Comparative Study of Hatching Rates of African Catfish (*Clarias gariepinus* Burchell 1822) Eggs on Different Substrates

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Abstract

The hatching rates of African catfish *(Clarias gariepinus)* eggs on four natural substrates: the roots of Nile cabbage *(Pistia stratiotes)*, water hyacinth *(Eichhornia crassipes)*, pond weed *(Ceratophyllum dermasum)* and green grass leaves *(Commelina* sp.*)*, and four artificial substrates: sisal mats, nylon mats, papyrus mats and kakaban mats, was assessed. Concrete slabs were used as control. The natural substrates performed better than the artificial ones. *Pistia* roots gave the best mean hatching rate of 66.2 ± 3.62%. Green grass leaves were second with a mean rate of 54.0 ± 3.46%, water hyacinth was third with 49.7 ± 3.16% and *Ceratophyllum* fourth with a mean of 13.0 ± 2.37%. Concrete slabs gave a mean rate of 18.6 ± 2.8%, sisal mats 18.6 ± 2.0%, papyrus 12.2 ± 1.2% and kakaban 11.8 ± 1.9%. Nylon mats were the last, with a mean rate of 4.0 ± 0.7%. The best performing natural substrates were those with the ability to float and thin fibrous roots that seemed to allow higher aeration of the eggs during incubation. The cost of using natural substrates was minimal.

Introduction

Clarias gariepinus, currently synonymous with *C. mossambicus, C. lazeras* and *C. senegalensis,* is endemic to Africa and ranges from Natal and the Orange River in South Africa through Central, West, East and North Africa where it is under culture (Teugels 1986). The widespread distribution is a reflection of their ability to tolerate a wide range of environmental parameters. *Clarias* species have rapid growth, a high reproductive potential and sturdy resistance to environmental variations (Clay 1977; Hetch et al. 1988; Hogendoorn 1980). *C. gariepinus* spawn naturally in floodplains during the rainy season, and spawning is induced by rise in water levels (Pillay 1990). However, seed collection from the wild is unreliable and limited to the rainy season.

Demand for *C. gariepinus* fingerlings in Kenya, both for aquaculture and as bait, has increased substantially in the last few years. The Fisheries Department estimates that the demand for *C. gariepinus* fingerlings for aquaculture activities is 10 million per year, while the demand for use as bait in the Lake Victoria capture fisheries is about 18 million fingerlings per year. (Government of Kenya Fisheries Department 1998). The government supplies about 5 million catfish fingerlings per year through the fish farms of the Fisheries Department and the Lake Basin Development Authority (LBDA). There is over-reliance on the government as the producer and supplier of fish seed as there are no established private fingerling producers.

The culture of *C. gariepinus* in Kenya is still low in volume as indicated by the production data (Government of Kenya Fisheries Department 1998). In 2001, total aquaculture production was 1 000 t and *C. gariepinus* contributed only 2 % of this (Government of Kenya Fisheries Department 2002). In contrast, tilapia production accounted for 48% of aquaculture production over the same period (Maitha et al. 2002; Owiti 2002).

There is an urgent need to increase the supply of seed through the development of simple and efficient seed production and management protocols that are easy to adopt by small-scale fish farmers themselves. The aim of this experiment was to test several simple, readily available and low-cost substrates for hatching *C. gariepinus* eggs.

Materials and Methods

The study was carried out at Kibos Fish Farm of the Lake Basin Development Authority in Kisumu District, Nyanza Province, Kenya. At the start of the experiment, mature broodstock were seined from the broodstock pond and transferred to concrete hatching tanks. The ripe males and females were selected and their weights measured and recorded. They were acclimatized to the hatching tanks for one day without feeding. To induce spawning, the selected females were injected with pituitary suspensions obtained from sacrificed male or female fish of similar size. After 12 hours, the eggs were stripped into a dry bowl and fertilized with milt obtained from the ripe males. One male was used to fertilize eggs from three females. The fertilized

eggs were then incubated on different test substrate materials. A bird's feather was used to spread the eggs evenly on the substrates in bunches of 600-1 200 eggs. The natural substrates tested were roots of Nile cabbage *(Pistia stratiotes)*, water hyacinth *(Eichhornia crassipes)*, pond weed *(Ceratophyllum dermasum)* and green grass *(Commelina* sp.*)* leaves. The artificial substrates tested were kakaban mats, sisal mats, papyrus mats and nylon mats, all with an equal surface area of 1 350 cm^2. Concrete slabs were used as the control as they are widely used as a hatching medium in Kenya. All the test substrates were put in flow-through concrete troughs. Water temperature was maintained at 22.9 ±1.1 °C, D.O. at 5.9 ± 0.2 mgl^{-1}, pH at 7.0 ± 0.5 and conductivity at 648 ± 10.2 µs throughout the period of the experiment. The percentage of hatching was obtained by using the formula as stipulated in Viveen et al. (1985). The cost of using each of the hatching substrates was assessed by accounting for all expenses incurred for each of the methods assessed. Completely Randomized Block Design (CRBD) was used to allocate 600-1 200 eggs into each of the experimental units.

The resulting hatching rates were analyzed by two-way analysis of variance (ANOVA). Multiple comparison analysis was used to assess any heterogeneity. The Multiple Range Test was used to discriminate among means (Zar 1984). The tests were at the 95% significance level ($p<0.05$). The two-way ANOVA was also carried out to assess for differences between the hatching rates of eggs from different female spawners.

Results

The hatching rates of the eggs on natural substrates were significantly higher than on the artificial ones. The mean rates were 66.2, 54.0, 49.7 and 13.0% for *Pistia*, green grass leaves *(Commelina* sp.*)*, *E. crassipes* and *C. dermasum*, respectively (Figure 1). The difference between the means of the four data samples was statistically significant at the 95% confidence level.

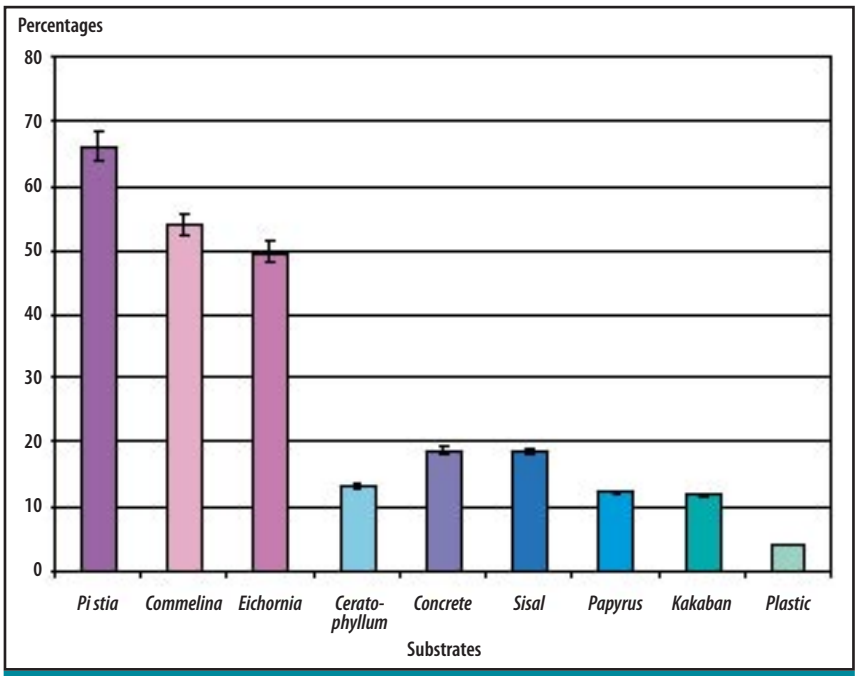

Figure 1. The percentage hatching rates using different test substrates.

The multiple range tests revealed that all the means were significantly different from each other except for one pair – the difference between green grass leaves and water hyacinth roots was insignificant. Three groups of means were identified, with *C. dermasum* performing between 15-18%, the green grass leaves *(Commelina* sp.*)* and *E. crassipes* roots rates falling between 43-60%, and the *Pistia* rates ranking the highest at between 62-76%.

The difference between the means of the hatching rates of all the artificial test substrates was also statistically significant. The hatching rates of the eggs on this category of substrates were generally low, with the highest being 18.6% for both the concrete slabs (control) and sisal mats. The other mean rates were 4.0, 11.8, and 12.2 for nylon, kakaban, and papyrus mats, respectively (Figure1). The difference between the means of the four data samples was also statistically significant at the 95% confidence level.

Multiple range tests revealed that all the means for the artificial substrates were statistically different from each other. However, for two pairs of means – the concrete slab and sisal mats; and kakaban and papyrus mats – the difference within each pair was insignificant. Three groups of means were identified in ranking the substrates performance. Nylon performed below 8% and was ranked the lowest, kakaban and papyrus mats performed between 8-16%, while sisal mats and concrete slab performed between 15-25% and were ranked in the highest group.

There was a significant cost difference between the use of the artificial substrates and the natural substrates. The cost of using the artificial substrates was higher than for the natural ones. The cost ranged between US$ 0.12-0.27 for artificial substrates and US$ 0.01-0.03 for natural substrates (Table 1). Direct costs accounted for much of the cost incurred in the use of artificial materials, in contrast to the indirect costs incurred in the use of the natural materials. The indirect cost was the opportunity cost of the man-hours spent in collecting the substrate materials.

Discussion

The results indicate that the natural substrates performed better than the artificial substrates. This was probably

Table 1. Costs of the hatching on different substrates.

Substrate material	Cost (US $)	Remarks
Nile cabbage (*Pistia*)	0.03	Readily available, costs incurred are labor related (collection, washing, etc.)
Water hyacinth (*E.Crassipes*)	0.03	Readily available, costs incurred are labor related (collection, washing, etc.)
Pondweed (*Ceratophylum dermasum)*	0.03	Readily available, costs incurred are labor related (collection, washing, etc.)
Green grass leaves (*Commelina Sp.*)	0.01	Readily available, costs incurred are labor related (collection, washing, etc.)
Kakaban mats	0.13	Readily available, have to be purchased readymade from local market
Sisal mats	0.12	Readily available, have to be purchased readymade from local market
Plastic mats	0.13	Readily available, have to be purchased readymade from local market
Papyrus mats	0.13	Readily available, have to be purchased readymade from local market
Concrete slabs	0.27	Readily available, have to be purchased readymade from local market

because, unlike the artificial substrates, most of the natural substrates used were able to float thus ensuring better aeration of the eggs. During incubation, the eggs should be well oxygenated for maximum hatching to occur (de Graaf and Jansen 1996; Hogedoorn 1980; Viveen et al. 1985). This experiment demonstrated high hatching rates of the eggs incubated on the roots of free-floating substrates such as water hyacinth *(Eichhornia crassipes)*, Nile cabbage *(Pistia stratiotes)* and the green grass leaves *(Commelina* sp.*)*. The best performing were the *Pistia* roots, probably due to their numerous thin fibrous roots that allowed greater aeration of the eggs during incubation. However, the hatching rates from the *C. dermasum* substrate were quite low; this could have been due to their characteristic of decaying and gradually sinking to the bottom. A decaying substrate usually hosts pathogenic microorganisms that cause bacterial, fungal *(Saprolegnia* sp.*)* and protozoan *(Vorticella* sp.*, Epistylis* sp.*)* infections of eggs and larvae, resulting in low egg hatchability and high larval mortality. The hatching rates in the artificial substrates were low because of the relatively low dissolved oxygen levels at the bottom of the concrete hatching tanks where the artificial substrates were placed. In Kenya, it is common practice in hatcheries to spread the eggs on mud, sand or concrete surfaces, with manual separation of dead eggs, shells and hatchlings. The hatching rates usually average about 25% (Obuya et al. 1995), which is well below the 50-70% recorded in well-managed hatcheries in other countries (de Graaf et al. 1995). Moreover, the poor survival of eggs and larvae is mainly the result of inadequate nutrition during the nursing phase and careless nursery management practices. Successful hatching of fish eggs and careful feeding of larvae during the early stages of their development is essential for better survival of larvae.

The main limitation on the expansion of catfish culture in Kenya is the inadequate supply of high-quality seed, especially at the right time and place, for stocking purposes. It is totally dependant on the government to produce and supply the fish seed. One way to overcome this constraint is to develop and promote low-input systems for producing the fish seed by the farmers themselves. The technology for such hatching and nursing systems should be quite simple, use local materials and be easily transferable to rural fish farmers (Charo and Oireri 2000; Dugan 2003; Jamu and Ayinla 2003). In this experiment the hatching rates of eggs on natural substrates, especially those of the *Pistia*, were high as compared to the hatching rates recorded in government fry production centers in Western Kenya where artificial substrates are commonly used (Obuya et al. 1995). The *C. gariepinus* hatching protocols described in this study are easy for small-scale fish farmers to follow, and they are particularly suitable for rural areas with no electricity and where most of the small-scale farmers are based.

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References

Charo, H. and W. Oireri. 2000. River-based artificial propagation of the African catfish *Clarias gariepinus*: an option for the small fish farmer. NAGA, ICLARM Q. 23(1):14-16.

Clay, D. 1979a. Biology of the tropical catfish family (Claridae) with special emphasis on its suitability for culture. Fish & Marine Ser. Manu. Rep. 11-58 Fish & Envi., Canada.

de Graaf, G.J., F. Galemoni and B. Banzoussi. 1995. The artificial reproduction and fingerling production of the African catfish, *Clarias gariepinus* (Burchell 1822) in protected and unprotected ponds. Aquaculture Research 26: 233-42.

de Graaf, G. and H. Janssen. 1996. Artificial reproduction and pond rearing of the African catfish *Clarias gariepinus* in sub-Sahara Africa. Nesfisco Foundation, Amsterdam, the Netherlands.

Dugan, P. 2003. Investing in Africa: the WorldFish Center's African strategy in summary. NAGA, WorldFish Center Q. 26(3):4-8.

Government of Kenya Fisheries Department. 1998. Fish Farming Annual Report - Western Kenya. Unpublished.

Government of Kenya Fisheries Department. 2002. Fish Farming Annual Report - Western Kenya. Unpublished.

Hecht, T., W. Uys and P.J. Britz. 1988. The culture of sharp tooth catfish *Clarias gariepinus* in Southern Africa. South Africa National Scientific Programmes Report No. 153.

Hogendoorn, H. 1980. Controlled propagation of the African catfish *Clarias lazera* (C&V). II. Feeding and growth of fry. Aquaculture 21:233-241.

Jamu, D.M. and A.O. Ayinla. 2003. Potential for the development of aquaculture in Africa. NAGA, WorldFish Center Q. 26(3):9-13.

Maithia, J., H. Charo, A. Ototo and H. Ouma. 2000. The aquaculture potential of Lake Victoria's catchments area - Kenya sector. In Lake Victoria 2000 International Conference 16th-19th May, 2000. Jinja, Uganda.

Obuya, S., J. Ochieng and D. Cambell. 1995. Integration of chicken raising and rearing of larval *Clarias gariepinus* in large ponds. Field Document No. 3, FAO Project KEN/86/026, Kisumu, Kenya.

Owiti, D.O. 2000. Status of Aquaculture in Kenya's Lake Victoria Basin: strategies for reactivation. In Lake Victoria 2000 International Conference 16th-19th May, 2000. Jinja, Uganda.

Pillay, T.V.R. 1990. Aquaculture principles and practices. Fishing News Books, London.

Teugels, G.G. 1986. A systematic revision of the African species of genus *Clarias* (Pisces: Claridae). Koninklijk Museum voor Midden-Afrika, Tervuren, Belgium.

Viveen, W.J.A.R., C.J.J. Richter, P.G.W. Van-Oordt, J.A.L. Janssen and E.A. Huisman. 1985. Practical manual of the culture of African catfish, *Clarias gariepinus*: Directorate General International Cooperation for the Ministry of Foreign Affairs. The Hague, the Netherlands.

Zar, J.H. 1984. Biostatistical analysis. Prentice-Hall Inc. New Jersey.

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