at that time maturing male gonads were not documented, and the gonads may have actually

56 Rimmer (1985b) indicated that *A. graeffei* breed in the upper estuary of the Clarence River in NSW when water temperatures reach 26°C.

57 Rimmer (1985a) indicated that both males and female *A. graeffei* from the upper estuary of the Clarence River in NSW began to mature at ~250 mm standard length and 250 g weight; all were mature by 350 mm (females) and 325 mm (males) and 1000g.

been developing. In the 1979 Late-wet–Early-dry season, one spent and three recovering-spent or immature males were caught. These data also suggest breeding had occurred some time between the Late-dry and the end of the Wet season.

Although all spent and mature fish were caught in corridor waterbodies in the Nourlangie Creek system, there is not enough information to be sure where they spawn.

Most members of the family Ariidae are buccal incubators; however, Semon & Wiedersheim (quoted in Breder & Rosen 1966) maintained that *A. graeffei* made a nest in the form of a circular depression in the gravel of rapidly flowing streams, and that the eggs (about 2.5 mm in diameter) were buried after spawning. In contrast, Bancroft (1923) described a specimen of this species with eggs in its mouth. Furthermore, Semon & Weidersheim recorded significantly smaller egg diameters than the 14 mm generally quoted for ariids; theirs more closely resemble plotosid egg diameters. Possibly Semon & Weidersheim had found a plotosid nest and wrongly attributed it to *A. graeffei*. Unfortunately, no ovaries were collected from *A. graeffei* during the present study, so egg diameters and fecundities could not be studied.[58]

## Feeding habits

### Overall diet

The stomach contents of 48 specimens were examined; 38 contained food. A summary of the diet of *A. graeffei* is given in fig 23; details of the components are given in table 23.

The main components of the diet were teleosts (23%), terrestrial plant material (22%), macrocrustaceans (19%) and aquatic insects (9%). The teleosts were mainly scales from *L. calcarifer* and *S. jardinii,* with traces of *M. splendida inornata* and *G. giuris*. The macrocrustaceans consisted mainly of *Macrobrachium* and *Paratelphusa transversa*.

Terrestrial insects (5%) were also found in the stomachs, as well as traces of bivalves, detritus and inorganic material. Large quantities of unidentified organic material (16%) were also found, as well as nematode and microcrustacean parasites. *Arius graeffei* can therefore be classified as a macrophagous omnivore.[59]

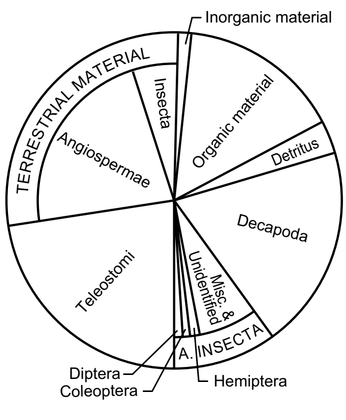



**Figure 23** The main components of the diet of *A. graeffei*

58 Rimmer (1985b) has subsequently examined the reproductive cycle of *A. graeffei* from the upper estuary of the Clarence River in NSW: gonadal cycle, secondary sex characters, spawning stimuli, egg size, fecundity and sex ratio. Rimmer (1985c) examined early development and buccal incubation from the same population.

59 Rimmer and Midgley (1985) indicated that larvae which had almost completed yolk absorption showed feeding habits similar to those of adults, which are opportunistic omnivores. Rimmer (1985a) indicated that the stomach fullness of *A. graeffei* from the Clarence River upper estuary in NSW was at a maximum during late-autumn to early-winter, and at a minimum during the breeding season in late-spring to summer.

**Table 23** Dietary composition of *A. graeffei*

| | Seasons | | | |
|---|---|---|---|---|
| | 1978 | 1979 | Overall | |
| Stomach contents | Late-dry | Late-wet–Early-dry | Sub-mean | Main-mean |
| **Aquatic animals** | | | | |
| Bivalvia | | | | 0.3 |
| *Velesunio* | 0.6 | – | 0.3 | |
| Macrocrustacea | | | | 19.2 |
| *Macrobrachium* | 2.2 | 31.3 | 17.5 | |
| *P. transversa* | – | 3.3 | 1.7 | |
| Insecta | | | | 9.2 |
| Fragmented | 12.5 | 1.0 | 6.5 | |
| Hemiptera | | | | |
| Naucoridae | 0.6 | 0.5 | 0.5 | |
| Coleoptera | | | | |
| Miscellaneous | – | 2.5 | 1.3 | |
| Diptera | | | | |
| Chironomidae (larvae) | 0.6 | 0.3 | 0.4 | |
| Chironomidae (pupae) | 1.1 | – | 0.5 | |
| Teleostomi | | | | 22.6 |
| Fragmented | 0.6 | – | 0.3 | |
| Scale | 35.6 | 2.8 | 18.3 | |
| *S. jardinii* (scale) | – | 1.0 | 0.5 | |
| *M. splendida inornata* | – | 0.5 | 0.3 | |
| *G. giuris* | – | 2.0 | 1.1 | |
| Egg material | 5.3 | – | 2.5 | |
| **Terrestrial plants** | | | | |
| Angiospermae | | | | |
| Fragmented | – | 19.5 | 10.3 | 21.5 |
| Miscellaneous | 11.9 | 10.0 | 10.9 | |
| *Pandanus* (seed) | – | 0.5 | 0.3 | |
| **Terrestrial animals** | | | | |
| Insecta | | | | 5.4 |
| Fragmented | – | 10.3 | 5.4 | |
| **Parasites** | | | | |
| Nematoda | 2.2 | 0.5 | 1.3 | 1.3 |
| Microcrustacea | | | | 1.6 |
| *Argulus* | 3.3 | – | 1.6 | |
| Detrital material | 7.2 | – | 3.4 | 3.4 |
| Inorganic material | 1.9 | 0.3 | 1.1 | 1.1 |
| Organic material | 17.2 | 14.0 | 15.5 | 15.5 |
| Number of empty fish | 5 | 5 | 10 | 10 |
| Number of fish with food | 18 | 20 | 38 | 38 |

### Seasonal changes

The stomachs of 48 *A. graeffei* were examined (all habitats combined): 23 (22% empty) from the 1978 Late-dry and 25 (20% empty) from the Late-wet–Early-dry seasons. Fish scales, aquatic insects and terrestrial plant material were the main items eaten in the 1978 Late-dry season. Large portions of *Macrobrachium*, terrestrial plant material and insects were eaten in the Late-wet–Early-dry season.

# Family PLOTOSIDAE

The Plotosidae is a predominantly freshwater family of fish with several marine and estuarine representatives, but almost nothing is known about the habits or biology of its tropical Australian members.[60]

Many of the eleven species of freshwater plotosid catfishes listed by Lake (1978) are reputedly common where they occur, but there is considerable confusion as to their identification. Lake (1978) found it impossible to allocate specific names, as he found the original descriptions inadequate. *Anodontiglanis dahli*, however, is easily identified amongst the species found in the Alligator Rivers Region.

Although the colour of a fish is often a poor diagnostic character, Lake found little trouble in separating several of these fishes by their common names, which are based on their colour when alive. Pollard (1974) referred to the plotosid catfishes he collected as ‘yellow-finned’ and ‘black-finned’ species. In the present study we initially used a similar colour-based system (for all except *A. dahli*): *Neosilurus* sp. A = ‘yellow-bellied’; *Neosilurus* sp. B = ‘black-blotched’ (fins and body), and *Neosilurus* sp. C = ‘yellow-finned’. However, specimens kept in aquaria could change colour with stress or changes in lighting, eg *Neosilurus* sp. A (and sometimes *Neosilurus* sp. C) could appear to turn into *Neosilurus* sp. B with reduction in light intensity. Morphometric characters such as dorsal head profile, snout length and distance to dorsal fin origin appeared to vary within each of the colour-types.

A key to the plotosid catfishes by Feinberg and Nelson became available from the Australian Museum after the Mid-wet season sampling.[61] This key, which distinguished three species on the basis of morphometric characters, was adopted for subsequent samples. These specimens are cross-referenced with the colour-types.

The species composition of the colour-type classification used in the first three sampling periods was:

| | Colour-type | | | | | |
|---|---|---|---|---|---|---|
| | A | | B | | C | |
| | *n* | % | *n* | % | *n* | % |
| *N. ater* | 79 | 82.3 | 24 | 72.7 | 3 | 0.7 |
| *N. hyrtlii* | 10 | 10.4 | 6 | 18.2 | 105 | 24.7 |
| *P. rendahli* | 7 | 7.3 | 3 | 9.1 | 318 | 74.6 |
| Total | 96 | 100.0 | 33 | 100.0 | 426 | 100.0 |

Each colour-type contained specimens from all three identified species: *Neosilurus* sp. A contained mainly *N. ater* with less than 20% contamination from *N. hyrtlii* and *P. rendahli; Neosilurus* sp. B contained mainly *N. ater* with less than 30% contamination from *N. hyrtlii*;

60 The reproduction and development of *N. ater* and *N. hyrtlii* from Queensland has since been described by Orr and Milward (1984). Reproduction and development of *Neosilurus ater* (Perugia) and *Neosilurus hyrtlii* (Steindachner) (Teleostei: Plotosidae) in a tropical Queensland stream, *Australian Journal of Marine and Freshwater Research* 35, 187–195.

61 Feinberg and Nelson’s key was never published. A field guide to Australia’s freshwater fishes, including plotosid catfish, is at present being prepared by Dr GR Allen. The names used in this section follow the *Zoological Catalogue of Australia* vol 7, 1989 (AGPS, Canberra).

and *Neosilurus* sp. C contained mainly *P. rendahli* with less than 30% contamination from *N. hyrtlii* and only traces of *N. ater*.

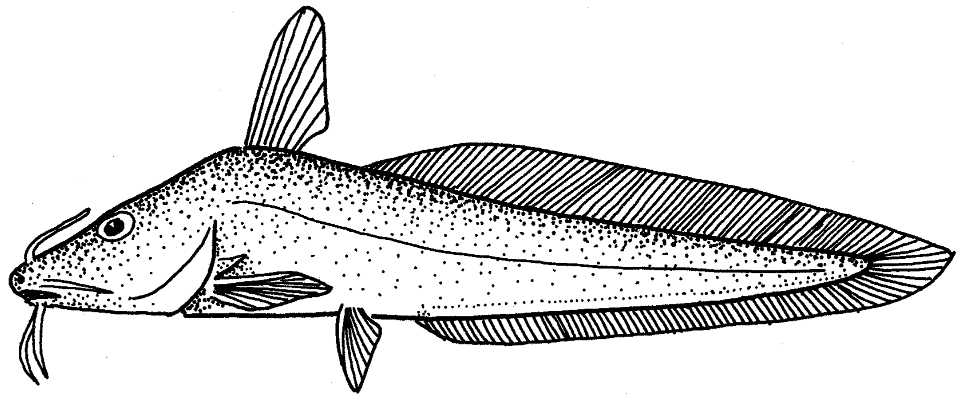
Therefore, as *Neosilurus* sp. A mainly comprises *N. ater*, results on these two are presented together. Similarly, results on *Neosilurus* sp. C are presented with *P. rendahli*.

To allow a condensed presentation, results on *Neosilurus* sp. B are presented with *N. hyrtlii*. The high proportion of *N. ater* in the *Neosilurus* sp. B samples is recognised and identified where appropriate. Escarpment mainchannel waterbodies were the main sites where *N. ater* dominated *Neosilurus* sp. B captures.

# Family PLOTOSIDAE

## 3.8 *Anodontiglanis dahli* (Rendahl)

*Anodontiglanis dahli* is commonly known as the toothless catfish. It is endemic to Australia and is found in the Timor Sea and Gulf of Carpentaria drainage divisions (see map 3). Midgley (1973) collected this species from Coopers Creek, Deaf Adder Creek and Baroalba Creek in the Alligator Rivers Region.



*Anodontiglanis dahli*

Information on catches at each site and in each season is given in volume 2. In summary, this species was found, but only rarely, in an escarpment mainchannel waterbody, a backflow billabong and a corridor waterbody in the Nourlangie Creek catchment. One specimen was captured in the Cooper Creek system.

### Size composition

#### Length–weight relationship

The lengths and weights of 31 specimens were determined. The length–weight relationship was described by the expression:

$W = 0.17 \times 10^{-2} L^{3.43}$ r = 0.98 (length in cm, weight in g)

Seasonal mean lengths, weights and condition factors are shown in table 24. The condition factors in the 1978 Late-dry and the 1979 Late-wet–Early-dry seasons were similar; the few specimens captured in the 1978–79 Early-wet and Mid-wet seasons had higher factors.

**Table 24** Mean length, mean weight and condition factor of *A. dahli*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| Late-dry (1978) | 23 | 385.9 | 452.0 | 1.00 |
| Early-wet (1978–79) | 2 | 384.9 | 463.8 | 1.04 |
| Mid-wet | 1 | 185.0 | 39.6 | 1.08 |
| Late-wet–Early-dry (1979) | 5 | 420.8 | 587.0 | 0.97 |
| Overall | 31 | 382.1 | 436.7 | 1.00 |

### Length-frequency distribution

The lengths of specimens ranged from 185 mm to 490 mm TL (mean = 382 mm, modal = 390 mm TL) (fig 24). Lake (1971) had suggested the maximum length of *A. dahli* was 400 mm TL. Only a few specimens were less than 360 mm TL; most were between 360 and 420 mm TL. It is not known why so few smaller specimens were captured, as small specimens of other species of plotosid catfishes were frequently captured in gillnets. It is most likely that small *A. dahli* were present in unsampled habitats.

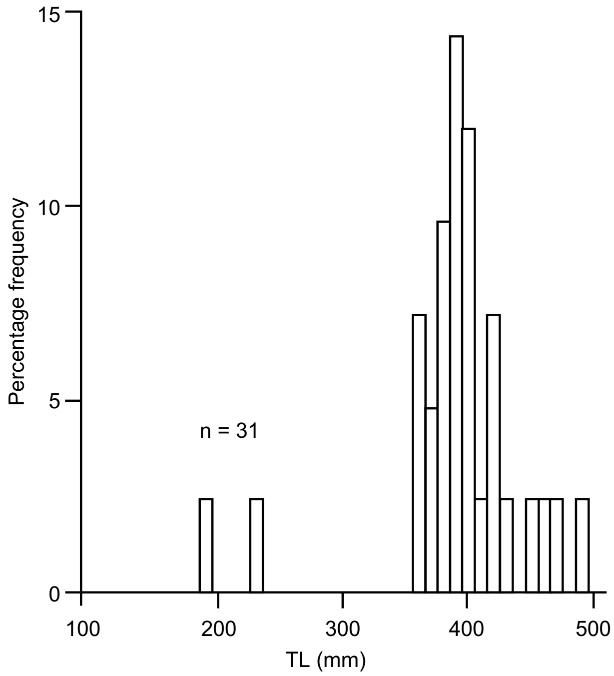



**Figure 24** Length-frequency distribution of all *A. dahli* captured

### Seasonal changes in distribution

The smallest specimen (185 mm TL) was captured during the 1978–79 Mid-wet season. The largest specimen (490 mm TL) and the second smallest specimen (220 mm TL) were captured during the 1978 Late-dry season.

### Habitat differences in distribution

All specimens were captured in the Nourlangie Creek catchment, mainly in escarpment mainchannel waterbodies and to a lesser extent in sandy corridor waterbodies. The smaller specimens were captured in a channel backflow billabong.

## Environmental associations

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

### Physico–chemical variables

*Temperature*

*Anodontiglanis dahli* was captured in waters with surface temperatures ranging from 27 to 33°C (mean = 30.2°C), and bottom temperatures from 26 to 32°C (mean = 28.6°C). Both means were ranked in the lower-middle quarter (fig 170). *Anodontiglanis dahli* was mainly captured in cooler, escarpment mainchannel habitats.

*Dissolved oxygen*

Dissolved oxygen concentrations in surface water ranged from 4.4 to 7.4 mg/L (mean = 5.8), and in bottom water from 0.6 to 6.8 mg/L (mean = 4.5). Both means were ranked in the lower-middle quarter (see fig 171). Low bottom-water DO concentrations appear to be characteristic of the habitats of bottom-dwelling plotosid catfishes.

*Visibility*

Secchi depths ranged from 3 to 210 cm (see fig 172). The mean of 136 cm was placed in the upper quarter, as might be expected for a species that was typically captured in clear escarpment waters.

*PH*

Surface water pH ranged from 5.4 to 7.0 (mean = 6.2), and bottom water pH from 5.1 to 7.0 (mean = 6.1). These means were placed in the lower and upper-middle quarters, respectively (see fig 173).

*Conductivity*

Surface-water conductivity ranged from 6 to 24 µS/cm and bottom water from 6 to 47 µS/cm. These conductivities are exceptionally low and the range narrow; this species was mostly captured in habitats with permanent flow or seepage from sandy aquifers and only a few conductivity readings were taken.

### Habitat–structural variables

*Substrate*

The main substrate over which *A. dahli* was captured was sand (upper quarter), followed distantly by mud, then clay. A few specimens were captured in channels with rocky substrates.

*Hydrophytes*

*Anodontiglanis dahli* was infrequently found in waters with vegetation (vegetation-occurrence index 21.1%). Of this limited vegetation, submergent hydrophytes were dominant (63.6%), followed by floating-attached hydrophytes (27.3%). Emergent vegetation was notably sparse.

## Reproduction

Of the 31 *A. dahli* captured, 30 were examined for reproductive condition: 15 males (length range 226–400 mm TL), 14 females (380–490 mm TL) and one sexually indistinguishable (185 mm).

The gonad maturity stages differ macroscopically from the generalised description given in volume 1. A more accurate description of each stage is given in Davis (1977b).

### Length at first maturity

Although the sample size was small, the LFM was estimated as 370 mm TL for males and 400 mm TL for females (fig 25).

The LFM was estimated from 10-mm-length groups. No maturing fish were found below the LFM. Males were generally smaller and matured at a smaller size than females.

### Sex ratio

The sex ratios were not significantly different from 1:1 during any sampling period.

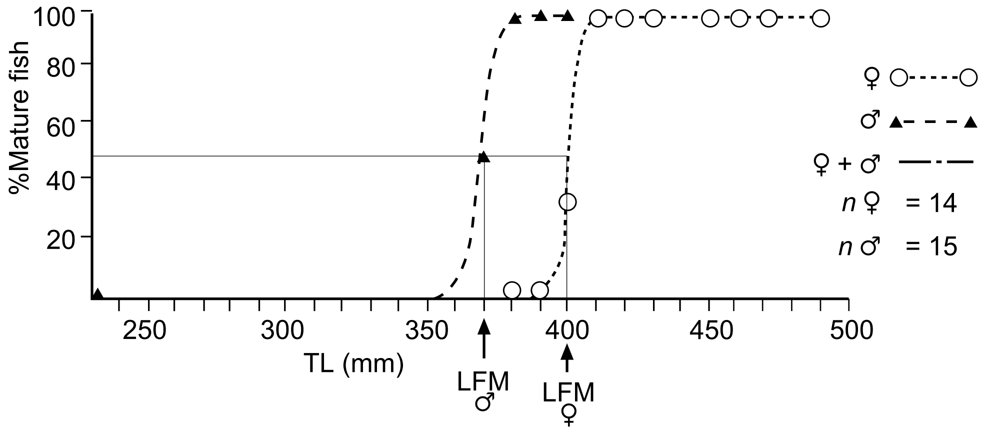



**Figure 25** Estimated length at first maturity (LFM) of male and female *A. dahli*

**Breeding season**

Insufficient data were available to determine the breeding season; however, higher GSI and GMSI (table 25 and fig 26) were recorded in the 1978 Late-dry season than in the 1979 Late-wet–Early-dry. The presence of mature and ripe fish in the former season and spent fish in the latter indicates that spawning most likely occurred during the Wet season.

**Table 25** Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *A. dahli* over all habitats

| Parameter | Sex | Statistic | Sampling period | | |
|---|---|---|---|---|---|
| | | | Late-dry 1978 | Early-wet 1978–79 | Late-wet–Early-dry 1979 |
| **Sex ratio** | | | | | |
| Juveniles | F | *n* | 11 | – | 3 |
| + adults | M | *n* | 11 | 2 | 2 |
| | | $\chi^2$ | 0 | 2.0 | 0.2 |
| | | P | n.s. | n.s. | n.s. |
| Adults only | F | *n* | 8 | – | 3 |
| | M | *n* | 6 | 2 | 2 |
| | | $\chi^2$ | 0.3 | 2.0 | 0.2 |
| | | P | n.s. | n.s. | n.s. |
| **GSI** | | | | | |
| Adults only | F | mean | 1.9 | – | 0.5 |
| | | s.d. | 1.4 | – | 0.1 |
| | M | mean | 0.3 | 0.4 | 0.2 |
| | | s.d. | 0.3 | 0.3 | 0.1 |
| | F+M | mean | 1.2 | – | 0.4 |
| | | s.d. | 1.3 | – | 0.2 |
| **GMSI** | | | | | |
| Adults only | F | mean | 4.4 | – | 2.0 |
| | | s.d. | 1.4 | – | 0.0 |
| | M | mean | 3.8 | 3.0 | 2.0 |
| | | s.d. | 0.8 | 1.4 | 0.0 |
| | F+M | mean | 4.1 | – | 2.0 |
| | | s.d | 1.2 | – | 0.0 |

*n* = number; $\chi^2$ = Chi-squared value; n.s. = not significant (P > 0.05); s.d. = standard deviation

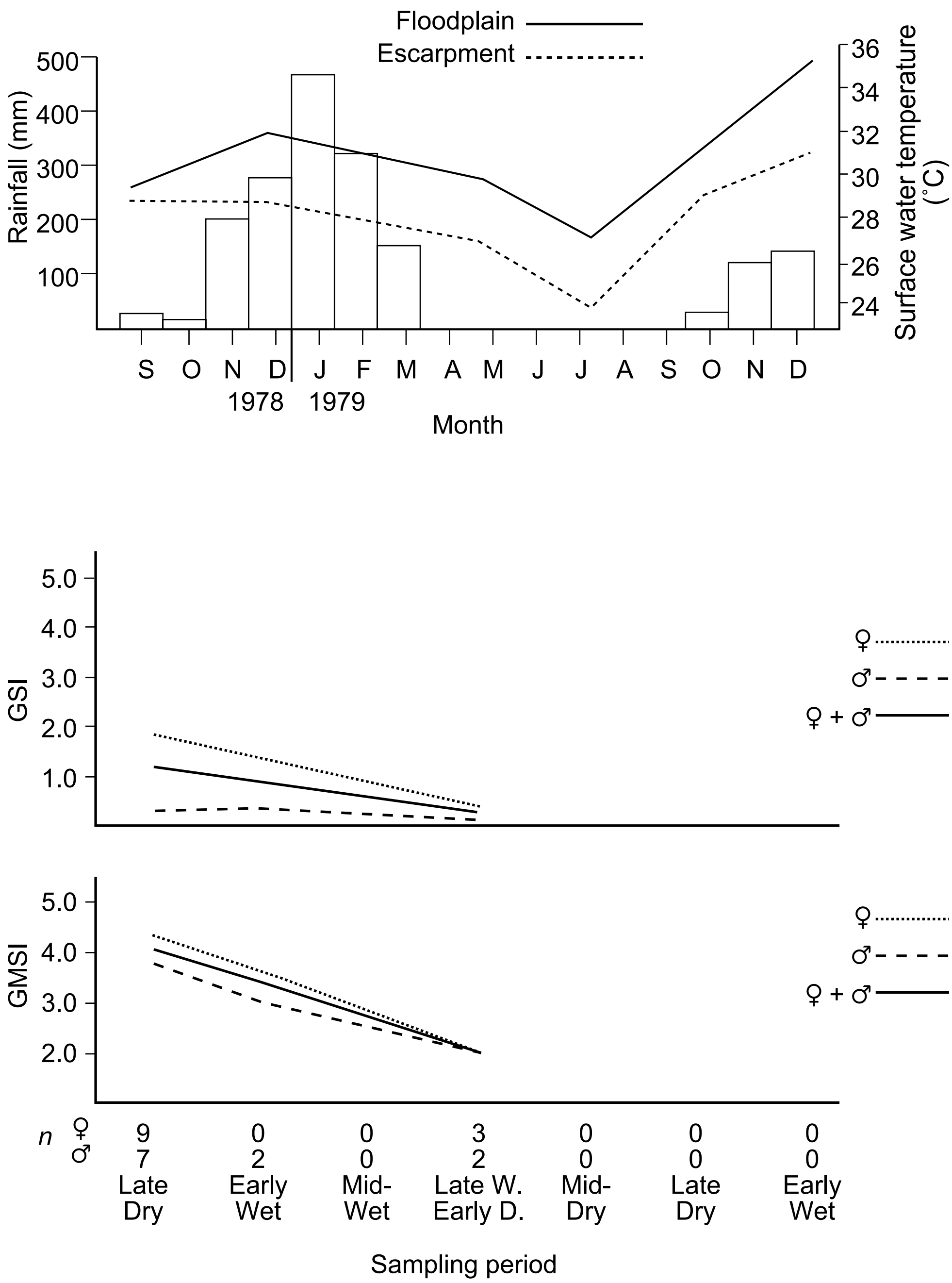



**Figure 26** Seasonal fluctuations in gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *A. dahli*

**Site of spawning**

*Anodontiglanis dahli* was mainly captured in the Nourlangie Creek system (one spent female was collected in the Nabarlek Dam on Cooper Creek). Mature, ripe and spent fish were collected from an escarpment mainchannel waterbody (Camp 1, Deaf Adder Creek); two deep corridor waterbodies (Nourlangie East and Skull Rock); and a channel backflow billabong (Baroalba Crossing) (table 26) in the Nourlangie Creek system. Spawning thus appears to be widespread through the Nourlangie system.

**Table 26** Possible sites of spawning of *A. dahli,* as indicated by the abundance (*n*) of mature, ripe and spent fish

| | Gonad stage | | | | | |
|---|---|---|---|---|---|---|
| | Mature (V) | | Ripe (VI) | | Spent (VII) | |
| Habitat | F | M | F | M | F | M |
| **Escarpment** | | | | | | |
| Mainchannel waterbody | 1 | – | – | – | – | – |
| **Lowlands** | | | | | | |
| Backflow billabong | – | – | – | – | – | 1 |
| **Corridor** | 1 | 1 | 2 | – | 3 | 2 |

## Feeding habits

### Overall diet

The stomach contents of 27 specimens were examined; all stomachs contained food. The diet of *A. dahli* is summarised in fig 27; details of the components are given in table 27. The main components of the diet were aquatic insects (37%) and incidental inorganic material (14%). Large quantities of unidentified organic material (20%) and trematode parasites (15%) were also found in the stomachs together with traces of algae, microcrustaceans, terrestrial plant material and detrital material. *Anodontiglanis dahli* can therefore be classified as a meiophagous benthic carnivore. This species has no teeth in its mouth, only in its gullet, and was frequently observed grazing on aquatic organisms over sandy substrates in escarpment mainchannel waterbodies and sandy corridor waterbodies.

No description of the feeding habits of this species could be found, though many of the plotosids are considered to be essentially carnivorous (Lake 1978).

### Seasonal changes

A total of 22 specimens of *A. dahli* (all habitats combined) were examined in the 1978 Late-dry season, and 5 in the 1978–79 Late-wet–Early-dry. All the fish had food in their stomachs.

The diet in the 1978 Late-dry season consisted of a wide variety of aquatic insects (mainly chironomids), together with terrestrial plant and detrital material and traces of algae; many trematodes were found in the stomachs along with large quantities of unidentified organic material. The few specimens captured in the Late-wet–Early-dry season were eating only chironomid larvae.

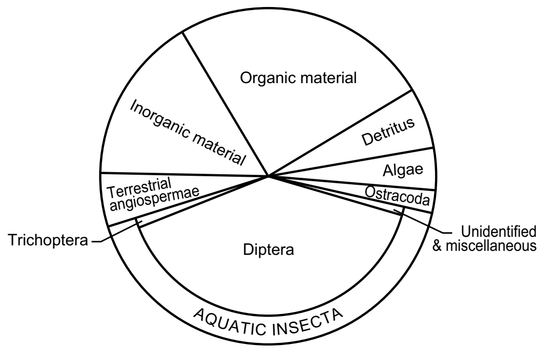



**Figure 27** The main components of the diet of *A. dahli*

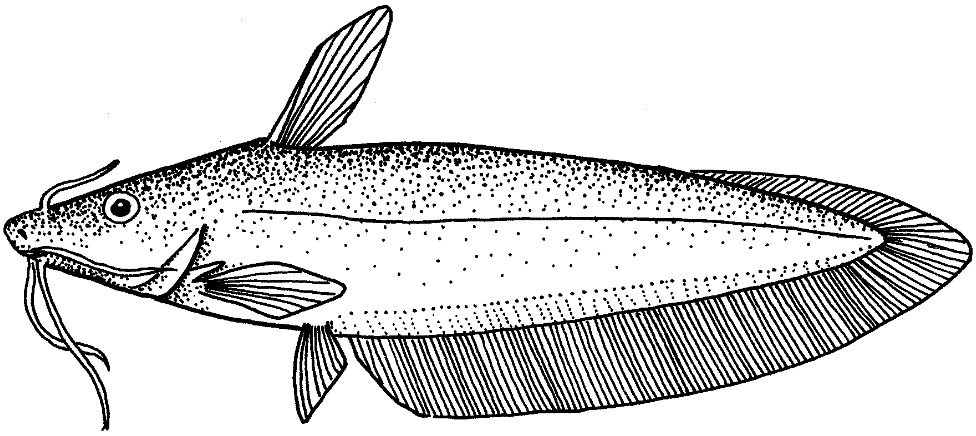
**Table 27** Dietary composition of *A. dahli*

| | Season | | Overall | |
|---|---|---|---|---|
| | 1978 | 1979 | | |
| Stomach contents | Late-dry | Late-wet–Early-dry | Sub-mean | Main-mean |
| **Aquatic plants** | | | | |
| Algae | | | | 2.5 |
| Conjugatophyta | 3.2 | – | 2.5 | |
| Aquatic animals | | | | |
| Microcrustacea | | | | 2.1 |
| Ostracoda | – | – | 2.1 | |
| Insecta | | | | 36.8 |
| Fragmented | 0.9 | – | 0.7 | |
| Ephemeroptera | | | | |
| Baetidae | 0.5 | – | 0.4 | |
| Diptera | | | | |
| Culicidae | 0.5 | – | 0.4 | |
| Chaoborinae | 2.7 | – | | |
| Chironomidae (larvae) | 17.3 | 96.0 | 30.7 | |
| Chironomidae (pupae) | 2.3 | – | 1.8 | |
| Trichoptera | | | | |
| Leptoceridae | 0.9 | – | 0.7 | |
| **Terrestrial plants** | | | | |
| Angiospermae | | | | 3.8 |
| Miscellaneous | 8.6 | – | 3.8 | |
| **Parasites** | | | | |
| Trematoda | 19.6 | – | 15.4 | 15.4 |
| Detrital Material | 6.4 | – | 5.0 | 5.0 |
| Inorganic Material | 16.4 | 4.0 | 13.6 | 13.6 |
| Organic Material | 23.2 | – | 19.6 | 19.6 |
| Number of empty fish | – | – | – | – |
| Number of fish with food | 22 | 5 | 27 | 27 |

# Family PLOTOSIDAE

## 3.9 *Neosilurus ater* (Perugia)

*Neosilurus ater* is commonly known as the narrow-fronted tandan, butter jew or black catfish. Data on *N. ater* will be presented together with that for the colour-type *Neosilurus* sp. A. This species is found in the Timor Sea and Gulf of Carpentaria drainage divisions (see map 3) and Papua New Guinea.[62] Miller (in Taylor 1964) found it in large billabongs and creeks in the Oenpelli area, and in lower riverine floodplain billabongs.



*Neosilurus ater*

Detailed information on catches at each site and in each season is given in volume 2. In summary, *Neosilurus* sp. A / *N. ater* were found commonly in all floodplain billabongs, corridor waterbodies, escarpment mainchannel waterbodies and perennial streams, and in most backflow billabongs and sandy creekbed habitats. In the Late-dry season it was found mainly in escarpment mainchannel and corridor waterbodies; in the Mid-wet season mainly in lowland habitats and flood plains; and in the Late-wet–Early-dry season in escarpment mainchannel and corridor waterbodies, when large numbers moved upstream into escarpment perennial streams from lowland habitats.

### Size composition

The lengths and weights of 224 specimens of *Neosilurus* sp. A and 106 specimens of *N. ater* were determined.

Seasonal length-frequency distributions and condition factors are based on the *Neosilurus* sp. A colour-type until the Late-wet–Early-dry season and on *N. ater* from then to the end of the study.

Most specimens were captured by gillnet, though some of the small juveniles were captured by seine net. The narrow peaks in the length-frequency distributions were probably partly caused by the mesh selectivity of the gillnets.

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62 Recent surveys over Cape York Peninsula by Herbert et al (1995) indicated that *N. ater* are found in most streams along the east coast of the Cape. That is, their distribution extends to the north-east coast drainage division.

#### Length–weight relationship

The length–weight relationships for *Neosilurus* sp. A and *N. ater* were described respectively by the expressions:

$W = 0.29 \times 10^{-2} L^{3.30}$ r = 0.97 (length in cm, weight in g)

$W = 0.73 \times 10^{-2} L^{3.04}$ r = 0.97 (length in cm, weight in g)

The difference in the length–weight relationship between the classification types may have been caused by seasonal changes in condition (see later). In the closely related *T. tandanus*, there is little difference between sexes and some differences between size groups (Davis 1977*a*).

Seasonal mean lengths, weights and condition factors for *Neosilurus* sp. A and *N. ater* are shown in table 28. Seasonal condition fell dramatically from the 1978 Late-dry season to the 1978–79 Early-wet season; it was possibly caused by spawning activity. Davis (1977*a*) noted that the condition of both sexes of *T. tandanus* was highest in the summer months before breeding, and that a drop in condition due to reduction in gonad weight was expected. By the Mid-wet season the condition factor reached its peak. The apparent drop in condition in the Late-wet–Early-dry season was probably a result of 'unfavourable' environmental conditions caused by anoxic benthic waters, which were frequently recorded in backflow billabongs during this season. After the Mid-dry season the condition factor decreased through the Late-dry season to reach a minimum in the Early-wet season similar to that recorded in the 1978–79 Early-wet season. Body condition was much lower in the 1979 Late-dry season than in the 1978 season.

**Table 28** Mean length, mean weight and condition factor of *Neosilurus* sp. A and *N. ater*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| *Neosilurus* sp. A | | | | |
| Late-dry (1978) | 68 | 358.0 | 424.1 | 1.08 |
| Early-wet (1978–79) | 80 | 338.5 | 291.4 | 0.89 |
| Mid-wet | 24 | 260.3 | 155.7 | 1.13 |
| Late-wet–Early-dry (1979) | 33 | 334.9 | 326.6 | 1.03 |
| All seasons combined | 205 | 336.8 | 312.3 | 1.00 |
| *N. ater* | | | | |
| Mid-dry 1979 | 41 | 320.0 | 305.4 | 1.09 |
| Late-dry | 26 | 360.0 | 389.5 | 0.97 |
| Early-wet 1979–80 | 8 | 334.4 | 273.9 | 0.86 |
| All seasons combined | 75 | 317.0 | 272.0 | 1.00 |

#### Length-frequency distribution

The lengths of *Neosilurus* sp. A ranged from 22 to 508 mm TL, and of *N. ater* from 72 to 460 mm TL (fig 28). Differences in the lower range are attributable to the presence of small juveniles of *Neosilurus* sp. A in the 1978–79 Early-wet and Mid-wet seasons and the absence of *N. ater* juveniles in the corresponding 1979–80 seasons. Lake (1971) recorded that *N. ater* grows to 400 mm TL. The closely related *T. tandanus* was found to grow to 596 mm TL in the Gwydir River, New South Wales (Davis 1977*a*); however, Lake (1971) reported it can grow to 900 mm TL.

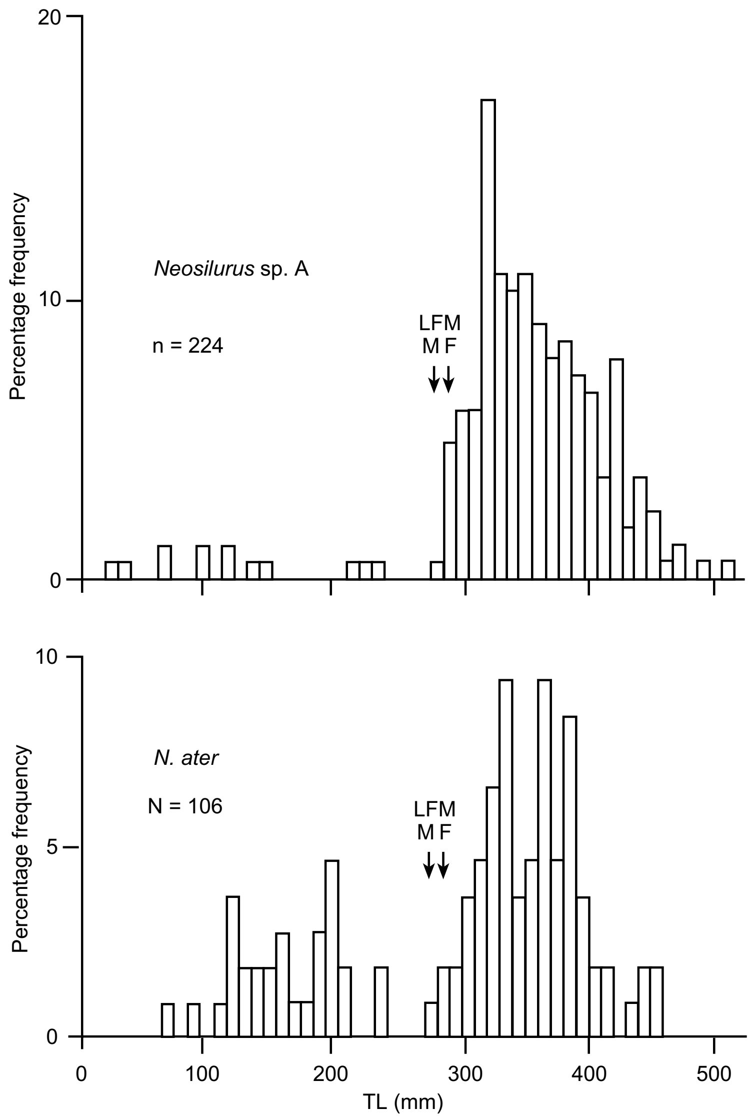


**Figure 28** Length-frequency distribution of all *Neosilurus* sp. A and *N. ater* captured

The mean lengths of *Neosilurus* sp. A and *N. ater* were similar: 337 and 317 mm TL, respectively. More adults than juveniles were collected: the LFM for both *Neosilurus* sp. A and *N. ater* was 255 mm TL for males and 275 mm TL for females. Most specimens were between 300 and 400 mm TL.

### Seasonal changes in distribution

The smallest specimens of *Neosilurus* sp. A were found in the 1978–79 Early-wet and Mid-wet seasons, and of *N. ater* in the Mid-dry season; this difference between classification types can be readily explained by seasonal growth of juveniles (ie juveniles are smaller earlier in the respective sampling periods). The smallest specimens of *Neosilurus* sp. A captured during the 1978 Late-dry season and of *N. ater* in the 1979–80 Early-wet season were much larger than the smallest specimens captured in other seasons. The largest specimens (*Neosilurus* sp. A) were captured in the 1978–79 Early-wet and Mid-wet seasons.

Only adult *Neosilurus* sp. A were captured in the 1978 Late-dry season, and only adult *N. ater* in the 1979–80 Early-wet season (fig 29). In all other seasons, both adults and juveniles were captured. The length-frequency distribution in the 1978 Late-dry season was similar to that in 1979 except that there were fewer juveniles in 1979.

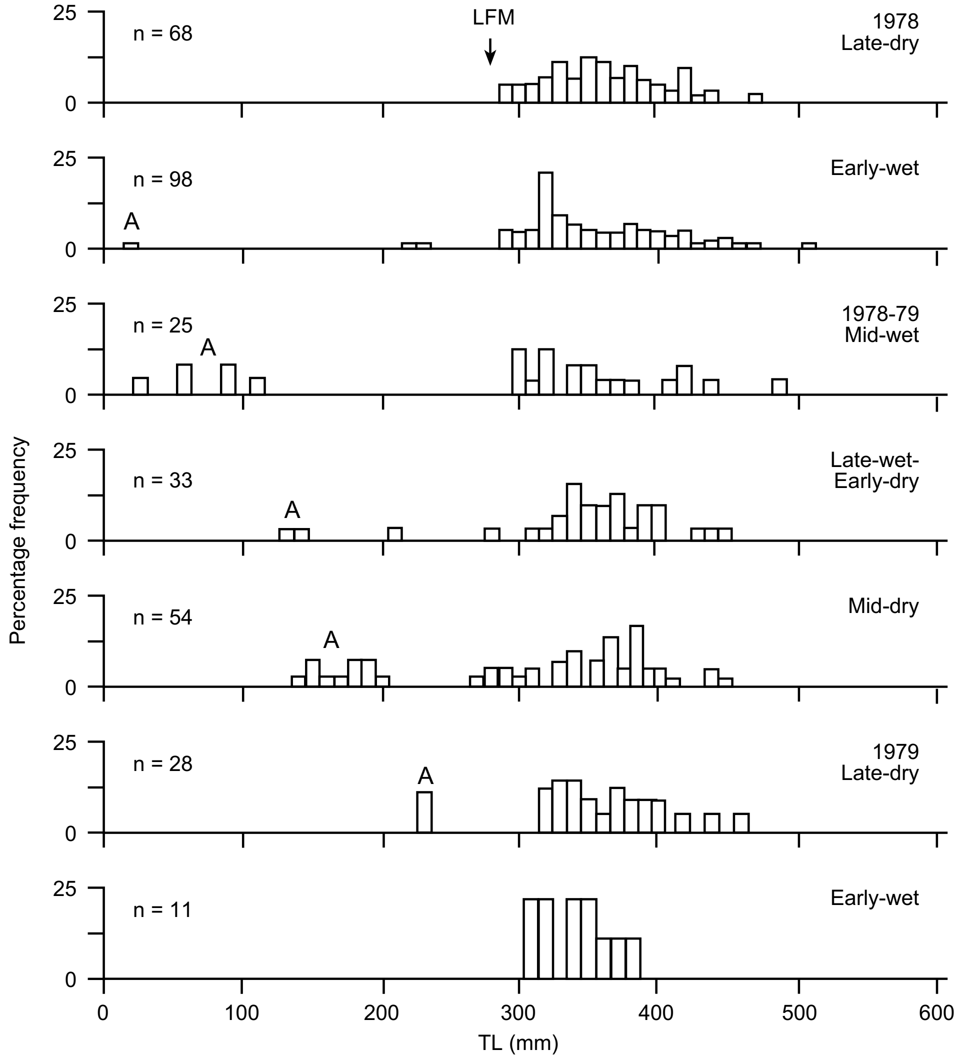


**Figure 29** Seasonal length-frequency distribution of all *Neosilurus* sp. A and *N. ater* captured

During the 1978–79 Early-wet season, the adult component of the distribution remained similar in form to the previous season's peak; however, a few juveniles had appeared.

During the Mid-wet season the adult peak persisted while the small juvenile peak strengthened and the animals were slightly larger. By the Late-wet–Early-dry season the juvenile peak had progressed further and the gap to the strong adult peak had narrowed; these changes continued through the 1979 Mid- and Late-dry seasons until the juveniles that had been spawned in the 1978–79 Early-wet season merged with the persistent adult peak by the 1979–80 Early-wet season (however, sample sizes were small in this season).

Juvenile recruitment appeared to be strongest in the 1978–79 Early-wet and Mid-wet seasons. No juveniles were found in the 1979–80 Early-wet season; the absence of strong flow and the extreme conditions in the Late-dry season may have been unfavourable for spawning.

**Growth rate**

No published information on the growth of *N. ater* was found; however, the closely related *T. tandanus* attains 200 mm TL by year two and 450 mm TL by year five (Davis 1977*a*) .

The pattern of early growth of *Neosilurus* sp. A / *N. ater* can be interpreted from the seasonal length-frequency distributions by following the progression of juveniles (modal length at 20 mm TL; A on fig 29) from the 1978–79 Early-wet season to the 1979 Late-dry season (modal length at 230 mm TL). Growth appears to be very fast: about twice that recorded for *T. tandanus* by Davis (1977a); if true, then *N. ater* could attain the LFM in one year.

**Habitat differences in distribution**

Length-frequency distributions showing habitat preferences for *Neosilurus* sp. A and *N. ater* caught at regular sampling sites in the Magela Creek catchment are given in fig 30.

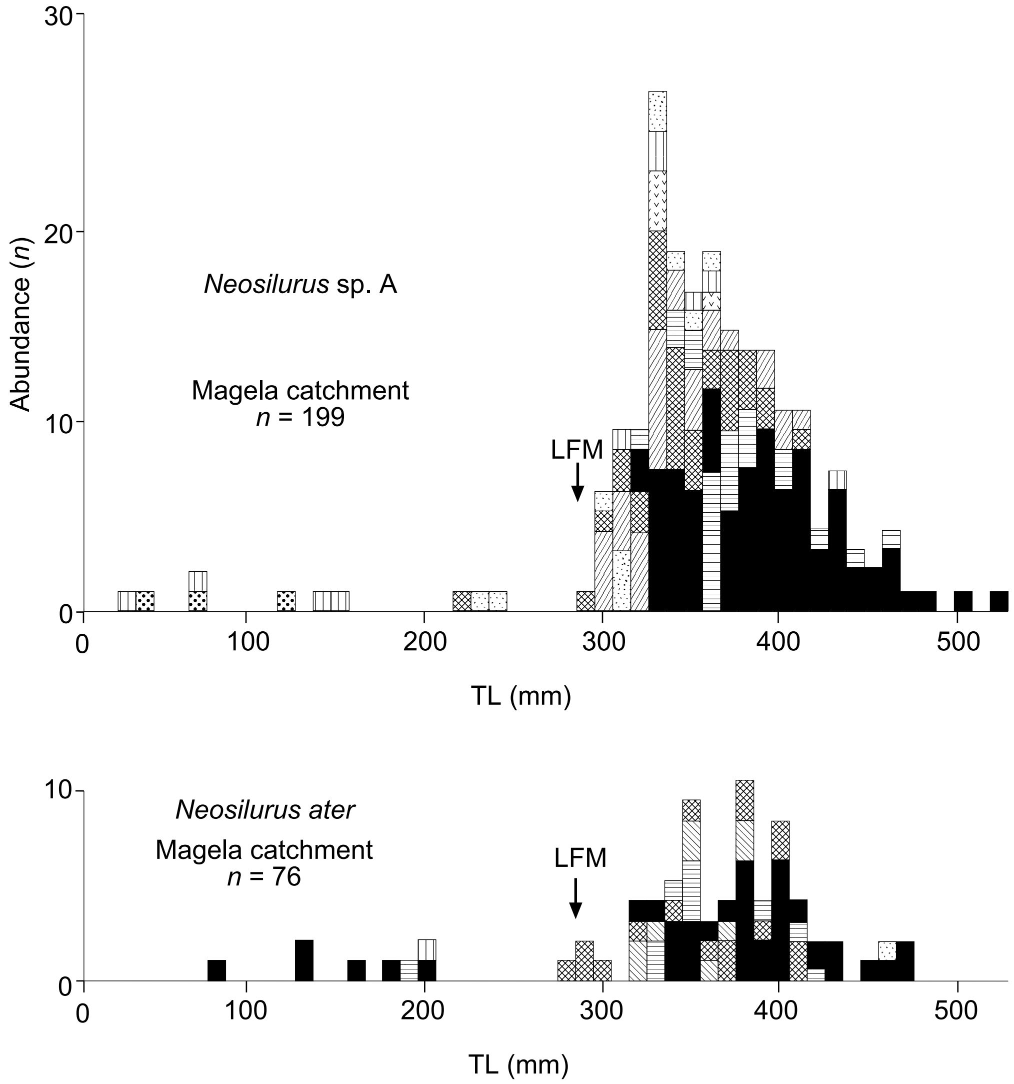


**Figure 30** Length-frequency distributions and habitat preferences of *Neosilurus* sp. A and *N. ater* captured at regular sampling sites in the Magela catchment (see appendix 5 for key to the habitats)

*Magela catchment*

Smaller juveniles of *Neosilurus* sp. A were found in shallow backflow billabongs both up- and downstream of RUPA, while smaller juveniles of *N. ater* were found in floodplain billabongs; this could be a seasonal effect (ie the juveniles migrated from the lowlands to the floodplains) or an effect of contamination by other plotosid species of the *Neosilurus* sp. A sample. Larger juveniles of both classification types appeared to be more abundant in sandy corridor waterbodies. Juvenile *N. ater* were observed in escarpment perennial streams in the Late-wet–Early-dry and 1979 Late-dry seasons.

Smaller adult *Neosilurus* sp. A were found mainly in lowland sandy creekbeds and sandy corridor waterbodies, while small adult *N. ater* were most frequently found in the latter habitat. Overall, the adults of both *Neosilurus* sp. A and *N. ater* were mainly found in floodplain and corridor (usually sandy-bottomed) billabongs; the main differences were that *Neosilurus* sp. A was more abundant in lowland sandy creekbeds and backflow billabongs (this might be an effect of contamination by other plotosid species, especially in the backflow billabongs), and *N. ater* included representatives from escarpment mainchannel waterbodies. It was apparent that specimens classified as *Neosilurus* sp. B in escarpment mainchannel waterbodies were in fact *N. ater.* The largest adults of *Neosilurus* sp. A and *N. ater* were found in floodplain billabongs.

*Nourlangie catchment*

In the Nourlangie system, small adult *N. ater* and *Neosilurus* sp. A were found in escarpment mainchannel waterbodies and perennial streams (in the 1979–80 Early-wet season), and shallow backflow billabongs. Large adults were often observed in escarpment perennial streams. Juveniles of *N. ater* were observed in lowland-sandy creeks in the Late-wet–Early-dry and 1979 Late-dry seasons.

## Environmental associations

Rank numbers for *N. ater* and *Neosilurus* sp. A for the physico-chemical and habitat-structural variables are shown in table 155.

### Physico–chemical variables

*Temperature*

*Neosilurus* sp. A was found in waters with surface temperatures between 27° and 35°C (mean = 31.3°C), and bottom temperatures between 25° and 34°C (mean = 29.4°C) (see fig 170). Both means ranked in the upper quarter, indicating a tendency for these fish to live in warmer waters (although this may be a seasonal effect, highlighted by the change in classification system). *Neosilurus ater* was found in waters with surface temperatures from 23° to 33°C (mean = 28.5°C), and bottom temperatures from 23° to 32°C (mean = 27.3°C). Both means were ranked at the base of the lower quarter, indicating an apparent preference for cooler benthic waters (similar to those preferred by *P. rendahli* and *N. hyrtlii*).

*Dissolved oxygen*

Dissolved oxygen concentrations in waters inhabited by *Neosilurus* sp. A ranged from 0.1 to 8.8 mg/L (mean = 5.8) on the surface, and from 0.4 to 6.8 mg/L (mean = 3.5) on the bottom. Both means were ranked at the base of the lower quarter. *Neosilurus ater* favoured a similar range of DO concentrations (2.7–8.2 mg/L at the surface, and 0.6–6.2 mg/L on the bottom), and mean DO concentrations associated with it (5.5 mg/L and 3.4 mg/L) also ranked in the lower quarter (see fig 171). *Neosilurus ater* was amongst the fish killed at Leichhardt Billabong (Bishop 1980) when surface DO concentrations fell to 0.1 mg/L.

*Visibility*

Secchi depths of waters in which *Neosilurus* sp. A was found ranged from 1 to 270 cm. The mean depth of 93 cm was ranked in the upper quarter; this species was typically captured in the clearer corridor and escarpment waterbodies. *Neosilurus ater* was found in waters with Secchi depths between 2 and 360 cm, with a mean of 95 cm; this mean also ranked in the upper quarter (see fig 172).

*pH*

*Neosilurus* sp. A was captured in waters with surface pH ranging from 4.8 to 8.1 (mean = 5.9) and bottom pH ranging from 4.5 to 6.8 (mean 5.7). The pH of waters in which *N. ater* was found ranged from 4.0 to 7.2 (mean = 6.1) on the surface, and from 5.3 to 7.0 (mean = 5.9) on the bottom. The means ranked in the lower and lower-middle quarter respectively (see fig 173).

*Conductivity*

The waters in which *Neosilurus* sp. A was captured had conductivity readings from 2 to 160 µS/cm on the surface, and from 4 to 234 µS/cm on the bottom. *Neosilurus ater* was found in waters with conductivities from 2 to 120 µS/cm on the surface and from 2 to 70 µS/cm on the bottom. These ranges are both narrow and low, indicating a tendency for *Neosilurus* sp. A / *N. ater* to be found in waters with low concentrations of dissolved solids.

### Habitat–structural variables

*Substrate*

*Neosilurus* sp. A was associated with a wide range of substrates: sand (upper-middle quarter), mud (upper-middle quarter), then clay, leaves, gravel, boulders and rocks. The substrate most commonly associated with *N. ater* was clay (upper quarter), followed by sand (lower-middle quarter) then mud, rocks, leaves and gravel. This wide range of substrates can be expected of such a widely distributed species. The predominance of clay and sand substrates would correspond to the clearness of waters in which this species was typically captured.

*Hydrophytes*

*Neosilurus* sp. A was typically found in vegetated waters (vegetation-occurrence index 70.8%) with submergent (42.3%), emergent (35%) and floating-attached (18.7%) hydrophytes. The order of dominance for *N. ater* was: submergent (41.5%), floating-attached hydrophytes (26.2%) and emergent (24.6%) hydrophytes (vegetation-occurrence index 65%).

## Reproduction

Of the 353 *N. ater* and *Neosilurus* sp. A (referred to in this section as *N. ater*) examined for reproductive condition, 214 were females (length range 120–508 mm TL), 119 were males (110–420 mm) and 20 were sexually indistinguishable. The gonad maturity stages differ macroscopically from the generalised description given in volume 1; a more accurate description of each stage is given in Davis (1977b).

### Length at first maturity

The LFM was estimated to be 255 TL for males and 275 mm for females (all calculations based on 10-mm-length groups); the smallest maturing male was 260 mm and the smallest maturing female was 220 mm (fig 31). Davis (1977b) found male and female *T. tandanus* maturing at the same age and weight.

### Sex ratio

In the entire sample, significantly more females than males were identified in the 1978 Late-dry, 1979 Mid-dry ($P < 0.001$) and the 1979 Late-wet–Early-dry ($0.001 < P < 0.01$) seasons, and in the adult sample in the 1978 Late-dry ($P < 0.001$) and 1979 Mid- and Late-dry ($0.001 < P < 0.01$) seasons (table 29).

Higher proportions of adult females were found in the seasons just before the breeding period (Early-wet season); equal ratios of males and females were found in the 1978–79 and 1979–80 Early-wet and 1978–79 Mid-wet seasons.[63] However, more research is required to determine the sex ratio of this species, as misidentification of immature fish and behavioural differences in the sexes are two likely causes of the unequal sex ratios found in this study.

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63 A sample of spawning *N. ater* taken during the Mid-wet season from the Ross River in northern Queensland had a sex ratio not significantly different from 1:1 (Orr & Milward 1984).

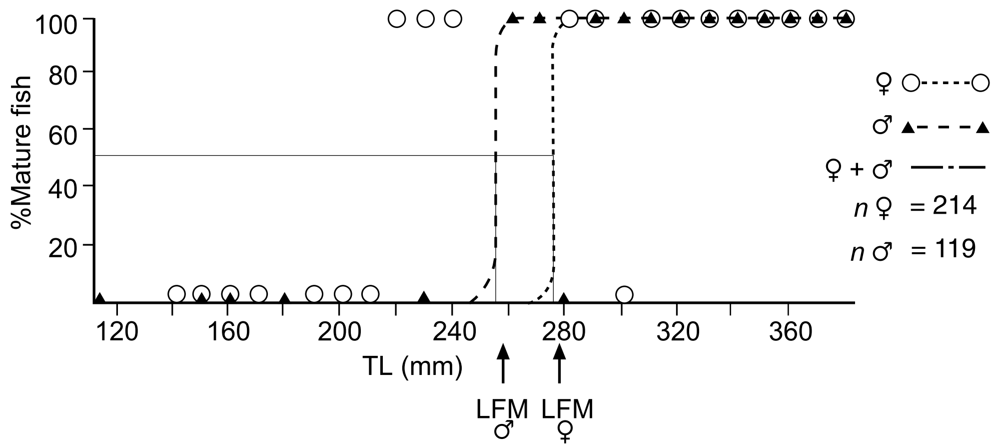



**Figure 31** Estimated length at first maturity (LFM) of male and female *N. ater*

**Table 29** Seasonal changes in sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *N. ater* 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* | 74 | 40 | 10 | 29 | 37 | 18 | 6 |
| adults | M | *n* | 27 | 44 | 10 | 11 | 12 | 10 | 5 |
| | | $\chi^2$ | 21.9 | 0.2 | 0 | 8.1 | 12.8 | 2.3 | 0.1 |
| | | P | *** | n.s. | n.s. | ** | *** | n.s. | n.s. |
| Adults only | F | *n* | 71 | 38 | 10 | 20 | 30 | 17 | 6 |
| | M | *n* | 25 | 44 | 9 | 10 | 10 | 4 | 5 |
| | | $\chi^2$ | 22 | 0.4 | 0.1 | 3.3 | 10 | 8 | 0.1 |
| | | P | *** | n.s. | n.s. | n.s. | ** | ** | n.s. |
| **GSI** | | | | | | | | | |
| Adults only | F | mean | 1.0 | 6.0 | 0.4 | 0.3 | 0.5 | 1.8 | 5.3 |
| | | s.d. | 0.9 | 2.5 | 0.3 | 0.1 | 0.3 | 1.1 | 1.0 |
| | M | mean | 0.4 | 1.7 | 0.2 | 0.3 | 0.2 | 1.3 | 1.3 |
| | | s.d. | 0.2 | 0.9 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 |
| | F+M | mean | 0.7 | 4.7 | 0.3 | 0.3 | 0.4 | 1.5 | 3.7 |
| | | s.d. | 0.8 | 3.0 | 0.3 | 0.1 | 0.3 | 1.0 | 2.2 |
| **GMSI** | | | | | | | | | |
| Adults only | F | mean | 3.2 | 4.1 | 2.0 | 2.1 | 2.7 | 3.9 | 4.3 |
| | | s.d. | 0.9 | 1.1 | 0.0 | 0.3 | 0.7 | 1.1 | 0.5 |
| | M | mean | 3.6 | 4.5 | 2.5 | 2.3 | 3.1 | 4.2 | 5.0 |
| | | s.d. | 0.7 | 0.5 | 0.9 | 0.9 | 1.0 | 0.7 | 0.0 |
| | F+M | mean | 3.3 | 4.8 | 2.2 | 2.1 | 2.8 | 4.0 | 4.6 |
| | | s.d | 0.9 | 0.9 | 0.6 | 0.3 | 0.8 | 0.9 | 0.5 |

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

### Breeding season

The GSI and GMSI show a peak in gonad development around the 1978–79 Early-wet season and a steady increase in development from the 1979 Mid-dry season to the 1979–80 Early-wet season peak (fig 32, table 29). Most of the mature fish were found in the 1978–79 Early-wet season, although they were found at other seasons, except the 1978–79 Mid-wet season. All ripe fish, except for one female, were captured in the 1978–79 Wet season. Spent female fish were found in all seasons between the 1978 Late-dry and the 1979 Mid-dry, and spent males from the 1978–79 Mid-wet through to the 1979 Mid-dry.

Thus the data suggest that the main breeding season was the 1978–79 Early-wet season, possibly with some spawning during the preceding Late-dry season. Although fish were maturing towards the 1979 Late-dry and 1979–80 Early-wet seasons, no evidence of actual spawning was observed.

Midgley (1980) observed large numbers of running-ripe male and female plotosids appearing to spawn soon after the start of flow down Magela Creek during the 1979–80 Wet season; this phenomenon was only observed over two days.

### Site of spawning

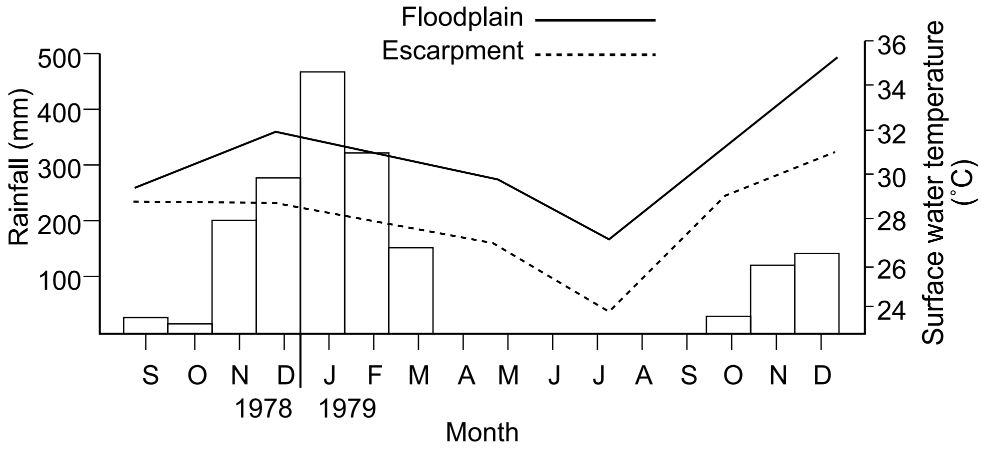
Ripe fish were identified in a wide range of habitats (table 30), including sandy creekbed sites and escarpment mainchannel waterbodies, channel backflow billabongs, and corridor and floodplain billabongs. Thus this species most likely spawns throughout its preferred range. Midgley (1980) observed plotosids apparently spawning in water about 0.5 m deep amongst grass and timber immediately upstream of Magela Crossing, below a corridor waterbody.[64] *Tandanus tandanus* from southern Australia is reported to breed in ponds (Davis 1977b).[65]

**Table 30** Possible sites of spawning of *N. ater* as indicated by the abundance (*n*) of mature, ripe and spent fish

| | Gonad stage | | | | | |
|---|---|---|---|---|---|---|
| | Mature (V) | | Ripe (VI) | | Spent (VII) | |
| Habitat | F | M | F | M | F | M |
| **Escarpment** | | | | | | |
| Mainchannel waterbody | 8 | 6 | 2 | – | 3 | 1 |
| **Lowlands** | | | | | | |
| Sandy creekbed | 3 | 11 | 4 | – | 4 | 1 |
| Backflow billabong | 4 | 3 | 1 | – | 5 | 5 |
| **Corridor** | 11 | 4 | 1 | – | 22 | 5 |
| **Floodplain billabong** | | | | | | |
| Upper | 12 | 8 | 5 | 1 | 21 | 4 |
| Lower | 1 | – | – | – | – | – |

64 From observations in the Ross River in northern Queensland, Orr and Milward (1984) stated that *N. ater* is a lithophilic flood spawner that undertakes spawning migrations.

65 Merrick and Midgley (1981) recorded *T. tandanus* spawning over a nest site in a flowing stream in south-eastern Queensland. The site had the following characteristics: coarse gravel substrate, water velocity 0.05–0.07 m/s, water depth 0.6 m and surface temperature 20°C. Hutchison (1992) recorded a run habitat within a flowing stream to be the probable spawning site of the closely related *T. bostocki* from the Murray River in Western Australia. Eggs appeared to be laid within the coarse substrate of the run.



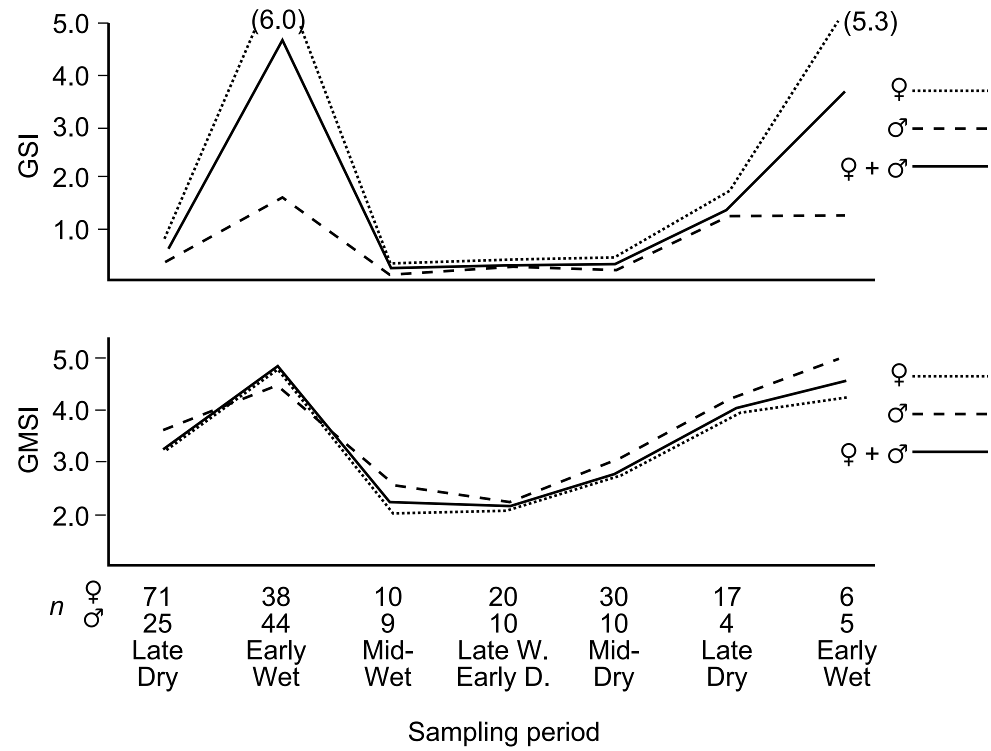




**Figure 32** Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *N. ater*

**Fecundity**

The eggs of 13 ripe ovaries (4.89 g to 92.21 g) were counted. The mean fecundity was 7890 (s.d. = 6060), and the range was 2540 to 26 070 eggs.[66]

Oocyte diameter ranged from 0.85 to 1.64 mm with a mean of 1.40 mm. Within the ovaries were small clusters of tiny eggs (mean diameter = 0.16 ± 0.012 mm).[67] Midgley (1980) reported plotosid eggs were demersal, non-adhesive and 2 mm in diameter when water-

66 Orr and Milward (1984) estimated fecundities of *N. ater* to range from 14 600 to 20 400 for individuals 348–440 mm standard length taken from the Ross River, northern Queensland.

67 Egg and larval development of *N. ater* have been described by Orr and Milward (1984).

hardened. Davis (1977b) found a linear relationship for *T. tandanus* between egg diameter and fish weight and length, and found that egg size increased with an increase in fecundity.

#### Summary

*Neosilurus ater* had a peak in reproductive development around the 1978–79 Early-wet season, although some may have spawned earlier. Gonads started maturing for the next season's spawning around the 1979 Mid-dry season. The data indicate that *N. ater* is probably capable of breeding throughout its entire preferred habitat. Around 8000 medium-sized (1.4 mm) eggs are spawned, although it is not known if the species lays these all at once or over many spawnings.

In the Murray–Darling river system and south-east coastal drainages *T. tandanus* matures after four years (Davis 1977b). It spawns during spring or summer when water temperatures rise above 24°C (Lake 1967). It builds a nest with pebbles or gravel (or sticks or small stones where gravel is scarce) up to two weeks before spawning. If a sudden drop in water level exposes the nest before egg laying, it is invariably abandoned, even if the water level is restored shortly afterwards, and *T. tandanus* builds another nest elsewhere. If water levels fluctuate often, spawning will not take place, even though several nests are built; the ovaries are then resorbed.

The large demersal eggs settle within interstices of the gravel without actually adhering, and one parent remains in attendance until after hatching. Fecundity varies from 2800 at 39 cm TL (0.8 kg) to 20 000 ova at 53 cm TL (2.3 kg) (Davis 1977b). Hatching takes about seven days at temperatures between 19° and 25°C, at which time the larvae are 7 mm long. The eyes and most of the body are pigmented, but there are no barbels or pectoral fins. Barbels appear in three days, and by three weeks the larvae have most of the characteristics of adult fish (Davis 1977b; Pollard et al 1980).

A noticeable difference between *T. tandanus* and the northern *N. ater* is the size of the oocyte. Although fecundities are comparable, the egg diameters are 2.3–3.0 mm for *T. tandanus* (and greater than 3.2 mm when water-hardened [Davis 1977b]) and 0.9–1.6 mm for *N. ater*.

Sexual dimorphism amongst the plotosids was observed. The urinogenital papilla in females was swollen and cylindrical, whereas that of the males was triangular. These external sexual characteristics were noticeable in *T. tandanus* after it reached one year old (Davis 1977b).

The main factor stimulating spawning is believed to be temperature (Davis 1977b), which may act either by stimulating maturation of the gonads or, indirectly, by increasing the food supply. Day-length and flooding have also been suggested as spawning stimuli.

## Feeding habits

#### Overall diet

The stomachs of 202 specimens of *Neosilurus* sp. A (161 containing food) and 115 of *N. ater* (99 containing food) were examined. The overall diets are shown in fig 33; details of the components are given in table 31. The main components were aquatic insects (37% and 60%, respectively), microcrustaceans (7% and 8%) and unidentified organic material (33% and 15%). There appears to be a difference between the quantity of aquatic insects each species ate, but this is probably a result of the change in the classification system highlighting the seasonal availability of food items.

**Table 31** Dietary composition of *Neosilurus* sp. A and *N. ater*

| | *Neosilurus* sp. A | | | | | | *N. ater* | | | | | Habitat | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1978 | 1978–79 | 1978–79 | Late-wet– | Overall | | 1979 | 1979 | 1979–80 | Overall | | | | | |
| Stomach contents | Late-dry | Early-wet | Mid-wet | Early-dry 1979 | Sub-mean | Main-mean | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean | Em | Bb | Cb | Fb |
| **Aquatic plants** | | | | | | | | | | | | | | | |
| Algae | | | | | | 0.8 | | | | | 1.4 | | | | |
| Miscellaneous | 1.5 | 0.9 | – | – | 0.8 | | – | 4.4 | – | 3.0 | | – | – | 2.5 | – |
| Conjugatophyta | | | | | | | | | | | | | | | |
| *Mougeotia* | – | – | – | 0.4 | | | – | – | – | | | – | – | – | – |
| *Spirogyra* | – | – | – | – | – | | – | – | – | 0.4 | | – | – | – | – |
| Hydrophytes | | | | | | 0.3 | | | | | – | | | | |
| *Pseudoraphis* | – | 0.9 | – | – | 0.3 | | – | – | – | – | | – | – | – | – |
| **Aquatic animals** | | | | | | | | | | | | | | | |
| Oligochaeta | – | 0.9 | – | – | 0.3 | 0.3 | – | – | – | – | – | – | – | – | – |
| Gastropoda | | | | | | 0.4 | | | | | – | | | | |
| Miscellaneous | – | – | 1.2 | 1.4 | 0.4 | | – | – | – | – | | – | – | – | – |
| Bivalvia | | | | | | 0.6 | | | | | – | | | | |
| *V. angasi* | 0.9 | – | – | 1.4 | 0.6 | | – | – | – | – | | – | – | – | – |
| Microcrustacea | | | | | | 6.6 | | | | | 8.0 | | | | |
| Conchostraca | | | | | | | | | | | | | | | |
| Miscellaneous | – | – | 3.2 | – | 0.5 | | – | – | – | – | | – | – | – | – |
| *Cyzicus* | – | 11.3 | 16.4 | 2.1 | 5.1 | | 2.4 | – | – | 0.3 | | – | – | 2.0 | – |
| Cladocera | | | | | | | | | | | | | | | |
| Miscellaneous | – | – | 2.2 | – | 0.3 | | 0.6 | – | – | 1.2 | | – | – | 0.5 | – |
| *Diaphanosoma* | – | 0.8 | – | – | 0.3 | | – | – | 20.0 | 3.5 | | 20.0 | – | – | 4.4 |
| Ostracoda | 0.4 | – | 1.2 | 0.7 | 0.4 | | – | – | – | 3.4 | | – | – | – | – |
| Copepoda | – | – | – | – | – | | – | – | – | 0.1 | | – | – | – | 0.6 |
| Macrocrustacea | | | | | | 0.8 | | | | | – | | | | |
| *Macrobrachium* | 1.1 | – | – | 2.1 | 0.8 | | – | – | – | – | | – | – | – | – |
| Insecta | | | | | | 36.8 | | | | | 60.3 | | | | |
| Fragmented | 0.2 | 4.2 | 8.0 | – | 2.7 | | 2.7 | 2.4 | – | 6.7 | | – | – | 2.3 | 6.3 |
| Ephemeroptera | | | | | | | | | | | | | | | |
| Baetidae | – | 5.3 | 4.2 | – | 2.4 | | – | – | 40.0 | 3.1 | | 40.0 | – | – | – |
| Tasmanocoenis | – | – | – | – | – | | – | 0.4 | – | 1.0 | | – | – | 0.3 | – |
| Odonata | | | | | | | | | | | | | | | |
| *I. heterosticta* | – | – | – | – | – | | 1.2 | – | – | 0.4 | | – | – | 1.0 | – |
| Libellulidae | – | 1.1 | 7.6 | – | 1.6 | | 4.4 | 4.4 | – | 5.2 | | – | 45.0 | 3.8 | 0.6 |
| Gomphidae | – | – | 1.6 | – | 0.3 | | – | – | – | – | | – | – | – | – |

Table 31 continued

| Stomach contents | *Neosilurus* sp. A 1978 Late-dry | 1978–79 Early-wet | 1978–79 Mid-wet | Late-wet–Early-dry 1979 | Overall Sub-mean | Overall Main-mean | *N. ater* 1979 Mid-dry | 1979 Late-dry | 1979–80 Early-wet | Overall Sub-mean | Overall Main-mean | Habitat Em | Bb | Cb | Fb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hemiptera | | | | | | | | | | | | | | | |
| Naucoridae | – | – | – | – | – | | 0.6 | – | – | 0.2 | | – | – | 0.5 | – |
| Corixidae | – | 0.4 | 4.0 | – | 0.8 | | – | – | – | 0.2 | | – | – | – | 1.3 |
| Coleoptera | – | 2.5 | 1.2 | – | 1.0 | | 0.6 | – | – | 0.2 | | – | – | 0.5 | – |
| Diptera | | | | | | | | | | | | | | | |
| Chaoborinae | – | – | – | – | – | | 7.2 | 2.2 | – | 3.0 | | – | – | – | 18.4 |
| Chironomidae (larvae) | 42.6 | 21.1 | 13.4 | 37.5 | 20.5 | | 30.3 | 72.8 | 2.0 | 32.4 | | 2.0 | 55.0 | 46.3 | 40.3 |
| Chironomidae (pupae) | 2.7 | 0.4 | – | 20.4 | 0.6 | | 2.9 | 0.2 | – | 2.0 | | – | – | – | 6.6 |
| Miscellaneous (larvae) | 1.8 | 2.5 | – | – | 1.4 | | – | – | – | – | | – | – | – | – |
| Ceratopogonidae | – | 3.9 | – | – | 1.3 | | 0.3 | – | – | 0.8 | | – | – | 0.3 | – |
| Trichoptera | | | | | | | | | | | | | | | |
| Lepteroceridae | 3.3 | 2.1 | 12.6 | 2.5 | 4.2 | | 1.0 | – | 20.0 | 5.1 | | 20.0 | – | 0.9 | – |
| Teleostomi | | | | | | 1.3 | | | | | – | | | | |
| Scales | – | – | – | 2.9 | 0.5 | | – | – | – | | | – | – | – | – |
| Egg material | 0.6 | 1.9 | – | – | 0.8 | | – | – | – | – | | – | – | – | – |
| **Terrestrial plants** | | | | | | | | | | | | | | | |
| Angiospermae | | | | | | 2.9 | | | | | 3.3 | | | | |
| Fragmented | 8.5 | – | – | – | 2.9 | | 7.1 | 3.9 | – | 3.3 | | – | – | 6.8 | 3.8 |
| **Terrestrial animals** | | | | | | | | | | | | | | | |
| Arachnida | 1.5 | 1.0 | – | – | 1.1 | 1.1 | – | – | – | – | – | – | – | – | – |
| Insecta | | | | | | | | | | | | | | | |
| Odonata | | | | | | 0.6 | | | | | – | | | | |
| Zygopteran (adults) | – | 0.1 | – | – | + | | – | – | – | – | | – | – | – | – |
| Anisopteran (adults) | | | | | 0.6 | | – | – | – | – | | – | – | – | – |
| Dipteran (larvae) | – | 1.9 | – | – | – | | – | – | – | – | | – | – | – | – |
| Scolopendromorpha | – | 1.9 | – | – | 0.6 | 0.6 | – | – | – | – | – | – | – | – | – |
| **Parasites** | | | | | | | | | | | | | | | |
| Trematoda | 4.4 | 12.5 | – | – | 5.3 | 5.3 | – | – | – | – | – | – | – | – | – |
| Nematoda | 0.7 | – | – | – | 0.6 | 0.6 | – | – | – | – | – | – | – | – | – |
| Detrital material | – | – | – | – | 4.6 | 4.6 | 8.7 | 3.0 | 18.0 | 8.9 | 8.9 | 18.0 | – | 7.4 | 10.6 |
| Inorganic material | 4.8 | 20.0 | – | – | 3.4 | 3.4 | 3.5 | 4.4 | – | 1.4 | 1.4 | – | – | 5.5 | – |
| Organic material | 25.0 | – | 23.0 | 3.0 | 32.9 | 32.9 | 28.4 | – | – | 14.5 | 14.5 | – | – | 19.8 | 10.9 |
| Number of empty fish | 10 | 26 | – | 5 | 41 | 41 | 6 | 3 | 3 | 16 | 16 | 2 | – | – | 1 |
| Number of fish with food | 55 | 53 | 25 | 28 | 161 | 161 | 34 | 23 | 5 | 99 | 99 | 5 | 2 | 40 | 16 |

Figures represent the mean percentage volume determined by the estimated volumetric method.
All habitats are in the Magela system. Em = escarpment mainchannel; Bb = lowland backflow billabongs; Cb = corridor billabongs; Fb = floodplain billabongs

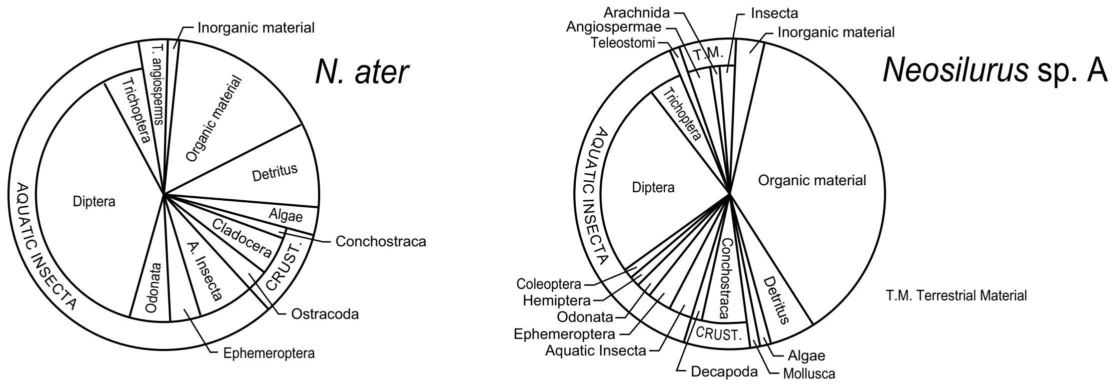



**Figure 33** The main components of the diet of *Neosilurus* sp. A and *N. ater*

The main identifiable aquatic insects were chironomid, leptocerid, libellulid and baetid larvae. The main microcrustaceans *Neosilurus* sp. A ate were conchostracans, while *N. ater* ate mostly ostracods and copepods. Other food items were traces of algae, hydrophytes, oligochaetes, gastropods, bivalves, macrocrustaceans, teleosts, terrestrial plant material, and terrestrial arachnids, insects and scolopendromorphs.

*Neosilurus ater/Neosilurus* sp. A can therefore be classified as a meiophagous carnivore that feeds predominantly on benthic fauna.[68]

Pollard (1974) noted that little appeared to be known of the feeding of the 'neosilurine' group of plotosid catfishes. However, the feeding habits of the closely related *T. tandanus* in the Gwydir River, New South Wales, were investigated by Davis (1977*c*), who found that decapods (*Macrobrachium australiense* and *Cherax neopunctatus*) were the most important component of the diet by weight, followed by chironomids, fish (*Hypseleotris klunzingeri*) and miscellaneous aquatic invertebrates. Macrocrustaceans and fish were not a large component of the diet of *N. ater/Neosilurus* sp. A in the Alligator Rivers Region. Davis (1977*c*) reported that ontogenetic changes in the diet of *T. tandanus* were progressive: entomostracans to dipterans to fish to decapods. *Macrobrachium* was the main food in summer and chironomids in winter.

### Seasonal differences

In sampling periods 1–4, respectively, 65 (15% empty), 79 (33% empty), 25 (0% empty) and 33 (15% empty) stomachs of *Neosilurus* sp. A were examined (all habitats combined).

In the 1978 Late-dry season, mainly chironomid larvae and other aquatic insects and some terrestrial plant material comprised the diet. Fewer chironomid larvae were eaten in the 1978–79 Early-wet season, while other aquatic insects (baetid larvae, coleopterans, ceratopogonid larvae) and microcrustaceans (*Cyzicus*) were eaten more often. By the Mid-wet season the diet consisted of microcrustaceans (*Cyzicus*) and a variety of aquatic insects (chironomid, leptocerid and libellulid larvae, and corixids and baetid larvae). During the Late-wet–Early-dry season, chironomid larvae and pupae become the most important food items.

In sampling periods 5–7, respectively, 40 (15% empty), 26 (11% empty) and 8 (38% empty) stomachs of *N. ater* were examined (all habitats combined).

During the 1979 Mid-dry season, *N. ater* ate mainly aquatic insects (chironomid, chaoborinid and libellulid larvae), terrestrial plant material and detritus. During the 1979 Late-dry season,

68 Pusey et al (1995b) found *N. ater* to primarily consume detritus in two rivers of the Australian wet tropics, northeastern Queensland.

it ate mainly chironomid larvae, as did *Neosilurus* sp. A in the previous year. The few specimens examined from the 1979–80 Early-wet season had eaten mainly baetid and leptocerid larvae, and microcrustaceans (this component appeared in the previous year for *Neosilurus* sp. A); however, *Diaphanosoma* was the main item in the 1979–80 Early-wet season, together with detrital material.

**Habitat differences**

A total of 66 stomachs of *N. ater* were examined (all seasons combined) from the Magela Creek catchment: 7 (29% empty) from escarpment mainchannel waterbodies; 2 (0% empty) from backflow billabongs; 40 (0% empty) from corridor billabongs; and 17 (6% empty) from floodplain billabongs. The highest proportion of specimens with empty stomachs was found in the escarpment mainchannel habitat.

The few specimens examined from escarpment habitats were feeding mainly on aquatic insects (mainly baetids and leptocerids), microcrustaceans (*Diaphanosoma*) and some detrital material. The two specimens from the backflow billabongs had eaten only aquatic insects (chironomid and libellulid larvae).

*Neosilurus ater* in the corridor waterbodies ate mainly chironomid larvae plus small portions of terrestrial plant and detrital material. The diet in the floodplain habitats was also dominated by chironomid larvae; however, there were also sizeable portions of chaoborinid larvae, chironomid pupae, detrital material and traces of terrestrial plant material.

**Fullness**

A summary of mean fullness indices of *Neosilurus* sp. A / *N. ater* for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments is shown in table 32. 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) fluctuated greatly, with peaks in the Late-wet–Early-dry and 1979 Late-dry season.

*Habitat differences*

In the Magela catchment the mean fullness indices of specimens from upstream of RUPA were highest in the shallow backflow billabongs and lowest in the escarpment mainchannel waterbody.

Downstream of RUPA the main indices were generally higher than those recorded in the upstream habitats; the mean fullness indices were highest in backflow and sandy corridor billabongs and lowest in corridor anabranch and floodplain billabongs.

In the Nourlangie catchment the range of mean fullness indices was larger than in the Magela catchment, possibly due to the smaller number of specimens examined from the latter catchment. The mean indices recorded in the escarpment mainchannel waterbodies and shallow backflow billabongs were comparable with those from equivalent habitats in the Magela catchment. The few specimens examined in the lowland sandy pool had high fullness indices.

**Table 32** Mean fullness indices of *Neosilurus* sp. A and *N. ater* in different sampling periods and habitats

| Habitat | Sampling period | | | | | | | Habitat mean |
|---|---|---|---|---|---|---|---|---|
| | *Neosilurus* sp. A | | | | *N. ater* | | | |
| | 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 | 1.1 (9) | n/s | n/s | | 0.3 (7) | n/s | 0.9 (8) | 0.8 (24) |
| Lowland shallow backflow billabong | n/s | n/s | 2.0 (3) | | 3 (1) | n/s | n/s | 2.3 (4) |
| Lowland sandy creekbed | n/s | 1.0 (4) | n/s | n/s | n/s | n/s | n/s | 1.0 (4) |
| Downstream of RUPA: | | | | | | | | |
| Lowland sandy creekbed | n/s | 1.8 | 4.0 (2) | n/s | 2.3 (4) | n/s | n/s | 2.0 (36) |
| Lowland channel backflow billabong | n/s | 1.0 (6) | 4.0 (5) | 2.5 (2) | 3 (2) | n/s | n/s | 2.5 (15) |
| Lowland shallow backflow billabong | n/s | 4 (1) | 2.4 (5) | 3.7 (6) | 5 (1) | n/s | n/s | 3.3 (13) |
| Corridor sandy billabong | 2.6 (20) | 3.7 (3) | n/s | 2.4 (8) | 1.6 (10) | 1.0 (7) | n/s | 2.3 (48) |
| Corridor anabranch billabong | 3.3 (11) | n/s | n/s | 0.7 (16) | 2.0 (2) | 1.9 (7) | n/s | 1.8 (36) |
| Floodplain billabong | 1.7 (18) | 0.7 (31) | 2.7 (10) | 2.8 (9) | 2.1 (27) | 3.3 (14) | n/s | 1.7 (109) |
| **Nourlangie Creek catchment** (regular sites only) | | | | | | | | |
| Escarpment main-channel waterbody | 0.6 (14) | 3.0 (3) | n/s | n/s | 1 (1) | n/s | n/s | 1.0 (18) |
| Lowland shallow backflow billabong | n/s | 3.0 (5) | n/s | 3 (1) | n/s | n/s | n/s | 3.0 (6) |
| Lowland sandy creekbed | n/s | n/s | n/s | 4.0 (2) | n/s | n/s | n/s | 4.0 (2) |
| **Seasonal mean (all sites)** | 2.2 | 1.5 | 1.5 | 3.0 | 1.9 | 3.1 | 1.3 | |

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

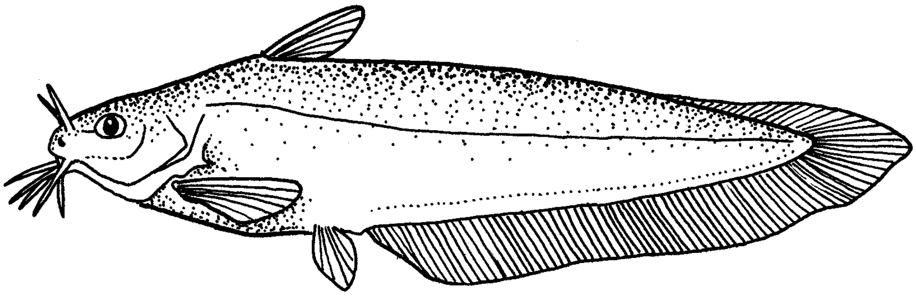
**Nourlangie catchment**

- lowland sandy creekbed; 1978–79 Late-wet–Early-dry season
- lowland shallow backflow billabong; 1978–79 Early-wet season
- escarpment mainchannel waterbody; 1978–79 Early-wet season

# Family PLOTOSIDAE

## 3.10 *Neosilurus hyrtlii* (Steindachner)

*Neosilurus hyrtlii* is commonly known as Hyrtl's tandan or eel-tailed catfish. The data on *N. hyrtlii* and *Neosilurus* sp. B will be presented together. This species, a native to Australia, is found in the Timor Sea and Gulf of Carpentaria drainages, and many of the central desert streams of South Australia, Queensland and the Northern Territory.[69]



*Neosilurus hyrtlii*

Detailed information on catches at each site and in each season is given in volume 2. In summary, the species was commonly found in all backflow billabongs and in some lowland sandy creeks, corridor and floodplain billabongs. In the 1978 Late-dry season *Neosilurus* sp. B was found only in a lowland sandy creekbed site; during the Mid-wet season no specimens were captured; by Late-wet–Early-dry season *N. hyrtlii* was common in some backflow billabongs and moderately abundant in some escarpment perennial streams and floodplain billabongs.

### Size composition

The lengths and weights of 43 *Neosilurus* sp. B and 121 *N. hyrtlii* were determined.

The records of *Neosilurus* sp. B may have been contaminated, particularly by *N. ater*; this will be indicated where possible. Seasonal length-frequency distributions and condition factors are based on *Neosilurus* sp. B to the Mid-wet season and on *N. hyrtlii* from then to the end of the study.

*Neosilurus* sp. B and *N. hyrtlii* and were mainly captured by gillnets, so the narrow peaks in the length-frequency distributions may have been partly caused by mesh selectivity. Some of the smaller specimens of *N. hyrtlii* were captured by seine net.

#### Length–weight relationship

The length–weight relationships for *Neosilurus* sp. B and *N. hyrtlii* were described respectively by the expressions:

$W = 0.42 \times 10^{-2} L^{3.19}$ r = 0.99 (length in cm, weight in g)

$W = 2.24 \times 10^{-2} L^{2.59}$ r = 0.91 (length in cm, weight in g)

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69 Herbert and Peeters (1995) and Herbert et al (1995) indicated that *N. hyrtlii* is found in almost all locations in Cape York Peninsula, and is particularly abundant in intermittent streams in the early to mid dry season, where they may school in their thousands. Accordingly, it is now known that the distribution of *N. hyrtlii* extends to the north-coast drainage division.

The difference in the form of these expressions may be the result of the difference in the size range of the two groups.

Seasonal mean lengths, weights and condition factors are shown in table 33. The condition of *Neosilurus* sp. B was highest in the 1978 Late-dry season and lowest in the 1978–79 Early-wet season. The condition of *N. hyrtlii* was low in the 1979 Late-wet–Early-dry season, but increased dramatically in the 1979 Mid-dry season; this increase may be related to the ending of the anoxic benthic conditions recorded in backflow billabongs during the previous season. After the Mid-dry season the condition of these fish fell again and remained low until the end of the study.

**Table 33** Mean length, mean weight and condition factor of *Neosilurus* sp. B and *N. hyrtlii*

| Sampling period | *n* | Mean length (mm) | Mean weight (g) | Condition factor (K) |
|---|---|---|---|---|
| *Neosilurus* sp. B | | | | |
| Late-dry (1978) | 34 | 303.7 | 228.7 | 1.01 |
| Early-wet (1978–79) | 4 | 320.0 | 243.2 | 0.91 |
| Mid-wet | 0 | – | – | – |
| All seasons combined | 38 | 287.5 | 189.4 | 1.00 |
| *N. hyrtlii* | | | | |
| Late-wet–Early-dry (1979) | 18 | 133.6 | 18.4 | 0.99 |
| Mid-dry | 42 | 147.8 | 26.8 | 1.11 |
| Late-dry | 26 | 139.9 | 19.1 | 0.91 |
| Early-wet (1979–80) | 19 | 130.5 | 16.0 | 0.91 |
| All seasons combined | 105 | 140.1 | 21.0 | 1.00 |

### Length-frequency distribution

The range of lengths of *Neosilurus* sp. B was 110–405 mm TL and of *N. hyrtlii* 48–242 mm TL (fig 34). The difference in the minimum lengths may be attributable to differences in sampling periods; the large differences in maximum lengths were caused by contamination of the *Neosilurus* sp. B by large *N. ater* from escarpment habitats. Lake (1971) reported that most species of *Neosilurus* usually grow to only 200 mm TL, the exceptions being *N. hyrtlii* and *N. ater* which grow to 400 mm TL.

The mean length of *Neosilurus* sp. B was 287 mm TL and of *N. hyrtlii* 140 mm TL; this difference could be a consequence of the contamination of *Neosilurus* sp. B by *N. ater*. The LFM was 135 mm TL for both male and female *N. hyrtlii*, indicating that equal numbers of juveniles and adults were captured. Most *Neosilurus* sp. B were captured at 270–370 mm TL, and *N. hyrtlii* at 100–160 mm TL; the length distribution of the former displayed positive skew and the latter negative skew.

### Seasonal changes in distribution

The smallest juvenile *N. hyrtlii* were captured in the Late-wet–Early-dry season. The largest adults were also found in this season, as well as in the 1979 Mid-dry season (fig 35).

Juvenile *N. hyrtlii* were most abundant in the Late-wet–Early-dry season when there were few adults. By the Mid-dry season the peaks of small juveniles had apparently progressed, leaving predominantly a large-juvenile/small-adult peak with fewer larger adults. During the 1979 Late-dry season the small-juvenile peak strengthened, and the number of adults in the sample declined. The 1979–80 Early-wet season was similar, with even fewer adults.

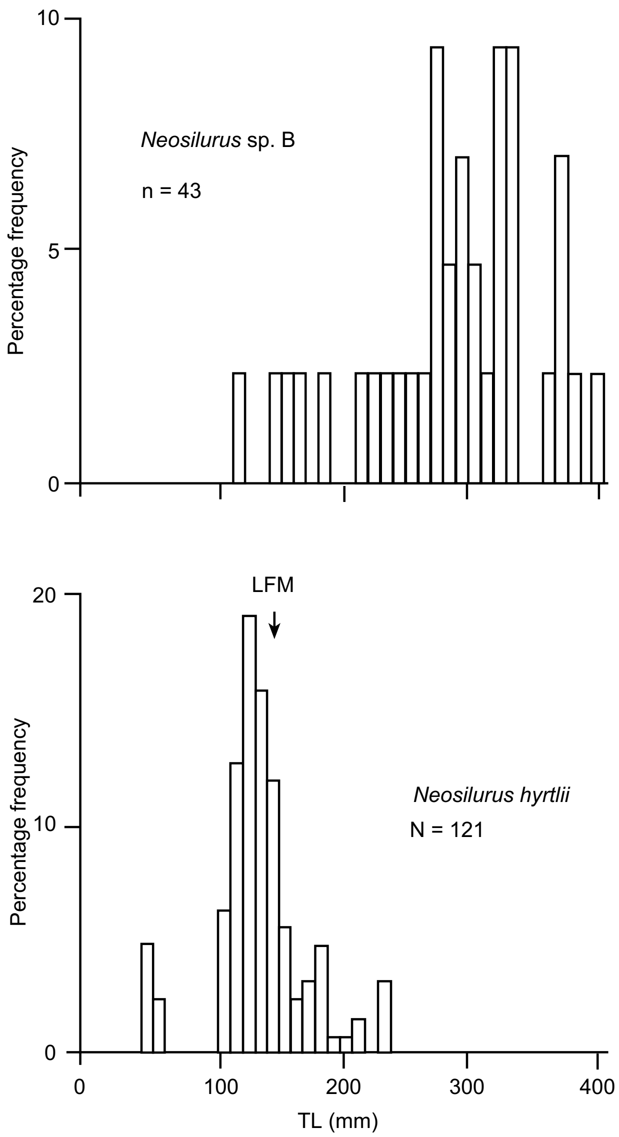



**Figure 34** Length-frequency distribution of all *Neosilurus* sp. B and *N. hyrtlii* captured

Juveniles therefore appear to have recruited before the Late-wet–Early-dry season; they may have been classified as *Neosilurus* sp. A or C before this season.

**Growth rate**

No published information could be found on the growth of *N. hyrtlii*. Estimation of growth rates from the seasonal length-frequency distribution was impossible due to contamination of the *Neosilurus* sp. B group, mesh selectivity and the wide range of habitats sampled.

**Habitat differences in distribution**

Length-frequency distributions showing the habitat preferences of *Neosilurus* sp. B and *N. hyrtlii* caught at regular sampling sites in the Magela and Nourlangie Creek catchments are given in fig 36.

*Neosilurus hyrtlii* juveniles were captured mainly in lowland backflow billabongs and lowland sandy creekbed habitats. Large juveniles appeared in the escarpment perennial streams during the Mid-wet season and remained there until the end of the study. Adults were found in similar habitats, and also in shallow backflow billabongs upstream of RUPA. The largest specimens were found in backflow billabongs. Small adults observed in escarpment perennial streams during the Mid-wet season remained there until the end of the study.

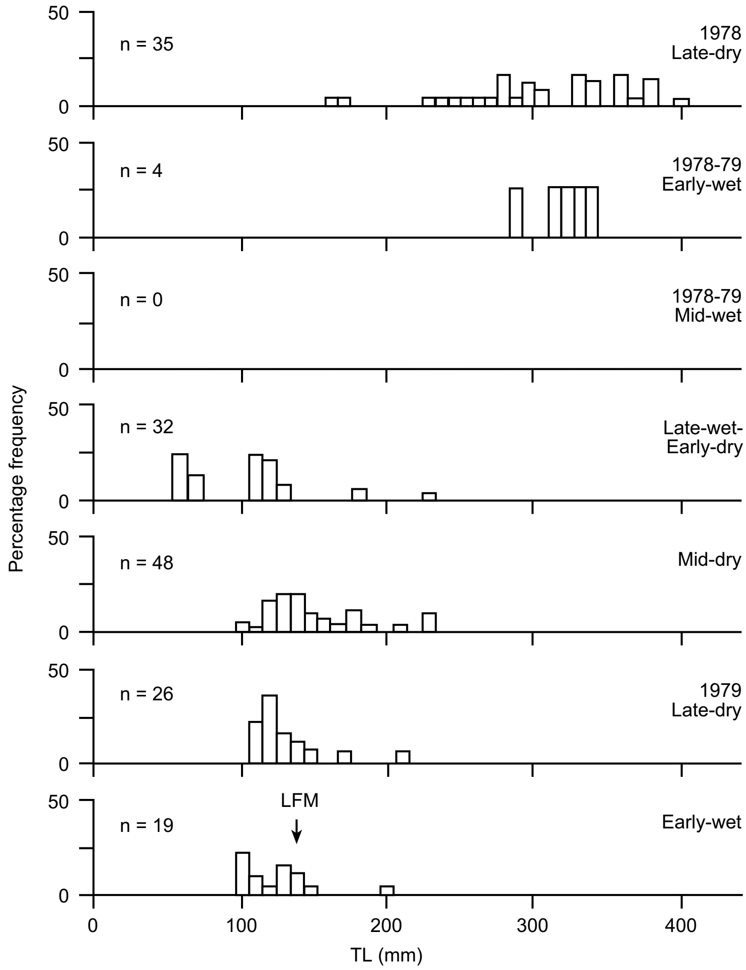



**Figure 35** Seasonal length-frequency distribution of all *Neosilurus* sp. B and *N. hyrtlii* captured

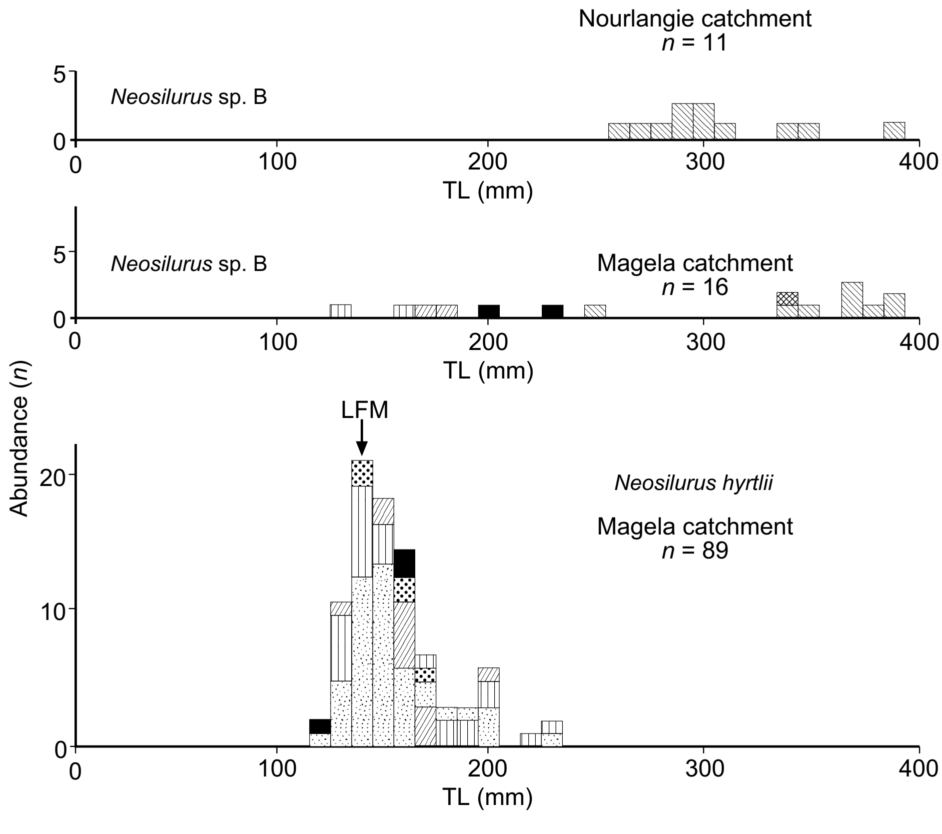



**Figure 36** Length-frequency distributions and habitat preferences of *Neosilurus* sp. B and *N. hyrtlii* captured at regular sampling sites (see appendix 5 for key to the habitats)

As *Neosilurus* sp. B was contaminated, its juvenile and adult habitats are not described. The larger-sized specimens, assumed to be *N. ater*, were captured in escarpment mainchannel waterbodies. Smaller *Neosilurus* sp. B were found in similar habitats to *N. hyrtlii*.

## Environmental associations

Rank numbers for *N. hyrtlii* and *Neosilurus* sp. B for the physico–chemical and habitat–structural variables are shown in table 155.

### Physico–chemical variables

*Temperature*

*Neosilurus hyrtlii* was found in waters with surface temperatures from 25° to 37°C (mean = 29.4°C) and bottom temperatures from 23° to 36°C (mean = 27.2°C). These means both ranked in the lower quarter, as would be expected for a primarily benthic-dwelling fish. However, specimens of '*Neosilurus*' have been found living in waters up to 38.8°C at Dalhousie Springs, South Australia, but they died when exposed to waters at 41.8°C (Ivantsoff & Glover 1974). *Neosilurus* sp. B was caught in waters with a similar range of temperatures to *N. hyrtlii* (26–37°C on the surface, 26–30°C on the bottom). The mean water temperatures for this colour-type (29.9°C surface and 28.2°C bottom) also ranked in the lower quarter (fig 170).

*Dissolved oxygen*

Dissolved oxygen concentrations in waters inhabited by *N. hyrtlii* ranged from 0.2 to 9.5 mg/L (mean = 6.5) on the surface, and from 1.0 to 9.7 mg/L (mean = 3.7) on the bottom. These means ranked in the upper-middle and lower-middle quarters, respectively. The range for *Neosilurus* sp. B was similar: 3.3–7.4 mg/L (mean = 5.8) on the surface, and 0.9–7.4 mg/L (mean = 5.2) on the bottom. These means ranked in the lower-middle and upper-middle quarters, respectively (see fig 171).

*Visibility*

*Neosilurus hyrtlii* was caught in waters with Secchi depths from 1–170 cm (mean = 39.9 cm). This mean was ranked in the lower quarter, indicating a tendency for *N. hyrtlii* to be found in more turbid waters. *Neosilurus* sp. B was caught in Secchi depths from 15–250 cm (mean = 136 cm). This mean, in contrast to that of *N. hyrtlii*, ranked at the top of the upper quarter, possibly because many *N. ater* from clear escarpment mainchannel waterbodies were classified as *Neosilurus* sp. B (see fig 172).

*pH*

The pH of waters in which *N. hyrtlii* was captured ranged from 4.0 to 8.6 on the surface (mean = 6.3) and from 5.2 to 7.3 (mean = 6.0) on the bottom. These means both ranked at the base of the upper-middle quarter. This range of pH was wider than for *Neosilurus* sp. B: 4.5–6.5 on the surface (mean = 5.8), and 5.3–6.5 (mean = 5.8) on the bottom. Both mean pH values ranked in the lower quarter (see fig 173).

*Conductivity*

*Neosilurus hyrtlii* was found in waters with surface and bottom conductivities between 4 and 620 µS/cm. The range was narrower for *Neosilurus* sp. B between 6 and 58 µS/cm, on both the surface and the bottom.

### Habitat–structural variables

*Substrate*

*Neosilurus hyrtlii* was caught over the entire range of substrates. Of these, mud was the main one (upper-middle quarter), followed by clay (upper quarter), then sand, gravel, leaves, rocks and boulders. Both the range and order of substrates are similar to *P. rendahli* habitats. *Neosilurus* sp. B was also captured over the entire range of defined substrate types; sandy substrates were markedly dominant (upper quarter), followed by rocks (upper quarter), then leaves, boulders, mud and gravel (i.e. generally similar to *N. ater* from escarpment habitats) (see fig 174).

*Hydrophytes*

*Neosilurus hyrtlii* was typically found in vegetated waters (vegetation-occurrence index 64.4%) of submergent hydrophytes (42.5%), floating attached (32.8%) and emergent hydrophytes (21.1%). The percentage of floating attached vegetation was unusually high, as observed in other plotosids habitats.

*Neosilurus* sp. B was infrequently found in vegetated waters (vegetation-occurrence index 30%) as expected for a form that was typically found over sand and rocks. Most of the vegetation was floating unattached (40.9%) followed by floating-attached (27.3%), then submergent and emergent (9.1%).

## Reproduction

The following information does not include the data on *Neosilurus* sp. B. Of the 121 *N. hyrtlii* collected during the last four sampling periods, 117 were examined for reproductive condition: 27 were sexually indistinguishable (length range 48–242 mm TL), 54 were females (110–240 mm TL) and 36 were males (110–240 mm TL). The gonad maturity stages differ macroscopically from the generalised description given in volume 1; a more accurate description of the stages for this species can be found in Davis (1977b).

### Length at first maturity

Very few fish (10) were collected with gonads at stages greater than III, and thus the LFM was difficult to estimate. It appears to be 135 mm TL for both sexes (fig 37). Only two fish (males, 130 and 134 mm) were less than the LFM but had gonads at maturity stages greater than III.

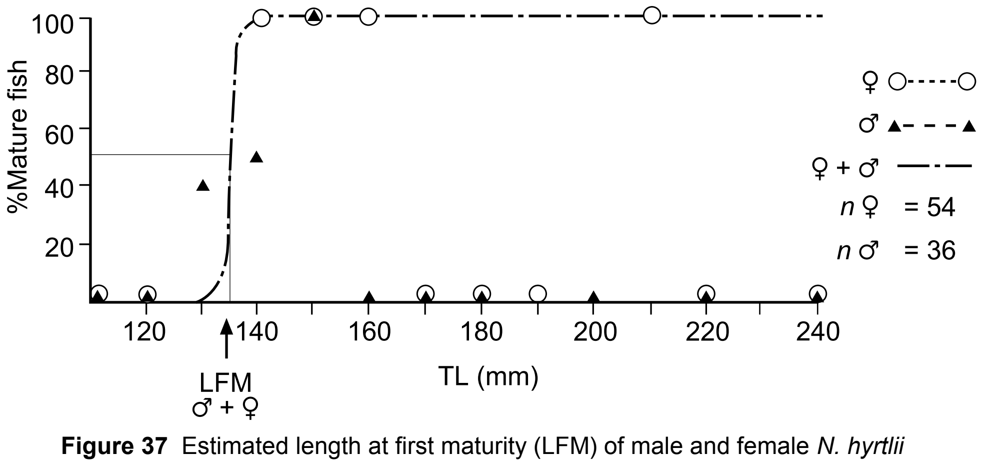



**Figure 37** Estimated length at first maturity (LFM) of male and female *N. hyrtlii*

### Sex ratio

The sex ratio was 1:1 in all seasons except the 1979 Late-wet–Early-dry, when there were significantly more females ($0.01 < P < 0.05$) in the entire population, and in the 1979 Late-dry season when there were significantly more females in the sample of mature fish (table 34).[70]

70 A sample of spawning *N. hyrtlii* taken during the Mid-wet season from the Ross River in northern Queensland had a sex ratio not significantly different from 1:1 (Orr & Milward 1984).

**Table 34** Seasonal changes in the sex ratio, gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of *N. hyrtlii* over all habitats

| Parameter | Sex | Statistic | Sampling period | | | |
|---|---|---|---|---|---|---|
| | | | Late-wet–Early-dry 1979 | Mid-dry | Late-dry | Early-wet 1979–80 |
| **Sex ratio** | | | | | | |
| Juveniles + | F | *n* | 11 | 22 | 11 | 10 |
| adults | M | *n* | 2 | 15 | 10 | 9 |
| | | $\chi^2$ | 6.2 | 1.3 | 0.04 | 0.05 |
| | | P | * | n.s. | n.s. | n.s. |
| Adults only | F | *n* | 4 | 16 | 9 | 6 |
| | M | *n* | 1 | 13 | 1 | 3 |
| | | $\chi^2$ | 1.8 | 0.3 | 6.4 | 1.0 |
| | | P | n.s. | n.s. | * | n.s. |
| **GSI** | | | | | | |
| Adults only | F | mean | 0.2 | 0.2 | 0.5 | 3.6 |
| | | s.d. | 0.1 | 0.1 | 0.2 | 3.4 |
| | M | mean | 0.2 | 0.1 | 0.2 | 0.4 |
| | | s.d. | – | 0.05 | – | 0.04 |
| | F+M | mean | 0.2 | 0.2 | 0.5 | 2.6 |
| | | s.d. | 0.1 | 0.1 | 0.2 | 3.2 |
| **GMSI** | | | | | | |
| Adults only | F | mean | 2.0 | 2.0 | 2.5 | 4.6 |
| | | s.d. | 0.0 | 0.8 | 0.4 | 0.5 |
| | M | mean | 3.0 | 2.3 | 3.0 | 3.8 |
| | | s.d. | – | 0.4 | – | 0.4 |
| | F+M | mean | 2.3 | 2.2 | 2.6 | 4.3 |
| | | s.d | 0.6 | 0.6 | 0.4 | 0.6 |

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

In the 1979 Late-wet–Early-dry season a large number of juvenile females, and in the 1979 Late-dry season a large number of juvenile males were caught. The causes of these unequal sex ratios are not known.

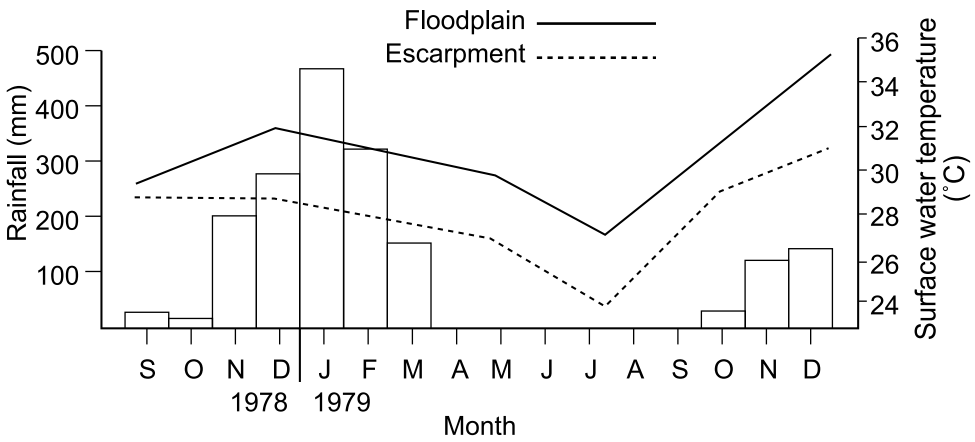
### Breeding season

The GSI and GMSI both increased as the 1979–80 Early-wet season approached (fig 38, table 34). Maturing fish were collected during the 1979 Late-dry and 1979–80 Early-wet seasons; mature fish during the 1979–80 Early-wet season only. No ripe or spent fish were caught during the study, which suggests that *N. hyrtlii* matured during the 1979–80 Early-wet season but may not have spawned until the start of the Wet season proper.

### Site of spawning

No evidence of spawning was observed. Only three mature fish were collected (from the backflow billabongs). Some members of the plotosid family spawn over gravel beds (Lake 1978, Davis 1977b) and others amongst grass and other aquatic vegetation or in shallow flowing waters (Midgley, pers comm).[71]

71 From observations in the Ross River in northern Queensland, Orr and Milward (1984) stated that *N. hyrtlii* is a lithophilic flood spawner which undertake spawning migrations.



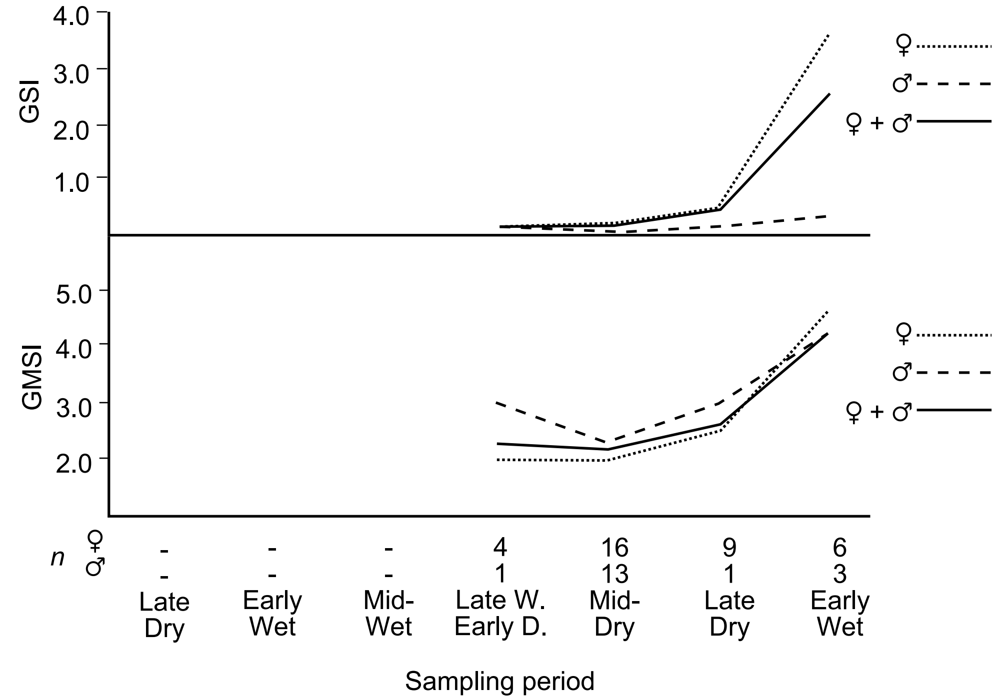




**Figure 38** Seasonal fluctuations in the gonadosomatic index (GSI) and gonad maturity stage index (GMSI) of male and female *N. hyrtlii*

**Fecundity**

The one ovary examined weighed 7.26 g. It was from a 205 mm TL fish (weighing 63 g) with a GSI of 10.13. The estimated number of eggs was 3630.[72] Their average diameter was 1.3 ± 0.09 mm.[73]

**Summary**

Males and females had the same length range and LFM (135 mm TL). The sex ratio was 1:1 except for the entire sample during the Late-wet–Early-dry season (when many were juvenile females) and for the adult portion of the sample during the 1979 Late-dry season.

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72 Orr and Milward (1984) estimated fecundities of *N. hyrtlii* to range from 1600 to 15 300 for individuals 186–267 mm standard length taken from the Ross River, northern Queensland.

73 Egg and larval development of *N. hyrtlii* have been described by Orr and Milward (1984).

The GSI and GMSI indicated that the gonads developed towards the 1979–80 Early-wet season but, although mature gonads were found at that time, neither evidence nor sites of spawning were found. The fecundity was estimated at around 4000 eggs with average diameters of 1.3 mm.

## Feeding habits

### Overall diet

The stomachs of 62 of 73 *N. hyrtlii* and 125 of 142 *Neosilurus* sp. B contained food. The overall diets of *Neosilurus* sp. B and *N. hyrtlii* are shown in fig 39; details of the components are given in table 35. The main components of the diet were aquatic insects (52% and 55%, respectively) and microcrustaceans (28% and 5%). Teleost scales (5%) also appeared in the diet of *Neosilurus* sp. B. Inorganic material (3% and 6%) and unidentified organic material (14% and 22%) were found in the stomachs of both forms. The main aquatic insects eaten were chironomid larvae, and the main microcrustaceans were cladocerans and ostracods. Traces of algae, gastropods, macrocrustaceans, terrestrial insects and detrital material were also found in the stomachs.

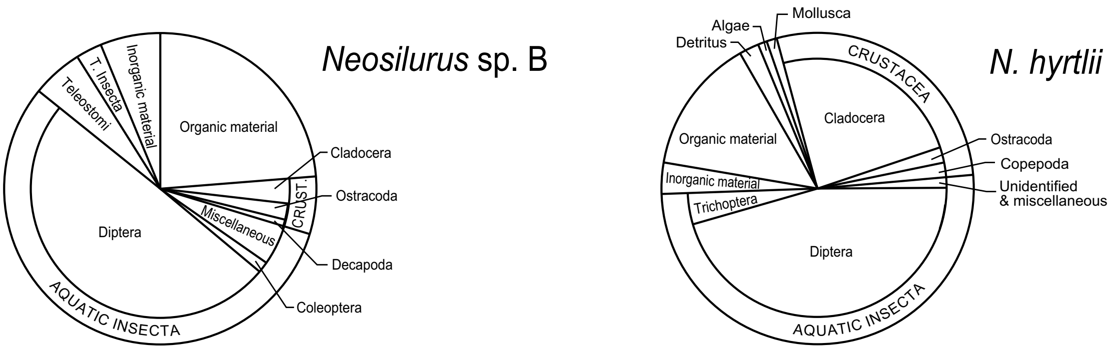


**Figure 39** The main components of the diet of *Neosilurus* sp. B and *N. hyrtlii*

*Neosilurus hyrtlii* and *Neosilurus* sp. B can therefore be classified as meiophagous carnivores that feed predominantly on benthic fauna.[74] Differences in the diet of the two groups may have been partly caused by seasonal availability of food items, an effect highlighted by the change in classification halfway through the study. Pollard (1974) noted that little appears to be known of the diets of the 'neosilurine' catfishes.

### Seasonal changes

In sampling periods 1 and 2 respectively, 34 (32% empty) and 4 (0% empty) stomachs of *Neosilurus* sp. B (all habitats combined) were examined. The highest proportion of specimens with empty stomachs was in the 1978 Late-dry season.

The diet in the 1978 Late-dry season was mainly aquatic insects (mainly chironomid larvae) with a small microcrustacean component. During the 1978–79 Early-wet season emphasis shifted from chironomid larvae to terrestrial dipterans, chironomid pupae and ceratopogonid larvae.

74 Pusey et al (1995b) found *N. hyrtlii* to consume detritus in two rivers of the Australian wet tropics, north-eastern Queensland. It was noted that it was possible that detritus was inadvertently ingested as they foraged for bivalve molluscs (*Sphaerium* sp.).

**Table 35** Dietary composition of *Neosilurus* sp. B and *N. hyrtlii*

| | *Neosilurus* sp. B | | | | *N. hyrtlii* | | | | | | Habitat | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Season | | Overall | | Season | | | | Overall | | | |
| | 1978 | 1978–79 | | | 1979 | 1979 | 1979 | 1979–80 | | | Magela Creek | |
| | Late-dry | Early-wet | Sub-mean | Main-mean | Late-wet–Early-dry | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean | Ls | Bb |
| **Aquatic plants** | | | | | | | | | | | | |
| Algae | | | | + | | | | | | 0.7 | | |
| Conjugatophyta | | | | | | | | | | | | |
| *Mougeotia* | – | – | – | | – | 1.1 | 0.5 | – | 0.7 | | – | 0.8 |
| **Aquatic animals** | | | | | | | | | | | | |
| Gastropoda | | | | – | | | | | | 0.8 | | |
| *Amerianna* | – | – | – | | – | – | – | – | 0.8 | | – | – |
| Microcrustacea | | | | | | | | | | | | |
| Conchostraca | | | | 5.0 | | | | | | 28.3 | | |
| *Cyzicus* | – | – | – | | 0.8 | – | – | – | 0.2 | | – | |
| Cladocera | | | | | | | | | | | | |
| Miscellaneous | 1.7 | – | 3.0 | | 36.9 | 0.3 | – | – | 7.3 | | – | 8.2 |
| *Diaphanosoma* | – | – | – | | – | 2.9 | – | 57.5 | 17.3 | | – | 4.2 |
| Ostracoda | 2.6 | – | 2.0 | | 7.7 | – | 3.0 | – | 1.5 | | – | 2.7 |
| Copepoda | | | | | | | | | | | | |
| *Cyclops* | – | – | | | – | – | 2.0 | 9.4 | 2.0 | | – | 3.5 |
| Macrocrustacea | | | | | | | | | | | | |
| *Macrobrachium* | 0.9 | – | 0.7 | | – | – | – | – | – | | – | – |
| Insecta | | | | 54.8 | | | | | | 51.7 | | |
| Fragmented | 7.0 | – | 5.3 | | – | – | 1.0 | – | 0.7 | | 1.7 | – |
| Ephemeroptera | | | | | | | | | | | | |
| Baetidae | – | – | – | | – | 0.5 | – | – | 0.2 | | 1.7 | – |
| Odonata | | | | | | | | | | | | |
| Libellulidae | – | – | – | | – | – | – | – | 0.4 | | – | – |

Table 35 continued

| | *Neosilurus* sp. B | | | | *N. hyrtlii* | | | | | | Habitat | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Season | | Overall | | Season | | | | Overall | | | |
| | 1978 | 1978–79 | | | 1979 | 1979 | 1979 | 1979–80 | | | Magela Creek | |
| | Late-dry | Early-wet | Sub-mean | Main-mean | Late-wet–Early-dry | Mid-dry | Late-dry | Early-wet | Sub-mean | Main-mean | Ls | Bb |
| Hemiptera | | | | | | | | | | | | |
| Corixidae | – | – | – | | – | – | 0.3 | – | 0.4 | | – | 0.1 |
| Coleoptera | – | 3.8 | 0.5 | | – | – | – | – | – | | | |
| Diptera | | | | | | | | | | | | |
| Chironomidae (larvae) | 46.1 | 10.0 | 45.0 | | 23.9 | 62.5 | 54.3 | 21.7 | 42.8 | | 83.3 | 46.3 |
| Chironomidae (pupae) | – | 12.5 | 1.7 | | – | 2.9 | 11.8 | 0.3 | 3.3 | | – | 5.6 |
| Ceratopogonidae | – | 17.5 | 2.3 | | – | – | – | – | 0.1 | | – | – |
| Trichoptera | | | | | | | | | | | | |
| Leptoceridae | – | – | – | | 15.4 | – | 10.0 | – | 3.8 | | – | 6.8 |
| Teleostomi | | | | 5.3 | | | | | | | | |
| Scales | 7.0 | – | 5.3 | | – | – | – | – | – | | – | – |
| **Terrestrial plants** | | | | | | | | | | | | |
| Angiospermae | – | – | – | | | – | – | – | – | | – | – |
| **Terrestrial animals** | | | | 3.2 | – | | | | | | | |
| Insecta | | | | | | | | | | | | |
| Diptera (larvae) | – | 23.7 | 3.2 | | – | – | – | – | – | | – | – |
| **Parasites** | | | | | | | | | | | | |
| Trematoda | 4.4 | 12.5 | 5.0 | 5.0 | – | – | – | – | – | – | – | – |
| Nematoda | 0.6 | – | 0.4 | 0.4 | – | – | – | – | 0.4 | 0.4 | – | 0.7 |
| Detrital material | – | – | – | | – | – | 7.8 | – | 1.5 | 1.5 | – | 2.6 |
| Inorganic material | 4.8 | 20.0 | 6.3 | 6.3 | – | 3.2 | 9.5 | – | 3.0 | 3.0 | 13.3 | 2.5 |
| Organic material | 25.0 | – | 20.2 | 20.2 | 15.4 | 25.7 | – | 11.1 | 14.1 | 14.1 | – | 16.3 |
| Number of empty fish | 11 | – | 11 | 11 | 2 | 13 | – | 1 | 17 | 17 | – | 1 |
| Number of fish with food | 23 | 4 | 62 | 62 | 13 | 38 | 20 | 18 | 125 | 125 | 12 | 60 |

Figures represent the mean percentage volume determined by the estimated volumetric method. All habitats are in the Magela system. Ls = lowland sandy creek bed; Bb = lowland backflow billabongs

In sampling periods 4–7, respectively, 15 (13% empty), 51 (25% empty), 20 (0% empty) and 19 (5% empty) stomachs of *N. hyrtlii* (all habitats combined) were examined. The highest proportion of specimens with empty stomachs were in the 1979 Mid-dry season and the lowest in the following Late-dry season.

The diet in the Late-wet–Early-dry season consisted mainly of microcrustaceans (cladocerans and ostracods) and aquatic insects (chironomid and leptocerid larvae). By the 1979 Mid-dry season, the microcrustacean component was smaller and the diet was dominated by chironomid larvae, which continued to be the main component, with some chironomid pupae and leptocerid larvae (similar to *Neosilurus* sp. B in the previous year). During the 1979–80 Early-wet season there was a shift to microcrustaceans (mainly cladocerans and copepods) and chironomids became of secondary importance. Microcrustaceans did not appear in the diet of *Neosilurus* sp. B during the previous Early-wet season.

**Habitat differences**

In the Magela Creek catchment, 12 (0% empty) stomachs of *N. hyrtlii* were examined (all seasons combined) from lowland sandy creekbeds and 61 (2% empty) from backflow billabongs.

The specimens captured in the lowland sandy creekbeds were feeding mainly on chironomid larvae. In the backflow billabongs, they were eating mainly aquatic insects (chironomid larvae and pupae, leptocerid larvae) and to a lesser extent, microcrustaceans (cladocerans, ostracods and copepods).

**Fullness**

A summary of mean fullness indices of *N. hyrtlii/Neosilurus* sp. B for different sampling periods and habitat types in the Magela Creek and Nourlangie Creek catchments is shown in table 36. 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) rose in the 1978–79 Early-wet season and remained high until the 1979 Mid-dry season. No specimens were sampled in the Mid-wet season; however, this species was observed in escarpment perennial streams during this season. During the 1979–80 Early-wet season the index then fell to a level lower than that recorded the previous year.

*Habitat differences*

In the Magela catchment the few specimens from shallow backflow billabongs upstream of RUPA had mean fullness indices much lower than in equivalent downstream habitats.

Downstream of RUPA, the highest fullness indices were recorded in specimens from shallow backflow billabongs and the sandy corridor waterbody. Indices were lower for specimens from lowland sandy creekbeds and channel backflow billabongs and floodplain billabongs.

Only a few specimens were examined from the Nourlangie catchment; indices were comparable in the backflow billabongs.

**Table 36** Mean fullness indices of *Neosilurus* sp. B and *N. hyrtlii* in different sampling periods and habitats

| Habitat type | Sampling period | | | | | | | Habitat mean |
|---|---|---|---|---|---|---|---|---|
| | *Neosilurus* sp. B | | | | *N. hyrtlii* | | | |
| | 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 | 3.0 (1) | 2.8 (5) | n/s | 2.8 (6) |
| Downstream of RUPA: | | | | | | | | |
| Lowland sandy creekbed pool | 0 (2) | n/s | n/s | n/s | 3.5 (11) | 4.0 (1) | n/s | 3.1 (14) |
| Lowland channel backflow billabong | n/s | n/s | n/s | 4.0 (1) | 3.1 (15) | 3.5 (14) | 2.0 (8) | 3.0 (38) |
| Lowland shallow backflow billabong | n/s | n/s | n/s | 3.7 (11) | 4.0 (14) | 3.0 (1) | 3.0 (1) | 3.8 (27) |
| Corridor sandy billabong | n/s | 4.0 (1) | n/s | n/s | n/s | n/s | n/s | 4 (1) |
| Floodplain billabong | n/s | n/s | n/s | 2.9 (11) | 3.0 (3) | n/s | n/s | 2.9 (14) |
| **Nourlangie Creek catchment** (regular sites only) | | | | | | | | |
| Lowland channel backflow billabong | n/s | n/s | n/s | 4 (2) | n/s | n/s | n/s | 4 (2) |
| Lowland shallow backflow billabong | n/s | n/s | n/s | 4.0 (2) | 3.0 (1) | n/s | n/s | 3.7 (3) |
| **Seasonal mean (all sites)** | 1.1 | 3.3 | n/s | 3.4 | 3.7 | 3.3 | 2.1 | |

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

**Nourlangie catchment**

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