Technical note

Control of *Xenopus laevis* (Amphibia: Pipidae) in fish ponds with observations on its threat to fish fry and fingerlings

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Abstract

Predation by African clawed frogs *Xenopus laevis* threatened fry and fingerlings of common carp *Cyprinus carpio* and Chinese silver carp *Hypophthalmichthys molitrix* in nursery ponds in Transkei, Southern Africa. Competition for food (phytoplankton) between *Xenopus* tadpoles and silver carp appeared to affect the growth of the fish. However, the potential competition between *Xenopus* adults and common carp for benthic prey was not realised. Although solid barriers around ponds are the most efficient means of preventing recolonisation of frog-free ponds, the traps used were a viable, inexpensive means of control. The use of largemouth bass as a predator for controlling *Xenopus* tadpoles is not recommended for nursery ponds.

Introduction

The African clawed frog or platanna *Xenopus laevis* is widespread in Eastern and Southern Africa (Deuchar, 1975; Passmore and Carruthers, 1979). Feral populations have also become established in parts of North America (St. Amant *et al.*, 1973; McCoid and Fritts, 1980). Although primarily aquatic, *Xenopus* readily colonises new areas by migrating overland at night (Kalk, 1960; Passmore and Carruthers, 1979).

Adult *Xenopus* are predatory and take a wide range of benthic and nektonic organisms (Passmore and Carruthers, 1979; Nxiweni, 1982), including fish fry and fingerlings (Hey, 1945; Schoonbee *et al.*, 1979). In contrast, *Xenopus* tadpoles are primarily phytoplankton feeders (Lofts, 1974; Passmore and Carruthers, 1979). Owing mainly to the danger of predation, but also because of competition for food, *Xenopus* has been recognised as a threat to fresh-water aquaculture in Transkei (Schoonbee *et al.*, 1979) and elsewhere in Southern Africa (Safriel and Bruton, 1984).

Some measures for controlling *Xenopus* in fish ponds have been documented by Prinsloo *et al.* (1981). These include the erection of barriers to prevent frogs from recolonising frog-free ponds and the inclusion of largemouth bass *Micropterus salmoides* in fish ponds as a predator for controlling *Xenopus* tadpoles.

This paper reviews control measures used against *Xenopus*, with emphasis on trapping, and reports on predation and competition between *Xenopus* and the fry and fingerlings of common carp *Cyprinus carpio* and Chinese silver carp *Hypophthalmichthys molitrix* reared under semi-natural conditions in earthen nursery ponds.

Materials and methods

This study was conducted at the Umtata Dam Freshwater Fish Research Centre (31°33'S, 28°44'E) in Transkei. Four large "walk-in" live traps were built for capturing adult *Xenopus*. These traps consisted of a framework of 10 mm mild steel reinforcing rods covered with polyethylene shade cloth (30% shade, approx. 2 mm mesh size) (Figure 1). The traps were baited with fish offal and set overnight, half-submerged in the shallows of the nursery ponds. Each morning frogs were removed and counted.

The effects of *Xenopus* on fish fry and fingerlings were studied in three earthen nursery ponds (800 m²; max. depth 1,5 m). Pond 1 was stocked with common carp fingerlings (< 5 g), pond 2 with silver carp fingerlings (< 5 g) and pond 3 with a combination of small silver carp (< 1 g) and larger common carp (> 200 g). During December 1981 and January 1982 *Xenopus* adults were collected from these three nursery ponds using a fine mesh seine net (20 mm stretched mesh). Frogs were killed immediately using ether to prevent them regurgitating their stomach contents. Body length (tip of snout to cloaca) was then measured and the oesophagus and stomach removed and preserved in 10% formalin. Prey items were later separated, identified and weighed. Pennak (1978) and Wager (1965) were consulted for the identification of invertebrate and tadpole remains, respectively.

Results

The frog traps captured 688 *Xenopus* in 96 trap nights. Catches were highest on the first night of trapping ($\bar{x}$ = 23,5; S.D. = 20,8; range = 2 to 86 frogs per trap; n = 13 trap nights), but were significantly lower (paired t-test, p < 0,001) on the second night ($\bar{x}$ = 5,8; S.D. = 8,6; range = 0 to 34; n = 13). During 10 consecutive nights of trapping with four traps 257 frogs were removed from pond 2. This pond was then drained and 186 *Xenopus* remained, indicating that at least 58% of the frogs in the pond had been captured.

The stomachs of 152 out of 233 *Xenopus* contained identifiable prey remains. In pond 3, where the fish were small (< 1 g), more than 25% of frogs, all except the smallest size class, took fish (Table 1). In ponds 1 and 2 where the fish were larger (4 g) only 5% and 8% of frog stomachs contained fish. In these two ponds only the largest frogs preyed upon fish (Table 1). However, the bulk of the food of *Xenopus* in all three ponds comprised tadpoles of *Bufo*, *Rana* and *Xenopus* frogs (Table 2). In pond 2 dipteran larvae and pupae (chiefly *Chironomus* spp.) were also important prey items.

Discussion

Although fish are not the most important prey item of *Xenopus*

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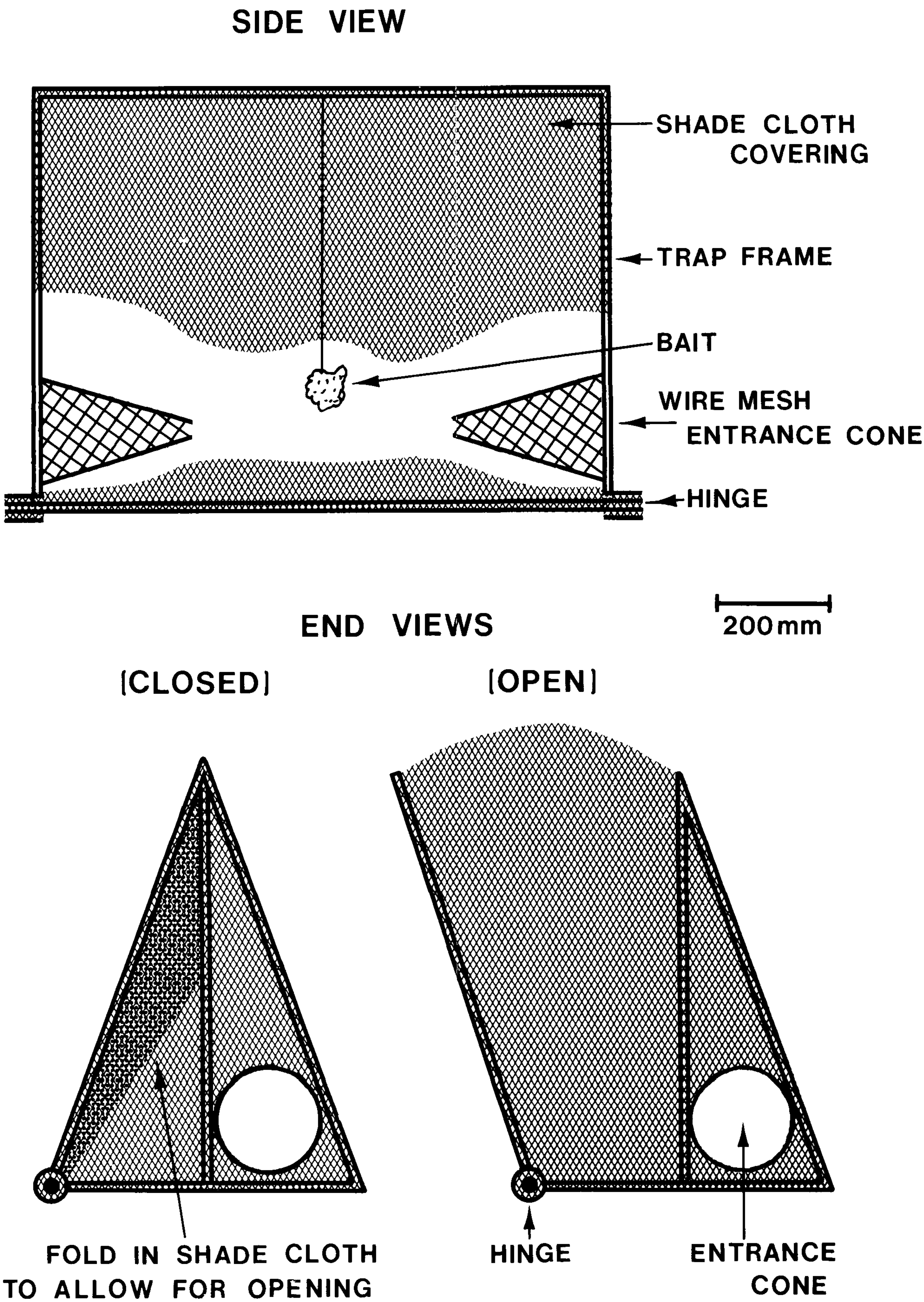

Figure 1
Design of a live trap used for catching African clawed frogs Xenopus laevis *in fish ponds.*

TABLE 1
PERCENTAGE CONTRIBUTION OF FISH (BY MASS AND FREQUENCY) IN THE STOMACH CONTENTS OF FOUR SIZE CLASSES OF *XENOPUS LAEVIS* FROM THREE FISH NURSERY PONDS CONTAINING DIFFERENT SIZES AND/OR SPECIES OF FISH FINGERLINGS

	Mean mass (g) ± S.D. of fish in pond	Body length (mm) of *Xenopus*				All size classes	Mean size (mm) ± S.D. of *Xenopus* sampled
		20,5 – 40,5	40,5 – 60,5	60,5 – 80,5	80,5 – 100,5		
Percentage mass							
Pond 1 (common carp)	4,4 ± 0,96 n = 50	no data	0 n = 17	28,2 n = 19	65,4 n = 4	24,4 n = 40	65,8 ± 13,20 n = 40
Pond 2 (silver carp)	3,7 ± 0,63 n = 50	0 n = 2	0 n = 48	9,1 n = 11	62,3 n = 4	7,1 n = 65	55,2 ± 8,58 n = 65
Pond 3 (silver carp and large common carp*)	0,6 ± 0,28 n = 21	0 n = 1	27,1 n = 16	19,2 n = 24	13,6 n = 6	19,2 n = 47	66,1 ± 12,10 n = 47
Percentage frequency							
Pond 1 (common carp)	4,4 ± 0,96 n = 50	no data	0 n = 17	5,6 n = 19	50,0 n = 4	7,7 n = 40	65,8 ± 13,20 n = 40
Pond 2 (silver carp)	3,7 ± 0,63 n = 50	0 n = 2	0 n = 48	33,3 n = 11	25,0 n = 4	4,6 n = 65	55,2 ± 8,58 n = 65
Pond 3 (silver carp and large common carp*)	0,6 ± 0,28 n = 21	0 n = 1	18,8 n = 16	29,1 n = 24	33,3 n = 6	25,5 n = 47	66,1 ± 12,10 n = 47

*common carp > 200 g

TABLE 2
PERCENTAGE COMPOSITION (BY MASS AND FREQUENCY) OF STOMACH CONTENTS OF *XENOPUS LAEVIS* FROM THREE FISH NURSERY PONDS CONTAINING DIFFERENT SIZES AND/OR SPECIES OF FISH FINGERLINGS

	Annelids	Arthropods						Fish	Frogs (tadpoles)	Plant remains	Sample size
		Crustaceans	Insects								
			Odonata nymphs	Hemiptera adults/nymphs	Coleoptera adults	Diptera larvae/pupae	Orthoptera adults				
Percentage mass											
Pond 1 (common carp)	—	—	0,5	<0,1	0,2	—	—	24,1	74,8	0,4	n = 40
Pond 2 (silver carp)	<0,1	0,4	5,8	1,6	0,4	38,4	0,7	7,1	45,0	—	n = 65
Pond 3 (silver carp and large common carp*)	—	0,1	14,0	0,7	<0,1	0,1	0,2	19,2	64,8	0,9	n = 47
Percentage frequency											
Pons 1 (common carp)	—	—	5,1	5,1	2,6	—	—	7,7	97,4	10,3	n = 40
Pond 2 (silver carp)	1,5	3,1	15,4	63,1	1,5	87,7	1,5	4,6	72,3	—	n = 65
Pond 3 (silver carp and large common carp*)	—	2,1	36,2	4,3	6,4	6,4	—	25,5	46,8	8,5	n = 47

*common carp > 200 g

adults in nursery ponds, the large numbers of frogs which rapidly accumulate in ponds clearly pose a threat to fish fry and fingerlings. Small fish (< 1 g) are particularly vulnerable and need to be given some form of protection from *Xenopus* predation.

Xenopus adults can recolonise freshly cleared ponds within less than two weeks (Personal observation). Screening of the inlets to ponds confirmed that the frogs did not enter with the incoming water, but most likely moved in overland. Therefore the only certain way of preventing the invasion of nursery ponds by *Xenopus* is to surround the ponds with a solid barrier (see Prinsloo *et al.*, 1981). It is important that the barriers are made of smooth material since *Xenopus* are able to climb up rough surfaces (Personal observation). Corrugated iron or asbestos sheeting is particularly suitable. The erection of barriers is expensive and trapping, although not ideal, is a viable inexpensive alternative. Once a pond has been drained and the frogs removed, traps can help to reduce the rate of recolonisation and afford some protection to the fish fry until they are large enough to be immune to predation (> 5 g). The frogs trapped in this study and subsequently have been sold for use as bait by anglers and as experimental material at schools and universities. The sale of frogs can provide an additional source of revenue to fish farmers.

Xenopus tadpoles can be equally undesireable in fish ponds as indicated by this study and by Schoonbee *et al.*, 1979. Prinsloo *et al.* (1981) have shown that largemouth bass as small as 20 g are able to control *Xenopus* tadpoles. During the present study, bass were maintained in cages together with carp fingerlings of various size classes ranging from 1 to 9 g. Even the smallest size class of bass tested (20 to 40 g) took carp up to 9 g. Bass are therefore unsuitable for the control of *Xenopus* tadpoles in nursery ponds since they would pose a threat to the fish themselves. It would be better to limit the number of *Xenopus* tadpoles in the ponds by restricting the access and therefore breeding of adult frogs or by the use of poisons. Poisoning has been successfully used in the control of various tadpole species infesting fish culture systems (Kane *et al.*, 1985).

In addition to the threat of predation, under semi-natural rearing conditions, *Xenopus* may also compete with fish for food. The natural diet of *Xenopus* in Transkei comprises mainly tadpoles and chironomid larvae and pupae (Nxiweni, 1982). However, chironomids are also an important natural food of common carp (Schoonbee, 1969; Matlak and Matlak, 1976; Zur, 1980; Crivelli, 1981) and therefore there is potential for competition for food where frogs and carp co-exist. However, in the nursery ponds with common carp (ponds 1 and 3), *Xenopus* took a significantly smaller proportion (Chi-square test, $p < 0,001$) of chironomids than the *Xenopus* in pond 2 where there were no common carp (Table 2). Nxiweni (1982) also found that *Xenopus* in natural ponds took fewer chironomids when common carp were present. It appears therefore that the potential for competition between *Xenopus* and carp was not realised, but this can only be conclusively proved with concurrent diet studies of carp and frogs together with analyses of available prey.

In contrast with the benthic feeding common carp, silver carp feed mainly on phytoplankton and suspended detritus (Cremer and Smitherman, 1980; Opuszynski, 1981). *Xenopus* tadpoles which are also phytoplanktivorous (Lofts, 1974; Passmore and Carruthers, 1979) apparently seriously compete with silver carp for food. In pond 2 where there were no *Xenopus* tadpoles, the mean mass of silver carp was 3,7 g but in pond 3 where there were almost four times more tadpoles than fish, silver carp of the same age weighed only 0,6 g (Table 1). This difference is highly significant (t – test, $p < 0,001$). Since the stocking densities and feeding regimes of the fish in the two ponds were similar, it seems likely that competition with tadpoles was at least partly responsible for the slower growth of silver carp in pond 3.

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