Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 91, Number 2, March 1982, pp. 143-152.

# Effect of salinity on the survival and growth of *Chanda* (=*Ambassis*) *gymnocephalus* (Lac.) fry (Pisces; Centropomidae)

J RAJASEKHARAN NAIR, N K BALASUBRAMANIAN and
N BALAKRISHNAN NAIR
Department of Aquatic Biology and Fisheries, University of Kerala,
Trivandrum 695 007, India

MS received 12 May 1981

**Abstract.** The survival and growth of *Chanda* (= *Ambassis*) *gymnocephalus* (Lac.) fry (8·8 ± 0·2 mm) collected from Murukumpuzha Lake (9·34‰) for a ninety day period in different salinity grades were studied. A faster rate of growth is exhibited by the fish in the highest salinity grades (22·41 and 28·51‰), even though during the first month, growth and health was apparently better in the lower salinity grades (4·11, 10·21 and 16·31‰). Assimilation efficiency also showed a similar gross picture. Thus in *C. gymnocephalus*, an euryhaline species, the fry show preferred salinity gradients for optimum growth within the fluctuating salinity regime at a stable temperature (26 ± 2° C) and hence may make salinity bound emigrations with growth.

**Keywords.** Salinity; growth efficiency; assimilation efficiency; satiation; *Chanda gymnocephalus*.

## 1. Introduction

*Chanda gymnocephalus* is an euryhaline glassy perchlet inhabiting the coastal waters and the estuarine and brackishwater tracts of Kerala. A shoal of fry (8·8 ± 0·2 mm) was collected from the shallow protected region of the Murukumpuzha lake (9·34‰) about 2 to 3 km away from the Perumathura bar-mouth (pozhi) which was open. According to Nair (1957) " *Ambassis gymnocephalus* spawns in coastal waters near the bar-mouth. Large quantities of the pelagic eggs spawned in the vicinity of the bar-mouth are passively carried into the lake by the strong tidal currents. Reaching the main body of the lake, these eggs and larvae drift into the shallow protected regions. " In order to understand the salinity preferences for growth and the salinity bound movements of the fry and early juveniles, the salinity tolerance and its effect on the growth pattern of the fry for a three month period under laboratory conditions were studied. Salinity preferences in emigratory movements of the presmolt coho salmon have been studied by Garrison (1965) in natural waters and by Otto and McInerney (1970) and Otto (1971) under laboratory conditions. There is also considerable field information (Canagaratnam 1959, 1966; Gunther 1961; Holliday 1971) and experimental evidence (Gibson and

Hirst 1955 ; Kinne 1960 ; Holliday 1971 ; Weatherly 1972) suggesting that growth and size of euryhaline fish are influenced by salinity.

## 2. Materials and methods

In about four to five weeks after hatching, the larvae reach a length of 8 mm (Nair 1957). Thus the fry were about 1–1·5 months old at the start of the experiment. Immediately on arrival at the laboratory, the fry were transferred into a large cement tank (4′ × 3′ × 3′) containing water of 10·21‰ at 26 ± 2°C for two days for acclimation. The salinity tolerance of the fry for a 48 hr period was studied in seven different grades (0·96, 4·11, 10·21, 16·31, 22·41, 28·51 and 31·56‰). At 31·56‰ (seawater) and 0·96‰ (wellwater) there was 70% and 30% mortality in 48 hr while there was no mortality in other grades. Therefore only the five salinity ranges (4·11 to 28·51‰) were chosen for the growth studies.

After the tolerance tests the shoal in the cement tank were divided into batches of 100 each and reared in five aquarium tanks (60 cm × 30 cm × 30 cm) in five different grades, while about 200 specimens were kept in the cement tank as control at 10·21‰. Once in the experimental tanks they were allowed a 12–18 hr period to acclimate. There was no mortality during this period. Feeding began the next morning and the fish were fed to satiation twice a day. For the first twenty days they were fed on *Artemia* nauplii and thereafter, till the end of the experiment on chopped tubifex worms (*Tubifex tubifex*).

At the end of every ten days (11, 21, 31,. . ., 91) five fish were collected at random (retarded individuals were discarded) and sacrificed for length and weight measurements and the average taken for each grade. Length measurements were made using a micrometer (up to 1/100th of a mm) and weight using an electric monopan balance (up to 1/100th of a mg).

At the end of every ten days (15, 25, 35,......, 85) the satiation amount, the amount of faecal matter excreted (in 24 hr) and the total weight of fish in each salinity grade were also measured for the rough estimation of digestibility ( = digestion coefficient) as given by Kapoor *et al* (1975) and dealt with in the present study as 'assimilation efficiency', and for the estimation of growth efficiency for each ten-day period.

$$\text{Assimilation efficiency} = \frac{A_{fa} \times 100}{A_{fe}},$$

(Digestibility)

where $A_{fa} = A_{fe} - A_{fm}$.

$$\text{Growth efficiency}_{10\ \text{days}} = \frac{A_{fa} \times G_{10}}{A_{fe}}$$

where $A_{fe}$ = amount of food eaten, $A_{fm}$ = amount of faecal matter excreted, $A_{fa}$ = amount of food assimilated, $G_{10}$ = growth in weight during the corresponding ten-day period.

The different salinity ranges were prepared by diluting seawater with wellwater making 10, 30, 50, 70 and 90% seawater and were maintained throughout the experimental period at ± 1‰. Salinities were determined using a salinometer. All experimental tanks were maintained at a water temperature of 26 ± 2° C and the oxygen kept at air saturation level using aerators every alternate day. The excess of food was removed within two hours of feeding. To inhibit the accumulation of metabolites and bacterial growth, water was changed every fifth day.

The salinity tolerance (48 hr) of a new stock of early juveniles (22–27 mm) collected from near the bar-mouth (pozhi) was also studied.

## 3. Results

The cumulative growth in length and weight are plotted against time (days) for the different salinities and the corresponding regression equations are given in figures 1 and 2. The regression equations are calculated using the least square method of analysis. The correlation coefficient values for cumulative growth in length and weight for the different salinities are given in table 1. All the values are significant at the 1% level. A faster rate of growth is exhibited by the fish in the highest salinities (22·41 and 28·51‰), even though during the first month growth and health were apparently better in lower salinities (4·11, 10·21 and 16·31‰).

Estimates of assimilation efficiency and growth efficiency are given in tables 2 and 3. Changes in growth pattern are clearly reflected in the growth efficiency changes with time (figure 3) and the corresponding regression equations are given.

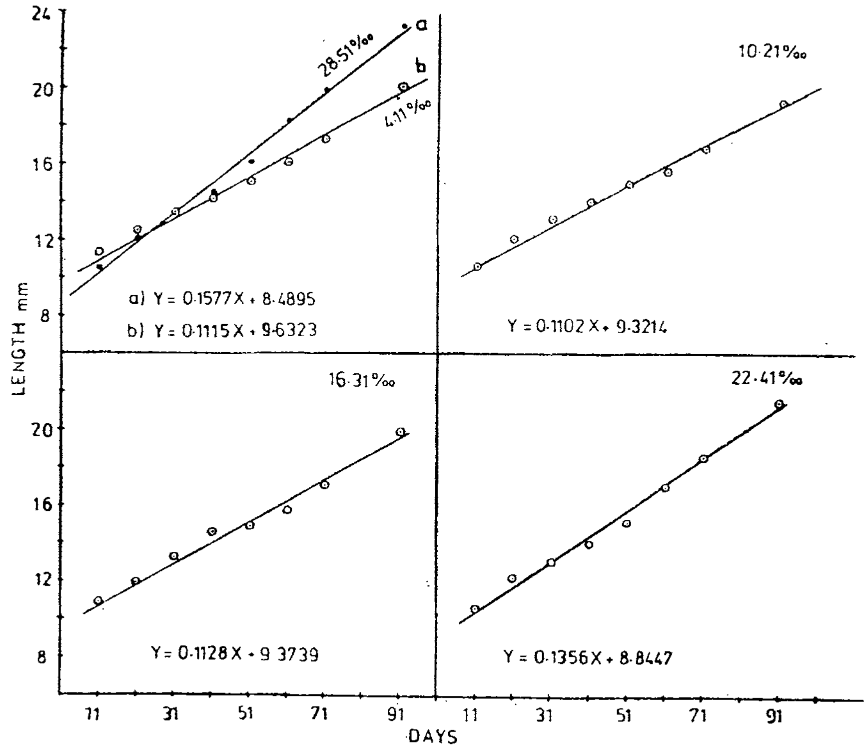

**Figure 1.** Regression lines and equations for growth in length in different salinities.

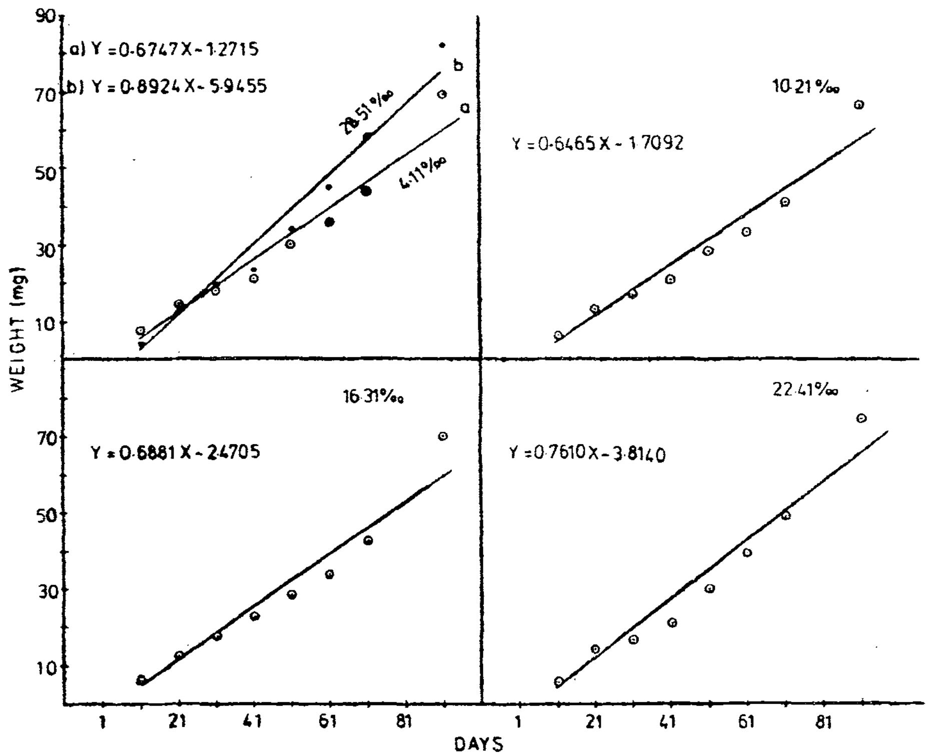

**Figure 2.** Regression lines and equations for growth in weight in different salinities.

**Table 1.** The correlation coefficient values for cumulative growth in length and weight.

| | Salinity (‰) | Correlation coefficient values | |
|---|---|---|---|
| | | Growth in length | Growth in weight |
| 1. | 4·11 | 0·9925 | 0·9716 |
| 2. | 10·21 | 0·9955 | 0·9725 |
| 3. | 16·31 | 0·9931 | 0·9695 |
| 4. | 22·41 | 0·9957 | 0·9735 |
| 5. | 28·51 | 0·9974 | 0·9765 |

In the initial stages better assimilation efficiency is shown by the lower salinities, but with growth higher salinity grades show greater efficiency as may be seen in figure 4. The estimates of the satiation amount, in percentage of fish wet weight, are presented in table 4.

In the control (10·21‰) the fish weight and length were 67·4 mg and 20·1 mm at the end of the experiment (66·2 mg and 19·44 mm for the experiment 10·21‰) showing that their growth was in no way inhibited.

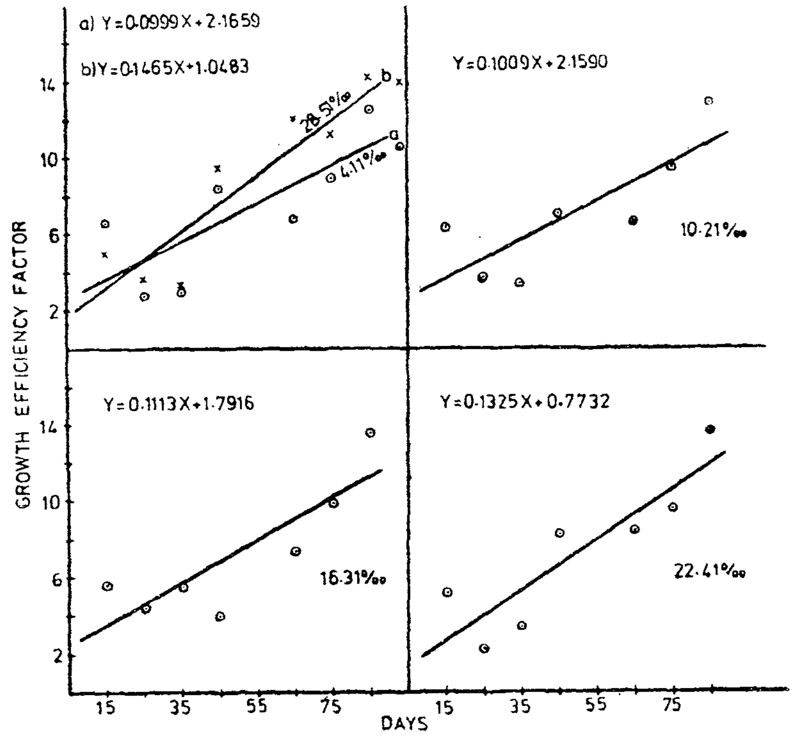

**Figure 3.** Changes in growth efficiency factor with time in different salinities.

The salinity tolerance range of the early juveniles was between 5·5‰ and 33·60‰ (figure 5).

## 4. Discussion

In order to analyse and understand growth phenomena, it is convenient to consider short growth periods or stanzas for arbitrarily defined time periods (Webb 1978).

For the initial three ten-day periods (one month), growth was inhibited in the two higher salinities of 22·41 and 28·51‰, whereas the three lower salinities had little effect on the growth, the fish showing uniform growth. Of primary interest in the series of experiments is the gradual maximisation of growth in the two higher salinities (22–29‰) and the gradual decline in the rate of growth for fish maintained at the two lower salinity grades (4–17‰). A precipitous decline in the rate of growth and growth efficiency at all salinity grades occurred during the 21–41 day period even though the assimilation efficiency was not affected. This may be due to the change in food from *Artemia* nauplii to chopped tubifex worms, since after this period growth rates picked up fast and then showed steady increase in all salinities especially in the two higher grades.

Corresponding to changes in growth rates, the growth efficiency in different salinities showed similar fluctuations (figure 3). In the initial stages, higher growth efficiency was shown by fish in the three lower salinities. Even though food

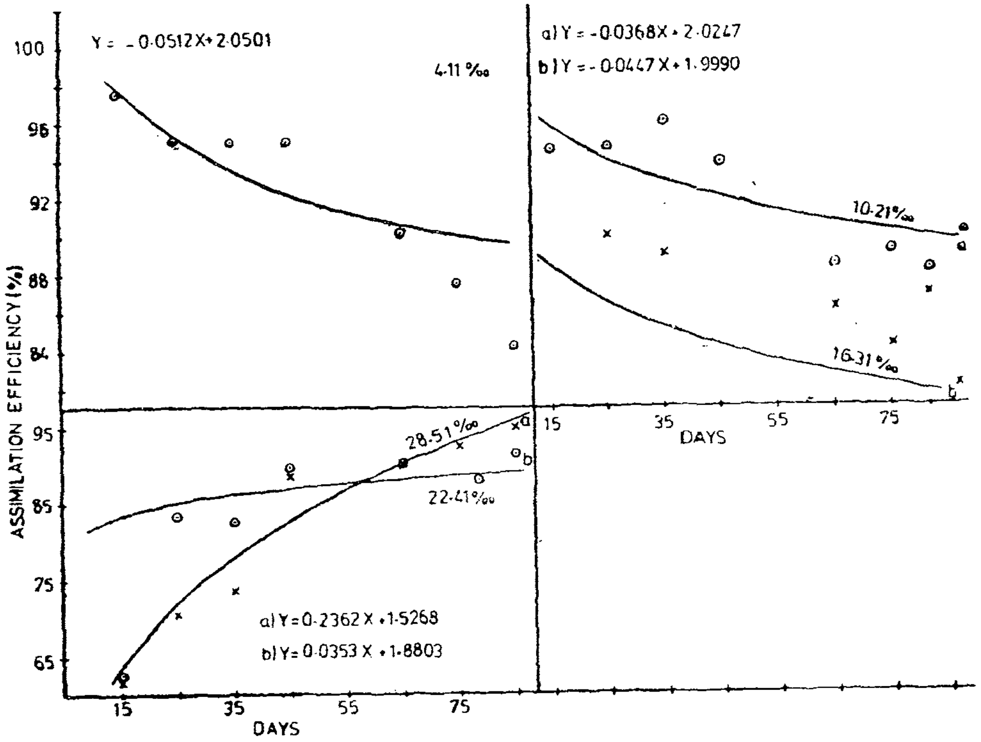

**Figure 4.** Changes in assimilation efficiency with growth in different salinities.

consumption was high in the higher grades at this time, the assimilation efficiency was as low as 62·5 % (22·41‰) and 61·3 % (28·51‰) whereas it was as high as 97·61 % (4·11‰) ; 94·66% (10·21‰) and 87·99% (16·31‰) during the 11–21 day period. But slowly the assimilation efficiency picked up in the higher salinities while the lower grades showed marginal decrease with time as is clearly brought out in figure 4. According to Paloheimo and Dickie (1966a,b) and Warren and Davis (1967) salinity may affect growth through its influence on food conversion efficiency and activity, which are important components of the bioenergetic budget of fishes, as is seen in the present study also. Also according to Webb (1978), "In general total food intake is greatest and metabolism smallest under least stress so that growth is then maximal", as is seen in the lower salinities during the initial stages and in the higher grades with acclimation and passage of time.

Another interesting aspect was the schooling behaviour of the fry. In the higher salinities during the initial stages of the experiment the fish were scattered as individuals but with passage of time formed loose-knit shoals and by the 41–51 day period were shoaling well and behaving as a unit. In the lower salinity grades the fry were shoaling well from the initial period of introduction but tended to scatter in the later stages. From the fluctuations in the assimilation efficiency it may be noted that schooling tend to reduce metabolism. Parker (1973) has made similar observations in the case of 21 species of fish. According to Weihs (1973) schooling appears to exert a 'calming' effect and there may be further hydrodynamic energy

**Table 2.** Changes in assimilation efficiency with growth in different salinities.

| Time (days) | 4·11‰ | 10·21‰ | 16·31‰ | 22·41‰ | 28·51‰ |
|---|---|---|---|---|---|
| 15 | 97·61% | 94·66 | 87·99 | 62·50 | 61·38 |
| 25 | 95·17 | 94·74 | 89·97 | 83·77 | 70·33 |
| 35 | 95·10 | 96·01 | 89·02 | 82·72 | 73·63 |
| 45 | 95·00 | 93·88 | 73·79 | 89·62 | 88·68 |
| 65 | 90·36 | 88·48 | 86·13 | 89·03 | 90·14 |
| 75 | 87·54 | 89·07 | 84·13 | 87·96 | 92·46 |
| 85 | 85·15 | 88·02 | 86·75 | 91·78 | 95·00 |

**Table 3.** Changes in growth efficiency with time in different salinities.

| Period | 4·11‰ | 10·21‰ | 16·31‰ | 22·41‰ | 28·51‰ |
|---|---|---|---|---|---|
| 11–21 | 6·74 | 6·44 | 5·65 | 5·25 | 4·94 |
| 21–31 | 2·68 | 3·79 | 4·50 | 2·22 | 3·69 |
| 31–41 | 2·95 | 3·41 | 5·60 | 3·43 | 3·39 |
| 41–51 | 8·55 | 7·09 | 4·02 | 8·33 | 9·44 |
| 61–71 | 6·82 | 6·72 | 7·45 | 8·59 | 11·99 |
| 71–81 | 9·10 | 9·53 | 9·97 | 9·61 | 10·17 |
| 81–91 | 12·68 | 12·94 | 13·75 | 13·70 | 14·25 |

**Table 4.** Changes in satiation as percentage of wet body weight with growth in different salinities.

| Time (days) | 4·11‰ | 10·21‰ | 16·31‰ | 22·41‰ | 28·51‰ |
|---|---|---|---|---|---|
| 15 | 26·48 | 31·57 | 29·05 | 29·58 | 38·41 |
| 25 | 32·43 | 32·29 | 29·88 | 30·00 | 34·88 |
| 35 | 31·90 | 34·80 | 35·54 | 37·98 | 46·52 |
| 45 | 31·17 | 34·95 | 35·57 | 34·64 | 45·18 |
| 65 | 33·36 | 27·61 | 36·05 | 43·98 | 56·55 |
| 75 | 35·16 | 26·00 | 48·48 | 52·55 | 57·39 |
| 85 | 34·42 | 26·53 | 48·85 | 53·16 | 58·05 |

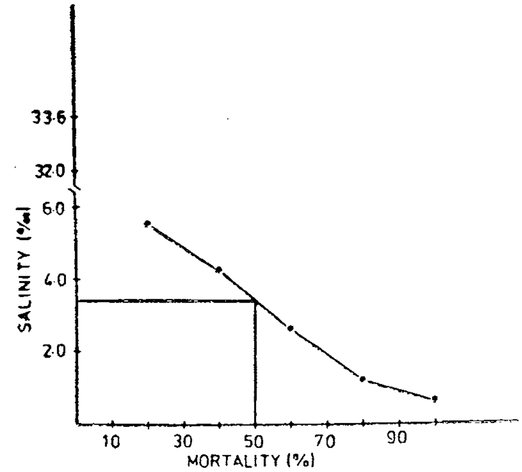

**Figure 5.** 48 hr mortality rates of juveniles in different salinities.

economics. However, the 'size hierarchy' of Brown (1957) or 'growth depensation of Ricker (1958), i.e., dominant fish tend to monopolise food and show better growth, even though apparent, was not taken into account in the present study since the fish showing retarded growth were discarded from the growth studies.

The satiation amount as percentage of wet body weight (3·2–84·3 mg) ranged from 26·48%–58·05% for the 91-day experiment period at 26 ± 2° C. Davis and Warren (1968) found young chinook salmon *Onchorhynchus tshawytscha* (0·6 g) would consume 20% body weight/day and Krivobok (1953) as cited by Winberg (1956) obtained daily rations as high as 54% dry weight in very young carp (0·016 g). Brett (1971) computed a daily intake of 30% dry weight at 15° C for one gram sockeye fry.

By the time the fry reach a length of about 17–18 mm they move towards the main body of the lake (Nair 1957). In the present study, by the time the fry reach this length (61 days), the fish show much better growth in the two higher salinities and better shoaling habits too and hence may start moving up the lake towards the bar-mouth seeking the optimum salinity gradients in the niche. The capture of early juveniles (22–27 mm) and their salinity tolerance level (5·5–33·6‰) strengthen the above conclusion.

Using the regression formula for growth in length in the 28·51‰ ($Y = 0 \cdot 1577 X + 8 \cdot 4895$), the fish may reach a length of about 6·6 cm during the 0–1 year period and about 4·8 cm in 7–8 months time. Thus the 0-year class individuals of the species mainly contribute to the annual fishery in the estuaries as also noted by Nair (1957) and Raman *et al* (1975) and start breeding towards the end of the 0–1 year period. It is also quite possible that with their increased preferences to higher salinities with growth, the adult fish may escape into the sea when the bar-mouth is open contributing to the marine stock. Nair (1957) and Raman *et al* (1975) have noted the seaward migration of this species and Raman *et al* report that the adult fish migrate to the sea and grow to larger sizes there.

Thus in *C. gymnocephalus* an euryhaline species, the fry show preferred salinity gradients for optimum growth within the fluctuating salinity regime at a stable temperature of 26 ± 2° C in the laboratory, while similar salinity bound emigrations have been noted in the natural waters by other workers.

## Acknowledgement

One of the authors (JRN) is grateful to the Council of Scientific and Industrial Research for the award of a Junior Research Fellowship during the tenure of which this work was carried out.

## References

Brett J R 1971 Satiation time, appetite and maximum food intake of sockeye salmon (*Onchorhynchus nerka*); *J. Fish. Res. Bd. Canada* **28** 409–415

Brown M E 1957 Experimental studies on growth ; In *The Physiology of Fishes* (ed.) M E Brown (New Yark: Academic Press) **1** 361–400

Canagaratnam P 1959 Growth of fishes in different salinities ; *J. Fish. Res. Bd. Canada* **16** 121–130

Canagaratnam P 1966 Growth of *Tilapia mossambica* Peters in different salinities ; *Bull. Fish. Res. Sta. Ceylon* **9** 47–50

Davis G E and Warren C E 1968 Estimation of food consumption rates ; in IBP Handbook No. 3 *Methods for assessment of fish production in freshwaters* (ed.) W E Ricker (Oxford : Blackwell Scientific Publication) pp. 204–225

Garrison R L 1965 Coho salmon smolts in ninety days ; *Prog. Fish-Cult.* **27** 219–230

Gibson M B and Hirst B 1955 The effect of salinity and temperature on the preadult growth of guppies ; *Copeia* **3** 241–243

Gunther 1961 Salinity and size in marine fishes ; *Copeia* **2** 234–235

Holliday F G T 1971 Salinity-Fishes ; In *Marine ecology* (ed.) O Kinne (New York : John Wiley) Vol. **1** Part II pp. 997–1083

Kapoor B G, Smith H and Verighina I A 1975 The alimentary canal and digestion in Teleosts in *Advances in Marine Biology* (eds.) F S Russel and Sir M Yonge (London: Academic Press) **13** 109–239

Kinne O 1960 Growth, food intake and food conversion in a euryplastic fish exposed to 2 different temperatures and salinities ; *Physiol. Zool.* **33** 288–317

Nair G S 1957 On the breeding habits and development of *Ambassis gymnocephalus* (Lac.) ; *Bull. Cent. Res. Inst. Univ. Travancore* **5** 69–76

Otto R G 1971 Effects of salinity on the survival and growth of presmolt coho salmon (*Onchorhynchus kisutch*) ; *J. Fish. Res. Bd. Canada* **28** 343–349

Otto R G and McInerney J E 1970 The development of salinity preference in presmolt coho salmon (*Onchorhynchus kisutch*) ; *J. Fish. Res. Bd. Canada* **27** 793–800

Paloheimo J E and Dickie C M 1966a Food and growth of fishes. II Effect of food and temperature on the relation between metabolism and body weight ; *J. Fish Res. Bd. Canada* 23 869–908

Paloheimo J E and Dickie L M 1966b III. Relation among food, body size and growth efficiency ; *J. Fish. Res. Bd. Canada* **23** 1209–1248

Parker F R 1973 Reduced metabolic rates in fishes as a result of induced schooling : *Trans. Am. Fish Soc.* **102** 125–131

Raman K, Kaliyamurthy M and Rao G R M 1975 Studies on the biology of *Ambassis gymnocephalus* (Lac.) from Pulicat and Vembanad lakes ; *Matsya* **1** 49–52

Ricker W E 1958 Handbook of computations for biological statistica of fish populations ; *Fish. Res. Bd. Canada Bull.* **119** 1–300

Warren C E and Davis G E 1967 Laboratory studies on the feeding bioenergetics and growth of fish ; In *The biological basis of freshwater fish production* (ed.) S D Gerking (London : Blackwell Scientific Publications) pp. 175–214

Weatherly A H 1972 *Growth and ecology of fish populations* (London and New York : Academic Press) p. 293

Webb P W 1978 Partitioning of energy into metabolism and growth ; in *Ecology of freshwater fish production* (ed.) S D Gerking (London : Blackwell Scientific Publications) pp. 184–214

Weihs D 1973 Hydrodynamics of fish schooling ; *Nature* (*London*) **241** 290–291

Winberg G G 1956 Rate of metabolism and food requirements of fishes ; Belorussian State University Minsk *Fish Res. Bd. Canada Transl. Ser. No.* **194** (1960) p. 251