Hatchability of African Catfish *Clarias gariepinus* Eggs in Hapas and in Basins: a Diagnostic Study of Frequent Inhibition by Rainfall and Water Stagnation

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Summary

To diagnose inhibition of egg hatchability by rainfall and water stagnation, some incubating eggs were protected against the physical impact of raindrops, some were subjected to various turbidity levels and others, to various incubation densities (number of eggs/litre of water) in flowing vs. stagnant water. Data analyses showed that, unaffected by raindrops (P> 0.05), hatchability was inversely proportional to both turbidity (coefficient= -0.971) and incubation density (coefficient= -0.973). Only the properly constructed ponds (i.e., with elevated and compacted dykes) which do not receive any runoff should therefore be chosen for to hold incubation hapas, and the pond inlets should be turned off during heavy rainfall. Hatchability depression by stagnant water could be forestalled by limiting incubation density to 480 eggs / litre or by partially renewing the incubation water on a daily basis. By so doing, some Cameroon smallholders have successfully engaged in regular on-farm reproduction of Clarias gariepinus*.*

Résumé

Eclosion des œufs de poisson chat africain *Clarias gariepinus* en hapas et en bassins: étude diagnostique de l'inhibition fréquente par la pluie et la stagnation de l'eau

Pour diagnostiquer l'inhibition fréquente d'éclosion d'œufs de Clarias gariepinus *par la pluie et par la stagnation de l'eau, le taux d'éclosion d'oeufs protégés contre l'impact directe des gouttes de pluie a été comparé à celui d'œufs non protégés. Certains oeufs ont été incubés dans l'eau de turbidité variable et d'autres ont été soumis à diverses densités d'incubation (nombre d'œufs / litre d'eau stagnante). L'analyse des données a montré que la protection d'œufs n'a pas d'effet significatif (P> 0,05) et que le taux d'éclosion est inversement proportionel à la turbidité (coefficient= -0,971) ainsi qu'à la densité d'incubation (coefficient= -0,973). Seuls les étangs bien construits (à digues élevées et compactées) et insusceptibles d'entrée d'eau de ruissellement devraient être choisis pour installer les hapas d'incubation, et leur dispositif d'admission d'eau devraient être fermé pendant le ruissellement. La réduction du taux d'éclosion par la stagnation de l'eau pouvait être évitée en limitant la densité d'incubation à 480 œufs / litre d'eau stagnante ou en renouvelant l'eau d'incubation pour éviter l'anoxie. En faisant ainsi, quelques paysans parviennent déjà à reproduire avec succès leurs géniteurs de* Clarias gariepinus *au Cameroun.*

Introduction

The technique described by Janssen (7) for artificial reproduction of *Clarias gariepinus* requires an ample flow of good quality water, a reliable supply of electricity and a stable optimal temperature. Because these requirements lie beyond the socio-economic reach of most rural smallholders, they cannot adopt the technique and continue to lack catfish fingerlings for on-growing.

As part of a participatory catfish reproduction research project in Cameroon, farmers were assisted in the development of methods by which they could reproduce *Clarias gariepinus* using only available materials, that is, without needing to buy any tools or to set up any costly systems. Some farmers chose to incubate fertilized eggs in hapas installed directly in earthen ponds while others chose to do so in household basins. It was subsequently observed that in-hapa hatchability was often reduced by heavy rainfall during incubation while in-basin hatchability was equally inhibited at high incubation densities in contained stagnant water.

These authors found no information on the effect of rainfall or turbidity on egg hatchability. On the other hand, Haylor (4) found that incubation of *C. gariepinus* eggs was not only possible, but even faster in stagnant than in flowing water, but did not report any effects of egg density on hatchability. The objective of this work was to investigate how rainfall and water stagnation affect incubation and thus adapt Hogendoorn and Koops's (6) technique to guarantee reliable and satisfactory hatchability of *C. gariepinus* eggs under on-farm conditions.

Materials and methods

This experiment was jointly conducted with farmers who were interested in producing at least their own *Clarias gariepinus* fingerlings. Farmers learned how to extract pituitary glands, crush between table and tea spoons, suck into syringes and inject gravid females. They also practised the stripping of ovulated females and the process by which to obtain testis and fertilize as well as incubate eggs described by De Graaf and Janssen (3).

To investigate the effect of raindrops and turbidity on hatchability, 21 samples of fertilized eggs were spread directly at the bottoms of identically cut-open plastic water bottles (diameter= 8 cm, depth= 25 cm) containing different volumes (syringe-measured to ± 0.1 ml) of water. All but 3 of the samples were permanently covered with opaque white polythene bags which are locally available and which are efficient reflectors of sunrays and hence serve to moderate temperature (Yong-Sulem *et al*., unpublished results). This triplicate was incubated in clean water (with no mud introduction, turbidity = 0 %) and served as the experimental

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treatment for studying the effect of impacting raindrops, as it was always uncovered during rainfall. Another triplicate which was also incubated in water of 0 % turbidity served as the control, as it differed only by being permanently covered.

Varying quantities of mud were introduced into the remaining 15 samples (and carefully stirred without perturbing the already-adhered eggs) to obtain 5 triplicate treatments with mud concentrations (turbidity) of 2.5, 5.5, 7.5, 10.0 and 17.5%. For measuring the mud, a 10 ml syringe was cut open and a spatula was used for successively stuffing in desired quantities. Table 1 presents the volumes of mud and water which were used to obtain the experimental turbidities.

The control triplicate of the raindrop experiment also served the turbidity experiment as a control, as it differed from the latter only by containing no mud (0% turbidity).

As for investigating the effect of water stagnation, 6 triplicate batches of 160, 320, 480, 640, 800 and 960 eggs were each incubated in 1 liter of stagnant water. The control experiment consisted of incubating another triplicate at a density of 960 eggs per litre in flow-through water. Above densities were constituted by determining the mean number of eggs (n) required to weigh 1 g and applying simple proportion to determine the weight (w) of the required number (N = nw) of eggs which was then weighed out, wet-fertilised and spread on 1 mm meshes disposed at the surface of 1 liter of stagnant water held in small basins (usually owned and used by farmers for hand washing).

So set up, all systems were left unperturbed for 40 hours under a shade tree at a temperature of 25 ± 2 ° C to ensure completion of the hatching process. Thereafter, the contents of each vessel were analysed into hatched and unhatched eggs, which were respectively counted. Counts enabled calculation of hatchability, here defined as

$$100\left(\frac{\text{Number of hatched eggs}}{\text{Total number of eggs incubated}}\right)$$

The hatching rates obtained at the turbidity of 0% in the containers which were always uncovered during rainfall were compared with those which were permanently covered at the same turbidity, using the student's t test while those obtained at the various levels of turbidity and incubation densities were correlated, regressed and compared with Duncan's new multiple range test (8).

Results

Exposure of eggs to raindrops did not affect their incubation as there was no significant difference between the hatchability of eggs that were exposed to raindrops (56.4 ± 7.6%) and the hatchability of those which were not (57.7 ± 6.8%)

In treatments with turbid water, mud particles eventually settled around the eggs, virtually enveloping them and forming layers at the bottom of the bottles. The tendency for particles of more than 1 mm in grain size was to fall to the bottom rather than envelop the eggs. The thickness of each bottom layer was proportional to the turbidity of its water.

The hatching rate obtained at turbidity 0% was significantly ($P< 0.01$) higher than that obtained at 17.5%, but not than those obtained at 2.5, 5, 7.5 and 10%. At turbidity 2.5%, hatching rate was additionally significantly ($P< 0.05$) higher than at 5% but statistically equal to those obtained at all the other levels of turbidity. Those obtained at 7.5 and 10% did not differ ($P> 0.07$) from any other hatchability. In contrast, average hatching rates were inversely proportional (coefficient= -0.971) to water turbidity as shown in table 2.

Table 1
Volumes of water and mud that were mixed to obtain treatments with different turbidity levels

Treatments +	Control	I	II	III	IV	- Control
Water (ml)	100	97.5	95	92.5	90	82.5
Mud (ml)	0	2.5	5	7.5	10	17.5
Turbidity (%)	0	2.5	5	7.5	10	17.5

Table 2
Hatchabilities of *Clarias gariepinus* eggs obtained through incubation in waters of various turbidities (averages with the same superscripts are not significantly different)

Turbidity (%)	Hatched	Unhatched	% Hatchability	Average %
0	70	56	55.6	(57.7 ± 6.8)[a]
	59	54	52.2	
	77	41	65.3	
	44	52	45.8	
2.5	75	47	61.5	(56.4 ± 9.1)[a]
	42	26	61.8	
	26	24	52.0	
5	16	54	22.9	(38.9 ± 14.8)[ab]
	18	25	41.9	
	21	27	43.8	
7.5	14	45	23.7	(34.4 ± 10.1)[b]
	21	38	35.6	
	23	41	35.9	
10	16	52	23.5	(31.5 ± 6.9)[b]
	15	28	34.9	
	6	84	6.7	
17.5	10	58	14.7	(14.0 ± 7.0)[bc]
	16	62	20.5	

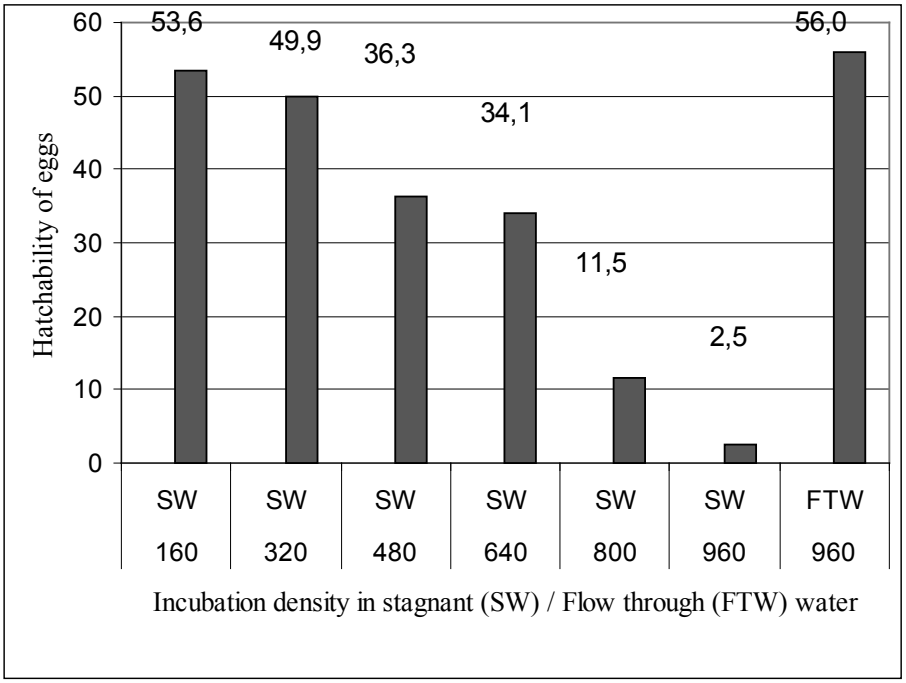

Figure 1: Decrease in hatchability (%) of *C. gariepinus* eggs with increasing incubation density (number of eggs/l of water) in stagnant water (SW) as compared with a high value (56%) obtained in flow-through water (FTW) despite high density.

Based on averages, the turbidity levels could be classified into three groups:

i) Group (a) comprised 0 and 2.5% with hatching rates of more than 55%.
ii) Group (b) comprised 5, 7.5 and 10% with rates of 30 to 39% and
iii) Group (c) comprised 17.5%, which has never yielded a hatchability of more than 15.0%; even during preliminary works.

Concerning the effect of incubation density in stagnant water, hatchability was inversely proportional to incubation density (coefficient= - 0.973) and reduced significantly when up to 480 eggs were incubated per liter (Figure 1). There was no significant hatchability difference ($P > 0.05$) under flow-through conditions, and those of densities 160 and 320. Dissolved oxygen concentration (DO) significantly dropped ($P < 0.05$) under the conditions of densities 800 and 960 with effect from 10 hours post incubation onset compared with the DO of flow through-water. That of densities 480 and 640 equally dropped 21 hours post incubation onset. At this point, average DO stood at 7.1, 6.5, 5.1, 4.5, 2.5 and 2.1 mg/l for respective densities of 160, 320, 480, 640, 800 and 960 eggs / liter of stagnant water. The water additionally turned misty in appearance, particularly under conditions of densities 800 and 960. Corresponding hatchability rates were positively correlated to the DO concentration (coefficient= + 0.991) and negatively correlated to incubation densities (coefficient= -0.973).

Discussion

Results nullified the hypothesis that the physical impact of raindrops on incubating eggs could disturb their hatchability on one hand and confirmed the one that, it is because run offs increase the turbidity of incubation water, that rainfall inhibits the hatchability of *Clarias gariepinus* eggs, on the other hand. They also implicated depletion of dissolved oxygen for inhibition of hatchability at high incubation densities in stagnant water, although other factors (such as nitrite concentration), which could not be measured due to logistic constraints, could have equally contributed.

This agrees with the synchrony between the species' season of natural reproduction and local periods of maximum rainfall (1) and indicates that as eggs can resist raindrop impact under natural conditions, so can they under on-farm conditions. It also justifies the practice of constructing relatively expensive sedimentation tanks through which hatchery water should pass prior to being used for incubation and suggests that the possibility to incubate in stagnant water (5) may not go beyond 480 eggs / liter.

Only the hatchability rates obtained at 0 and 2.5% turbidity were significantly higher than that of the negative control and while hatchability at 5% was significantly lower than that at 2.5%, it was statistically equal to that at 0%. These authors cannot attribute this to 2.5% turbidity being better for incubation than 0% - it would appear that such anomalies ensue from intra-treatment variability arising from other factors. It was however clear from correlation of average hatching rates and turbidity levels that the turbidity of incubation water jeopardises egg hatchability in *C. gariepinus*. Flatness of incubation vessels and coarseness of particles could attenuate this defect through respectively lessening the thickness of bottom layers and peri-ovular envelops.

Reduction in fluxes across the chorions due to mud envelops and in freedom of tail movements by mud layers could account for observed hatchability declines. This agrees with Woynarovich and Hovarth, cited by Janssen (7), who identified water absorption across the chorion as pre-required for the swelling of eggs that triggers mitotic divisions and formation of tissues. In turn, swelling of eggs causes cleavage of chorions and emergence of tails, thanks to the beatings of which abdomens and heads can also be withdrawn from the chorions (personal observation). Vigorous tail beatings were also identified as equally instrumental for the hatching of the neotropical freshwater siluriforme *Platystoma coruscans* by Cardoso *et al.* (2). It is likely that high turbidity not only disturbs water absorption but also restrains the tail beatings and hence inhibits the hatchability of affected eggs.

That the hatchability of eggs in stagnant water did not drop when incubation densities were lower than 480 eggs/l

of stagnant water implies that, like fry (4) and fingerlings (6), the eggs of *C. gariepinus*, can tolerate high densities under incubation conditions and even in stagnant water. An optimum density for maximisation of outputs should lie above 320 eggs/liter whereat hatchability was similar to that of flow-through water and below 480 eggs/liter. Although some eggs incubated at the maximum densities of 800 and 960 / liter could develop right to hatching, resulting larvae were unviable.

Conclusion

The aim of this experiment was to diagnose the roles of rainfall and water stagnation in observed inhibition of hatchability under on-farm conditions. Results implicated the turbidity of incubation water as caused by runoffs into hapas and depletion of dissolved oxygen during high-density incubation in stagnant water. These authors therefore recommend disruption of water entry into incubation ponds during rainfall, limitation of incubation density to less than 480 eggs/liter of stagnant water and transfer of incubating eggs (along with the meshes to which they are attached) into spare basins of fresh water, kept aside for that purpose.
To this end, incubation ponds should be so constructed (elevation and compaction of dykes) that water can only enter and leave through the inlet and outlet devices which operators can turn on and off at will. The spare water should be fetched beforehand and kept beside the incubating water so as to minimize sharp temperature/pH differences upon transfer. The application of these measures has consistently conferred satisfactory hatchability of *Clarias gariepinus* eggs in Cameroon. Extending the adapted technique should empower tropical smallholders with a tool for producing their own fingerlings and consequently boost regional farming of catfishes.

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