Relative Importance of Various Predators in Clarias gariepinus Fry Mortality in Cameroon

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Abstract

To estimate the relative importance of the most common predators of Clarias gariepinus fry, increasing levels of protection were afforded to exclude amphibians, aquatic arthropods and birds. At a stocking density of 10 larvae/m² in nursing ponds, fencing off amphibians resulted in a 28 per cent decrease in mortality. Holding fry in hapas to protect them from both amphibians and aquatic arthropods decreased mortality by an insignificant 5.7 per cent. Installation of bird-netting over the hapas reduced mortality by 21.7 per cent. The remaining 4.9 per cent of total mortality, which could not be explained, was attributed to opportunistic cannibalism, disease and/or handling stress. Increasing stocking density to 40/m² and, thus, reducing the food available per fry increased mortality by 28.3 per cent.

Introduction

Fast growing, omnivorous and air-breathing, the African sharptooth catfish, *Clarias gariepinus*, would be an excellent candidate for aquaculture but for a generally low and highly variable fry survival rate in nursing ponds (Hogendoorn 1979; Viveen et al. 1985; de Graaf and Janssen 1996). Nguenga et al. (2000) identified the major causes for low and variable survival of *C. gariepinus* in Cameroon as predation (primarily by amphibians and aquatic arthropods) and cannibalism (exacerbated by low food availability). The objective of this study was to successively eliminate each source of mortality in an effort to quantify its relative importance and prioritize strategies to increase survival and reduce variability in *C. gariepinus* nursing.

Materials and Methods

A comparison of survival rates under increasing levels of protection was used to estimate predation from amphibians, aquatic arthropods and birds. Treatments were based on observation of predator behavior over more than 20 years of pond-based culture of *C. gariepinus* at the Participatory Aquaculture Research Center (PARC) in Yaoundé, Cameroon. For example, amphibians are regularly observed in unfenced but not in fenced ponds, aquatic arthropods in open ponds but not in *hapas*, and kingfishers are often seen escaping from open but not from closed *hapas*. It was these observations and those published in the available literature (Micha 1976; Hogendoorn 1979; Janssen 1985a,b,c; Nguenga 2000) that led to the selection of the treatment conditions (Table 1).

Treatment A was designed to estimate total mortality under typical pond nursing conditions in Cameroon. Two days prior to stocking, triplicate 85 m² earthen ponds at the PARC were dried and limed with quicklime (CaO) at a rate of 250 kg/ha and fertilized with fresh pig manure at a rate of 800 kg/ha. Ponds were stocked at 10 fish/m² with 2-day old *C. gariepinus* larvae resulting from artificial reproduction of brood fish captured from a local reservoir. Supplemental feed was added daily in the form of a 50:50 mixture of dried brewery waste and wheat bran at a rate of 100 kg/ha.

Table 1. Production systems used to successively eliminate major causes of *Clarias gariepinus* fry mortality in earthen ponds.

Treatment	Estimate	Calculation
A. Pond drying + CaO + manure + wheat bran and brewery waste + stocking density = 10/m².	Total mortality (including opportunistic cannibalism)	A
B. As in Treatment A + fences + screened water inlets.	Amphibian predation	A-B
C. As in Treatment B + open *hapas*.	Aquatic arthropod predation	B-C
D. As in Treatment B + closed *hapas*.	Bird predation	C-D
E. As in Treatment D + stocking density = 40/m²	Induced cannibalism	E-D

Treatment B was designed to exclude the amphibians *Ptychadena oxyrhinchus* and *Bufo regularis*, which abound in the PARC and have been confirmed by stomach content examination as predators on catfish larvae. To the basic pond management used in Treatment A was added a 1 m high frog fence (de Graaf et al. 1985) manufactured from locally-available woven nylon bags, cut and sewn together and buried 20 cm into pond dikes. In addition, filters of double layered mosquito netting were put over water inlets. Such fencing is considered standard for exclusion of amphibian predators wherever African catfish are nursed.

Treatment C was designed to additionally exclude aquatic arthropods, most notably dragonfly larvae (Odonata), that enter the pond after filling through direct oviposition from the airborne female. To the standard conditions used in Treatment A were added triplicate 1 m^3 *hapas* fabricated from the same materials as the frog fence and into which catfish larvae were stocked at the standard rate of 10/m^2. The selection of such *hapas* as a defense against aquatic insects was based on the observation that these predators are common in open ponds at the PARC, but have never been found in *hapas*. Presumably, any insect eggs laid directly into a *hapa* are vulnerable to predation by the larval catfish.

Treatment D was designed to exclude the typical bird predators at the PARC, i.e., kingfishers (Alcedinidae) and cattle egrets (*Bubulcus ibis*). In addition to the conditions of Treatment C, 2 cm mesh bird nets were added as covers to the *hapas*.

Treatment E was designed to estimate cannibalism, both opportunistic cannibalism arising from coincidental encounters among siblings and cannibalism exacerbated by competition for food. Treatment conditions were the same as in Treatment D, except that the stocking rate of fry was increased to 40 larvae/m^2 to decrease the availability of food per fry and increase the number of casual encounters between larvae.

Larval mortality in *C. gariepinus* at the PARC is sometimes caused by surface growth of the duckweed, *Lemna paucicostata*, which impedes light penetration and leads to low morning dissolved oxygen (DO). To rule this out as a possible source of mortality, pond surfaces were raked on a weekly basis and DO concentration was measured daily at 06:00 H with an Otterbine Sentry III Oxygen/Temperature Monitor. During the nursing period, morning dissolved oxygen was never measured below 4 mg/l.

After 42 days of nursing, fingerlings were harvested, counted and weighed to calculate survival, mortality, number per m^2 and specific growth rate (SGR). SGR (percent per day) was calculated according to the formula:

$$SGR = 100 \left(\frac{\ln Wt_f - \ln Wt_i}{Days} \right) \quad (1)$$

Where Wt_f is the final average weight of harvested fingerlings and Wt_i is the initial average weight of stocked fry. To estimate the significance of various causes of mortality, Student's *t* test was used to compare Treatments A and B, B and C, C and D and D and E, respectively.

Results and Discussion

Fingerling production data are shown in Table 2. Growth rates were inversely proportional to final fingerling density. Overall, growth and survival rates were in the range reported for similar systems throughout Africa by de Graaf and Janssen (1996).

Fig. 1 shows the relative importance of predators in *C. gariepinus* nursing. Frog fencing (Treatment B) significantly (P<0.05) reduced total mortality to 32.3 per cent compared to 60.3 per cent in unprotected ponds (Treatment A). Stocking fish in open *hapas* (Treatment C) reduced mortality by an insignificant 9.4 per cent (P<0.32) relative to simple frog fencing. However, protecting *hapas* with bird netting (Treatment D) was significantly effective

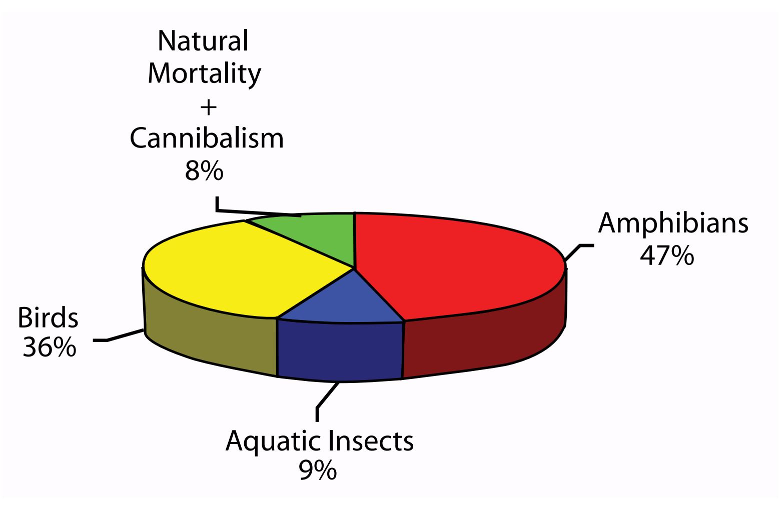

Figure 1. Percentage of total Clarias gariepinus larval mortality attributable to various predators in earthen nursing ponds in Cameroon.

Table 2. Average weight, number of fingerlings harvested, survival and specific growth rate (SGR) of *Clarias gariepinus* nursed for 42 days in earthen ponds in Yaoundé, Cameroon.

Treatment	Final average weight (g)	Fingerlings harvested/m²	Survival (%)	SGR (%)
A	11.2 8.8 9.0 **9.66 ± 1.30**	3.7 4.6 3.6 **3.97 ± 0.54**	37.0 45.9 36.1 **39.66 ± 5.42**	14.7 14.2 14.2 **14.37 ± 0.31**
B	9.2 8.4 5.4 **7.65 ± 2.03**	6.5 6.6 5.3 **6.11 ± 0.74**	84.4 66.0 52.6 **67.67 ± 15.97**	14.3 14.1 13.0 **13.76 ± 0.69**
C	9.8 8.0 5.3 **7.68 ± 2.25**	7.0 8.0 7.0 **7.33 ± 0.58**	70.0 80.0 70.0 **73.33 ± 5.77**	14.4 13.9 13.0 **13.76 ± 0.74**
D	6.4 5.4 5.7 **6.05 ± 0.51**	10.0 10.0 9.0 **9.50 ± 0.58**	100.0 100.0 90.0 **96.67 ± 5.77**	13.4 13.0 13.1 **13.26 ± 0.21**
E	1.8 3.5 3.1 **2.78 ± 0.9**	26.0 25.0 29.0 **26.67 ± 2.08**	65.0 62.5 72.5 **66.67 ± 5.2**	10.3 12.0 11.7 **11.32 ± 0.86**

($P<0.008$) in reducing mortality to 3.3 per cent (i.e., 97 per cent survival). Exclusion of amphibians and birds, thus, decreased mortality by 46 per cent and 48 per cent, respectively, while exclusion of larger aquatic arthropods made no real contribution to reduction in mortality. The residual mortality is attributable to natural mortality, cannibalism and other causes. While the exact cause of each individual's mortality cannot be ascertained without analysis of predator abundance and stomach contents, the fact that increasing levels of protection led to substantial decreases in larval mortality indicates that the treatment conditions themselves did not adversely affect survival.

Increasing stocking density in covered *hapas* to 40 larvae/m² (Treatment E) significantly ($P<0.02$) increased mortality to 33.3 per cent as compared to those of treatment D. Although it is not impossible to rule out other effects, it seems most likely that this can be associated with increased competition for space and food, possibly exacerbated by cannibalism (Hecht et al. 1988), a common problem in *C. gariepinus* nursing, that can lead to mortality rates in the region of 98 per cent, particularly at higher (e.g., 100 fry/m²) stocking densities (de Graaf and Janssen 1996). At the PARC, a four-fold increase in stocking density precipitated a six-fold increase in fry mortality from 5 per cent to 32 per cent. The small size of the fingerlings harvested after 42 days seems to indicate that any cannibalism that took place occurred relatively late in the nursing period.

Conclusions

The aim of this work was to rank the various sources of predation and cannibalism with a view to prioritizing strategies for improving survival. Results show that under conditions of low stocking density and abundant food, predator exclusion leads to substantial increases in survival, with amphibians and birds being of equal importance in larval mortality. However, reduction of predation by amphibians and birds can be nullified if stocking densities increase to the point where either food or space become limiting and cannibalism becomes a dominant cause of reduced larval survival.

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