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The Effect of Salinity on Eggs and Larvae of *Oreochromis niloticus* (Linnaeus)

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ABSTRACT A review of the effects of salinity on the early stages of fish is given, and methods used to study the effect of salinity on percentage of egg hatching and survival of *Oreochromis noliticus* (Linnaeus) larvae are described. Eggs of *O. niloticus* fertilized in a natural salinity of 2.1‰ were tested for hatching and for survival of the larvae in five salinity concentrations of 5, 10, 15, 20 and 25‰. Results show that successful egg hatching could be obtained at salinities up to 20‰. Two lethal limits are also reported: at salinity 25‰ for larvae hatched in salinities 5, 10 and 15‰; and at salinity 30‰ for those hatched in 20‰. Both the two lethal limits were found to be extended to higher salinity by acclimation of the larvae.

Salinity is an important factor affecting the early development and hatching of fish eggs as well as the physiology, metabolism and distribution of larvae and adults.

Fish species differ in their ability to tolerate changes in salinity, among the family Cichtidae, for example, species of the genus *Tilapia* have been found to tolerate a wide range of salinity levels (Potts *et al.* 1967, Farmar and Beamish 1969, Beamish 1970). While *T. aurea* could tolerate a salinity of 24 ‰ (Boyd and Lichtkoppler 1979) *T. mossambica* has been reported to tolerate sea water (Potts *et al.* 1967). Such high salinities, which have been reported to be favourable to adults and larval stages, may not favour the development of the eggs (Heut 1947, Kinne and Kinne 1962, Holliday 1965). Small fish and larvae of most species are more susceptible than adults to sudden changes in salinity (Boyd and Lichtkoppler 1979).

It has been suggested that larvae from eggs allowed to remain in the same salinity as at hatching might exhibit a high growth rate and develop adjustments that might persist throughout their lives (Kinne 1962). To test that assumption, a

preliminary investigation on the effect of salinity at a constant temperature on the euryhaline fish *Oreochromis niloticus* (Linnaeus) was undertaken on hatching rate and survival of the larvae.

Material and Methods

Eggs of *O. niloticus* fertilized at 2.1‰ salinity were obtained by washing out the mouth contents of 4 brooding female fish. Different salt concentrations were prepared by dissolving the salts used for making artificial sea water as presented in Table 1 (Hale 1958), and the pH was maintained at reasonable level of 6.5-8.5 (7.5 on the average) using sodium bicarbonate buffer solution (Mahoney 1966).

Hatching of the Eggs

Five treatments (salinities 5, 10, 15, 20 and 25‰), each with three replications, were stocked with fertilized eggs in 40 × 20 × 10 cm enamel trays at the rate of 200 eggs/L. The temperature in each treatment was maintained at 27°C using an electric thermostat and the percentage of hatched eggs was recorded. After hatching, individuals remained in each treatment for 14 days before being subjected to high salinities.

Table 1. Chemical salts used for making artificial sea water (Hale 1958).[1]

Salt	Anhydrous form (g)	Hydrated form (g)
NaCl	23.991	
KCl	0.742	
$CaCl_2$	1.135	
($CaCl_2 . 6H_2O$)		2.240
$MgCl_2$	5.102	
($MgCl_2 . 6H_2O$)		10.898
Na_2SO_4	4.012	
($Na_2SO_4 . 10H_2O$)		9.1
$NaHCO_3$	0.197	
NaBr	0.085	
($NaBr . 2H_2O$)		0.115
$SrCl_2$	0.011	
($SrCl_2 . 6H_2O$)		0.018
H_3BO_3	0.027	

[1] All salts were dissolved in 1 litre distilled water to obtain the required salinity of artificial sea water (34.33‰).

Survival of the Larvae

(i) Lethal Limit

To determine the lethal limit of salinity and subsequent acclimation levels to increase this limit, different sets of three samples, each of 20 larvae, were taken from each hatching treatment and suddenly subjected to different higher salinities as shown in the experimental design (Fig. 1). Since no eggs survived after hatching in salinity 25‰, only those in the lower salinities (5, 10, 15 and 20‰) were used. The lethal limit for any level of salinity was determined when dead individuals in each sample exceeded 50% in less than 24 hr.

(ii) Acclimiation

Acclimation of the larvae to the higher salinities was undertaken in two phases: in the first phase a set of three samples (each of 20 larvae) was collected from each hatching salinity and acclimation started by increasing the salinity 5‰ every 48 hr. When all samples were subjected to a salinity of 20‰, the second phase of acclimation started by increasing the salinity 1‰ every 48 hr. Samples of larvae from the

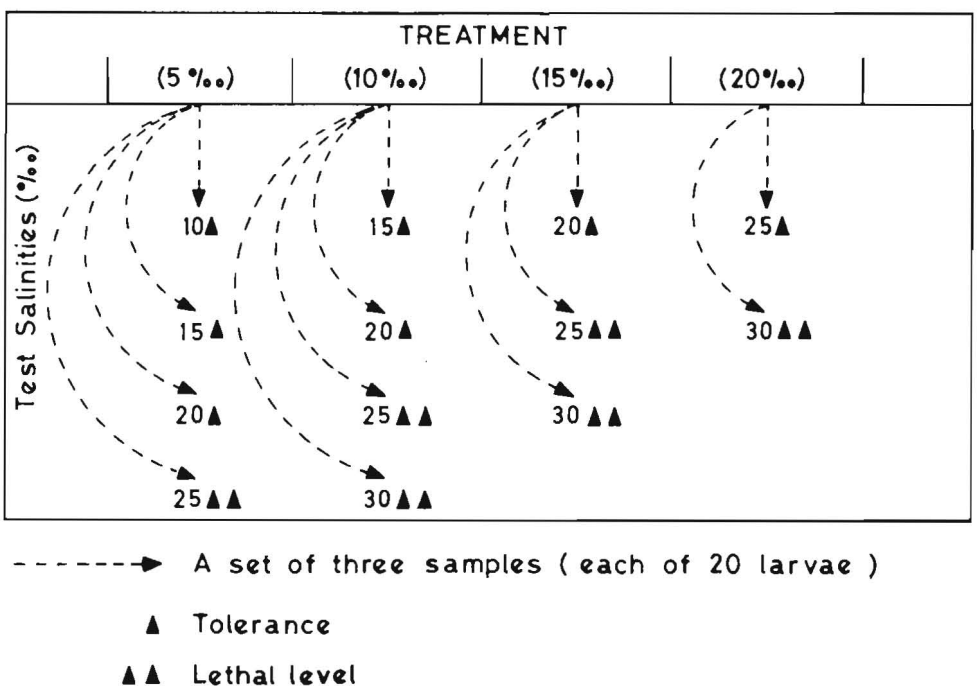

Fig. 1. Experimental design for sudden exposure of *O. niloticus* larvae to different salinities (‰)

hatching salinity of 20‰ were subjected to 5‰ increase up to 25‰, then to 1‰ increase in salinity every 48 hr. In all treatments, the temperature was maintained constant at 27°C, oxygen was supplied from an electric air-pump and live *Artemia* (larvae) were fed to the larvae. Tolerance to higher salinities after acclimation was determined when 50% of the larvae treated remained alive for at least 24 hr.

Results

Hatching of the Eggs

Successful hatching (over 70%) was observed in salinities of 5, 10, 15 and 20‰. The hatching time in all treatments was 3-4 days, and yolk-sac absorption was complete after 14 days from hatching. The mean percentage of hatched eggs is reported in Table 2. Dead individuals exceeded 50% in salinity 25‰ after 24 hr post-hatching.

Analysis of variance (Table 3) indicated no significant difference ($P_{.} > 0.05$) in the mean total number of hatched eggs within the five treatments.

Table 2. Total number (mean, range) and percentage of hatched eggs at different salinities.

Replicates	Total number of hatched eggs/salinity (‰)				
	5	10	15	20	25
A	168	154	151	141	127
B	170	163	155	142	114
C	178	169	163	150	96
Mean	172	162	156	144	112
Range	168-178	163-169	155-156	142-150	112-96
Mean %	86	81	78	72	56

Table 3. The analysis of variance for the total number of hatched eggs at the five treatments (salinities 5, 10, 15, 20 and 25‰).

Source of variation	df	SS	MS	F	P
Between treatments	4	4498.15	1124.538	0.35	N.S.[1]
Within treatments	10	31844.80	3184.480		
Total	14	36342.95	4309.018		

[1] N.S. = Not significant at the 5% probability level.

Survival of the Larvae

(i) Lethal Limit

Two lethal limits were reported in the course of this study when larvae were suddenly exposed to high salinities; at salinity 25‰ for larvae hatched in salinities 5, 10 and 15‰; and at salinity 30‰ for those larvae hatched in salinity 20‰ (Fig. 1). In each replicate, mortality had exceeded 50% at the lethal salinity in less than 24 hr.

(ii) Acclimation

The lethal salinities determined in all treatments were found to be increased by acclimation (Fig. 2 and 3). Larvae from hatching salinities of 5, 10 and 15‰ were found to tolerate salinities 26, 26 and 27 and showed more than 50% mortality at salinities of 27, 27 and 28‰, respectively. Those larvae from the hatching salinity

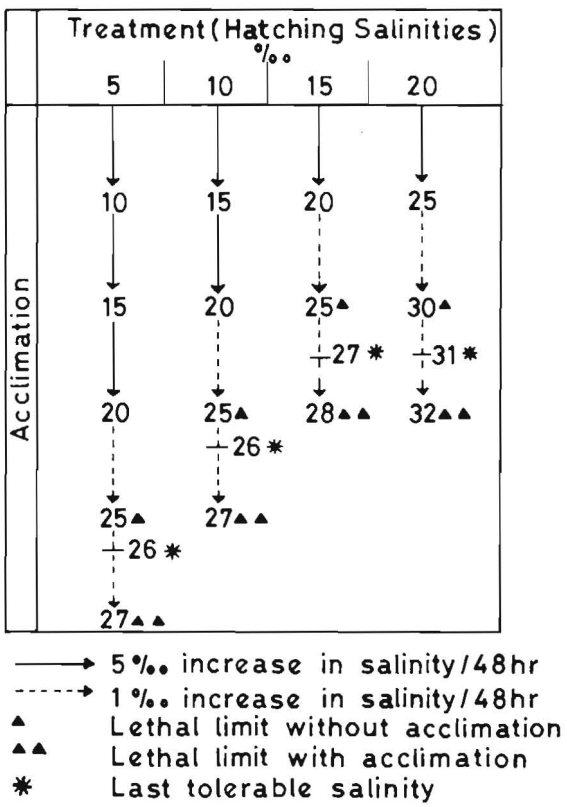

Fig. 2. Acclimation of *O. niloticus* larvae.

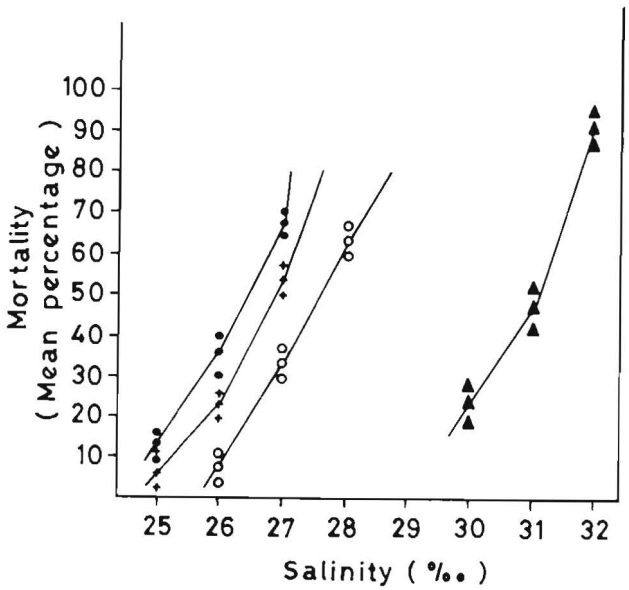

Fig. 3. Salinity tolerance of *O. niloticus* larvae from different hatching salinities after acclimation. (•, +, ○, ▲ are hatching salinities 5, 10, 15 and 20 ‰, respectively.

of 20‰ tolerated up to 31‰ and dead individuals exceeded 50% in less than 24 hr at salinity 32‰.

Discussion

Egg hatching comparable to that reported here for *O. nilotica* has been reported for other freshwater fishes in salinities of 10 to 20‰ and survival and hatching were better in salinities 2.5 and 5‰ (Bishai 1961, Kinne and Kinne 1962, Florkin and Schoffeniels 1965, Potts *et al.* 1967, Farmer and Beamish 1969, Beamish 1970). In marine fishes successful egg hatching has been found in salinities 50 to 70‰ (Kinne 1962, Holliday 1969).

Several authors have studied the effect of salinity on the general rate of development and hatching success of teleost fishes (Battle 1930, Lasker and Theilacker 1962, Kinne 1962, Conte *et al.* 1966). Kinne (1962) showed that an increase in the salinity results in a progressive retardation; Holliday (1969), however, attributed this phenomenon to lack of oxygen at higher salinities. Heut (1947) reported that the tolerance of the eggs to salinity depends on the characteristics of the species.

The most suitable maximum high salinity for *O. nilotica* larvae was found to agree with that reported by Farmer and Beamish (1969). Their findings showed

that *O. niloticus* is able to osmoregulate most efficiently at 15‰ the salinity closest to the isosmotic salinity 11.6‰. Though the mechanism of osmoregulation of *O. niloticus* at different salinities was not measured in this study, yet the survival of the larvae up to salinity 20‰ may support those findings. Change in salinity might have affected the inorganic constituent of *O. niloticus* larvae as reported in other fishes (Bishai 1961, Lang and Fugelli 1965, Potts *et al.* 1967). The tolerance of fish larvae to changes in salinity depends on their ability to regulate the osmotic and ionic concentration of the body fluids. Freshwater fishes develop their excretory structures in such a way as to tolerate certain levels of salinity; if exceeded they exhibit abnormal behavioral activities (Kinne and Kinne 1962, Alderdic and Forrester 1968, Farmer and Beamish 1969). Very likely certain parts of *O. niloticus* larvae, such as the gills, kidneys and other tissues, greatly affected when subjected to high salinity.

Results of the present study show that at a constant temperature of 27°C, sudden and large changes of salinity up to 20‰ will not greatly affect *Oreochromis* eggs and larvae. Moreover, exposure to salinities as high as 25 and 30‰ could be tolerated if larvae were acclimatized. Results also show that acclimation of the larvae above salinity 32‰ is practically impossible. Larvae from eggs hatched at higher salinities may be more resistant than those from eggs hatched at lower salinities. Whether such larvae have acquired the sort of adjustment assumed by Kinne (1962) that persists throughout their lives, needs further clarification.

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تأثير الملوحة على بيض و يرقات البلطى النيلي
(Oreochromis niloticus)

ناصر الأصقه

قسم علم الحيوان - كلية العلوم - جامعة الملك سعود - الرياض - المملكة العربية السعودية

أجريت دراسة على تأثير الملوحة على نسبة نجاح فقس بيض سمك البلطى النيلى (الأوريكرومس) ونمو اليرقات. جمعت عينات من البيض الملقح فى درجة ملوحة ٢,١ ..٪ ووضعت فى خمسة محاليل ذات درجات ملوحة ٥، ١٠، ١٥، ٢٠، ٢٥ ..٪، ووجـد أن بيض هذه السمكـة يمكن أن يفقس بصورة حسنة فى درجات ملوحة حتى ٢٠ ..٪ وأن اليرقات يمكنها أن تلائم درجتان من الملوحة (٢٥ و ٣٠ ..٪) حسب درجات الملوحة التى فقست بها، وأن كلتا الدرجتين يمكن تخطيهما إلى نسب أعلى بعد تأقلم اليرقات على درجات ملوحة متدرجة من أقل إلى أعلى.