Reproduction of *Labeo umbratus* (Pisces, Cyprinidae) in Wuras Dam, a shallow, turbid impoundment

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Female *Labeo umbratus* reach sexual maturity at a larger size than males and dominate the population in fish over 450 mm in length. The gonads are large (up to 20% of total body mass) and they have a high fecundity which increases linearly with an increase in body mass. Successful spawning is dependent on suitable floods during the spawning season which extends from November to March or April. Spawning apparently occurred in the impoundment. All females did not spawn simultaneously and evidence suggests that individuals might spawn more than once during a particular season.

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Vroulike *Labeo umbratus* bereik geslagsrypheid by 'n groter lengte as mannetjies en oorheers die bevolkings van visse groter as 450 mm. Die gonades is groot (tot 20% van totale liggaamsmassa) en die vis het 'n hoë vrugbaarheid wat lineêr toeneem met toename in liggaamsmassa. Suksesvolle voortplanting is afhanklik van geskikte vloedtoestande gedurende die broeiseisoen wat vanaf November tot Maart of April strek. Die vis het blykbaar in Wurasdam gebroei. Al die wyfies het nie gelyktydig kuitgeskiet nie en daar is aanduidings dat individue meer as een maal per seisoen mag broei.

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Labeo umbratus is endemic to the Orange River system and Cape coastal rivers from the Gouritz to the Nahoon (Jubb 1967). Owing to its ability to utilize detritus, a stable food source in lentic systems, it occurs in high densities in most impoundments within its distribution range and therefore plays an important role in energy cycling. In Wuras Dam, in which energy cycling is detritus-based, this species makes up 70% of the mass of fish (Pieterse & Keulder 1982).

Wuras Dam is situated in the central highveld area of South Africa (19°40'S/26°00'E) in the Fourie Spruit, an annual tributary of the Modder River, Orange River system. It has a maximum surface area of 76 ha and depth of 5 m and is fringed by dense *Phragmites* and *Typha* beds. Inflow is highly irregular and only occurs after heavy rains during the summer season which extends from September to April.

Materials and Methods

Fish were collected with a seine-net on 25 January and 4 March 1980 and monthly with a series of floating multifilament gillnets with stretched mesh sizes of 40, 50, 64, 85, 110 and 145 mm from May 1980 to April 1981. The fork length, mass and gonad mass of each specimen were recorded and 'ripe' ovaries preserved in modified Gilson's fluid (see Bagenal & Braum 1971). Gonado-somatic indexes were calculated by dividing the gonad mass by total fish mass (including gonad mass) and multiplying this figure by 100. Fecundity was determined by Simpson's dry method (Bagenal & Braum 1971) with subsamples of 500 eggs. During monthly surveys the shallows were sampled for small fish with a fine-meshed (2 mm) seine-net.

Results

Sex ratio

Male *L. umbratus* were more abundant than females in fish smaller than 350 mm (Table 1). The ratio changed to 1:1 in the 360 to 450 mm range and in larger fish females were more abundant. Only 13% of fish over 450 mm in length were males.

Table 1 Sex ratios of *Labeo umbratus* from Wuras Dam

Size range (mm)	Sample size	% Males
0 – 350	259	63
360 – 400	383	51
410 – 450	249	47
460 +	52	13

Size at maturity

The smallest sexually mature female *L. umbratus* collected was 300 mm long but the majority only became mature at 360 mm. All females over 370 mm in length collected from October to January had egged ovaries. The smallest mature male collected was 270 mm in length. Most males over 300 mm and all over 360 mm were mature.

Figure 1 shows that *L. umbratus* has large gonads. Although the gonado-somatic indexes varied considerably, the average values show a clear increase with increase in fish size. In large females the ovaries can make up as much as 20% of body mass.

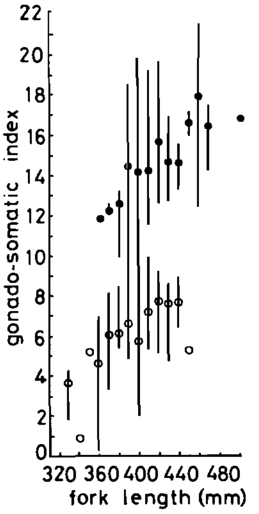

Figure 1 Relationships between lengths and gonado-somatic indexes (mean and range) of mature male (o) and female (●) *Labeo umbratus* from Wuras Dam, 28 October 1980 to 16 January 1981.

Spawning season and success

Figure 2 shows that the testes of *L. umbratus* started enlarging at the end of August, reached a peak at the end of October, gradually decreased in size by January and then became rapidly smaller, probably due to spawning before the survey in February. The general pattern of development is similar in the two size groups.

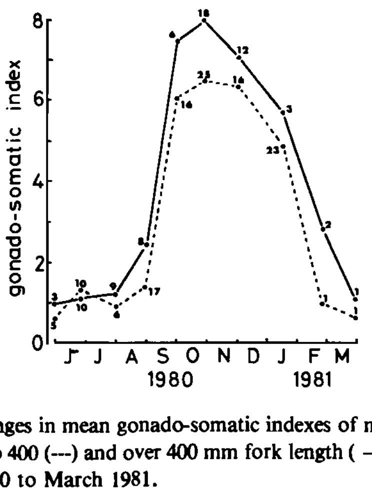

Figure 2 Changes in mean gonado-somatic indexes of male *Labeo umbratus* of 360 to 400 (---) and over 400 mm fork length (—) from Wuras Dam, May 1980 to March 1981.

The ovaries of mature females also enlarged at the end of August but only reached their maximum size in December and

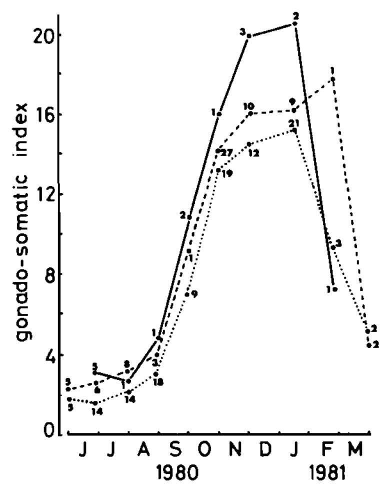

Figure 3 Changes in mean gonado-somatic indexes of female *Labeo umbratus* of 360 to 400 (....), 410 to 450 (----) and over 450 mm fork length (—) from Wuras Dam, May 1980 to March 1981.

January (Figure 3). Unfortunately only a few mature females were collected in February and March, but the decrease in gonado-somatic indexes shows that spawning probably took place when the impoundment filled before these surveys. Apparently all females did not spawn simultaneously because one of the four females collected in February was completely spent, two were partially spent and one had an unspent ovary.

Juveniles of *L. umbratus* were collected for the first time on 24 February 1981 substantiating the presumption that spawning occurred after the preceding survey. The juveniles varied in size from 10 to 27 mm with a modal length of 19 mm (Figure 4) and were found at all sites (five) sampled on that day. Three of these sites (on both sides of the wall and shallow area opposite the wall) were far removed from feeder streams or other inlets and it must be assumed that *L. umbratus* spawned in the impoundment. However, Wuras Dam is so small that it might present riverine rather than lacustrine conditions during flooding. By the end of March two size groups of juveniles were collected (Figure 4), substantiating the observation based on gonad studies that multiple spawning took place.

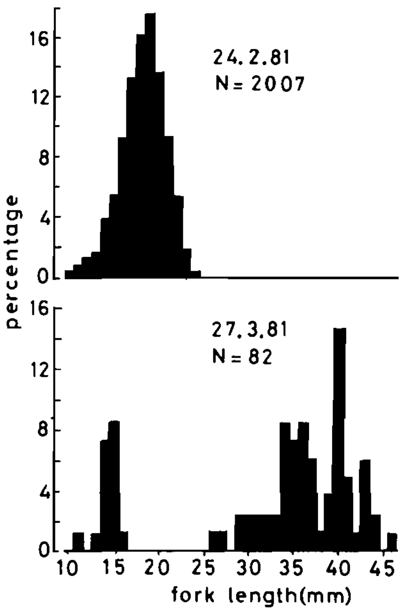

Figure 4 Length frequency distributions of juvenile *Labeo umbratus* collected from Wuras Dam during February and March 1981.

Age determinations (Pieterse & Keulder 1982) showed that no recruitment of *L. umbratus* occurred in Wuras Dam between March or April 1978 and the present study. Figure 5 shows that recruitment is dependent on flooding or filling of the impoundment during the spawning season. Successful recruitment apparently took place when Wuras Dam filled in March to April 1978. During the 1978/79 spawning season no rise in water level and consequently no recruitment took place. The flood in September 1979 was apparently too early for the fish to spawn because no females of a large sample collected in January 1980 had spent ovaries and no juveniles were found in the impoundment. A rise in water level of about 200 mm that occurred in February 1980 might have stimulated partial spawning (see next section) but if so, the eggs or larvae did not survive because no recruitment took place. During the 1980/81 spawning season flooding occurred at the right time resulting in highly successful recruitment.

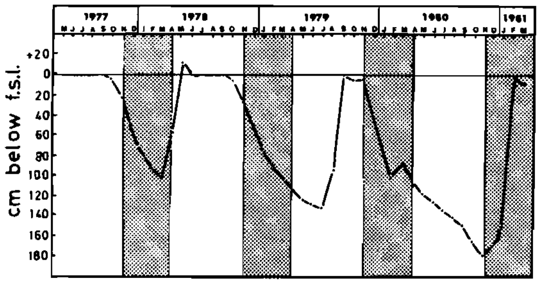

Figure 5 Peak spawning season of *Labeo umbratus* (shaded) superimposed on water level fluctuations in Wuras Dam.

Fecundity

Figure 6, based on specimens collected in January 1980 and from September 1980 to January 1981, shows a linear relationship between fish mass and fecundity which is described by the equation:

$$\text{Fecundity} = -48143{,}2 + 246{,}7 \text{ mass (g)} \; (r = 0{,}88).$$

The relationship between fork length and fecundity is described by the equation:

$$\text{Fecundity} = 2179{,}55 \, e^{0{,}0109 \text{ length (mm)}} \; (r = 0{,}75).$$

The ovaries of females collected in March 1980, shortly after inflow occurred and the water level rose by about 200 mm, contained fewer eggs than those of fish collected in January (Figure 7). This could have been due to unsuccessful partial spawning or to reabsorbtion.

The fecundity of *L. umbratus* in Wuras Dam with results reported from three other localities are compared in Figure 8. The fecundity in Wuras Dam is higher than at the other localities but comparable to that of Barber's Pan (Göldner 1967), while the results of Hamman (1981) and Mulder (1973) are roughly similar.

There is a good linear relationship between gonad mass and fecundity but the relationship varies depending on the date of collection owing to an increase in egg size through the spawning season (Figure 9). These relationships can be used to calculate fecundity from known ovary masses. However, it seems as if the relationship might vary from one locality to another because the relationship determined by Hamman (1981) for fish collected from the Hendrik Verwoerd Dam in December is comparable to the relationship obtained for fish

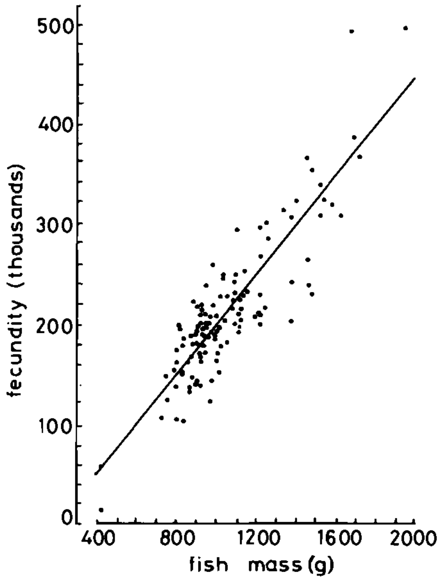

Figure 6 Relationship between fecundity and mass of *Labeo umbratus* from Wuras Dam.

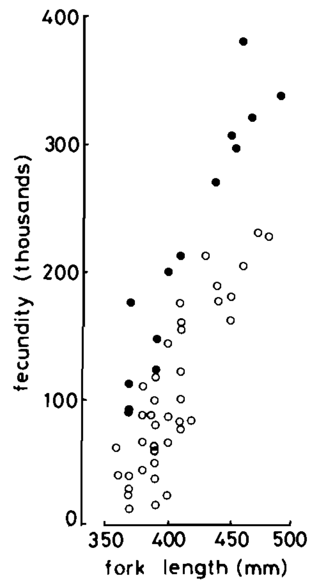

Figure 7 Relationship between length and fecundity of *Labeo umbratus* from Wuras Dam on 25 January (●) and 4 March (o) 1980.

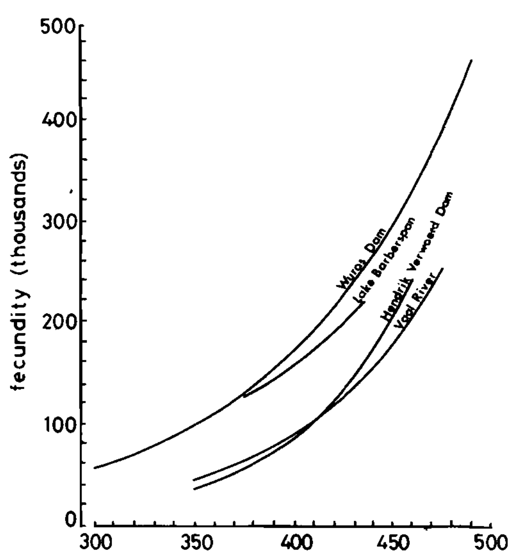

Figure 8 Relationships between fish length and fecundity of *Labeo umbratus* from Wuras Dam, Barber's Pan (after Göldner 1967), Hendrik Verwoerd Dam (after Hamman 1981) and the Vaal River (after Mulder 1973).

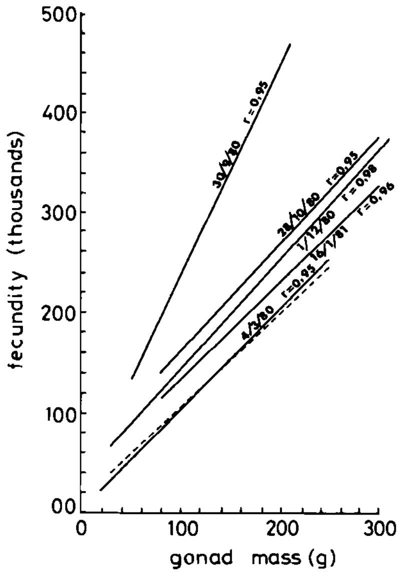

Figure 9 Relationships between gonad mass and fecundity of *Labeo umbratus* from Wuras Dam (—) and the Hendrik Verwoerd Dam (--- after Hamman 1981).

collected from Wuras Dam in March 1980.

Discussion

The study confirmed that *L. umbratus* is a floodplain spawner with a relatively high fecundity and long life cycle.

Reported sex ratios for all size groups of *L. umbratus* combined vary from 0,9 to 1,5 females to each male (Gaigher, Ntloko & Visser 1975; Göldner 1967; Hamman 1981; Mulder 1973). Gaigher *et al.* (1975), Hamman (1981) and the results of the present study showed that the ratio changed in favour of females in large fish. In the Tyume River, eastern Cape, which has a population with a much smaller size range than in the Orange River system populations studied, females dominated in fish over 240 mm in length. In the Hendrik Verwoerd and Wuras Dams this occurs in fish larger than 400 and 450 mm respectively. Göldner (1967), Mulder (1973) and Hamman (1981) found that the sexes of this species grow at the same rate and the dominance of females in large fish must therefore be attributed to a longer life span of this sex. *L. umbratus* also reaches sexual maturity at a smaller size of 140 and 200 mm for males and females respectively (Gaigher *et al.* 1975) in the Tyume River than at the Orange River system sites where males become mature between 220 and 320 and females between 310 and 370 mm in length (Göldner 1967; Hamman 1982; Mulder 1973). The size at maturity in Wuras Dam falls within the upper limit of this range.

Reports from various localities show that *L. umbratus* has an extended spawning season. Gaigher *et al.* (1975) collected 'ripe running' and 'spent' individuals from October to December in the Tyume River. They also collected fertilized eggs in October and observed spawning behaviour in November. Jackson & Coetzee (1982) observed spawning of this species on 6 November in a tributary of the Bushmans River, eastern Cape. According to Hamman (1981) gonad development cycles showed that its spawning season extends from September to February or March in the Hendrik Verwoerd Dam. In Wuras Dam the ovaries of *L. umbratus* only reached their maximum average size in December or January but it is possible that at least part of the population would spawn in November or even October if suitable floods occur. Spawning can apparently take place as late as March or April.

Gonado-somatic indexes, egg counts and the size distribution frequencies of juveniles indicate that *L. umbratus* might be a multiple spawner and that all females do not spawn simultaneously. Based on gonad development and size distribution frequencies of juveniles Göldner (1967) came to the same conclusion and is of the opinion that this species spawned four times in Barber's Pan between October 1965 and June 1966.

In Wuras Dam successful spawning is apparently dependent on substantial flooding during the spawning season. For this reason no recruitment took place during the 1978/79 and 79/80 spawning seasons. It was impossible to determine the required degree of flooding but limited inflow from local rains and even a rise in water level of 200 mm were insufficient. Available information (Cambray, Hahndiek & Hahndiek 1978; Gaigher *et al.* 1975 and Jackson & Coetzee 1982) indicate that *L. umbratus* spawns in lotic water. Although actual spawning in Wuras Dam was not observed, the distribution of larvae and juveniles strongly suggest that they spawned in the impoundment. This observation is not necessarily in contradiction to other authors' findings because water might have been 'flowing' through the small impoundment during that specific period but it does point to a need for more studies on this aspect.

The fecundity of *L. umbratus* differs from one locality to another and is relatively high in Wuras Dam. The significance of these differences is not clear but might be related to certain environmental conditions or the fact that the eggs had been absorbed during preceding breeding seasons.

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