GROWTH AND PRODUCTION POTENTIAL OF YOUNG GROUPER *EPINEPHELUS TAUVINA* (FORSKÅL) REARED IN FIXED NET CAGES

ABSTRACT

Growth of *Epinephelus tauvina* was studied in the fixed cage culture system in Mandapam (Gulf of Mannar) coastal waters employing net cages of 5×5×2 m dimension made of HDPE net material with 20 mm mesh size. The fishes were fed with trash-fish once in 2 days and the culture period varied from 163 days to 334 days. The average growth increment in length was 145.5 mm in 8.71 months at the rate of 16.3 mm/month and the average growth increment in weight was 413.9 g at the rate of 47.5 g/month. The basic growth data were subjected to various statistical analysis and different parameters have been estimated. The asymptotic growth L_{∞} is 671 mm, the growth constant K is 0.4619 and the age at 0 length t_0 is assumed to be 0. The life span is estimated to be 10.7 yrs and the natural mortality coefficient M is 0.4333 at 1% survival level. The optimum age for harvesting is estimated to be 3 yrs and the optimum culture period which can yield the highest production for this species is 28 months for the prevailing age at stocking of 8 months. The cost and return of this culture technique is also discussed.

IN FINFISH culture, rearing of selected species in restricted locals or physical enclosures such as fixed and floating cages within a natural expanse of water like sea, lake, etc. is gaining importance and wide usage in view of its inherent advantages. In recent years, this method has been widely used by several countries apart from Southeast Asian countries where this is practised for the past several decades (Hamsa, 1983). In Malaysia, culture of estuarine groupers (*Epinephelus salmoides* Maxwell) in floating net cages is carried out by many fish farmers commercially on a small-scale (Chua, 1973; Chua and Teng, 1977).

The groupers being different from other cultivable species such as mullets, *Chanos*, etc. in their behaviour and mode of feeding and in order to assess their suitability for cage culture, a research project on the fixed and floating net cages was initiated at Mandapam in 1984. Present account deals on the growth and production potentials of the grouper *Epinephelus tauvina* (Forsskal) reared in fixed net cages.

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Materials and methods

Experimental fish: Juveniles of *Epinephelus tauvina* (Pl. I A) in the size range 139-250 mm were collected alive from drag net operations and special perch-traps. They were initially maintained and fed on trash fish in the wet laboratory for a minimum period of 2-3 weeks before stocking in the fixed net cages.

Culture cages: Net cages of 5 × 5 × 2 m dimension were fabricated with HDPE net material with mesh size of 20 mm. The cages were fixed in shallow waters of 2 m depth near C.M.F.R.I. jetty in the Gulf of Mannar with the help of casuarina poles which were coated with Kriside to minimise fouling. The cages were tied to the poles errected at a distance of 3 m, in such a manner that the

bottom of the net was just about 40-50 cm above the sea bed (Pl. I B). A 70 m long bridge constructed with casuarina and bamboo poles alongside the cages, served as working platform at the time of sampling, feeding and other maintenance work. The poles and net cages were cleaned periodically in order to minimise the fouling mostly by algae and barnacles. The stocking rate was 100 fish/cage and the fish were periodically measured and weighed while changing the net cages.

Food and feeding : The groupers were fed with chopped trash fish at a rate of 10% of their body weight at 48 hours frequency, *i.e.* once in 2 days as recommended by Chua and Teng (1978). They experimentally proved that optimal growth, good food conversion and higher survival rate were obtained in grouper cultured in net cages fed to satiation with one feeding in 2 days. The trash fish used as food were mostly low cost fishes landed by mechanised trawlers as by-catch.

Results and discussion

In all four experiments were carried out during 1984 and the growth data are given in Tables 1-5. It may be seen that after a period of 334 days, the fishes reared in cage 1 have attained average length of 363 mm and average weight of 770 g from the initial

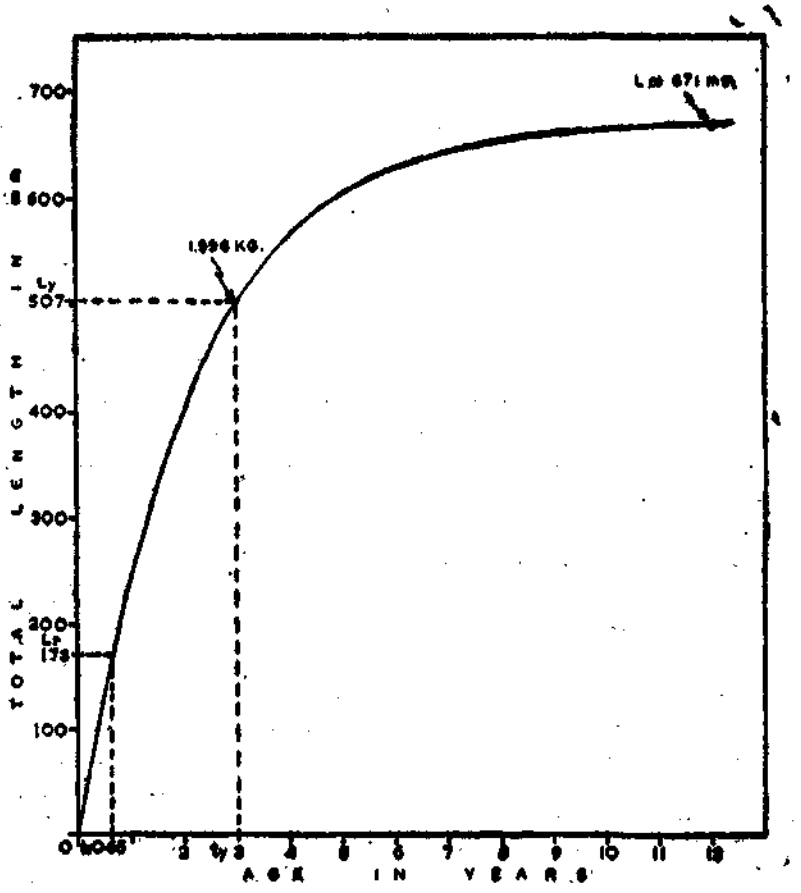

FIG. 1. Growth curve of *E. tauvina* as per the growth parameters obtained from the culture experiments. The age at recruitment into the culture system 'tr', the corresponding length at recruitment, optimum age for harvesting and the corresponding size are indicated.

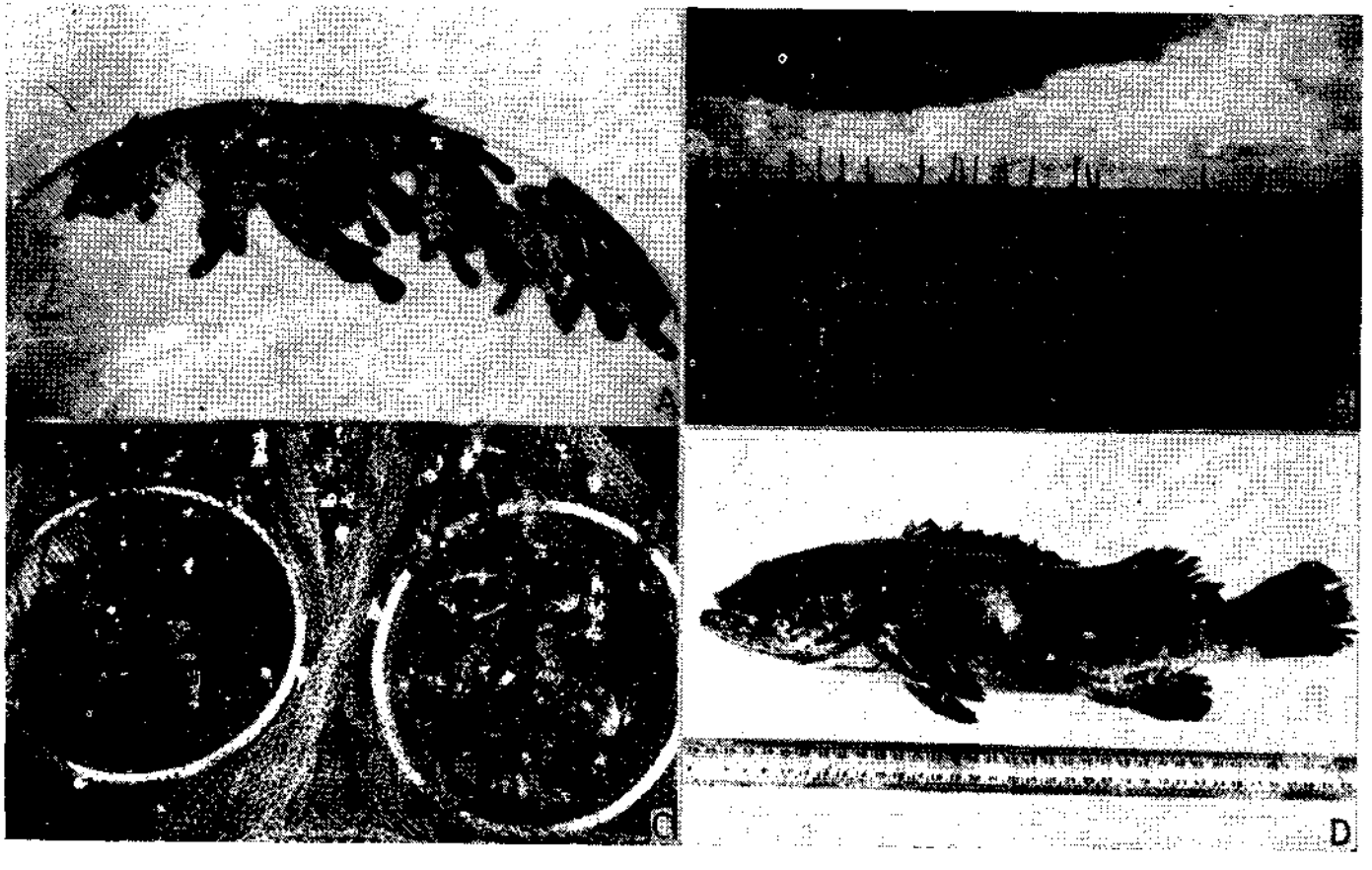

PLATE I A. Juveniles of the grouper *Epinephelus tauvina*, B. Fixed net cage in the sea, C. A portion of harvested *E. tauvina* and D. *E. tauvina* at harvest.

average stocking size of 184 mm and average weight of 92 g with growth rate of 16.4 mm and 61.9 g per month (Table 1). In experiment 2 the fish have grown from 179 mm and 102 g to 265 mm and 288 g at the rate of 16.1 mm and 34.8 g/month in a duration of 163 days (Table 1) and the growth in experiment 3 was from 190 mm and 97 g to 335 mm and 521 g at the rate of 17.1 mm and 50.1 g/month in 258 days (Table 1), whereas in experiment 4 the growth was from 139 mm and 42.5 g to 295 mm and 410 g in 307 days at the growth rate of 15.5 mm and 63.5 g/ month (Table 1). The survival was 97%, 92%, 90% and 79.1% in these 4 experiments respectively.

TABLE 1. *Growth in length and weight of* Epinephelus tauvina *reared in fixed net cages for different duration of time at Mandapam during* 1984

Experimental Cages	Duration of Expt. (months)	Growth increment in mm	Growth rate mm/month	Growth increment in g	Growth rate g/month
1 ..	10.95	179.0	16.4	678.0	61.9
2 ..	5.34	86.0	16.1	186.0	34.8
3 ..	8.46	145.0	17.1	424.0	50.1
4 ..	10.07	156.0	15.5	367.5	36.5
Mean ..	8.71	141.5	16.3	413.9	47.5

The data on the mean length at starting of the culture experiment (L_1), at harvesting (L_2) and growth increment (mm/day) were subjected to further analysis to obtain the asymptotic growth $L\infty$ as per the method of Gulland and Holt (1959) and the growth constant K from the relation $K = \frac{y}{(L\infty - \bar{x})}$ and the results are shown in Table 6. The $L\infty$ is estimated to be 671 mm and the growth constant K 0.4557. In addition to this the average length $\bar{L}$ and growth rate were regressed to obtain 4 sets of growth parameters $L\infty$ and K. Another set of $L\infty$ and K were obtained from the average $\bar{L}$ and growth rate as shown in Table 3. All these estimates were summarised in Table 4 to obtain the average values of different parameters as detailed below.

Assuming in nature that the survival is one per cent among the population of this grouper when they attain a length of $L\infty - 0.5$ cm, the T_{max} is obtained using

$$\frac{Ln\left(1 - \frac{L\infty - 0.5}{L\infty}\right)}{-K} = t - t_0$$

and employing the relation $N_t/N_0 = 0.01 = e^{-MT}$ an estimate of natural mortality 'M' is arrived at as per the example $L\infty$ 692, K 0.4739.

$$T_{max} = \frac{Ln\left(1 - \frac{687}{692}\right)}{-0.4739} = 10.4 \text{ yrs.}$$

$N_{11}/N_0 = 0.01 = e^{-10.4M}$ and $M = 0.4428$ at 1% survival. The mean length at entry (L_r) into the culture experiment 1 is 194 mm and the age is 0.6522 yr. For this study the age at 0 length *i.e.* t_0 is taken as 0 as t_0 is always close to 0 in most cases. The optimum age of exploitation t_y and the potential yield per recruit Y' have been estimated as per Krishnan Kutty and Qasim (1968). The asymptic growth

in weight Wcc have been estimated from the length weight relationship equation :

Log W = — 4.5817 + 2.9130 Log L wherein the length in mm and weight in g (Table 4).

$L_t = 671\ [1-e^{-3\,4619\ (t+t_o)}]$ wherein t_o is assumed to be zero. The growth curve obtained from the estimated values as per the above said equation is given in Fig. 1 wherein the length at recruitment into the

TABLE 2. *Length at starting of culture experiment (L_1), length at termination of the experiment (L_2), average length (L) and growth rate of* Epinephelus tauvina *reared in fixed net cages. The asymptotic growth L_∞ is estimated to be 671 mm by regressing L on the growth rate as per Gulland and Holt* (1959). *The estimates of K were obtained from the relation*

Experimental Cages	L_1 (mm)	L_2 (mm)	$\bar{L}$ (mm) $\bar{X}$	Duration (days) $\bar{Y}$	Growth rate in mm/day	K (Annual)
1 ..	184	363	273.5	334	0.5359	0.4921
2 ..	179	265	222.0	163	0.5276	0.4289
3 ..	190	335	262.5	258	0.5620	0.5022
4 ..	139	295	217.0	307	0.5081	0.4085
Mean ..	173	314.5	243.75	265.5	0.5334	0.4557

TABLE 3. *Estimates of L_∞ and K from the average length ($\bar{L}$) and average growth rate taken from 4 experiments.*

Experimental Cages	Average length $\bar{L}$ in mm	Average growth rate mm/day	L^∞ (mm)	K (annual)
1 ..	279.4	0.5352		0.5669
2 ..	228.7	0.5275		0.4871
			624	
3 ..	258.4	0.5744		0.5735
4 ..	220.0	0.5059		0.4571
Mean ..	246.1	0.5348		0.5165

The average of all these parameters obtained from the 4 experiments have been taken as the reliable estimate and based on this the growth of *E. tauvina* may be expressed as per von Bertalanffy growth equation as followed :

culture system *i.e.* L_r 173 mm and the age t_r 0.6470 year are indicated along with the optimum age of harvesting *i.e.* t_y 3.0 years and the length L_y 507 mm. This is to say that the *E. tauvina* measuring 173 mm aged

8 months and weighing 87 g may be reared to attain a length of 507 mm and weight of 2.0 kg in 28 months. It is desirable to harvest this species when they are 3.0 years old as the yield per recruit of this species estimated to be the highest at this stage, *i.e.* 703 g and this tends to decline in ages either higher or lower than 3.0 years.

Table 4. *Estimates of various parameters obtained from the net cage culture experiments*

Parameters		Expt. 1	Expt. 2	Expt. 3	Expt. 4	Data from Table 6	Data from Table 7	Average
L_∞ (mm)	..	692	675	687	674	671	624	671
K (Annual)	..	0.4739	0.4314	0.4869	0.4068	0.4557	0.5165	0.4619
T_{max} (yr.)	..	10.4	11.4	10.1	12.1	10.8	9.4	10.7
M1% (survival)	..	0.4428	0.4040	0.4560	0.3806	0.4264	0.4899	0.4333
tr (yr)	..	0.6522	0.7143	0.6649	0.5677	0.6543	0.6286	0.6470
ty (yr)	..	2.9865	3.2768	2.9031	3.4766	3.1034	2.7181	3.0774
Ly (mm)	..	524	511	520	510	508	471	507
Wy (g)	..	2,186	2,032	2,138	2,020	1,998	1,603	1,996
Y' (g)	..	778	721	770	668	703	575	703
W_∞/(g)	..	4,915	4,572	4,812	4,552	4,493	3,636	4,497

Yaman (1982) reported a growth of 0.6 kg per fish in 10-12 months in the case of grouper (*Epinephelus* spp.) fed extraneously with trash fish. Lee (1982) recorded the growth in *Epinephelus tauvina* from 100 g to 600-800 g in 6-8 months in net cages floated in Singapore coastal waters. Lanjumin (1982) obtained a growth of 600-700 g/fish from 150-200 g in 5-6 months in *E. tauvina* cultured in the floating net cages in Indonesian coastal waters. In the present study, the growth rate of *E. tauvina* cultured in fixed net cages in Indian conditions is significant and comparable with elsewhere.

At Mandapam (Gulf of Mannar) the culture period could not be extended beyond 11 months as the culture cages are exposed to the fury of strong southwest monsoon wind from June to September every year. A part of the net cages and supporting wooden structruers were uprooted during this study. In order to extend the culture period, two alternatives are available (*a*) artificial breakwater may be provided to protect the cages from wind and wave action during monsoon or (*b*) cage culture may be carried out in relatively calm area. Otherwise this work can be carried out only during October to April at Mndapam and during monsoon period intensive seed collection work may be carried out in addition to the preparatory work for the ensuing season for cage culture.

The other problem is the settlement of fouling organisms on the net cages and wooden structures. The net cages suspended in the coastal waters of the Gulf of Mannar were found infested mostly by algae and smaller bivalve molluscs. The casuarina poles on the other hand had only barnacles as foulers. The cages and other supporting structures were periodically cleaned to control the fouling organisms. The problems of fouling in cage fish culture have been discussed in detail by Milne (1972, 1979).

The economics of rearing *Epinephelus tauvina* in a fixed net cage worked out is given in

Table 5. The operational cost of a single cage of 5 × 5 × 2 m size was Rs. 3,750 and the value of fish harvested in a crop was Rs. 5,760. The net profit out of a single harvest after a period of eleven months was Rs. 2,010. The method is simple and economically viable and can be easily adopted by the fish farmers. When the culture period is extended to 28 months instead of 11 months, the total expenditure is Rs. 6,455, gross income is 14,400 and the net income is Rs. 7,945 which works out to an annual income of Rs. 3,405 against Rs. 2,193 per annum of 11 months.

TABLE 5. *Estimated cost and return outlay of a single 5 × 5 × 2 m fixed net cage for a culture period of 11 months presenty employed and proposed culture period of 28 months*

	Culture period 11 months	Culture period 28 months
A. Operational expenses :	Rs.	Rs.
Cost of palmyrah poles (8 Nos.) ..	200	200
Cost of net material including fabrication charges ..	1,500	1,500
Cage installation charges ..	100	100
Cost of Seeds 400 Nos @ Rs. 0.5/seed ..	200	200
Cost of feed (Trash fish) ..	650	1,655
Labour charges for feeding and maintenance ..	1,100	2,800
Total ..	3,750	6,455
B. Gross Income :		
Sale of 360 Nos. (assuming a survival rate of 90%) of marketable fish weighing 750-800 g each @ Rs. 20 per kg (after 11 months) ..	5,760	—
Sales of 360 Nos. of fish weighing 2.0 kg each @ Rs. 20 kg (after 28 months).	—	14,400
C. Net Income ..	2,010	7,945
D. Net Income per annum ..	2,193	3,405

From the recent findings it is evident that the fishes of *Epinephelus tauvina* are highly suitable for cage culture as their growth and survival rates are found to be good. The availability of grouper seeds also indicates the possibility of planning and developing cage culture into a viable small-scale commercial farming in the cosatal areas around Mandapam where the young groupers occur in fairly good numbers.

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EFFECTS OF DIFFERENT PHOTOPERIODS ON DIATOMS *THALASSIOSIRA FLUVIATILIS* AND *SKELETONEMA COSTATUM*

ABSTRACT

Effects of different photoperiods on growth of *Thalassiosira fluviatilis* and *Skeletonema costatum* revealed that both the species preferred longer duration of light for their maximum growth. The growth of *T. fluviatilis* was higher than that of *S. costatum* in different photoperiods. In *T. fluviatilis* maximum growth was observed at continuous light (24 hrs) and in *S. costatum* at 20.4 LD cycles. Short term exposure to light like 8 and 6 hrs did not enhance good growth in both the species.

LIGHT is one of the significant physical parameter that controls the productivity of the aquatic ecosystem and responsible for the temporal variability in local production. The neritic species might be adapted to utilize the light that occurs for only short periods of time (Harris and Piceinin, 1977). Studies on the effects of photoperiod on unicellular algae have been made by Paasche (1967, 1968), Hobson (1974), Admirral (1977), Nelson and Brand (1979), Chisolm and Brand (1981) and Brand and Guillard (1981). The present work deals with the effects of various photoperiods on growth of two centric diatoms *Thalassiosira fluviatilis* and *Skeletonema costatum*.

Material and methods

Thalassiosira fluviatilis and *Skeletonema costatum* were isolated by single cell isolation method from phytoplankton samples collected from the mouth region of the Vellar Estuary (11°29'N; 79°49'E). Unialgal culture of *T. fluviatilis* and *S. costatum* was grown in F/2 medium (Guillard and Ryther, 1962) under 3000 lx continuous light at 30‰ (Temp) 28±2°C, pH 7±0.5). During preliminary study, 3000 lx light intensity was found to promote maximum growth of *T. fluviatilis* and *S. costatum*. The different durations were determined by running the experiments at various exposure periods to light.