Production of the sharptooth catfish *Clarias gariepinus* (Burchell) and the European common carp *Cyprinus carpio* L. with artificial feeding in polyculture in maturation ponds at Seshego, Lebowa

J F Prinsloo,[1] H J Schoonbee,[3*] I H van der Walt,[2] and M Pretorius,

1 *Limnological Research Unit, University of the North, Private Bag X1106, Sovenga, South Africa.*

2 *Department of Agriculture and Nature Conservation, Private Bag X01, Chuenespoort, 0745, South Africa.*

3 *Department of Zoology, Rand Afrikaans University, P O Box 524, Johannesburg 2000, South Africa.*

Abstract

A fish polyculture production investigation was done using overwintered fish of the Aischgrund variety of the common carp, *Cyprinus carpio,* and the sharptooth catfish *Clarias gariepinus* in final maturation pond effluent water. Equal numbers of both species were initially stocked at a total density of 11 045 fish ha^{-1}. There was a continuous throughflow of water during the production period of 100 d. The total fish yield over this period was 4,55 t of fish ha^{-1}, of which 64% was contributed by the common carp. Problems were encountered with the overfeeding of the sharptooth catfish, which led to some mortalities. However, the study showed that these two species can be grown together successfully in polyculture, subject to a specific feed application programme being followed to prevent overfeeding by the catfish.

Introduction

Advances in recent years in the controlled propagation and domestication of the African sharptooth catfish *Clarias gariepinus* (Burchell) (Teugels, 1982a,b) in Europe and North and Central Africa have been reviewed in detail by Huisman and Richter (1987).

The potential of *C. gariepinus* as a candidate for aquaculture in South Africa has been recognised since the 1960s (Groenewald, 1961). First attempts at the large-scale production of larvae and juveniles and pond production of this species in the Transvaal were made by Van der Waal (1972, 1978). The first successful artificial spawning of the sharptooth catfish was conducted by Schoonbee *et al.* (1980), based on work done on the induced spawning of Chinese carp species using carp pituitary gland homogenates and human chorionic gonadotrophins (Schoonbee *et al.*, 1978). Since then, several more attempts have been made to improve the large-scale artificial spawning of this fish under local conditions (Hecht *et al.*, 1982; Steyn *et al.*, 1985; Van der Waal, 1985; Schoonbee and Prinsloo, 1986; Polling *et al.*, 1987). The larval rearing of *C. gariepinus* in South Africa, using live and artificial diets, also received the attention of local researchers (Hecht, 1981, 1982; Uys and Hecht, 1985; Polling *et al.*, 1988). Despite the amount of research work conducted in the induced spawning and larval rearing of *C. gariepinus* in South Africa, very little published information had been available locally on the commercial pond production of this fish prior to 1985. Production on an experimental basis was conducted by Van der Waal (1972, 1978) whilst Bok and Jongbloed (1984) made use of poultry-manured ponds in the semi-intensive production of this fish. Prinsloo and Schoonbee (1987a), realising the potential of the sharptooth catfish in combination with the poultry industry, made use of chicken offal to produce more than 2 t of *C. gariepinus* per ha over a comparatively short period of 75 d. Little published information is available on the production of the sharptooth catfish in polyculture with other warm-water fish species. According to Hogendoorn and Koops (1983), Jansen (1983, 1984, 1985), Huisman (1986) and Huisman and Richter (1987), this fish was grown successfully in ponds with *Oreochromis niloticus* in Cameroon and in the Central African Republic, yielding as much as 10 t ha^{-1} a^{-1}.

In view of the omnivorous feeding habits of *C. gariepinus* (Groenewald, 1964; Schoonbee, 1969; Bruton, 1979), it was decided to investigate the intensive production of this fish with the benthic feeding European common carp *Cyprinus carpio* in nutrient-rich final effluent maturation pond water at Seshego, Pietersburg, Transvaal. Use was made of a relatively low-cost chicken broiler 18% protein pellet as supplementary feed.

Materials and methods

Fish ponds

Two ponds of 0,972 and 0,884 ha in size were provided with a continuous flow of water from a final effluent sewage maturation pond installation of the Seshego Township near Pietersburg. The retention period of water in both ponds was estimated at approximately two weeks.

Physical and chemical analysis of the pond water

A Thies hydrothermograph was installed at a depth of one meter in one of the ponds, providing a continuous recording of water temperature (°C).

Weekly water samples for chemical analysis were collected from both ponds between 08h00 and 09h00 at a point which was considered representative of the general conditions in the ponds. The following water quality parameters were analysed for according to APHA (1980): oxygen (mg ℓ^{-1}), pH, conductivity (μS cm^{-1}), ammonia (mg ℓ^{-1}), nitrite (mg ℓ^{-1}), nitrate (mg ℓ^{-1}), phosphate (mg ℓ^{-1}), alkalinity as $CaCO_3$ (mg ℓ^{-1}) and total hardness as $CaCO_3$ (mg ℓ^{-1}).

Stocking and weighing of fish

The ponds were stocked with overwintered fish kept in two fingerling rearing ponds at the Seshego fish production unit. The

*To whom all correspondence should be addressed.

Received 4 May 1988.

fish were originally spawned at the Limnological Research Unit's laboratory of the University of the North according to procedures described by Schoonbee and Prinsloo (1986), whilst the larvae were reared following procedures described by Prinsloo and Schoonbee (1986a) and Polling *et al.* (1988). At the time of stocking at the end of October 1987 the mean individual mass of the common carp was 124,0 g, whilst that of the sharptooth catfish was 166,4 g. Stocking densities per hectare for the common carp and sharptooth catfish were 5 575 and 5 470 respectively.

In order to adjust feed dosage quantities, approximately 10% of the fish in each pond were seined and weighed fortnightly.

Feed used

An 18% protein chicken broiler finisher pellet (Prinsloo and Schoonbee, 1987b), being the least expensive pelleted feed on the market, was used. Daily feed application was 2%, as dry mass, of the calculated total biomass of the fish in each pond for the first 28 days, when there is usually natural food available in the ponds which can be utilised by the fish (Cronje, 1981). Due to a decline in growth performance observed during the second fortnight, daily feeding rates were increased to 4%. This feeding level was maintained for 100 d after which all the fish were of a marketable size.

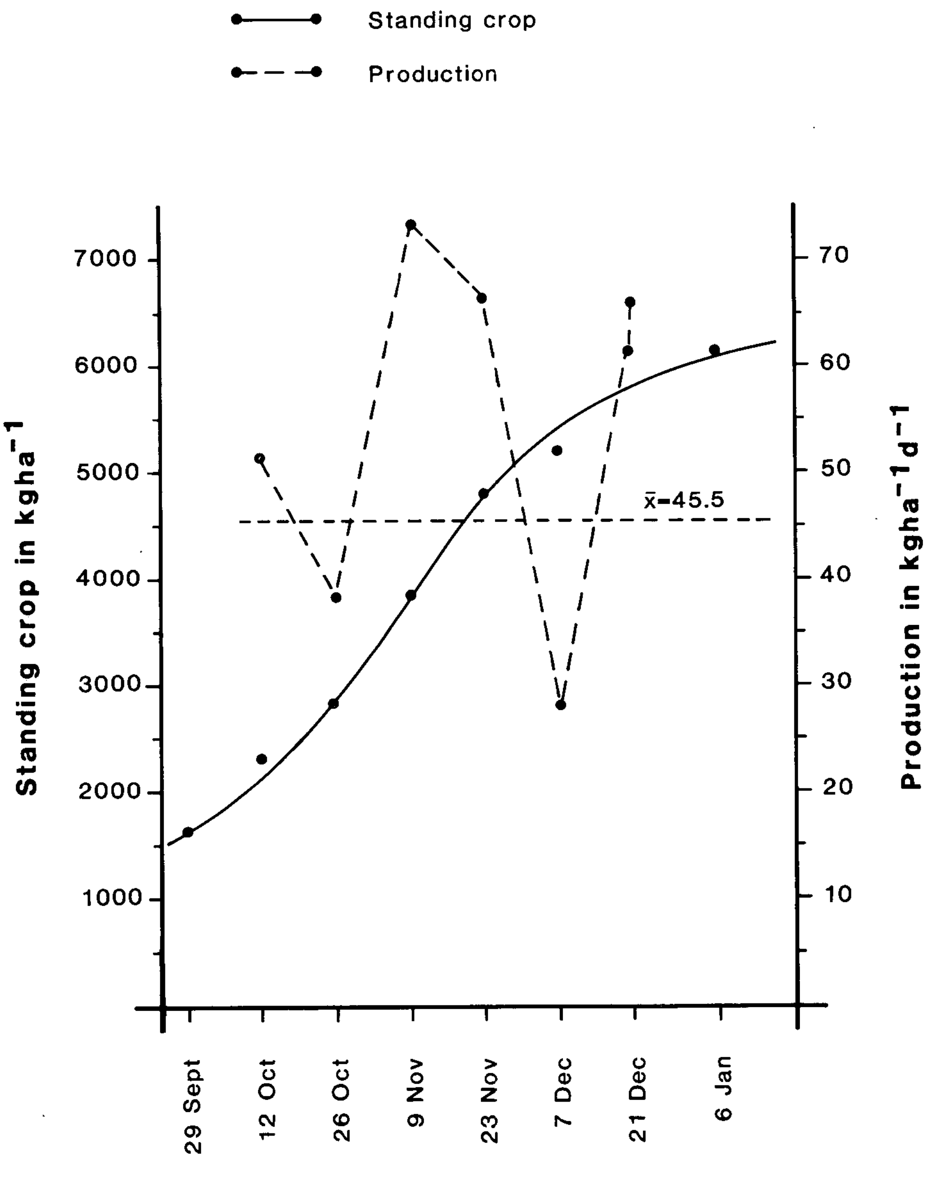

Figure 1
Standing crop (kgha^{-1}) and production (kgha^{-1} d^{-1}) of sharptooth catfish and the common carp fed in polyculture in ponds receiving final effluent water from maturation ponds.

TABLE 1
PHYSICAL AND CHEMICAL CONDITIONS OF FISH PRODUCTION PONDS AT SESHEGO RECEIVING FINAL EFFLUENT FROM THE MATURATION PONDS AT THE SESHEGO SEWAGE PURIFICATION WORKS

Chemical parameters	N	$\bar{x}$	min	max	SX	CV
Dissolved oxygen (mg ℓ^{-1})	13	7,75	5,4	12,1	1,70	21,93
pH	12		7,79	9,93	0,64	7,29
Conductivity (μS cm^{-1})	13	838,00	725,00	933,00	54,49	6,49
Nitrite (NO_2)(mg ℓ^{-1})	9	3,15	1,80	4,12	0,82	26,00
Nitrate (NO_3)(mg ℓ^{-1})	9	44,14	24,6	68,2	15,69	35,54
Ammonia (NH_4)(mg ℓ^{-1})	9	0,693	0,295	1,220	0,273	39,393
Orthophosphate (PO_4)(mg ℓ^{-1})	9	4,82	2,55	7,00	1,54	31,95
Alkalinity as $CaCO_3$(mg ℓ^{-1})	8	162,75	120,00	191,0	28,98	17,80
Ca hardness as $CaCO_3$ (mg ℓ^{-1})	9	57,72	49,00	62,50	4,39	7,60
Total hardness as $CaCO_3$(mg ℓ^{-1})	9	128,33	95,00	153,00	22,35	17,41

Because excessive food consumption by the sharptooth catfish caused gas formation in their stomachs, the application of food was subdivided into four portions as from day 70 onwards. Food was then provided daily at 08h00, 10h00, 12h00 and 15h00. By following this procedure, the abovementioned problem was largely eliminated.

Harvesting of fish

A selective harvesting programme was followed as soon as some of the fish reached a marketable size. Harvesting commenced on day 70 and continued until the remainder of the fish were cropped on 6 January 1988. All fish produced at the Seshego ponds were sold immediately after cropping.

Results

Pond water chemistry

Mean water temperatures in the ponds ranged between 18,8°C and 22,9°C during the production period (Table 2).

Results on the water chemistry obtained over the period of survey are shown in Table 1. Despite the relatively high fish stocking density and feed application, values for dissolved oxygen remained relatively high, fluctuating between 5,4 and 12,1 mg ℓ^{-1}. This phenomenon can be largely ascribed to the continuous throughflow of water. Phytoplankton activity in the water might have contributed to fluctuations in pH which ranged from 7,75 to 9,93. Although relatively high, conductivity fluctuated within a narrow range. As can be expected, nitrite and in particular nitrate concentrations in the pond water were abnormally high. Values for ammonia ranged between 0,295 and 1,220 mg ℓ^{-1}. Concentrations of orthophosphate were comparatively high as can be expected from final maturation pond effluent. Values for alkalinity, calcium and total hardness were in line with parameters such as conductivity and pH.

Fish yields obtained

Of the total quantity of fish produced, 136,8 kg of common carp and catfish were already of marketable size 70 days after commencement of the production trial, whilst a further 1 937 kg were cropped on day 84 (Table 2). The remainder of the fish, namely 4 078 kg, were cropped on day 100, providing a total mass of fish of 6,152 t per hectare (Fig. 1). A final yield of 4,550 t of fish per hectare comprising 64,1% carp and 35,9% sharptooth catfish (Table 3) was obtained.

Discussion

The major problem encountered was the overfeeding of the sharptooth catfish, resulting in the fermentation of food in their stomachs, which led to almost a 10% mortality rate and to a severe overall deterioration in the feed conversion ratios (FCR) for the period following day 42 until day 70, when the FCR came close to 3. Even so, the mean FCR over the entire period for both fish species in the two ponds, averaged 1,7. As a consequence of the problems experienced with the overfeeding of the catfish, the daily production in the ponds declined rapidly from a maximum of 73,6 kg ha^{-1} d^{-1} (day 42) to a low of 27,9 kg ha^{-1} d^{-1} (Fig. 1). Production recovered, however, to 66,8 kg ha^{-1} d^{-1} on 21

TABLE 2
STOCKING AND FINAL DENSITIES AND PRODUCTION RESULTS OF THE POLYCULTURE PRODUCTION OF THE COMMON CARP *CYPRINUS CARPIO* AND THE SHARPTOOTH CATFISH *CLARIAS GARIEPINUS* IN PONDS RECEIVING FINAL EFFLUENT WATER FROM MATURATION PONDS AT THE SESHEGO SEWAGE PURIFICATION WORKS.

Period	Days	Date	Mean and extreme temperatures (°C)	Stocking(s) and final (f) densities (fish ha^{-1})		Estimated mass of fish in ponds (kg)	Harvested fish mass (kg)	Estimated (E) and final (F) standing crop (kg ha^{-1})	Yield in kg ha^{-1}	Production kg ha^{-1}	Formulated feed dosage quantities in kg ha^{-1}	Feed conversion ratio(FCR)
0	0	29/9		11 045 (s)				1 601,3(E)				
1	14	29/9-12/10	18,8 23,0-13,5	9 407				2 324,9(E)	723,6	51,7	480,4	0,66
2	28	13/10-26/10	20,1 25,4-16,8					2 866,6(E)	541,7	38,7	663,2	1,22
3	42	27/10-09/11	23,5 28,0-19,8					3 897,1(E)	1 030,5	73,6	1 573,2	1,52
4	56	10/11-23/11	22,9 27,9-17,5					4 831,8(E)	934,7	66,7	2 018,2	2,16*
				Estimated numbers of fish	Number of fish harvested							
5	70	24/11-07/12	25,1 30,2-18,0	9 228	179	5 086,7	136,8	5 223,5(E)	391,4	27,9	1 143,5	2,92*
6	84	08/12-21/12	25,2 28,5-22,2	6 448	2 780	4 086,8	1 936,8	6 022,9(E)	936,0	66,8	1 304,9	1,40
7	100	22/12-06/01	25,4 30,3-20,3		6 448	—	4 078,2	6 151,5(F)	—	—	767,8	
Total					9 407 (f)		6 151,5				7 951,2	$\bar{x}$:1,70

*Poor feed conversion due to nutritional problems with catfish.

TABLE 3
INDIVIDUAL CONTRIBUTION OF THE COMMON CARP *CYPRINUS CARPIO* AND THE SHARPTOOTH CATFISH *CLARIAS GARIEPINUS* TOWARDS YIELDS OBTAINED DURING A POLYCULTURE PRODUCTION INVESTIGATION IN PONDS USING FINAL EFFLUENT FROM MATURATION PONDS AT THE SESHEGO SEWAGE PURIFICATION WORKS

Fish species	Stocking density and initial biomass/ha			Final number of fish harvested ha^{-1}	Mean final biomass (kg ha^{-1})	%	Mean final individual mass of fish in g.	Fish yield in kg ha^{-1}	%
	Mean stocking density ha^{-1}	Mean initial biomass in kg ha^{-1}	%						
Common carp	5 575	691,3	43,2	5 192	3 606,5	58,6	694,0	2 915,2	64,1
Catfish	5 470	910,0	56,8	4 215	2 545,0	41,4	603,7	1 635,0	35,9
TOTAL	11 045	1 601,3	100,0	9 407	6 151,5	100,0		4 550,2	

December, 84 d after commencement of the production trial (Table 2, Fig. 1). Overfeeding and the resultant mortalities among the catfish therefore clearly affected the potential production negatively. If this problem could be overcome, yields exceeding 4,5 t ha^{-1} during a 100-d growing period should be possible. In a fish polyculture investigation consisting mainly of different carp species with *Oreochromis mossambicus,* using overwintered fish, and with the use of pig manure with and without formulated fish feed in the Transkei, a yield of 8,57 t ha^{-1} was obtained by Prinsloo and Schoonbee (1986b) over a period of 175 d. The present production results therefore compare reasonably well with those of Prinsloo and Schoonbee (1986b). If it is taken into account that it may be possible to produce two crops of fish within the same summer season, using overwintered fish with the common carp and the sharptooth catfish in polyculture, then a total yield from the same pond in one year could comfortably exceed 9 t of fish ha^{-1}.

The use of enriched final maturation pond effluent obviously contributed towards the overall productivity of the ponds. The benthic feeding common carp, which exploits organisms such as benthic dwelling chironomid and oligochaeta (Cronje, 1981), probably benefitted particularly.

Although all the fish harvested appeared healthy, the possibility of the presence of human pathogenic organisms associated with the fish will have to be addressed. The transfer of fish from these ponds into clean, fresh water for a number of days before harvesting may contribute towards the elimination of certain pathogenic organisms, if they are present (Allan *et al.*, 1979; Hepher and Pruginin, 1981). This aspect, however, needs to be investigated further.

Acknowledgements

The authors wish to thank the Lebowa Government and the University of the North and the Rand Afrikaans University for facilities, equipment and pond space provided. The financial support of the CSIR and the Standard Bank of South Africa is greatly appreciated.

References

ALLEN, GH, BUSCH, RA and MORTON, AW (1979) Preliminary bacteriological studies on wastewater-fertilized marine fish ponds, Humbold Bay, California. In *Advances in Aquaculture.* FAO Technical Conference on Aquaculture, Kyoto, 1976. (Editors TVR Pillay and WA Dill). Fishing New Books Ltd. 493-498.

APHA (1980) *Standard Methods for the Examination of Water and Waste Water.* Washington, DC.

BOK, AH and JONGBLOED, H (1984) Growth and production of sharptooth catfish, *Clarias gariepinus* (Pisces: Clariidae), in organically fertilised ponds in the Cape Province, South Africa. *Aquaculture* **36** 141-155.

BRUTON, MN (1979) The food and feeding behaviour of *Clarias gariepinus* (Pisces: Clariidae) in Lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids. *Trans. Zool. Soc. Lond.* **35** 47-114.

CRONJE, LJJ (1981) Observations on the seasonal growth of various carp species in polyculture in manured fish ponds with and without pelleted fish feeds. M.Sc. dissertation. University of Transkei. 112.

GROENEWALD, AA VAN J (1961) *Clarias* the freshwater barbel. *Fauna and Flora* **12** 47-55.

GROENEWALD, AA VAN J (1964) Observations on the food habits of *Clarias gariepinus* (Burchell), the South African freshwater barbel (Pisces: Clariidae) in Transvaal. *Hydrobiologia* **23** 287-291.

HECHT, T (1981) Rearing of sharptooth catfish larvae (*Clarias gariepinus* Burchell, 1822: Clariidae) under controlled conditions. *Aquaculture* **24** 301.

HECHT, T (1982) Intensive rearing of sharptooth catfish larvae *Clarias gariepinus* Burchell, 1822 (Clariidae: Pisces). *S. Afr. J. Wildl. Res.* **12** 101.

HECHT, T, SAAYMAN, JE and POLLING, L (1982) Further observations on the induced spawning of the sharptooth catfish, *Clarias gariepinus* (Clariidae: Pisces). *Water SA* **8** 101.

HEPHER, B and PRUGININ, Y (1981) Commercial fish farming with special references to fish culture in Israel. John Wiley and Sons. NY. 261.

HUISMAN, EA (1986) The aquaculture potential of the African catfish (*Clarias gariepinus* Burchell, 1822). In EA Huisman (Editor) *Aquaculture Research in the Africa Region.* PUDOC, Wageningen. The Netherlands. 175-188.

HUISMAN, EA and RICHTER, CJJ (1987) Reproduction, growth, health control and aquacultural potential of the African catfish, *Clarias gariepinus* (Burchell, 1822). *Aquaculture* **63** (1-4) 1-14.

HOGENDOORN, H and KOOPS, WJ (1983) Growth and production of the African catfish, *Clarias lazera* (C.V.) I. Effects of stocking density, pond size and mixed culture with tilapia (*Sarotherodon niloticus* L.) under extensive field conditions. *Aquaculture* **34** 253-263.

JANSEN, JAL (1983) Premier rapport semestre 1983 du Project GCP/CAF/007/NET, FAO,Rome. 13.

JANSEN, JAL (1984) Premier rapport semestre 1984 du Project GCP/CAF/007/Nct, FAO Rome. 21.

JANSEN, JAL (1985) L'élévage du poisson-chat African, *Clarias gariepinus,* en République Centrafricaine, FAO; Rome. 100.

POLLING, L, VAN DER WAAL, BCW and SCHOONBEE HJ (1987) Improvements in the large-scale artificial propagation of the sharptooth catfish *Clarias gariepinus* (Burchell) in South Africa. *S. Afr. J. Anim. Sci.* 17(4) 176-180.

POLLING, L, SCHOONBEE, HJ, PRINSLOO JF and WIID, AJB (1988) The evaluation of live feed in the early larval growth of the sharptooth catfish *Clarias gariepinus* (Burchell). *Water SA* **14**(1) 19-24.

PRINSLOO, JF and SCHOONBEE, HJ (1986a) Comparison of the early larval growth rates of the Chinese grass carp *Ctenopharyngodon idella* and the Chinese silver carp *Hypophthalmichthys nobilis* using live and artificial feed. *Water SA* **12**(4) 229-234.

PRINSLOO, JF and SCHOONBEE, HJ (1986b) Summer yield of fish in polyculture in Transkei, South Africa, using pig manure with and without formulated fish feed. *S. Afr. J. Anim. Sci.* **16**(2) 65-71.

PRINSLOO, JF and SCHOONBEE, HJ (1987a) Utilisation of chicken offal in the production of the African sharptooth catfish *Clarias gariepinus* in the Transkei. *Water SA* **13**(2) 129-132.

PRINSLOO, JF and SCHOONBEE, HJ (1987b) Investigations into the feasibility of a duck-fish-vegetable integrated agriculture-aquaculture system for developing areas in South Africa. *Water SA* **13**(2) 109-118.

SCHOONBEE, HJ (1969) Notes on the food habits of fish in Lake Barberspan, Western Transvaal, South Africa. *Verh. Internat. Verein. Limnol.* **17** 689-701.

SCHOONBEE, HJ, BRANDT, F de W and BEKKER, CAL (1978) Induced spawning of the two phytophagous Chinese carp species *Ctenopharyngodon idella* (Val.) and *Hypophthalmichtys molitrix* (Val.) with reference to the possible use of the grass carp in the control of aquatic weeds. *Water SA* **4**(2) 93.

SCHOONBEE, HJ, HECHT, T, POLLING, L and SAAYMAN, JE (1980) Induced spawning of and hatchery procedures with the sharptooth catfish, *Clarias gariepinus* (Pisces: Clariidae). *S. Afr. J. Sci.* **76** 364-367.

SCHOONBEE, HJ and PRINSLOO, JF (1986) Use of the pituitary glands of the sharptooth catfish *Clarias gariepinus* in the induced spawning of the European common carp *Cyprinus carpio* and the Chinese grass carp *Ctenopharyngodon idella. Water SA* **12**(4) 235-237.

STEYN, GL, VAN VUREN, JHJ, SCHOONBEE, HJ and CHAO N-H (1985) Preliminary investigations on the cryopreservation of *Clarias gariepinus* (Clariidae: Pisces) sperm. *Water SA* **11**(1) 15.

TEUGELS, GG (1982a) A systematic outline of the African species of the genus *Clarias* (Pisces: Clariidae) with an annotated bibliography. *Ann. Mus. Afr. Centr.* Ser. in 8 *Sci. Zool.*, No. 236. 249.

TEUGELS, GG (1982b) Preliminary results of a morphological study of five African species of the subgenus *Clarias* (Pisces: Clariidae). *J. Nat. Hist.* **16** 439.

UYS, W and HECHT, T (1985) Evaluation and preparation of an optimal dry feed for the primary nursing of *Clarias gariepinus* larvae (Pisces: Clariidae). *Aquaculture* **47** 173-183.

VAN DER WAAL, BCW (1972) 'n Ondersoek na aspekte van die ekologie, teelt en produksie van *Clarias gariepinus* (Burchell) 1822. M.Sc. Thesis, Rand Afrikaans University.
VAN DER WAAL, BCW (1978) Some breeding and production experiments with *Clarias gariepinus* (Burchell) in Transvaal. *S. Afr. J. Wildl. Res.* **8** 13-17.
VAN DER WAAL, BCW (1985) Stripping male *Clarias gariepinus* of semen. *Aquaculture* **48** 137.