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VOLUME-DENSITY CHANGES IN A MARINE CATFISH *PLOTOSUS ANGUILLARIS*, IN DIFFERENT SALINITIES

By S. V. JOB[1] AND K. RAMACHANDRAN NAIR
Central Marine Fisheries Research Station, Mandapam Camp.

INTRODUCTION

IN the marine environment as well as in the estuarine environment salinity variations are a regular feature and salinity as a factor by itself can influence the free and unrestricted movements of the animals in those environments. Hukuda (1931) and Black (1951) have demonstrated both by biochemical as well as by physical tests the changes which the fish undergoes when transferred to different salinities, rather abruptly. The observations presented in the following pages were restricted to the measurement of physical changes only and were intended to supplement the data obtained on the same species of fish under identical conditions, on the metabolic response (Job, 1959) and are by no means exhaustive.

The catfish, *Plotosus anguillaris* (Bloch) is quite common in the Gulf of Mannar and in Palk Bay. As in the metabolism experiments the fish were acclimated to three levels of salinity and their physical changes of weight, volume and density— both absolute and reciprocal, were measured.

MATERIAL AND METHODS

The fish employed in the present study were held in large cement troughs of about 500 gal. capacity supplied continuously with sea water of average salinity 30.4‰. For obtaining salinities lower than that of sea water the local tapwater of 0.4‰ average salinity was mixed with sea water and the salinity maintained at 12.5‰ (average) by the use of a constant level mixer. For obtaining salinity of 40‰ (average) one lot of commercial sea salt was used throughout the acclimation and experimental period and mixed with sea water. In all cases the pH did not fall below 7.5. The average temperature in the cement troughs during the period was 29°C and the experiments were performed at that temperature. The oxygen concentration was maintained in all cases by aeration around 4.5 *ml/L*. Fish weighing from 2.5 to 6.5 gm. were used in the experiments.

The method employed for density measurements was the same as that employed by Black (1951). However, in parallel experiments carried out to measure the effect of acclimation in the weight-volume relationship a simple device was evolved to measure, with reasonable accuracy, the volume of the fish. The apparatus illustrated in Fig. 1 consists of a volumetric flask *a*, a microburette *b*, connected to *a* by a piece of pressure tubing of fine bore *c*. At the other end of *c* is a glass capillary *d* which passing through the rubber stopper *e* dips into the water column in the neck of *a*. The stopper is of a type that when pushed down to the maximum depth will always remain at a constant level and will not change the length

[1] *Present address :* University Zoology Laboratory, Madras. 5.

of the capillary tube dipping into water. At some point in the middle of the capillary there is a fine marking which can be so adjusted to stand exactly in line with the meniscus and the marking on the neck of the flask. By this means the length of the capillary dipping into water could be maintained constant and will not affect the volume measurements in any way. Through another piece of rubber tubing, *f* air can be blown into the flask or released from it *via* a second hole in *e*.

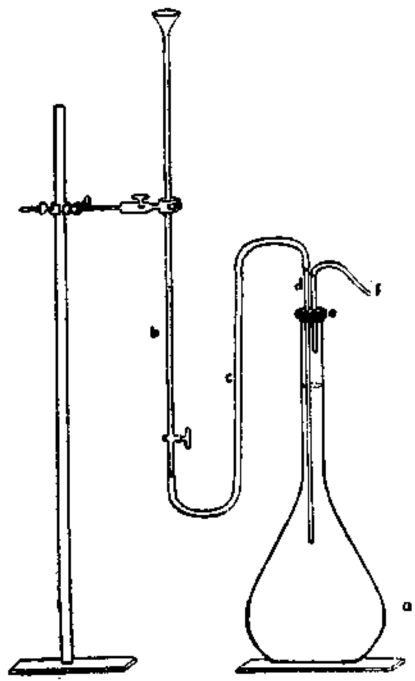

FIG. 1. A device for measuring the volume of a small fish. *a*—volumetric flask; *b*—micro-burette; *c*—pressure tubing; *d*—capillary tube; *e*—rubber stopper and *f*—piece of rubber tube.

Before the experiment is begun the flask is filled with water of the desired salinity and with the stopper in position, air is blown through *f* and some water allowed to flush *c* of air bubbles and the latter is now connected to the burette and the stopcock is opened. After a column of water between the middle and the end of the markings in *b* is thus raised the stopcock is closed. The marks on *a* and *d* which were earlier adjusted to be in line are used as reference and the meniscus of the water column in the neck of the flask is brought in line either by opening the stopcock of *b* or by blowing from the free end of *f* with the stopcock open; and closing the latter when the proper level is reached in *a*. Now the reading in *b* is noted as the starting point. The fish whose volume is to be measured is taken and wrapped in moist cloth to remove all extraneous water and is released into the flask and *e* is replaced to the same position as before. Air is blown through *f*, simultaneously opening the stopcock to allow water to rise in the burette. As before, looking against the marks in *a* and *d*, water is slowly released until the meniscus and the marks stand in line. With the stopcock simultaneously closed the reading on *b* is noted. The difference between the second and the first reading gives the volume of the fish. This can be repeated any number of times to obtain a mean volume. As in the metabolism experiments (*op. cit.*) fish used in this study were starved for 12 hours so as to avoid the release of faecal matter by the fish during the experiment.

Results

The data obtained were plotted on double logarithmic grid of density against weight or volume against weight and using the principle of the sum of least squares, the regression lines were drawn. From these curves the mean volume or density of a 5 gm. fish was obtained for further analyses. Table I, gives the mean density and mean volume of a 5 gm. fish acclimated to salinities of 12.5, 30.4 and 40‰ respectively as well as the density of water in the three salinities.

Table I

Mean density and volume of a 5 gm. fish acclimated to three salinities and the corresponding density of the water.

Salinity ‰	Density of water	Density of fish	Volume of fish ml.
12.5	0.9971	1.0067	4.786
(S.W.) 30.4	1.0097	1.0099	4.721
40.0	1.0185	1.0273	4.677

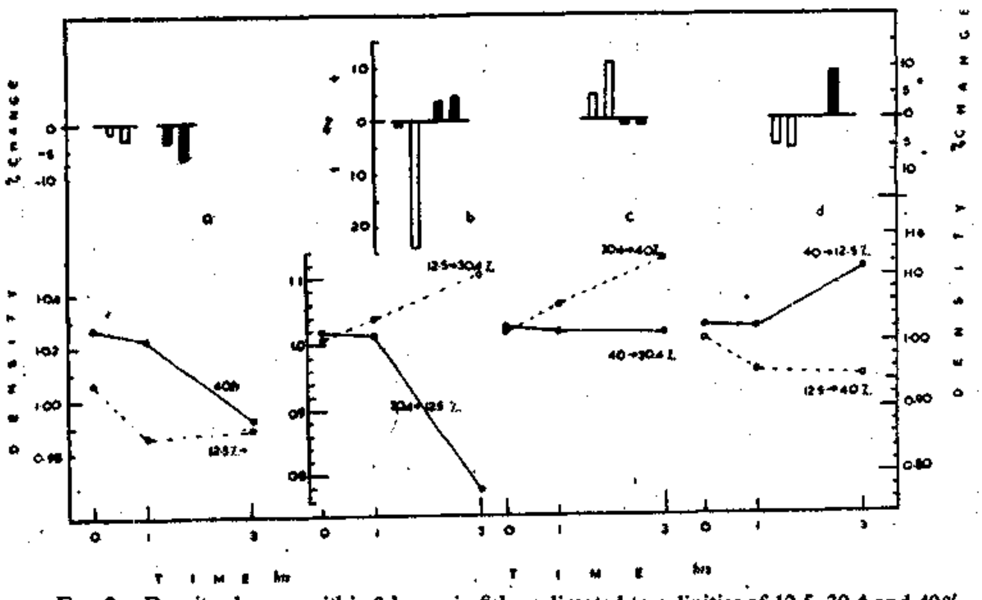

Fig. 2. Density changes within 3 hours in fish acclimated to salinities of 12.5, 30.4 and 40‰ and when interchanged. The broken line indicates transfer from low acclimation to high test salinity and the unbroken line transfer in the opposite direction. The histograms display the corresponding % of change over the initial the unshaded set representing the low to high salinity transfer and the shaded, the opposite.

Density Changes

In Fig. 2 the results of one way or reciprocal transfers to different media are illustrated. Except in Fig. 2*a*, the broken line indicates transfer from low acclimation salinity to high test salinity and the unbroken line, the transfer in the opposite direction. The histograms accompanying the curves indicate the % of change (increase if the column is above the horizontal line or decrease if otherwise) over the initial.

Transfer to Common Low Lethal Salinity

On transfer to tap water (0.4‰ sal.) it was found at the end of three hours that the density of the fish acclimated to 12.5 and 40‰ was about the same. But the fish acclimated to the former lost the density much faster even during the first hour (2%), whereas those of the latter offered greater resistance and lost only 0.4% during that period. However the net loss suffered was greater in the latter case as was to be expected.

Reciprocal Transfers

(*a*) *From* 12.5‰ *acclimation to* 30.4‰ *and vice versa.*—In Fig. 2*b*, can be seen the relative changes in the density. While the general trend is to display some reciprocity there appears to be a greater loss in the density of fish acclimated to 30.4‰ on transfer to 12.5‰, almost 20 times more than in the former case.

(*b*) *From* 30.4‰ *acclimation to* 40‰ *and vice versa.*—In this test the reciprocity is almost eliminated (Fig. 2*c*). The rate of change in the transfer from the lower to the higher salinity bore more or less the same relationship that was observed in the previous case (12.5 to 30.4‰). The transfer in the opposite direction produced only about 1% fall in the initial density.

(*c*) *From* 12.5‰ *acclimation to* 40‰ *and vice versa.*—In this test no correlation whatsoever could be found in that the relationship seen in the previous two cases tended to reverse altogether. The transfer from the high to the low salinity produced an increase in the density at the end of the third hour and that from the low to the high salinity the opposite effect more or less.

Volume Changes

Drawn on the same plan as that of Fig. 2 the volume changes under parallel conditions are illustrated in Fig. 3.

Transfer to Low Lethal Salinity (0.4‰)

In this test (Fig. 3*a*) the observation could not be extended beyond the one hour period. The results showed that while transfer from 30.4 and 40‰ showed an increase in the volume the transfer from 12.5‰ produced a fall. The first two were 3 and 2.3% higher and the last 3.8% lower than the initial volume.

Reciprocal Transfers

(*a*) *From* 12.5‰ *acclimation to* 30.4‰ *and vice versa.*—There was a steady decrease (15%) in three hours in the first case but in the opposite direction it produced only a 2% increase over the initial volume (in 30.4‰ salinity), Fig. 3*b*.

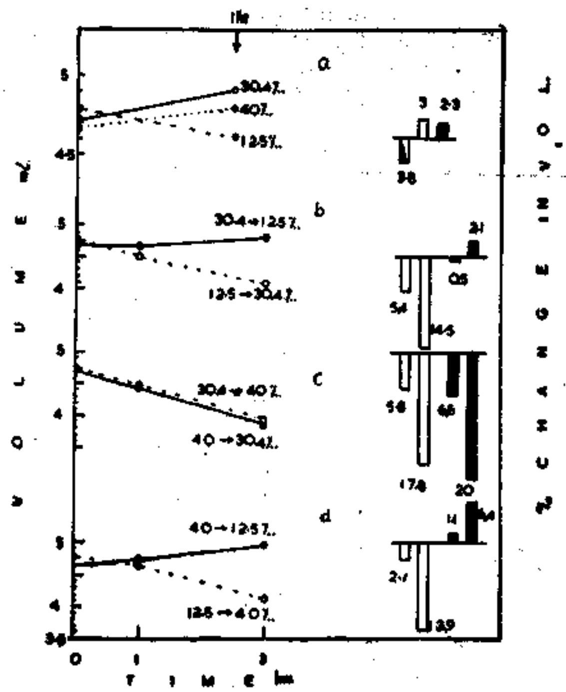

FIG. 3. Volume changes under identical conditions in which the density changes were measured are illustrated on the same plan as in Fig. 2.

(*b*) *From 30.4‰ acclimation to 40‰ and vice versa*.—In this case, Fig. 3c, there was no sign of any reciprocity and in both directions there was only a fall in the initial volume at the end of three hours and almost to the same extent, about 20%.

(*c*) *From 12.5‰ acclimation to 40‰ and vice versa*.—In this test the results showed that the same condition seen in (*a*) above was repeated but with the difference that the magnitude of change is proportionately greater. The fall in the volume in the first instance was 14% and the rise in the second instance was 6% at the end of three hours (Fig. 3*d*).

Acclimation Effect in Weight-Volume Relationship

The results of simultaneous measurements made to study the absolute effect of acclimation to the three salinities are presented in original form in Fig. 4, on a double logarithmic grid. The regression formulae obtained were:

$Y = 0.0169 + 0.9909x$ in 12.5‰ salinity;
$Y = 0.0241 + 0.9295x$ in 30.4‰ salinity (sea water) and
$Y = 0.0180 + 0.9391x$ in 40.0‰ salinity.

From the nature of the curves it could be seen that the weight-volume relationship for both the sea water and high salinity (40‰) acclimated fish are proportionately the same for all sizes in the range tested (2.5 to 5gm.) and that some divergence takes place in the case of fish acclimated to 12.5‰ salinity. In keeping with this difference, as is shown in Table I, the 5gm. fish does maintain an increased volume after prolonged acclimation to the lower salinity than it does in sea water and a slightly reduced volume in more concentrated water (40‰).

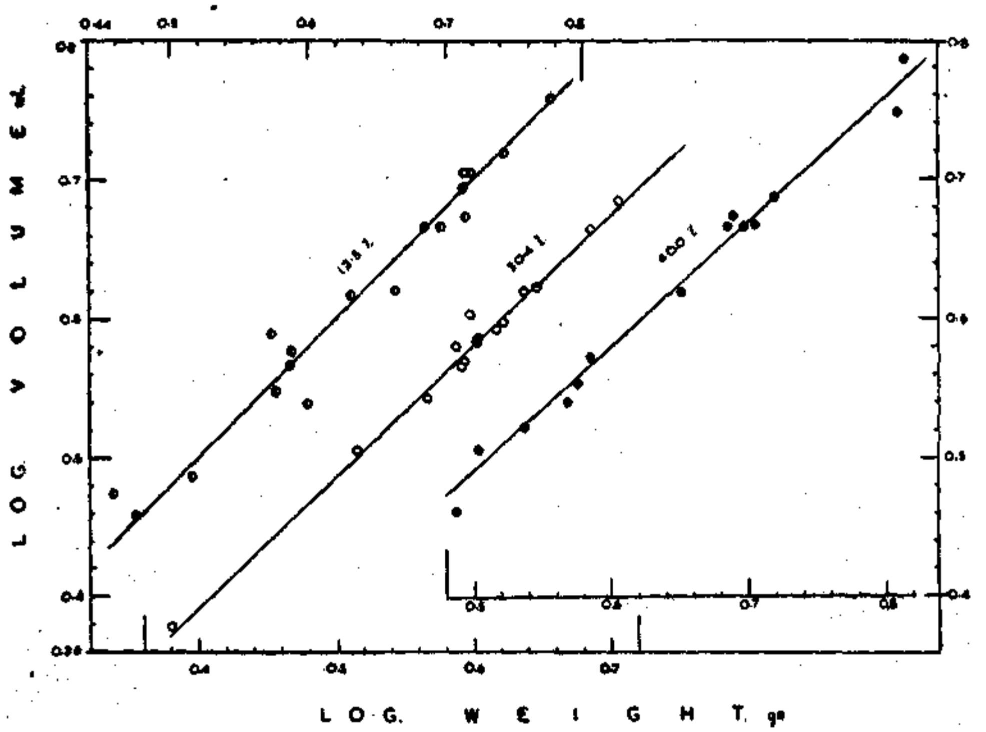

FIG. 4. Illustration of the weight-volume relationship under prolonged acclimation to salinities of 12.5, 30.4 and 40‰ (shaded circles, open circles and closed circles respectively). The curves in this double logarithmic plot were drawn on the principle of the sum of least squares.

DISCUSSION

The results presented agree to a limited degree, where comparison is possible, with Black's data (Black, 1951). The change in density on transfer from high to low salinity is much more rapid than in the opposite direction and is equally true of the volume changes also. But there appear to be exceptions to this as in the case of density change between 12.5 and 40‰ salinity acclimated fish. A similar exception also appears in the case of volume change as between 30.4 and 40‰ salinity acclimated fish. Black's results as well as those of Hukuda (1931), Gross (1954) and of the authors' in the present work, all seem to indicate that the differential effect of reciprocal changes between high and low salinity is due to a greater facility for water to enter inward of the animal than to leave it in the opposite direction.

It appears also from the results in the present work that in spite of prolonged acclimation this species is unable to maintain a volume independent of the environmental salinity even within the narrow viable range tested. Black observed that experiments in 50% sea water produced the least of casualties and that the fish appeared to do well in this medium. The same was the case in the present work as well and in a salinity of 12.5‰. The advantage of this particular medium to the fish had already been demonstrated in the earlier work (Job, 1959) wherein it was shown that there was a remarkable depression in the standard metabolism and that the fish was able to survive in such low concentrations of oxygen in the medium which level for fish held in sea water was lethal at the same temperature (29°C). Gross (1954) observed depression in the oxygen uptake rate, but both in 50% sea water and in 150% sea water. He explains that this is due to a permanent damage to the system on account of the extreme conditions of salinity. It is possible that such damage can occur. But from the results obtained with this species of teleost fish it appears that such damage must be ruled out at least in the case of 12.5‰, or nearly 50% sea water salinity. Post experimental observations revealed that fish transferred finally to 12.5‰ salinity survived and continued to live normally in all cases but not those treated otherwise.

Depression in metabolism can therefore take place with the onset of lethal effects of the adverse medium during the period of resistance when apparently the animal would be normal in appearance ; or else depression can take place in the metabolism because of some ionic changes in the environment. However it is of interest to note that damage in these circumstances is wrought in the alimentary tract of some animals as recorded by Beadle (1937 & 1957).

Summary

The changes in weight, volume and density of a marine catfish, *Plotosus anguillaris* (Bloch), of average weight of 5gm. acclimated to salinities of 12.5, 30.4 and 40‰ on abrupt transfer to different other salinities and within three hours of transfer, are recorded.

With a few exceptions the data indicate that there is greater facility for water to enter the fish body than to leave it and the change either in the density or in volume is relatively greater on transfer from high to low salinity than in the opposite direction in a 5 gm. fish.

Even after prolonged acclimation this species is unable to maintain a volume independent of the environmental salinity.

An instrument for measuring the volume of a small fish or other similar organism accurately, is described.

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