SOME ASPECTS OF ADAPTATION IN *CHANOS CHANOS* (FORSKÅL)

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INTRODUCTION

THE possibilities of culturing marine species of fishes in coastal belts containing salt or fresh-water have received much attention in recent years, following the lead given by Far Eastern countries in the culture of *Chanos*. In India, *Chanos* as well as species of mullets could be cultured on a large scale and a beginning in this direction has already been made in certain South Indian centres. A study of the mechanism of adaptation in these species is an essential prerequisite to any rational system of culture, since it will help in determining the optimal values of salinity and temperature of the environment for the various species.

Although presenting a general pattern of similarity in their osmotic relations, teleostean fishes differ considerably in the manner in which they adapt themselves to external salinity. In the adult eel, for instance, the gills do not appear to be able to extract chloride from fresh-water (Krogh, 1937) and the osmotic regulation is brought about by practically complete reabsorption of the chloride by the excretory system combined with a low permeability of the tissues to water (Keys, 1933). In *Fundulus heteroclitus*, on the other hand, certain cells in the gills have been considered responsible for salt regulation by the excretion of chloride in sea-water and the absorption of chloride from fresh-water (Copeland, 1948). These differences probably relate to the evolutionary history of the species, depending on whether the mechanisms of adaptation have been perfected for fresh or salt water. Specialisation has no doubt taken place even among groups and forms primarily belonging to the saline or fresh-water environment. But, as indicated by Krogh (1939), the functional peculiarities of adaptation in euryhaline teleosts are still not clear in spite of several studies on the problem.

The interspecific differences are very pronounced particularly as regards the lower limits at which fishes are able to extract chlorides. The ecological significance of this aspect of hypertonic regulation in fishes has been discussed by Krogh (1939) who has pointed out the possibilities of fresh-waters being low enough in chloride content to present difficulties to certain species. Black (1951) finds that calcium is effective in diminishing the exchange of salts and water by *Fundulus heteroclitus* transferred to fresh-water. It is, therefore, quite likely that the power of absorbing chlorides and the lower limits of salt concentration are modified by the calcium content of the water. The importance of these factors in the adaptation of fishes to estuarine conditions has been discussed by Panikkar (1950).

Other aspects of the influence of ambient salinity relate to the size of the fish and the condition of the endocrine organs. The eel is relatively stenohaline between the time of hatching and entrance into the new environment (Krogh, 1939). In the stickleback, the power of osmotic regulation is significantly diminished during the breeding season (Gueylard, 1924) and sexually mature sticklebacks prefer brackish or fresh water, this effect being simulated when thyroid is administered to the fish *via* the alimentary tract (Koch and Heuts, 1942; Heuts, 1943).

In contrast to the salinity, the temperature of the environment provokes more passive responses in fishes which are poikilotherms. Here, the possibility has, however, to be taken into consideration of a combined influence of salinity and temperature such as has been indicated in the case of certain invertebrates (Broekhuysen, 1936; Panikkar, 1940; Broekema, 1942). Heuts (1945) has found that the geographical distribution of two subspecies of *Gasterosteus aculeatus* corresponds with the results on the effects of temperature on salt balance. It is obvious then that descriptions of heat death, cold death and optimal temperatures are incomplete without reference to the salinity of the medium employed.

In the present paper, observations are reported on the adaptive responses of *Chanos chanos* to variations in the salinity and temperature of the external medium and on the probable influence of calcium ions on adaptation. *Chanos* is a coastal species the fry of which are observed in large numbers in many places on the Madras coast (Ganapati *et al.*, 1950). It is usually reported euryhaline but reliable experimental or field data on the limits of salinity and temperature tolerance of the species are lacking.

MATERIAL, METHODS AND RESULTS

Blood serum chloride in Chanos *fingerlings*

Fingerlings of *Chanos* (65–140 mm. long) were acclimatised to the experimental media (tap water, sea-water diluted with tap water or sea-water to which common salt had been added) for a minimum of 48 hours before blood samples were taken from the heart or caudal blood vessels by the use of glass cannulæ. The samples were kept in the frigidaire for the separation of serum from clot. For the determination of chloride, the method of Wigglesworth (1937) was used. In Fig. 1, the mean values of serum chloride of 3–6 specimens of *Chanos* are plotted against chloride in the external medium.

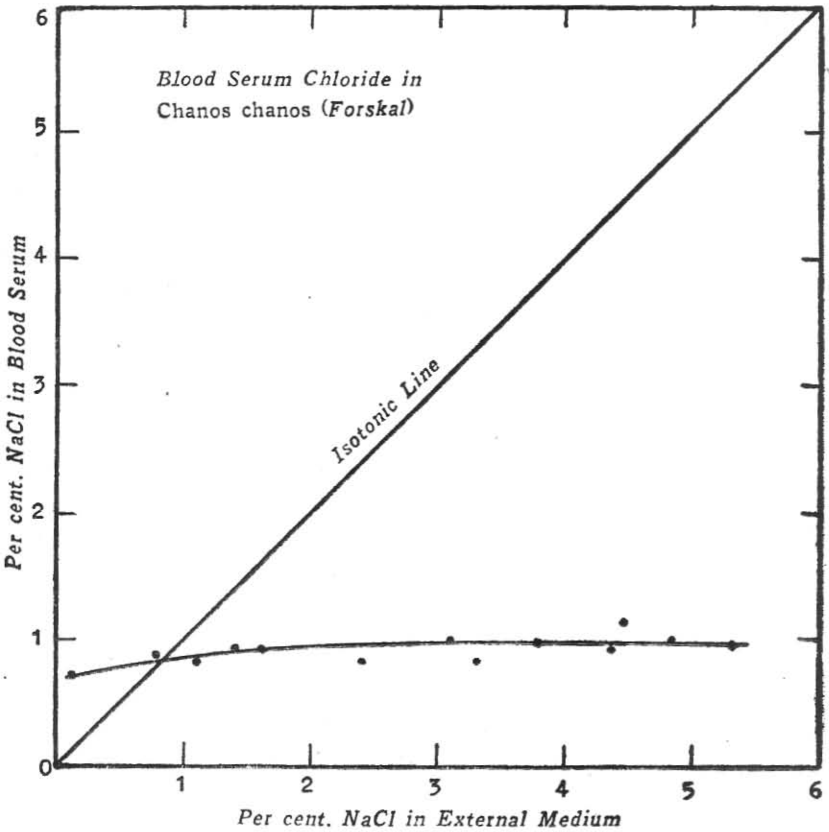

FIG. 1. Blood serum chloride in *chanos chanos* (Forskål)

Survival of Chanos *fingerlings in low salt concentrations*

In Tables I and II are given the results obtained by experiments with *Chanos* fingerlings in media containing low concentrations of salts. The external media were prepared by diluting tap water with glass-distilled water and by dissolving pure sodium chloride, calcium chloride and mixtures of these chlorides in glass-distilled water. The chloride and calcium content

TABLE I

Survival and Serum Chloride Values for Chanos *Fingerlings in Tap Water (Cl, 475 p.p.m. Ca, 112 p.p.m.) diluted with Glass-Distilled Water*

Date of experiment	% tap water in medium	Length of fish (mm.)	% NaCl in fish blood serum	Survival (hrs.)
26-12—49	100	70	0·969	*72
5-12—49	10	..	..	*24
7-12—49	1	..	..	*24
23-12—49	1	84	0·609	*72
9-12—49	0·1	..	..	*24
21-12—49	0·1	..	0·490	*24
17—1—50	0·1	123	..	19
4—4—50	0·1	..	..	*48
10-12—49	0·01	..	..	24
24—1—50	0·01	..	..	*48
19-12—49	0·008	96	0·372	*24
20-12—49	0·008	123	0·541	19
14-12—49	0·007	..	..	24
16-12—49	0·007	62	..	6
17-12—49	0·007	65	..	11
12-12—49	0·002	76	..	5
11-12—49	0·001	72	..	3

* The fish were alive at this stage but further observations were not made.

of tap water (and the fresh-waters listed in Table VII) were estimated by standard methods described in books on water analysis. Before transfer to the experimental media, the fingerlings were given a brief washing in glass-distilled water. One litre of medium was used per fingerling.

Thermal resistance of Chanos

The fish used were preacclimatised to the experimental media for a day.

(*a*) *Resistance to heat.*—*Chanos* fry, 10–20 in number, were kept in 1·5 l. of water contained in a glass cylinder (14 cm. ht.; 14 cm. diam.) and the temperature of the water was steadily raised by heating it in an air oven. The rate of increase of temperature was adjusted to about 4° C. per hour. The required temperature was maintained by switching the current on and off at intervals of 15 minutes. In experiments with the fingerlings, the fish was kept in 2·5 l. of water contained in a glass vessel (8″ diam.; 4″ ht.). The temperature of the water was raised over a closed type of electric hot plate (1,000 watts; 230 v.). The current was switched on initially for 1 minute and then at the rate of 1 minute for every 0·5 hr. till the temperature of water was 33° C. After this the rate of passing the current was increased to 1 minute per 15 minutes till the water attained the temperature of 35° C.

Table II

Survival and Serum Chloride Values for Chanos *Fingerlings in 'Artificial' Media: Figures within brackets in column* 3 *refer to calculated values of ionic concentrations, expressed in p.p.m.*

Expt. No.†	Date of expt.	Medium	Length of fish (mm.)	% NaCl in fish blood serum	Survival (hrs.)
(i) 1	25-11—49	Glass-distilled water	83	0·733	1·1
(i) 2	25-11—49	do	79	0·710	2·1
(ii) 3	20-10—52	do	76	..	*192
(ii) 4	20-10—52	do	97	..	*192
(ii) 5	20-10—52	do	89	..	192
(iii) 6	30-10—52	do	71	..	*24
7	16—8—50	NaCl (0·008)	87	..	1·3
8	4-12—49	do (84)	..	..	11
9	11—4—50	do (421)	..	..	*7
10	26—4—50	do (421)	..	..	*48
11	16—8—50	NaCl + $CaCl_2$ (Na, 0·003; Ca, 0·00002)	100	..	*48
12	9—2—50	do (Na, 0·177; Ca, 0·088)	..	..	5
13	4—2—50	do (Na, 0·177; Ca, 0·088)	71	..	*48
14	1—2—50	do (Na, 0·177; Ca, 0·883)	..	..	*48
15	29-11—49	$CaCl_2$ (14)	..	..	3·5
16	30-11—49	do (29)	83	..	*7
17	2-12—49	do (72)	..	..	7
(i) 18	28-11—49	do (144)	71	0·946	*48
19	28—3—50	do (144)	90	1·009	*48
20	28—3—50	do (144)	97	1·042	*48
21	28—3—50	do (144)	93	1·042	*48

* The fish were alive at this stage but further observations were not made.

† (i) Direct transfer from water of salinity 1·44% NaCl.

(ii) Fish preacclimatised for 4 months to fresh-water in a pond (salinity 1 part per 1000).

(iii) Fish preacclimatised for 4 months to fresh water and then for 42 hours to sea-water.

In experiments Nos. 7–17 and 19–21, the fish were collected from a saline pond and preacclimatised to tap water for 24 hours.

The subsequent maintenance of temperature at the required level was carried out by switching on the current for 0·5 or 0·75 minute at intervals of 15 minutes. Tables III and IV contain the results of experiments on the resistance of *Chanos* fry and fingerlings to heat.

(*b*) *Resistance to cold.*—The proportions of the number of fry (or fingerlings) and the volume of the medium were the same as in the experiments on the resistance of the fish to heat. The container was placed in a frigidaire for bringing down the temperature of the water. Tables V and VI contain the results of experiments on the resistance of *Chanos* fry and fingerlings to cold.

TABLE III

Resistance of Chanos *Fry* to Heat*

Date of expt.	Medium	No. of fry used	Temp. of water† (deg. C)		Time (Hours)										
			Initial	Test temp.‡	1	2	3	4	5	6	7	8	9	10	
25–4–50	Sea-water	20	30·6	39·7±0·1	100	100	90	85	..	..	..	..	..	..	
26–4–50	do	20	29·8	41·1±0·3	100	95	95	95	95	95	..	..	..	..	
27–4–50	do	20	29·6	41·6±0·2	75	65	55	55	..	50	50	50	..	..	
3–5–50	do	20	31·7	42·9±0·1	50	..	..	..	..	..	..	..	..	..	
1–5–50	do	20	30·0	42·9±0·2	60	55	40	..	25	..	20	15	5	0	
5–5–50	do	20	31·0	43·0±0·2	80	40	35	25	25	20	..	15	..	..	
3–5–50	do	20	29·6	43·1±0·4	20	0									
13–6–50	½ (sea-water)	10	29·9	39·2±0·2	100	100	100	100	100	..	..	..	..	..	Per cent. survival of fry
4–7–50	do	10	29·4	40·1±0·0	70	70	60	50	50	50	50	50	..	..	
5–7–50	do	10	30·0	41·4±0·4	100	80	80	70	70	70	..	..	..	..	
6–7–50	do	10	30·6	42·2±0·2	90	90	80	70	50	50	40	40	..	..	
29–5–50	Tap water	10	30·6	40·1±0·3	100	100	100	100	100	100	100	100	..	..	
30–5–50	do	10	30·0	40·8±0·4	100	100	100	100	100	..	..	..	..	..	
31–5–50	do	10	31·0	42·0±0·4	100	100	100	100	..	..	..	..	..	..	
1–6–50	do	10	29·8	43·0±0·3	10	..	..	..	..	..	..	..	..	..	

* Size of the fry used in the experiments : No. of fry whose lengths were measured 115 ; range, 13–30 mm. ; mean, 17·4 mm. ; & s.d., 3·3 mm.

† The rate of increase of temperature was about 4° C. per hour.

‡ Temperatures were recorded at intervals of 15 minutes and the figures correspond to (mean ± s.d.) of these readings.

The Analysis of variance of the data in Table III is given below:—

Source of variation	S.S.	D.F.	Variance	F by calcn.	F for P=0·05
Total ..	12124·3952	95	..	..	..
Temperatures, T ..	1161·1240	3	387·0413	4·08	2·83
Hours, H ..	2183·2593	7	311·8942	3·29	2·24
Salinities, S ..	40·2255	2	20·1127	4·72	19·5
Interaction : TS	314·4630	6	52·4105	1·81	3·8
Interaction : HS	621·2329	14	44·3738	2·14	2·3
Interaction : HT	3817·5219	21	181·7867	1·92	1·7
Residual ..	3986·5686	42	94·9183	..	..

At the P = 0·05 level, the only significant sources of variation are temperature, hour and interaction HT.

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