SALINITY TOLERANCE OF CERTAIN FRESHWATER FISHES

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ABSTRACT

To *Rhinomugil corsula* (Hamilton) salinities below 12.25 ‰ (S) are not lethal at any temperature within the tolerance limit, in acute exposure from freshwater. The optimum temperatures from 26 to 30°C favour salinity tolerance. Low temperature is more detrimental than high, though this species has higher resistance times at low temperature. *Sarotherodon mossambica* Peters resists salinity better than common carp and freshwater mullet. Among carps, the common carp is highly tolerant to salinity, mrigal is the least tolerant and fringelipped carp is intermediate. Salinity acclimation in the fringelipped carp has enhanced only the resistance to salinity and there is no change in the tolerance level.

INTRODUCTION

Studies on salinity acclimation, tolerance, metabolism and iono-osmoregulation in fishes have been made by Armitage and Olund (1962), Potts and Parry (1964), Potts and Evans (1967), Nelson (1968), Rao (1969, 1971), Parvatheswara Rao (1970), Prosser et al (1970), Feldmeth and Waggoner (1972), Mackay (1974) and others. Besides acclimation, the knowledge on salinity tolerance at different temperatures and the complex osmoregulatory mechanism it leads to is important, especially in view of the present stress being given on the aquaculture in saline and waste waters. The present study is on the salinity tolerance at different temperatures in *Rhinomugil corsula* and at ambient temperature (30°) in the case of *Cirrhinus mrigala, Labeo fimbriatus, Cyprinus carpio* and *Sarotherodon mossambica*.

MATERIAL AND METHODS

Five species—fingerlings of freshwater mullet *Rhinomugil corsula* (Hamilton (6.77 ± 1.11 cm; 2395.25 ± 1225.73 mg), fry of mrigal *Cirrhinus mrigala* (Hamilton) (1.26 ± 0.09 cm; 15.97 ± 4.09 mg), fringelipped carp *Labeo fimbriatus* (Bloch) (1.76 ± 0.19 cm; 41.76 ± 15.98 mg), common carp *Cyprinus carpio* Linnaeus (2.24 ± 0.22 cm; 109.43 ± 36.15 mg) and hatchlings of *Sarotherodon mossambica* Peters (0.77 ± 0.07 cm; 7.58 ± 1.06 mg)—were

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tested for salinity tolerance. *R. corsula* was acclimated to 28° ± 1°C and the rest were acclimated to 30 ± 1°C freshwater. However, in addition, *L. fimbriatus* was acclimated to saline water (5‰ (S)).

Samples of 10 fish were drawn at random from acclimation tank and were exposed abruptly to different preset lethal salinity and non-lethal temperature combinations. The lethal salinity levels were obtained by preliminary trial tests and non-lethal temperatures from thermal tolerance given by Kasim (1979). Time to death of individual fish was recorded by close inspection and the length and weight of individual fish were also noted down. Complete arrest of opercular beats and the onset of muscular contraction, followed by complete loss of response to external stimuli, were the symptoms to conclude that the fish was dead. The experiment was continued until all the fish died or up to 10,000 minutes (approximateliy 7 days). The data on time to death were statistically treated and graphically interpreted to explain the response to lethal salinity (Brett 1952). Temperature of the test medium was controlled at different levels only for *R. corsula,* whereas for the rest, including the saltwater-acclimated *L. fimbriatus,* the experiment was carried out at ambient temperature (30° ± 1°C) and the salinity range was from 5 to 35 ‰. The saline test medium was prepared by mixing commercial mother salt with tapwater (Raynold 1974; Ahohas and Duerr 1975). The elevation in salinity due to evaporation was compensated by addition of distilled water, and it was constantly checked with salinometer (Yellowspring Instrument Company, USA). The salinity fluctuation was within 0.5 ‰ for any set of experiments.

RESULTS

The raw data on times to death were initially plotted against percentage of fish dead on an arithmetic graph. As an example, the data of various exposures of *R. corsula* at different lethal salinities from 12.5 to 40 ‰ at 35°C are shown in Fig.1. The curves fitted through these plots were generally sigmoid in shape and they shift towards the time axis as the lethal level of salinity decreases. These mortality curves are converted into simple straight lines when plotted on a probability chart as shown in Fig. 2 for the same data. The median resistance times with respect to each salinity could be obtained from the probit curves at 50% level. The data on median resistance time thus obtained decreases with increase in lethal salinity and temperature.

These data are plotted on semilogarithmic graph in Fig. 3, and regression lines have been fitted through the plots, which describe the salinity-resistance response of this species at different temperatures. As the concentration of the salinity is decreased there will not occur total mortality below certain dose. The concentration which causes 50% mortality or, conversely, at which 50% of the sample survives for an indefinite exposure, is known as the 'Incipient lethal salinity'. The incipient lethal salinities computed as per the method of Miller and

Tainted (1944) are summarised in Table 1 along with the formulae for the regression lines shown in Fig. 3. These values are shown in Fig. 3 by a broken boundary line which terminates the regression lines at the higher ends and this line differentiates the zone of tolerance from the zone of resistance.

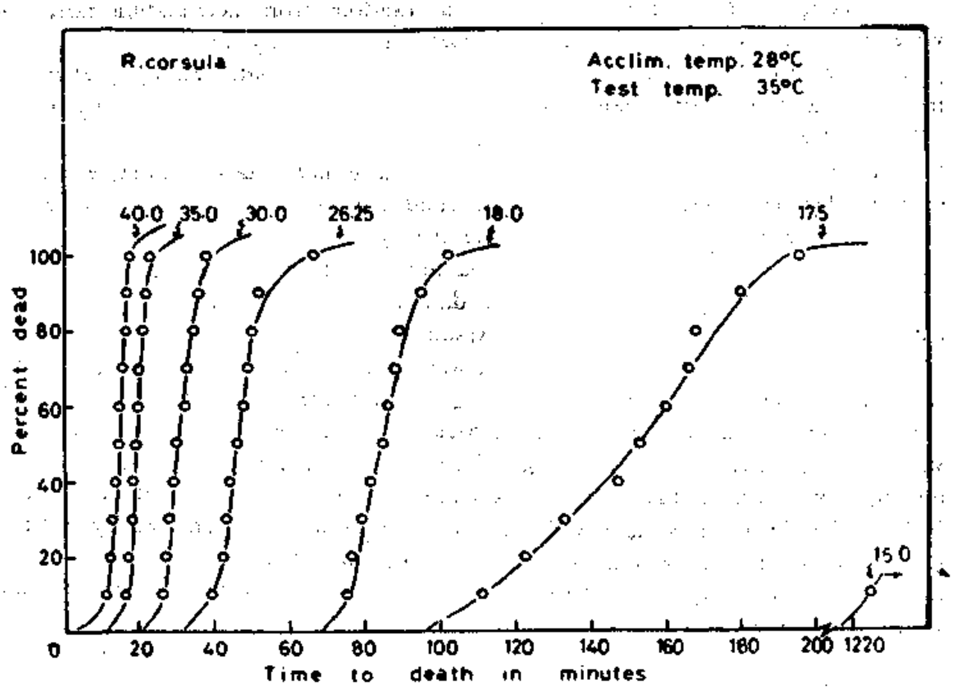

FIG. 1. Times to death in various lethal salinities at 35°C among freshwater mullet *Rhinomugil corsula* fingerlings acclimated to 28°C. Plotted on arithmetic graph.

TABLE 1. *Formulae for the regression lines describing the salinity resistance and the upper incipient lethal salinity ± one SD) for fingerlings of* Rhinomugil corsula *acclimated in freshwater at 28° ± 1°C and tested in various salinity and temperature combinations. (X is the salinity in parts per thousand; Y is the log time).*

Test temperature °C	Formulae	Upper incipient lethal salinity ‰ (S)
35.0	Y = 2.7807 - 0.0417 X	15.35 ± 1.2
30.0	Y = 2.5799 - 0.0336 X	17.90 ± 0.7
26.0	Y = 3.2145 - 0.0468 X	17.32 ± 1.3
20.0	Y = 3.6465 - 0.0547 X	12.25 ± 1.3
17.5	Y = 3.5590 - 0.0454 X	12.25 ± 1.3

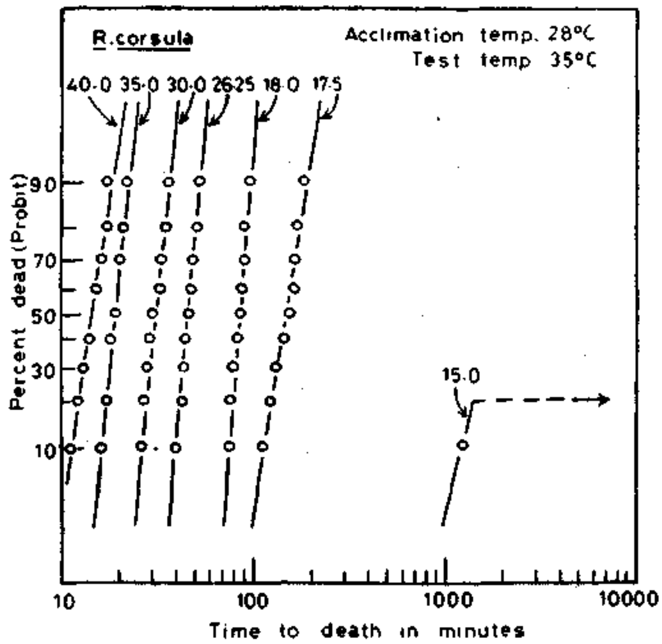

FIG. 2. Times to death in various lethal salinities at 35°C among freshwater mullet *Rhinomugil corsula* fingerlings acclimated to 28°C. Plotted on probit X logarithmic axes.

As in the case of *R. corsula*, the time-mortality curves of carps and *S. mossambica* were also simple and straight. There was also no change in the mortality pattern of both fresh- and saltwater-acclimated *L. fimbriatus* as shown in Fig. 4. On the other hand, as seen from this figure, the saltwater-acclimated fish resists salinity better than the freshwater-acclimated fish. This difference in salinity resistance is seen better at sharp lethal salinites (15 and 20‰). The median resistance times of all the species including freshwater mullet (30°C data taken from Fig. 3) are presented in Fig. 5 on a semilogarithmic chart and regression lines have been fitted through the plots of individual species. The broken line with dots represent the resistance response of the saltwater-acclimated *L. fimbriatus*. As seen from this figure, these regression lines are species-specific and the difference among the species in salinity resistance is aplty displayed. All the three carps occupy lower levels of resistance and exhibit little difference in resistance among them. On the other hand, *R. corsula* and *S. mossambica* exhibit wide difference from each other and also from carps. Comparatively, the resistance of *R. corsula* was, as already mentioned, sharp and shorter than all the rest. The median resistance time of carps and *S. mossambica* also increases towards the lower lethal salinity as in the case of *R. corsula*. The formulae for the regression lines shown in Fig. 5 are given in Table 2 along with the incipient lethal salinity of the respective species.

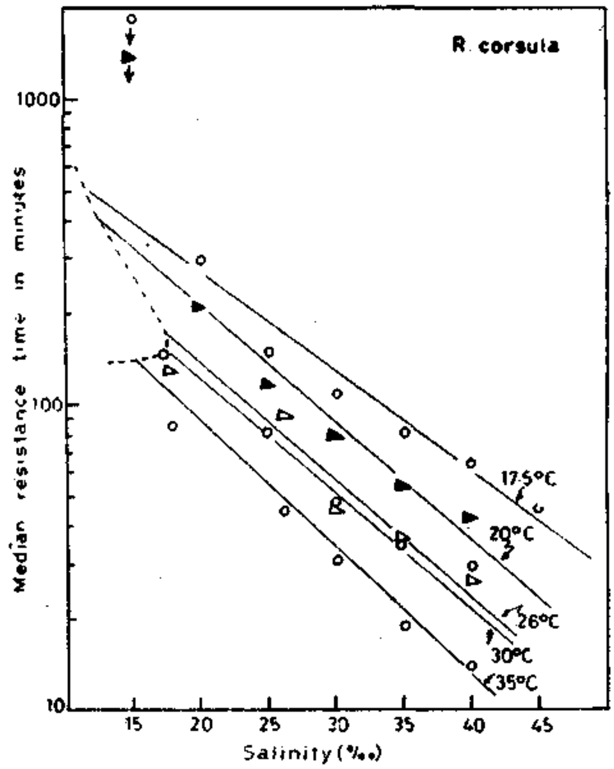

FIG. 3. Median resistance times to various lethal salinities at test temperatures indicated among freshwater mullet, *Rhinomugil corsula* acclimated to ambient temperature 28°C. Plotted on arithmetic X logarithmic axes.

TABLE 2. *Formulae for the regression lines describing the salinity resistance and the upper incipient lethal salinity of carps and* S. mossambica *tested in various salinity at 30°C. (X is the salinity in parts per thousand; Y is the log time).*

Species	Formulae	Upper incipient lethal salinity ‰ (S)
C. mrigala	Y = 3.6352 - 0.1285 X	3.54
L. fimbriatus	Y = 4.4825 - 0.1661 X	7.07
	Y = 3.6470 - 0.0915 X*	7.07*
C. carpio	Y = 4.1838 - 0.1387 X	8.13
S. mossambica	Y = 5.4628 - 0.1176 X	7.07

* Formula for salinity acclimated *L. fimbriatus*.

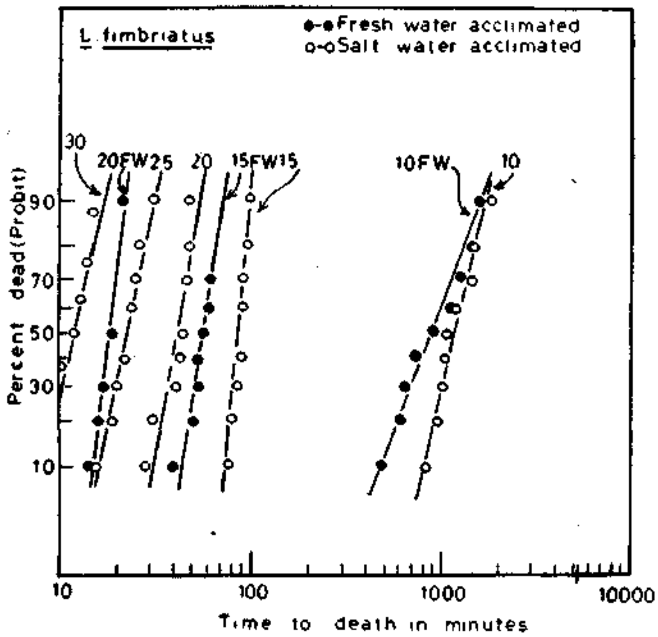

FIG. 4. Times to death in different lethal salinities among fringe-lipped carp *Labeo fimbriatus* acclimated to fresh and salt water (5%0 (S) at ambient temperature 30°C. Plotted on probit X logarithmic axes.

Discussion

Temperatures above 36.5° and below 16°C being lethal for 30°C-acclimated *R. corsula* (Kutty et al 1980), salinity-tolerance tests were carried out within tolerance limit from 17.5° to 35°C. The respective incipient lethal salinities at these thermal extremes are 12·25° and 15.35‰ and, whereas the highest incipient lethal salinity 17.32‰ has been obtained at 26°C. Salinities below 12.25‰ are non-lethal at all temperatures within thermal tolerance limit when exposed abruptly from freshwater.

The areas of resistance and tolerance of salinity are demarcated as in the case of of temperature tolerance (Kasim 1979) with the data on incipient lethal salinity in Fig. 3, and this clearly indicates that the highest salinity tolerance is obtained apparently at optimum temperatures from 26° to 30°C. Further, it is evident that at low temperature the salinity becomes more lethal even at a small dose 12.25 ‰ (S), whereas the resistance times are much higher at low temperatures. It is possible that at low temperature osmoregulatory system breaks down at lower salinity on a longer duration of time and vice versa at high temperatures. This complex response of this species to salinity and temperature like hyperosmotic regulators is owing to its euryhaline adaptability. This may be another instance of physiological versatility, where the same regulatory mechanism involving different structures like gills. kidney, gut etc. function with equal facility in either media, fresh and salt waters, through a reversal in its physiological polarity (Parvatheswara Rao 1970).

Comparatively, as seen from the incipient lethal salinities, mrigal is the least tolerant (3.54‰ (S)), the common carp the most tolerant (8.13‰) *L. fimbriatus* being intermediate (7.07 ‰). The euryhaline *S. mossambica* appears to be comparatively less tolerant than common carp, whereas the median

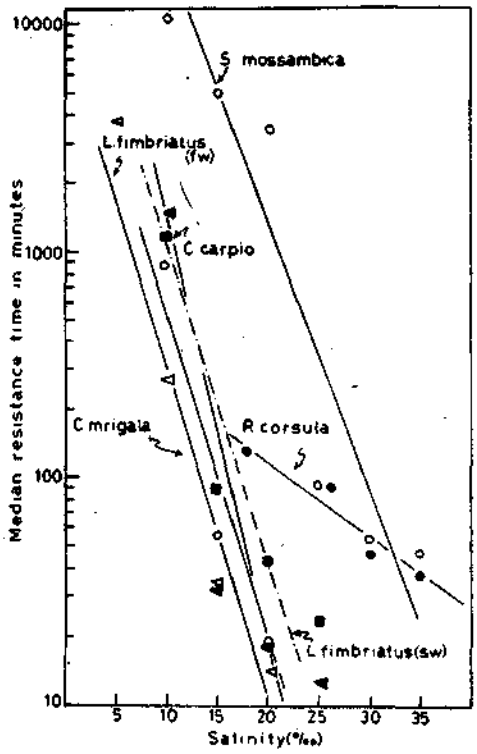

FIG. 5. Median resistance times to different lethal salinities among the species indiacated at ambient temperature 30°C. Plotted on arithmetic X logarithmic axes.

resistance times of *S. mossambica* are much higher than common carp. As such, *S. mossambica* exhibits higher resistance and lower tolerance than common carp as the adults of former species were observed to resist salinity as high as 35‰ (S) and the latter suffers immediate mortality above 25‰ (S). This inverse response observed in resistance and tolerance to salinity among the euryhaline *S. mossambica* and stenohaline common carp may be apparently owing to the use of hatchlings of *S. mossambica* and fry of common carp in the experiments. It could be inferred that the osmoregultory mechanism might not have developed well enough to tolerate the sudden salinity change among the hatchlings as in the case of common carp

An execessive loss of ion has been reported by Wickgren (1953) among carps at low temperatures; Morris (1960) also supports this finding based on

TABLE 3. *Results from analysis of variance of resistance times (logarithms) for fresh mullet acclimated to 28°C in freshwater and tested at various salinity and temperature combinations.*

Acclim. Temp.	Camparison	Sum of squares	Degrees of freedom	Variance	Value F ratio	Value F=0.05	Value F=0.01
	Between salinities (18.0, 26.25 30.0, 35.0, 40.0 ‰ (S)	70.6850	4	17.6713	114.82**	6.39	15.98
28°C	Between temperatures (30 and 35°C)	15.2384	1	15.2384	99.01**	7.71	21.20
	Salinity X temperature (error)	0.6156	4	0.1539			
	Total	86.5390	9				
	Between salinities (20, 25, 30, 35, 40 ‰ (S)	114.7656	4	28.6914	39.57**	3.84	7.01
28°C	Between temperatures (17.5, 20.0 and 26°C)	19.6015	2	9.8008	13.52**	4.46	8.65
	Salinity X temperature	5.7999	8	0.7250			
	Total	140.1670	14				

** Highly significant

his work on lampreys. Similar observation has been made in the case of *R. Corsula* as the salinity is progressively lethal at law temperature than at high. Thus, it appears that the susceptibility to salinity at low temperature is universal among all the species. Further studies by acclimating these species to different salinity and temperature may throw more light on the complex response of these species to salinity and temperature interaction.

CONCLUSIONS

Among the five species presently studied for salinity response, the fingerling of *R. corsula* tolerates salinity better than the remaining four species at the same temperature (30°C). Though the adult of *S. mossambica* were observed to survive total seawater, the hatchlings could not survive beyond 7.07‰ (S) owing to its lack of well-developed osmoregulatory mechanism. Among carps, common carp tolerates salinity better than mrigal and *L. fimbriatus*. Mrigal is the least tolerant among all the species. The results of analysis of variance for *R. corsula*, shown in Table 3, indicate very high significance at both the levels of comparisons. The saltwater acclimation in *L. fimbriatus* has not enhanced the survival limit of this species to salinity and it could only increase the resistance to salinity. As in the case of euryhaline *R. corsula* and *S. mossambica* the salinity acclimation did not bring about marked change in the tolerance limit among the stenohaline carp. *L. fimbriatus*. The stenohaline carps have comparatively low tolerance and adaptability to salinity.

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