Research Application Summary

Temperature-dependent egg development rates and hatching period of Chambo, *Oreochromis karongae* (Pisces: *Cichlidae*)

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Abstract

A study was conducted to assess the effect of temperature on egg development in an attempt to improve hatching success and fry production in *Oreochromis karongae*. Temperature-dependent development rates and hatching period for fertilized eggs stripped from *O. karongae*, a mouth brooder, were determined in a recirculating system set up in a hatchery at the National Aquaculture Center, Domasi, Malawi. Three treatments namely; 25ÚC, 27ÚC and 29ÚC, were replicated thrice in 2-Liter Macdonald type incubation jars stocked with 265 fertilized stage 1 eggs of *O. karongae*, at water flow rate of 0.15L/Sec. There was a curvilinear relationship between temperature and egg development, which was best described by a logarithm regression function. Hatching period decreased with increase in incubation temperature. The shortest hatching period was 7.3 days, which was observed at the highest incubation temperature (29ÚC) while the longest hatching period was 14.7 days, observed at the lowest temperature (25ÚC). Hatchability and fry survival were higher at higher temperatures. The study has, for the first time, ably described *O. karongae* egg development rates which suggest that increasing incubation temperature holds the potential to increase fry production, which is currently a bottleneck.

Key words: Egg development rates, hatchability, survival, hatching period, *Oreochromis karongae*, temperature-dependent

Résumé

Une étude a été menée pour évaluer l'effet de la température sur le développement des œufs dans une tentative d'améliorer le succès d'éclosion et de la production d'alevins en *Oreochromiskarongae*. Le taux de développement dépendant de la température et de la période d'éclosion des œufs fécondés dépouillés de *O. karongae*, une couveuse, ont été déterminées dans un système de recirculation mis en place dans une écloserie au Centre National Aquaculture de Domasi, au Malawi. Trois traitements à savoir; 25ÚC, 27ÚC et 29ÚC, ont été reproduits trois fois dans 2 – Dans une des jarres d'incubation de type de

Litre Macdonald, dans lesquels sont stockés avec 265 œufs d'*O. karongae* fécondés au stade 1, au débit d'eau de 0.15L/ Sec. Il y avait une relation curvilinéaire entre la température et le développement d'oeuf, qui a été le mieux décrit par une fonction de régression logarithmique. La période d'éclosion a diminué avec l'augmentation de la température d'incubation. La période la plus courte d'incubation était de 7,3 jours, ce qui a été observé à la plus haute température d'incubation (29ÚC), tandis que la plus longue période d'incubation était de 14,7 jours, observés à la température la plus basse (25ÚC). Le taux d'éclosion et la survie des alevins étaient plus élevés à des températures plus élevées. L'étude a, pour la première fois, bien décrit les taux de développement des œufs de *O. karongae* qui suggèrent, que l'augmentation de la température d'incubation possède le potentiel d'augmenter la production d'alevins, qui est actuellement un goulot d'étranglement.

Mots clés: Les taux de développement d'œufs, la position d'éclosion, la survie, la période d'incubation, *Oreochromis karongae*, dépendance de la température

Background

In Malawi development of aquaculture is constrained by, among other factors, lack of good quality seed. Through Research Into Use (RiU) the Government of Malawi has mandated a few fish hatcheries, of which the most prominent is the Fish Hatchery at the National Aquaculture Center (NAC), Domasi, Zomba to address the constraint. However, the state of the art hatchery installed based on technology from Thailand faces challenges in the production of the consumer preferred *Oreochromis karongae* (chambo) fingerlings. The main objective of the present study was to establish temperature- dependent development rates and hatching period for *O. karongae* eggs, in a recirculating system hatchery.

Literature Summary

Oreochromis karongae (Trewavas, 1941), locally known as "Chambo", is one of the indigenous mouth brooding *Tilapia* species endemic to Lake Malawi. Studies have shown that of the three species that constitute 93 percent of aquaculture production in Malawi, *O.karongae* exhibits superior growth characteristics over *Oreochromis shiranus* and *Tilapia rendalli* in earthen ponds, which is the most common aquaculture system (Msiska and Costa-Pierce, 1996). The species, is favored by consumers for its good flavor, shiny appearance and bigger size (Kaunda *et al.*, 2005), and contributes to tourist attraction in Malawi. For this reason, the species has been overfished from the major water bodies (Banda *et al.*, 2003). Scarcity of fingerlings remains the key constraint to the desired aquaculture production of *O.karongae* due to low fecundity coupled with low egg hatching success (Msiska, 1998). Temperature is known to be the main environmental factor governing fish egg development (Blaxter, 1992). Temperature affects certain morphological features, hatching rate and larval behavior (Bagenal and Braun, 1978). In earlier studies, temperature influenced egg development and hatching in *O. niloticus* (Bhujel, 2000), *Tilapia zillii* (Omotosho, 1988) common carp, *Cyprinus carpio* (El-Gamal, 2009), and cod, *Gadus morhua* L (Page and Frank, 1989; Geffen *et al.*, 2006). The effect of temperature on hatching of *O. karongae* eggs has not been studied in Malawi. Such information is necessary in: (i) the process of adapting a hatchery system for increased production of *O. karongae*, and (ii) setting the basis for developing egg development schemes that are required for management of aquaculture production schedules and for developing individual-based models such as IBMs and estimation of spawning stock biomass (Lo *et al.*, 1992; Armstrong *et al.*, 2001).

Study Description

The experiment was conducted at the National Aquaculture Centre, Domasi, Malawi. Brood stock were conditioned in earthen ponds for 30 days and were monitored for fertilized eggs. Applying the clutch removal method (Ahmed *et al.*, 2006), fertilized eggs were collected from the mouth, and were checked using the egg staging criteria (Geffen *et al.*, 2006). In each 2 Liter McDonald Type incubation jar, 265 eggs were stocked. Three temperature treatments: 25ÚC, 27 ÚC and 29 ÚC were replicated thrice, each in a separate recirculating system. Daily, 10 percent of the water was replaced with fresh water. Hatched, unhatched and dead eggs were enumerated at the end of each stage. Dissolved oxygen, pH, and temperature were measured twice daily at 10:00hrs and 14:00hrs, while ammonia was measured twice during the experiment. A regression function, in SPSS 16.0, was used to relate the cumulative time up to the end of each developmental stage, and stage duration with incubation temperature. The best model was then selected. Adequacy and suitability of model fit was assessed using standard procedures Hatching period was compared using Analysis of Variance (ANOVA).

Research Application

The longest hatching period was 14.7 days and was recorded at 25°C while the shortest hatching period was 7.3 days and it was in the highest temperature treatment (29^{o}C). Similar results were observed in common carp, *Cyrpinus carpio* (El-Gamal, 2009), *Oreochromis niloticus* (Bhujel, 2000), and in cod, *Gadus morhua* (Geffen *et al.*, 2006) where hatching period decreased with increase in incubation temperature. In another study on *O.niloticus*, hatching period decreased from 7 to 3.3 days with increase in temperature from 24 to 27 ^{o}C (El-Naggar, 2000). These findings confirm earlier studies suggesting that temperature is an important factor determining egg and larval development as it influences metabolic rate (Blaxter, 1992; Kamler, 2008) and cellular function (Somero and Hofmann, 1997). This phenomenon also resulted in higher hatchability rate at higher temperatures and low hatchability at low temperatures as also observed between 27 ^{o}C and 30 ^{o}C in *C. carpio* by El-Gamal (2009).

There was a curvilinear relationship between temperature and egg development, which was best described by a logarithm regression function (Equation 1), whose parameters are described in Table 1, with:

$D=\alpha+\beta\ ln(T)$ ………... (1)

where D is cumulative time (days) to end of development stage, *T* is mean incubation temperature (°C), residuals are normally distributed and á and â are estimated parameters

The logarithm temperature-dependent development model was selected, in this study, as it was easier to describe than the power model. The model described the curvilinear relationship between temperature and cumulative days after fertilization more adequately than the log-linear regression function used in other studies. The logarithm model was however close enough to the power model. This being the first research of its kind in *O. karongae* it is advisable to apply the model between 25 and 29°C.

Determining temperature-dependent development rate for *O. karongae*, in Malawi, is a novel idea. Thus the current findings have formed the basis for future comprehensive work on temperature-dependent development schemes for eggs of *O. karongae* and other important fish species for aquaculture and fisheries management.

Acknowledgement

This study, which forms part of the first author's PhD study is funded by RUFORUM and IDRC.

Table 1. Parameter estimates for regression model fit to *Oreochromis karongae* egg development data (A) cumulative days to end of stage and (B) stage duration.

Stage	Parameter	Estimate	S.E.	*T* value	*F* (d.f.)	R^2	Overall *P*
(A) Cumulative days to end of stage							
I	Á	24.791	4.662	5.317	23.211(1,7)	0.735	0.002
	Â	-6.818	1.415	-4.818			
II	Á	48.539	7.388	6.57	36.796(1,7)	0.817	0.001
	Â	-13.602	2.242	-6.066			
III	Á	73.373	13.987	5.246	23.211(1,7)	0.735	0.002
	Â	-20.453	4.245	-4.818			
IV	Á	143.732	18.29	7.859	53.854(1,7)	0.869	0.000
	Â	-40.74	5.552	-7.339			
V	Á	159.835	14.775	10.818	102.465(1,7)	0.927	0.000
	Â	-45.396	4.485	-10.123			
(B) Stage duration in days							
I	Á	24.791	4.662	5.317	23.211(1,7)	0.735	0.002
	Â	-6.818	1.415	-4.818			
II	Á	23.748	2.726	8.713	67.256(1,7)	0.892	0.000
	Â	-6.784	0.827	-8.201			
III	Á	24.834	6.599	3.763	11.700(1,7)	0.572	0.011
	Â	-6.851	2.003	-3.42			
IV	Á	70.358	4.303	16.35	241.233(1,7)	0.968	0.000
	Â	-20.287	1.306	-15.532			
V	Á	16.103	3.515	4.582	19.046(1,7)	0.693	0.003
	Â	-4.656	1.067	-4.364			

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