Some Observations on Biological and Other Control Measures of the African Clawed Frog *Xenopus laevis* (Daudin) (Pipidae, Amphibia) in Fish Ponds in Transkei

J.F. PRINSLOO,* H.J. SCHOONBEE** and J.G. NXIWENI*

* *Department of Zoology, University of Transkei, Private Bag X5092, Umtata, 5100, Transkei*
***Research Unit for Fish Biology, Rand Afrikaans University, P.O. Box 524, Johannesburg, 2000*

Abstract

Experience shows that *Xenopus laevis*, the African clawed frog or platanna, poses a serious threat to fish fry and fingerlings in fish ponds in most parts of Southern Africa and that its larval stages also compete for food with algal-feeding fish. Experiments were carried out to determine the possible effectiveness of barriers around ponds and of biological control measures through the use of the largemouth Black bass, *Micropterus salmoides* against the platanna. Preliminary results indicate that great care should be taken in the proper construction of barriers around ponds if this frog is to be prevented from entering. The use of black bass in *Xenopus* infested fish ponds and also in cage experiments was in both cases successful in either eliminating or reducing its numbers drastically over a relatively short period of time. It is recommended that *M. salmoides* be considered for inclusion in fish polyculture in areas where the platanna is a problem.

Introduction

Xenopus is the only South African amphibian which, despite the fact that it possesses lungs and gulps air in the adult stage, is totally aquatic under normal conditions. Of the six species of *Xenopus* which occur in Africa south of the Sahara (Nieuwkoop and Faber, 1956), *Xenopus laevis* (Daudin) 1802 has the widest distribution. This species not only invades impoundments, pools and sluggish flowing regions of rivers in the whole South Africa (Wager, 1965; Pienaar, *et al.*, 1976; Passmore and Curruthers, 1979; Jubb, 1980) but its subspecies also occur northwards in Angola, Maputo, Zimbabwe, Tanzania, Somalia, Kenia, Ethiopia, Cameroon and Uganda (Brown, 1970; Deuchar, 1975).

The success of the occurrence and abundance of *X. laevis* in water bodies in Southern Africa may be ascribed to a combination of factors. The adult frog is reported to be able to survive dessication in drying up water bodies by burrowing in the mud (Millard and Robinson, 1967; Brown, 1970; Jubb, 1980), but it is also known to be able to migrate over land from one dam to another (Hey, 1945; Wager, 1965; Jubb, 1980). The experience of fishery scientists working in Uganda (FAO/EPTA Fish Culturist, 1965) as well as that of the present authors, show that adult *X. laevis* also tends to migrate actively at night between ponds despite the abundance of water. Although it is not clear why this type of migration occurs, factors such as population pressure and relative shortage of food playing a role in this phenomenon cannot be excluded.

Xenopus laevis is adapted to a wide temperature range. It has been observed by the present authors to survive under ice, i.e. below 4°C but can also occur in waters at temperatures as high as 28°C (Brown, 1970). According to Brown (1970) the optimum water temperature for this species is 23°C.

The larval (tadpole) stages of *X. laevis* are primarily phytoplanktonic feeders, whereas the adult frogs can be described as omnivorous. It not only competes with trout for food, but is reported to be a scavenger, a carnivore and an important predator of fish fry and fingerlings (Hey, 1945; Brown, 1970; Deuchar, 1975; Pienaar, *et al.* 1976; Jubb, 1980.) Under adverse conditions, the platanna has been observed to be cannibalistic by feeding on its own tadpoles and even its eggs (Lesley, 1890; Brown 1970). Nakani (1979) found that large numbers of *Xenopus* larvae, when present in manured fish ponds, clearly affected the growth of the phytophagous Chinese silver carp (Fig. 1).

Xenopus laevis has a relatively long lifespan. It has been recorded to survive for 15 years in captivity (Hewitt quoted from Wager, 1965) and can easily grow to a mass of 200g and more under natural conditions.

The importance of this species as a predator of fish fry and fingerlings and therefore as a threat to fish culture has not only been observed in recent investigations in Transkei (Nakani, 1979; Schoonbee *et al.* 1979) but also by other investigators in Africa (Lesley, 1890; Hey, 1945; FAO/EPTA Fish Culturist, 1956; Jubb, 1980).

Despite the problems experienced by fisheries with *X. laevis* as a predator, relatively little has been done so far to investigate possible means of its control. In Zimbabwe, traps are being used to control the numbers of platanna populations in trout waters (Jubb, 1980). Hey (1945) reported that the numbers of platanna had been contained in water bodies in the Cape Province by the introduction of the largemouth bass *Micropterus salmoides* (Lacépède 1802) but on present day information, the use of bass to control the numbers of platanna is no longer actively pursued in South Africa.

Largemouth bass were first imported into South Africa from the Surrey Trout Farm, Haslemere, England, who obtained their original stock from the Netherlands (Robbins and MacCrimmon, 1974). Late in 1927, R.J. Neville of the Rand Piscatorial Association, Johannesburg received 49 fingerlings and in February 1928, 45 surviving fish were released into the Jonkershoek Hatchery Stellenbosch (Harrison, 1936; Robbins and MacCrimmon, 1974). According to Harrison (1936), 24 and 16 largemouth bass fingerlings were dispatched in 1935 from Jonkershoek to Messrs M.D. Mackay, Tsolo and A.B. Payn, Umtata, respectively. Information from the Transkei Nature Conservation Division, Department of Agriculture and Forestry, shows that the largemouth bass has since 1954 been introduced

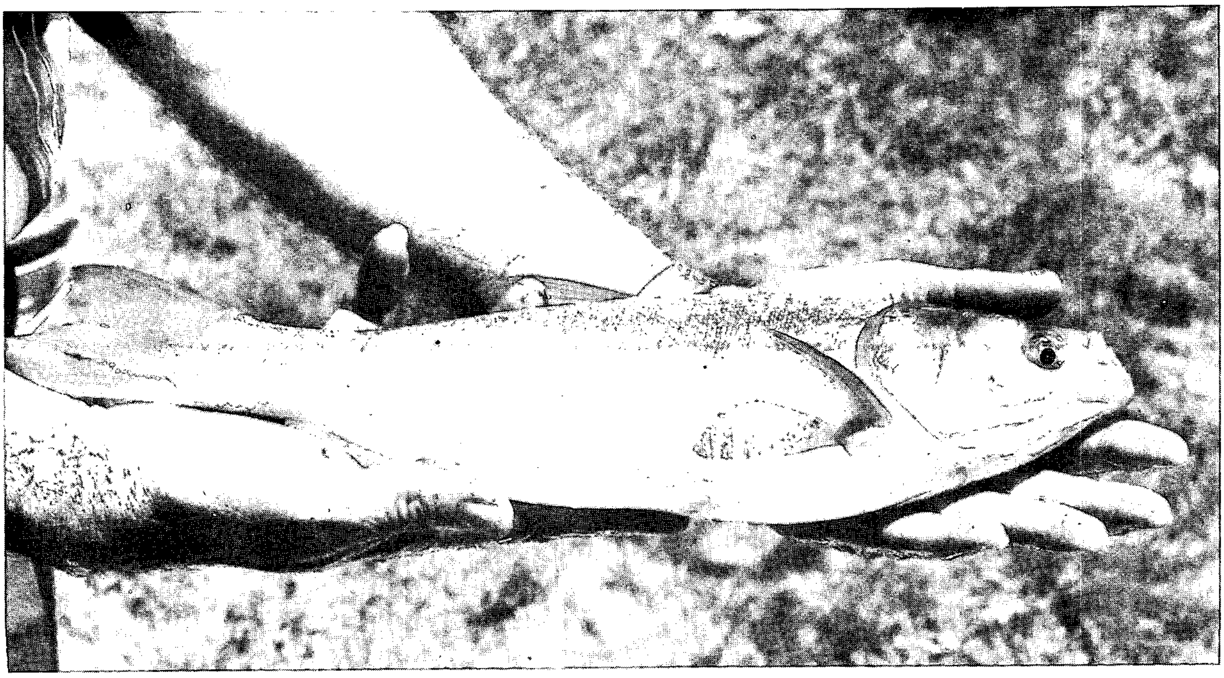
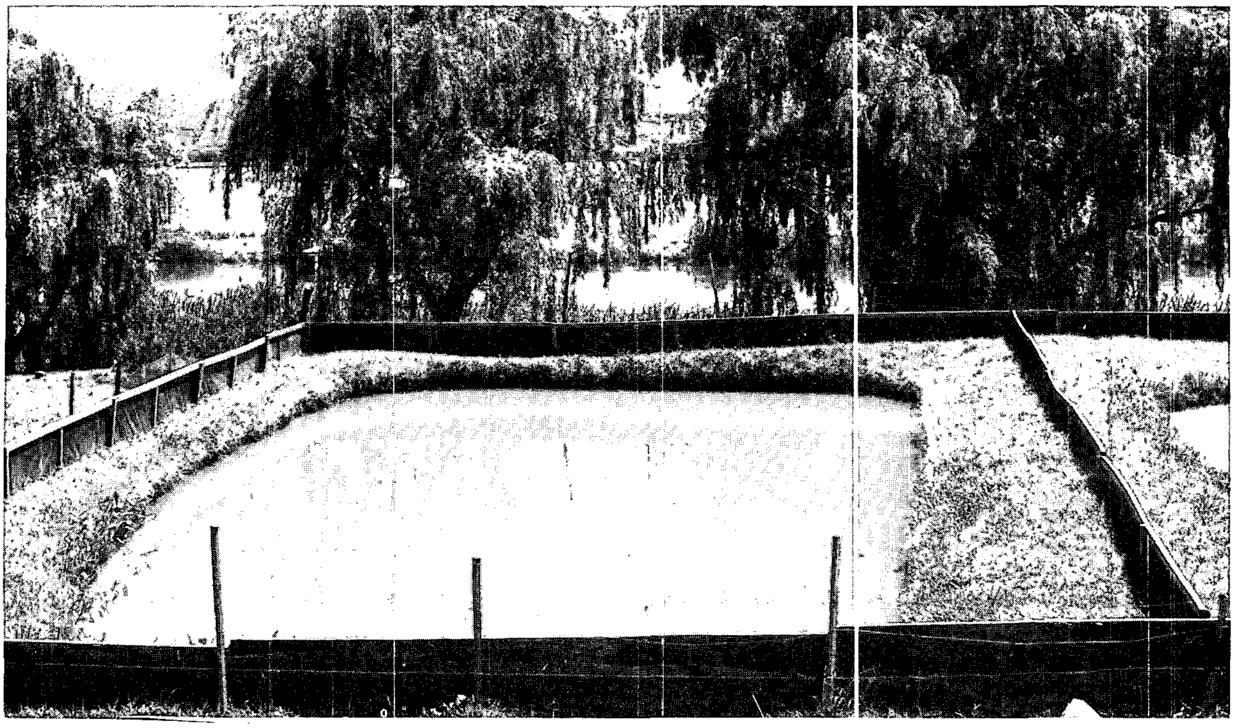


Figure 1
Tadpoles of Xenopus laevis *(top) removed from manured fish pond at Tsolo fish farm, Transkei, which competed for food with and affected growth of phytophagous Chinese silver carp,* Hypophthalmichthys molitrix (below)



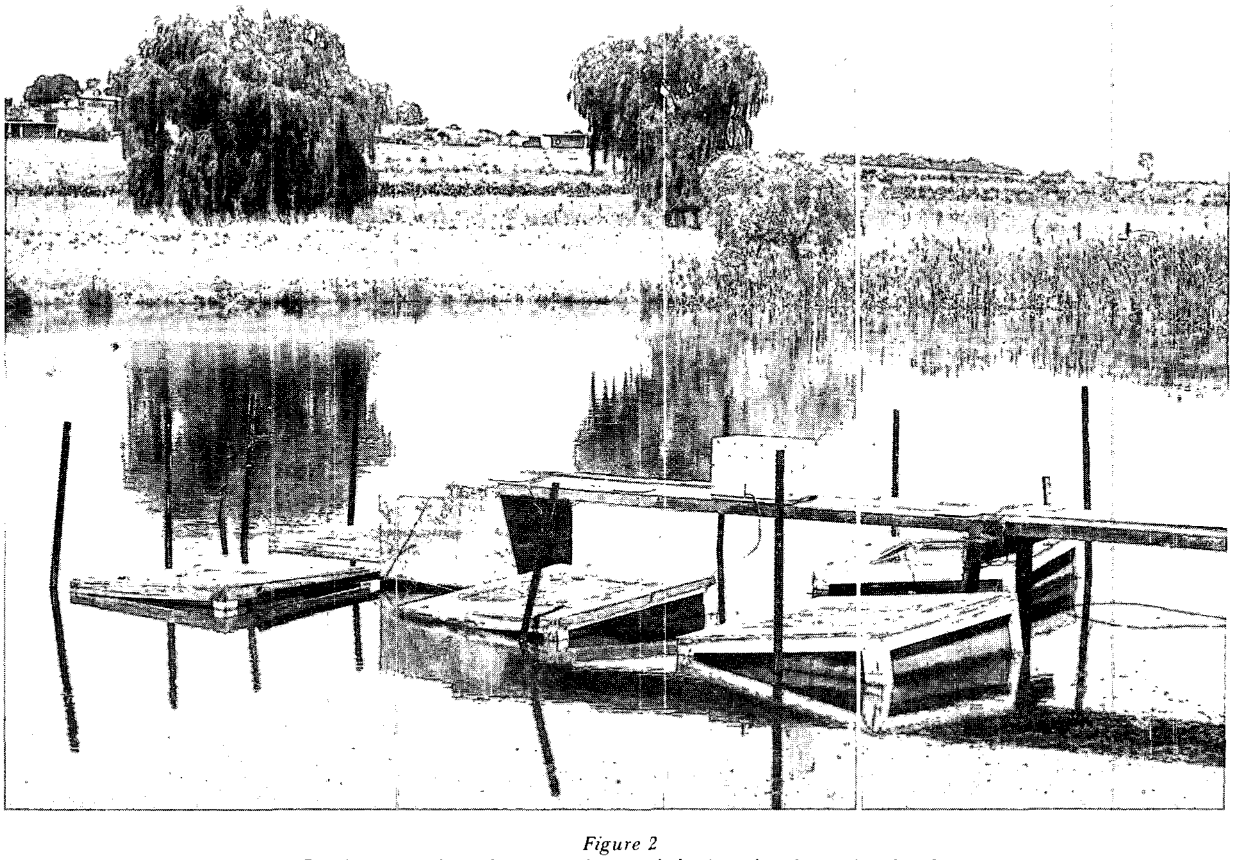


Figure 2
Barriers around ponds (top) and cages (below) used to determine the effectiveness of mechanical and biological control of platanna in ponds

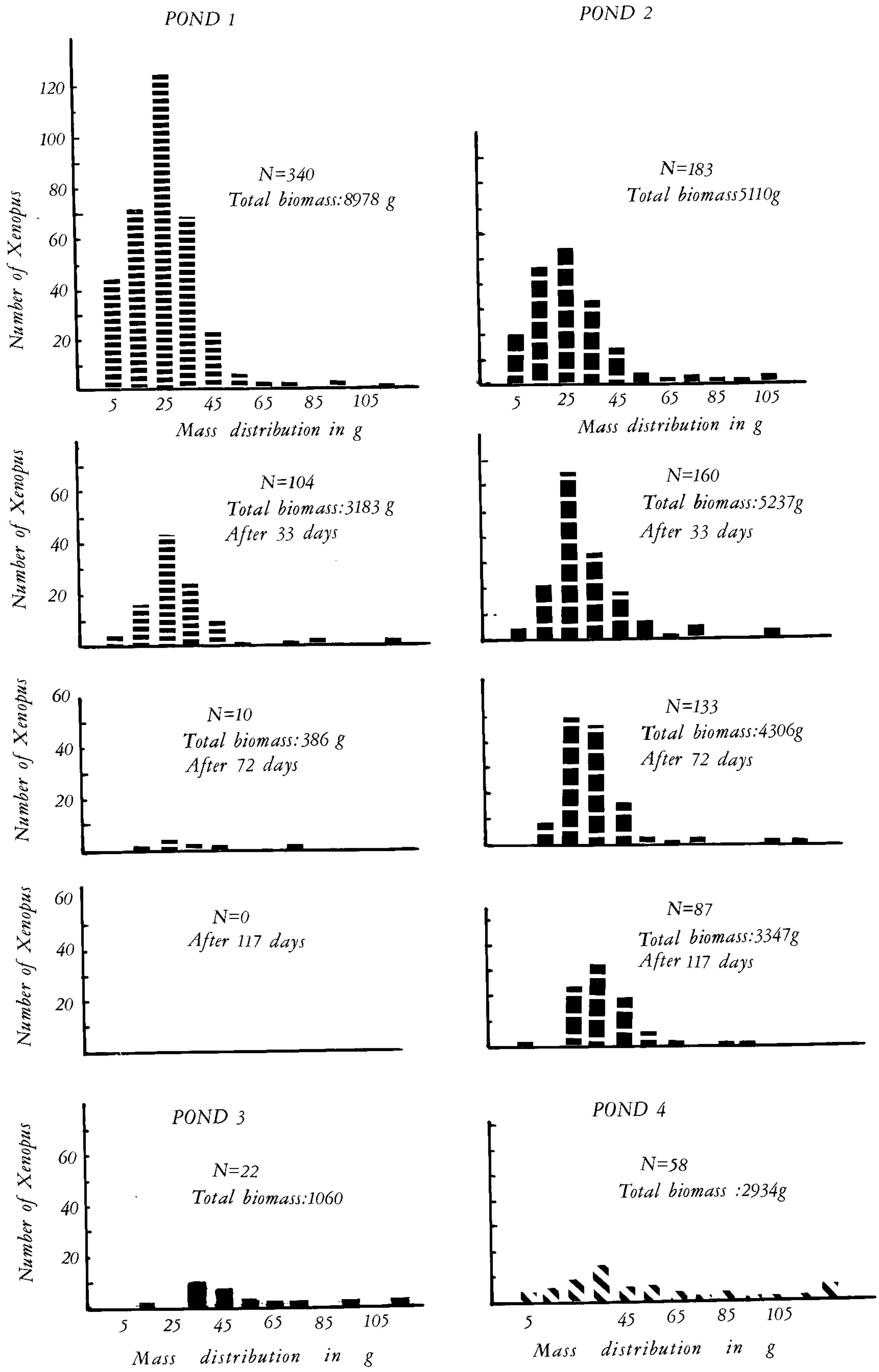


Figure 3
Total number and biomass of Xenopus *in ponds 1 and 2 stocked with black bass after 33, 72 and 117 days respectively compared with control pond 3 (enclosed) and pond 4 (open) at the end of the 117 day period*

into dams in Transkei as a sport fish.

Today *M. salmoides* is a commonly occurring fish species in river systems and reservoirs in Transkei. Its successful invasion of these water bodies appears to be related, at least partially, to the presence and abundance of the platanna, *X. laevis* as food. In view of the available information on the feeding habits of the largemouth bass, with frogs often being mentioned as a food item (Hey, 1954; Robbins & MacCrimmon, 1974), the present investigation was undertaken with the aim to establish the suitability of this fish as a predator of *X. laevis* tadpoles and adults in fish ponds in Transkei. The construction of mechanical barriers as an alternative to combat *X. laevis* was also investigated.

Materials and Methods

The investigation into the possible effects of mechanical barriers and the biological control of *X. laevis* in fish ponds were conducted in limited pond and cage space (Fig. 2). This approach was necessitated as most pond space was already taken up with the Chinese silver carp *Hypophthalmichthys molitrix* Val. and the Israeli Dor 70 variety of the common carp *Cyprinus carpio* L. which are raised there as future spawners. Four ponds were available, three (Ponds 1 — 3) of approximately 200 m² and one pond (Pond 4) of approximately 400 m² in size. Ponds 1 — 3 were each individually enclosed with a 1 m high wooden framework covered with plastic sheeting of which 25 cm was buried underground. All the ponds used were initially drained and then allowed to dry out for one month. All possible platanna eggs and live frogs, which could have been present in the dried-out bottom sediments in the ponds were eradicated by removing the top 50 mm layer of each of the four ponds intended for the study. Crab holes were filled up and the water inlets into each pond screened off with a 60% shade net which has an approximate mesh size of 100 apertures per cm². This was done to prevent *Xenopus* eggs, tadpoles or adult frogs from entering the ponds. All four ponds were then filled with water from a nearby water supply dam. Pond 3 (enclosed) and pond 4 (open) were not provided with fish or *Xenopus*. To pond 1 was added 15 black bass with a total biomass of 7 965 g and also 340 young and adult platanna with a total biomass of 8 978 g. Pond 2 (enclosed) received three large black bass (total biomass — 3 205 g) and 183 young and adult platanna with a total biomass of 5 110 g. In both ponds 1 and 2 therefore, there was an initial mass surplus of *Xenopus* compared to those of bass released but the aim was also to determine whether a low pond density of bass, such as in pond 2 (3 fish/200 m² as against 15 fish/200 m² for pond 1) would be able to control *Xenopus* equally effectively. No further additions of *Xenopus* material was made to these ponds for the duration of the experiment which lasted 117 days. During this period ponds 1 and 2 were drained on three occasions, after intervals of 33, 39 and 45 days, respectively, and all the fish and the remaining *Xenopus* in each pond counted and weighed. The two control ponds (Ponds 3 and 4) which did not receive fish or platanna, were only emptied at the end of the experiment. All the *Xenopus* which entered these two ponds during the period of survey were then counted and weighed. (Fig. 3.)

As mentioned, the lack of pond space necessitated the use of cages to supplement the pond experiments. The cages (1 m³ were enclosed with a 60 % shade net material of a mesh size of 100 apertures per cm² (Fig. 2). Twenty largemouth bass of known mass and size were placed in each cage (Table 1). In order to determine the possible effects of predation of bass on *Xenopus*, larval, juvenile and adult platanna of known biomass

TABLE 1
LENGTH, MASS, AND INCREASE IN BODY MASS OF LARGE MOUTH BASS USED IN CAGES TO DETERMINE THE EFFECT OF THIS FISH AS PREDATOR ON VARIOUS DEVELOPMENTAL STAGES OF THE PLATANNA

Cage No	Date of sampling	Duration of experiments in days	N	Fork Length in cm $\overline{X}$	Fork Length in cm Range	Fish Mass in g Total	Fish Mass in g $\overline{X}$	Fish Mass in g Range	*Xenopus* consumed as % of body mass bass/day
	10.10.79	12		11,89	9,5 — 13,6	407,4	20,37	9,6 — 37,3	8,9
	22.10.79	15		11,94	9,5 — 14,0	399,6	19,98	9,4 — 41,2	4,3
1	6.11.79	13	20	11,93	9,5 — 15,0	427,0	21,35	8,8 — 54,4	7,5
	19.11.79	16		12,13	9,5 — 15,8	444,8	22,24	8,8 — 66,1	6,8
									$\overline{X}$ 6,8
	10.10.79	12		11,23	7,8 — 13,4	360,5	18,03	5,5 — 35,1	9,0
	22.10.79	15		11,31	7,8 — 14,0	369,1	18,46	6,0 — 37,4	4,9
2	6.11.79	13	20	11,44	8,0 — 15,1	398,4	19,92	6,5 — 56,3	10,6
	19.11.79	16		11,22	7,8 — 15,8	431,5	21,58	5,6 — 66,6	8,3
									$\overline{X}$ 8,2
	10.10.79	12		14,88	12,7 — 17,3	779,4	39,97	29,2 — 66,5	6,4
	22.10.79	15		14,96	12,8 — 17,7	823,1	41,16	24,8 — 75,1	7,1
3	6.11.79	13	20	15,01	12,8 — 18,2	868,8	43,4	23,7 — 98,0	4,7
	19.11.79	16		14,95	12,5 — 18,5	940,8	47,04	22,9 — 107,8	3,4
									$\overline{X}$ 5,4

were released and kept in each cage with the fish for periods ranging from 12 — 16 days (Tables 2, 3, 4). At the end of each period the remaining *Xenopus* were counted and weighed. Weight increases of the bass were also noted. Fresh frogs were added each time and the process repeated for another three consecutive periods per cage.

Control of *Xenopus* in Ponds

The results obtained on the biological control of *Xenopus* in ponds were somewhat disappointing. In the case of pond 1 (Fig. 3) the total of 340 young and adult frogs were completely consumed within the period of 117 days. During this period, however, four of the 15 bass placed in pond 1, died within the first month, possibly as a result of the accidental introduction of carp into ponds 1 and 2, which stirred up the bottom sediments considerably developing high and prolonged periods of turbidity in the pond water. In pond 2, one bass died. There was nevertheless, a gradual decline in the numbers of *Xenopus* in this pond over the period of study and 87 of the 183 platanna initially released were present at the end of the study period.

Upon emptying pond 3, twenty-two platanna were discovered. A hole in the shade net material covering the water inlet into the pond is the only explanation for the presence of these platanna in the pond as this was the only possible way in which they could have entered. Pond 4, which was unprotected for the duration of the study period, contained a total of 58 platanna, which confirms the suspicion that *Xenopus* migrates from other ponds to invade new areas.

Results on Cage Experiments

Results on the number of platanna introduced into each cage and their subsequent reduction in numbers and biomass for consecutive periods ranging from 12 — 16 days each, are indi-

TABLE 2
MASS DISTRIBUTION OF TADPOLES, JUVENILES, YOUNG AND ADULT PLATANNA IN CAGE 1 FOR EACH OF THE FOUR CONSECUTIVE FEEDING TRIALS WITH *M. SALMOIDES*, WITH AN INDICATION OF THE TOTL BIOMASS OF PLATANNA CONSUMED DURING EACH TRIAL

Periods in days	Tadpoles and Juveniles	Young and adult Platanna										Remarks
	0—5	5,1—10	10,1—15	15,1—20	20,1—25	25,1—30	30,1—35	35,1—40	40,1—45	45,1—50	Total biomass in g	
	111	27	10	6	3	3	1	1	1	1	860,4	Initial number and biomass of platanna
12	1	6	2	6	2	3	1	—	1	1	426,6	Remaining number and biomass of platanna
											433,8	Biomass consumed by Bass
	134	70	4	6	2	3	1	—	1	1	1 078,9	Initial number and biomass of platanna
15	17	59	2	6	2	2	1	—	1	1	823,8	Remaining number and biomass of platanna
											255,1	Biomass consumed by Bass
	117	59	2	6	2	2	1	—	1	1	1 041,0	Initial number and biomass of platanna
13	10	32	2	6	2	2	1	—	1	1	622,9	Remaining number and biomass of platanna
											418,1	Biomass consumed by Bass
	110	32	2	6	2	2	1	—	1	1	825,1	Initial number and biomass of platanna
16	—	—	3	5	3	2	1	—	—	2	377,0	Remaining number and biomass of platanna
											448,1	Biomass consumed by Bass

cated in Tables 2 – 4. The growth performance of largemouth bass juveniles involved in the experiment for the various periods and over the entire duration of 56 days, in each of the three cages, is also indicated in Table 1.

Results obtained on the consumption of platanna by bass in all three cages show that the tadpole and juvenile stages of less than 15 g in mass, are usually eliminated (in the case of tadpoles) or in most cases, drastically reduced in numbers. Results also suggest that bass less than 50g in mass are apparently not capable of efficiently utilizing platanna larger than 15g.

A study of the growth of bass kept in the three cages (Table 1) shows that with the exception of only one period (10 – 22 October 1979, cage 1), there was a continuous growth of bass indicating that *Xenopus* can be utilized efficiently as food by this fish species. A calculation of the percentage biomass of *Xenopus* consumed per day expressed as a percentage of body mass of bass in each cage for each of the individual periods shows that the *Xenopus* consumed by the bass fluctuated from 4,3% (cage 1) to 10,6% (cage 2). Results on the consumption of *Xenopus* by bass (Table 1) further suggest that the percentage food intake appears to decline on the average with increasing size of bass.

Discussion

From the available literature as well as from the results obtained so far, indications are that *M. salmoides* may be suitable to control wild spawns of *Xenopus* in fish ponds. The results further suggest that bass are particularly useful in eradicating or containing the numbers of larval and younger stages of the platanna in ponds.

TABLE 3
MASS DISTRIBUTION OF TADPOLES, JUVENILES, YOUNG AND ADULT PLATANNA IN CAGE 2 FOR EACH OF THE FOUR CONSECUTIVE FEEDING TRIALS WITH *M. SALMOIDES*, WITH AN INDICATION OF THE TOTAL BIOMASS OF PLATANNA CONSUMED DURING EACH TRIAL

Periods in days	Tadpoles and Juveniles	Young and adult Platanna										Remarks
	0—5	5,1 —10	10,1 —15	15,1 —20	20,1 —25	25,1 —30	30,1 —35	35,1 —40	40,1 —45	45,1 —50	Total biomass in g	
	111	16	6	5	2	3	—	1	—	—	553,5	Initial number and biomass of platanna
12	—	1	1	3	—	2	—	1	—	—	163,9	Remaining number and biomass of platanna
											389,6	Biomass consumed by Bass
	121	54	6	3	—	2	—	1	—	—	756,4	Initial number and biomass of platanna
15	7	40	2	3	—	2	—	1	—	—	483,2	Remaining number and biomass of platanna
											273,2	Biomass consumed by Bass
	109	46	4	3	—	2	—	1	—	—	771,2	Initial number and biomass of platanna
13	1	6	2	3	—	2	—	1	—	—	223,1	Remaining number and biomass of platanna
											548,1	Biomass consumed by Bass
	106	30	15	5	—	2	—	1	—	—	781,7	Initial number and biomass of platanna
16	—	—	6	4	—	1	1	—	—	—	206,0	Remaining number and biomass of platanna
											575,7	Biomass consumed by Bass

It will be important, however, to take into account the relative sizes of other pond fish compared to those of the bass to be introduced in such ponds as it might endanger the existence of the fish fingerlings of other species.

Apart from the fact that bass might play an important role in the harvesting of *Xenopus* in pond fish polyculture, the use of this fish species may also be of value in eliminating tadpoles of *Xenopus* from ponds in which silver carp forms part of the polyculture system, as both the tadpoles and the silver carp compete for phytoplankton as food.

It is recommended that where bass is included in a polyculture system for the purpose just mentioned, the number of common carp be reduced in order to minimize the agitation of sediments from the bottom by this benthic feeding fish. Other fish which can be included in polyculture with the largemouth bass as predator of the platanna can be Chinese silver carp, *Hypophthalmichthys molitrix* (a phytoplankton feeder) and the Chinese bighead carp *Aristichthys nobilis* Richardson (zooplankton feeder).

Although the present study does not specifically provide answers to the numbers and sizes of blackbass which should be kept in ponds where *Xenopus* is a problem, the present findings, especially of the cage experiments indicate that the bass should be restricted to only a few specimens per fish pond.

Experiments on the possible effects of *Xenopus* and *Micropterus* on fish poly- and monoculture systems are at present being evaluated at the Umtata dam fish ponds. This may provide more information on the actual sizes and numbers of bass required under fish poly- and monoculture conditions.

TABLE 4
MASS DISTRIBUTION OF TADPOLES, JUVENILES, YOUNG AND ADULT PLATANNA IN CAGE 3 FOR EACH OF THE FOUR CONSECUTIVE FEEDING TRIALS WITH *M. SALMOIDES*, WITH AN INDICATION OF THE TOTAL BIOMASS OF PLATANNA CONSUMED DURING EACH TRIAL

Periods in days	Tadpoles and Juveniles	Young and adult Platanna										Remarks
	0—5	5,1 —10	10,1 —15	15,1 —20	20,1 —25	25,1 —30	30,1 —35	35,1 —40	40,1 —45	45,1 —50	Total biomass in g	
	117	35	16	8	7	6	2	—	2	—	1 214,8	Initial number and biomass of platanna
12	—	1	5	8	7	4	2	—	2	—	602,2	Remaining number and biomass of platanna
											612,6	Biomass consumed by Bass
	114	71	44	14	9	2	1	2	1	—	1 842,2	Initial number and biomass of platanna
15	—	13	28	9	9	1	1	2	—	—	962,0	Remaining number and biomass of platanna
											880,2	Biomass consumed by Bass
	102	31	36	10	9	1	1	2	—	—	1 402,2	Initial number and biomass of platanna
13	—	10	27	10	7	—	1	2	—	—	866,2	Remaining number and biomass of platanna
											516,0	Biomass consumed by Bass
	101	42	34	11	7	—	1	2	—	—	1 395,1	Initial number and biomass of platanna
16	—	12	30	11	6	1	1	1	—	—	883,8	Remaining number and biomass of platanna
											511,3	Biomass consumed by Bass

Acknowledgements

This project was made possible through the financial support of the Department of Co-operation and Development and the Department of Agriculture and Forestry of Transkei. The use of facilities of the Zoology Departments of the Rand Afrikaans University and the University of Transkei is gratefully acknowledged.

References

BROWN, A.L. (1970) The African clawed toad *Xenopus laevis*. A guide for laboratory practical work. Butterworths. London. 140 pp.

DEUCHAR, E.M. (1975) *Xenopus*, the South African clawed frog. John Wiley & Sons. London. 246 pp.

FAO/EPTA Fish Culturist (1965) Report to the Government of Uganda on the Experimental fish culture project in Uganda. 1962–64. Based on the Work of Yoel Pruginin. 25 pp.

HARRISON, A.C. (1936) Black bass in the Cape Province. Second report on the progress of American largemouth black bass (*Micropterus salmoides*, Lacépède). Union S.A. Dep. Commer. Indust. Fish Mr. Bist, Surv. Div. Invest. Rep 7.

HEY, D. (1945) Inland Fisheries Department. Prov. Admin. Cape of Good Hope. Report: 31–32.

JUBB, R.A. (1980) The platanna or "clawed frog" is an avid predator. Albany freshwater Angling Association. Newsletter 41. Febr. 1980.

LESLEY, J.M. (1980) Notes on the habits and oviposition of *Xenopus laevis*. *Proc. Zool. Soc. London.*, pp 69–71.

MILLARD, N.A.H. and ROBINSON, J.T. (1967) The dissection of the spiny dogfish and the platanna. Rev. ed. 1967. Maskew Miller. Cape Town. 105 pp.

NAKANI, V.S. (1979) The use of cattle manure and supplementary feed in growth studies of the Chinese silver carp *Hypophthalmichthys molitrix* Val. and the Israeli Dor 70 common carp *Cyprinus carpio* L. at the Tsolo fish farm, Transkei. M.Sc. Thesis. (Univ. of Fort Hare) 92 pp.

NIEUWKOOP, P.D. and FABER, J. (1956) Normal Table of *Xenopus laevis*. Daudin Amsterdam: N. Holland Pub. Co.

PASSMORE, N.I. and CARRUTHERS, V.C. (1979) South African frogs. Witwatersrand Univ. Press. 270 pp.

PIENAAR, U. de V., PASSMORE, N.I. and CARRUTHERS, V.C. (1976) The frogs of the Kruger National Park. Pretoria. National Parks Board.

ROBBINS, W.H. and MacCRIMMON, H.R. (1974) The Black bass in America and Overseas. Ontario. Canada. 196 pp.

SCHOONBEE, H.J., NAKANI, V.S. and PRINSLOO, J.F. (1979) The use of cattle manure and supplementary feeding in growth studies of the Chinese Silver carp in Transkei. *S.A. Jour. Sci.* **75** 489–495.

WAGER, V.A. (1965) The Platanna *Xenopus laevis*. *Afr. Wild Life* **9** 49–53.