J. mar. biol. Ass. India, 1990, 32 (1 & 2) : 129-141

POPULATION DYNAMICS OF *TACHYSURUS DUSSUMIERI* IN NORTH KERALA*

N. GOPINATHA MENON, V. N. BANDE AND K. BALACHANDRAN
Central Marine Fisheries Research Institute, Cochin 682 031

ABSTRACT

The paper presents the results of the study on age and growth of *Tachysurus dussumieri* from North Kerala Coast with particular emphasis on population dynamics. The recruitment pattern, stock position, mortality and yield per recruit studies indicated that the resource is at present under heavy fishing pressure. The influence of climatological, hydrological and water movements were understood and their effect was found from the fact that the fishery was mainly concentrated along the shallow coastal waters upto a depth of 70 m. The impact of mechanisation on the fishery causing heavy damage to the brooders with eggs/embryo, was critically analysed and suggestions and measures enumerated. It is suggested that the situation can be overcome by reducing fishing pressure or by extending the area of operation to midshelf as well as intensifying the hooks and line efforts along the existing fishing limits.

INTRODUCTION

THE DEMERSAL resources of Indian waters are well represented by marine catfishes of the family Tachysuridae which account for about 10% of the total demersal fish resources of the country. Among the four species of economic importance, *Tachysurus dussumieri* contributes about 30% of the total catfish catch of Kerala. This species forms large shoals and migrate both in vertical and horizontal directions depending on the phase of its life history and also on several environmental parameters. Prior to the introduction of mechanised trawlers and purse seiners, this resource was largely tapped by indigenous gears such as hooks and line, drift and bottom set gill nets, small boat seines, shoreseines, etc. with a steady catch. This coastal fishery is mainly dependant on climatic conditions and monsoon, which usually influence surface temperature, salinity, dissolved oxygen, water clarity, nutrients, etc. These factors usually regulate either the fish migration or restrict the artisanal fishermen to venture far out with their conventional craft and gear to exploit the resource along the mid and outer shelf. The introduction of mechanisation, though it has overcome these climatic limitations to certain extent, brought in several new problems regarding the sustainability of various stocks and catfish is one among them. Though there was an initial spurt in production due to mechanisation by trawlers and purse seiners for the past few years, substantial decline was noticed in the catches of recent years. The problem was further compounded by several instances of mass destruction of incubating catfishes and thereby causing enormous destruction of the young ones (Silas *et al.*, 1980; Dhulkhed *et al.*, 1982). In view of the enormity of the problem, attempts were made to study the population dynamics of one of the important species of catfish *T. dussumieri* relatively a larger member of the family Tachysuridae from North Kerala. Though

* Presented at the 'Symposium on Tropical Marine Living Resources' held by the Marine Biological Association of India at Cochin from January 12-16, 1988.

T. dussumieri is an esteemed fish occurring abundantly all along the coasts of India, there is a wide gap in the knowledge of its biology, migration, vital population parameters, population structure and catch and effort relationships, normally required for evaluating the resource. Attempts were made to study the various biological parameters of this species in relation to its fishery. The main purpose is to scientifically assess the status of *T. dussumieri* stock in the waters off North Kerala. So far there are not many publications on the population dynamics of commercially important tachysurid catfishes, except that of Dan (1981) on the mortality rate and yield per recruit of *T. tenuispinis* from the North-east coast of India and the stock assessment of some of the commercially important catfishes from selected centres (Anon., 1987). There are also some informations on the food habits and maturity and spawning of this species (Venkataraman, 1960 ; Suseelan and Nair, 1969 ; Menon, 1979 ; Vasudevappa and James, 1980).

The present investigation on the biology and fishery of this species was initiated in 1979 and all informations available till 1984 have been incorporated in this account to assess the stock position and future potential of the species along North Kerala, with the view to have a better understanding for forecasting and management of the fishery.

The authors are grateful to Dr. P. S. B. R. James, Director, Central Marine Fisheries Research Institute and Shri C. Mukundan, C.M.F.R.I., Cochin for their guidance and encouragement. Thanks are also due to Shri M. Srinath, for statistical consultations.

Data Base and Estimation of Parameters

The data base was the coastal waters off Calicut, where hooks and line, drift net and trawl-net fished at depths ranging from 10-70 m. The landing data on catch and effort of *T. dussumieri* in various gears were collected weekly. Fishes were grouped in 2 cm size classes for the estimation of catch in numbers and length frequency studies. The data available included approximately 10% of the landings and the rest was by estimation. The samples were pooled for the year in order to separate the various modes in the frequency polygon, by probability plot technique described by Cassie (1954).

From the age composition, estimates of total mortality (Z) were made by using the formula

$$Zt = \log e\ No - \log e\ Nt \ldots\ldots\ldots\ldots\ldots (1)$$

Using the length frequency data for each month, the proportion of fish in each age class was calculated and each age class for the year was estimated by summing up the monthly values. The **Z** was computed from the formula (1) for each year. The value of *Z* in the multi-aged population of *T. dussumieri* was also estimated by using the catch curves. Assuming that under no exploitation 99% of the fish die when they reach 95% of $L\infty$, then $M/K=1.54$, since $K=0.1203$ the value of $M=0.18$. The value of *M* (natural mortality) was also obtained based on the available data, by using multiple regression derived by Pauly (1980).

$$\log M = 0.0066 - 0.279 \log L\infty + 0.6543 \log K + 0.4634 \log T \ldots\ldots\ldots\ldots (2)$$

T = average surface temperature (30°C)

$L\infty$ = Asymtotic length (120.6 cm)

K = growth coefficient (0.1203)

The rate of expoiltation (μ), actually Ricker's (1958) rate of utilisation, was computed from the following formula

$$\mu = \frac{F}{Z}(1-e^{-Z}) \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where *F* and *Z* are instantaneous fishing mortality and total instantaneous mortality rates respectively.

Usually, the behaviour of the fish as well as the gear selection influence the rate of mortality. The age of entry to the exploited phase (t_{p}') is determined by the minimum size at which 50% of the fish are retained by the gear

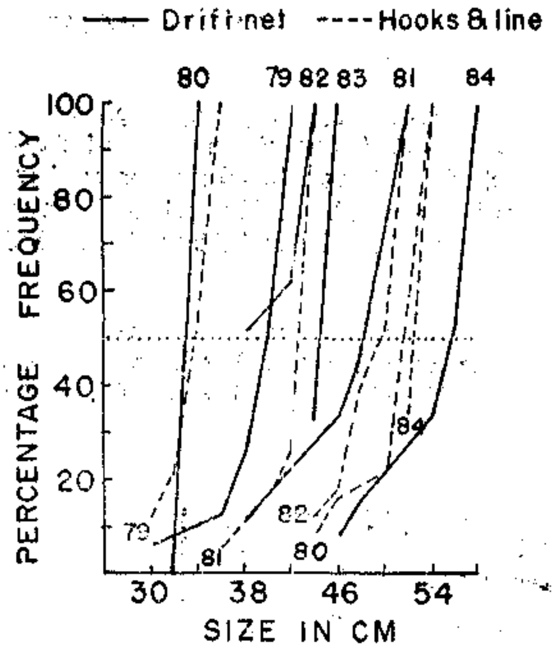

Fig. 1. Selection pattern of *T. dussumieri*, the values at 50% indicate the length at capture.

(Beverton and Holt, 1957). For the present study gear experiments could not be conducted and therefore selection length at 50% level was determined based on length frequency data of drift net and hooks and line. In drift net the minimum size of mesh used in the study area was 70 mm and the maximum of 140 mm. Since *T. dussumieri* is armed with barbed pectoral and dorsal spines, passage through 70 mm or 140 mm mesh by fishes above 1 year (age of recruitment, t_{p}) is ruled out. Therefore, the first mode in the length frequency data is taken for the calculation of 50% retention length. Percentage of size groups tallying with the first mode was calculated for each year and the cumulative values were plotted in Fig. 1, separately for the years 1979-1984 for drift net and hooks and line. For this study the 50% retention length of various years of a gear was packed and average value was taken for the study separately for drift net and hooks and line. The 50% retention length of *T. dussumieri* in the drift net was 2.1 year and in hooks and line the value was 2.3 year. Since the values of t_{p}' have not shown wide variation in the two gears, the values were combined. The relation between width of head and total fish length was derived by fitting a regression (Fig. 2) and this relationship also gave further evidence on the length at first capture. Estimation of yield per recruit at various levels of fishing mortality were made by following the formula of Beverton and Holt (1957), further simplified by Ricker (1958).

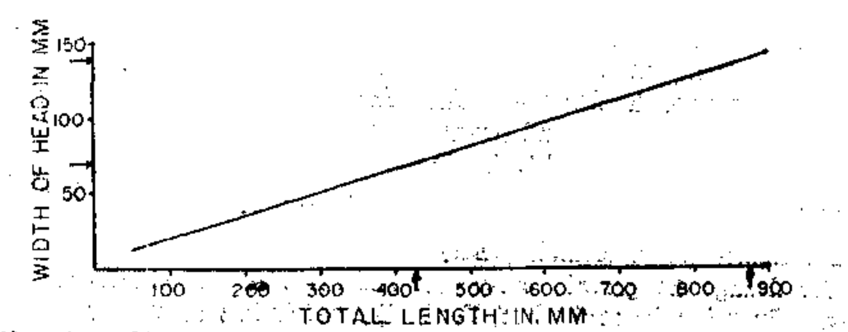

Fig. 2. Relationship of width of head and total length. Arrows on the Y-axis indicate the mesh size of gill net and those on X axis represent the size range in the fishery.

$$Yw/R = F e^{-M(t_\rho' - t_\rho)} W_\infty \left[\frac{1}{F + M} - \frac{3 e^{-K(t_\rho' - t_o)}}{F + M + K} + \frac{3 e^{-2K(t_\rho' - t_o)}}{F + M + 2K} - \frac{e^{-3K(t_\rho' - t_o)}}{F + M + 3K} \right] \quad \ldots (4)$$

Age Determination by Length Frequency

The age of *T. dussumieri* was determined by using the length frequency data of hooks and line and drift net landings for the period 1979-1984. The different age classes in the polymodal size frequency distribution of *T. dussumieri* were separated using probability paper. Since there was no appreciable variations between years, the data for 1979-1984 were pooled and average value was taken for study (Fig. 3). The first modal length is at 33.3 cm, which represents the first year. The second, third, fourth, fifth, sixth and seventh modes correspondingly represent 43.1, 52, 59, 65.9, 72.4 and 77.8 cm respectively.

The von Bertalanffy growth formula (VBGF) was used for fitting the growth curve of *T. dussumieri*. By using the method of Ford (1933) and Walford (1946) the value of L_∞ was determined and estimated to be 120.6 cm. The value of t_o was calculated both theoretically and graphically (Ricker, 1958) and the estimated value is −1.60. The value of growth coefficient 'K' was estimated to be 0.1203. Thus, the von Bertalanffy growth equation of *T. dussumieri* along North Kerala may be expressed as:

$$L_t = 120.6 \left[1 - e^{-0.1203\,(t - (-1.60))} \right]$$

This relationship adequately explains the growth of *T. dussumieri*, since the calculated lengths for each age class derived from above equation were almost identical to the mean lengths obtained by probability plot method (Table 1).

The growth in weight was estimated to be 0.56 kg in the first year, 1.04 kg in the second year, 1.72 kg in the third year, 2.4 kg in the fourth year, 3.1 kg in the fifth year, 4.02 kg in the sixth year and 4.6 kg in the seventh year. The value of W_∞ was derived by fitting the relationship.

$$W_t = W_\infty \left(1 - e^{-K(t - t_o)} \right)^3 \quad \ldots\ldots (5)$$

and the W_∞ was calculated to be 10.88 kg. The weight increment at ages 1 to 6 were 0.56, 0.48, 0.68, 0.70, 0.92 and 0.58 kg respectively.

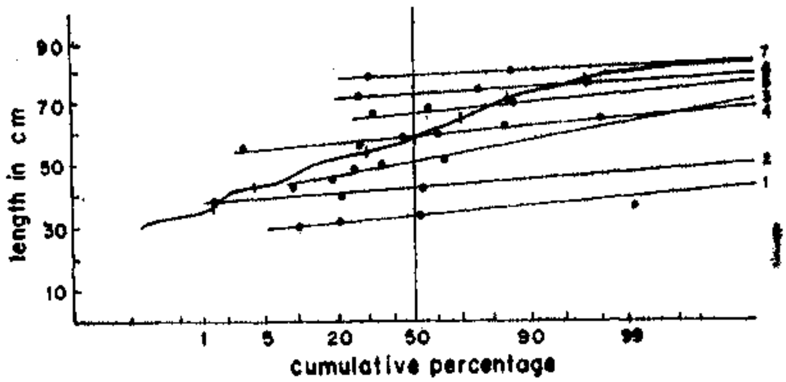

Fig. 3. Probability plot of length frequency distribution of *T. dussumieri* based on average data for 1979-1984.

TABLE 1. *Age and growth of* T. dussumieri *in length (cm) and weight (kg) by different methods*

Age in years	Probability plot (cm)	VBGF (cm)	Growth in weight (kg)
1	.. 33.3	32.5	0.56
2	.. 43.1	42.5	1.04
3	.. 52.0	51.4	1.72
4	.. 59.0	59.0	2.40
5	.. 65.9	66.2	3.10
6	.. 72.4	72.3	4.02
7	.. 77.8	77.8	4.60
8	.. —	82.6	—

LENGTH AND AGE COMPOSITION IN COMMERCIAL LANDINGS

Since 1979 records have been maintained on the length and age composition of *T. dussumieri* in commercial landings separately for hooks and line, drift net and trawl net. The age distribution of *T. dussumieri* in the commercial landings of hooks and line and drift net for the years 1979-1984 and the mean are given in Tables 2 and 3.

TABLE 2. *Estimated catch in numbers of* T. dussumieri *at different ages in hooks and line landings*

Years	Age in years 1	2	3	4	5	6	7	8	Effort	Catch (kg)
1979	880	1937	3768	14271	12440	6259	3243	236	2047	143112
1980	—	963	5088	12794	1112	3417	1728	347	2270	158254
1981	20	3710	3286	12456	8816	6280	1102	—	2066	101482
1982	—	442	3203	3171	7651	3473	815	—	1896	75702
1984	—	6593	582	5672	9308	4687	2230	—	1422	83590
Average	180	2729	3185	9873	7865	4823	1824	117	1940	112428
Percentage	0.5	8.9	10.4	32.3	25.7	15.8	6.0	0.4		

TABLE 3. *Estimated catch in numbers of* T. dussumieri *at different ages in drift net landings*

Year	Age in years 1	2	3	4	5	6	7	8	Effort	Catch (kg)
1979	22	382	2284	8413	5949	6586	3571	255	3462	93591
1980	50776	43525	883	4376	34466	28913	3099	—	3864	138343
1981	—	1078	3768	9237	13284	375	40	20	4170	68353
1982	—	535	327	1746	2161	3100	415	—	4907	34385
1983	—	168	1251	2453	1959	785	756	94	3414	24492
1984	—	—	178	942	2242	845	978	355	2733	22410
Average	8466	7615	1449	4528	10010	6767	1477	121	3758	63596
Percentage	20.9	18.8	3.6	11.2	24.8	16.7	3.7	0.3		

T. dussumieri are fully vulnerable to the hooks and line fishery by age 4 and to the drift net by age 5. In the hooks and line landings fishes below 2 year old are very poorly represented, probably because of their non-availability in the fishing area. The first year and second year class contribution by this gear is only 0.5 and 8.9% respectively. The age group 3 is fairly well represented with an annual average percentage of 10.4, but the age class 4 is predominant in the catches (32.3%). Thereafter the percentage contribution in the landings decreased with age: 5-25.7, 6-15.8, 7-6.0 and 8-0.4%. After age 6, there is a drastic decline in the relative number of fish caught (Table 2). In view of the fact that the age at first spawning is 5 years, in this gear on an average 47.9% of the fish caught are mature, at least spawned once.

In the drift net landings the age group 1 is well represented only during 1980 with an annual average percentage of 20.9. But from 1981 onwards, this age class was completely absent from the fishery. The age group 2 is recruited to the fishery with a mean annual percentage of 18.8. On the other hand the age group 3 and 4 are poorly represented with 3.6 and 11.2% respectively. The age group 5 is the fully recruited age class (24.8%) to the drift net; the percentage contribution of age groups 6, 7 and 8 showed progressive decline with percentages of 16.7, 3.7 and 0.3 respectively (Table 3). Though this gear is generally selective for many groups of fishes, at least to certain extent, this is not applicable in catfishes, because of the barbed spines, which may prevent the escape of even smaller fish through large meshes. That is the reason why fishes of age classes 1 and 2 are also appeared in the catch, when the same are available in the fishing ground. The average percentage contribution of mature fish in the drift net is 45.5 which include spawners and gestating males.

ANNUAL AND SEASONAL CATCH FLUCTUATIONS

The annual all gear *T. dussumieri* catch in the beginning of this study in 1979 was 261.4 t, which increased to 308 t in 1980. This increase in the catch has broadly reflected the increase in effort. During these two years, along with hooks and line and drift net, trawl net also contributed 36.1 t. Thereafter the all gear catch declined substantially from 169.9 t in 1981 to as low as 57.6 t in 1983 with proportionate decrease in the effort, and there was no catfish in the trawl catches during these years. Though the effort decreased further in 1984, the catch showed marginal improvement (106 t). The percentage contribution of *T. dussumieri* in the all gear total catfish catch was similarly the highest in 1979 (37.5%), which progressively declined to 8% in 1983 and then increased suddenly to 33.6% in 1984.

T. dussumieri by hooks and line showed almost a similar picture, the maximum annual catch was recorded in 1980, to the tune of 158.3 t and the minimum in 1983 (33.1 t). Though the catch of 1979 was low (143.1 t) its percentage contribution in the total catfish catch was 41.5, the highest observed during the course of this study, which steadily declined to 10.2% in 1983. In 1984 the landings again showed a slight revival (83.6 t) with a percentage contribution of 32. The overall decline in the landings of hooks and line is proportional to the decrease in effort expended, from 2270 units in 1980 to 1640 units in 1983. In this gear, on an average, *T. dussumieri* formed 28.9% of the total catfish catch.

The catfish catch in drift net showed a similar trend to that of hooks and line in the peaks and dips of annual landings. The peak catch of 138.3 t was recorded in 1980 with the percentage contribution of 63.6 in total catfish catch of the gear. The catch gradually declined to 22.4 t in 1984, but the percentage composition of this species in the total catfish catch of the gear has not shown any remarkable change. The annual average percentage occurrence of *T. dussumieri* in the drift net catch was 54.8. The drift net effort input also declined from 1980 to 1984.

The contribution of *T. dussumieri* in the trawl catch was only negligible, with an annual average of 6 t. It landed 24.7 t and 11.5 t in 1979 and 1980 respectively (Table 4).

Though *T. dussumieri* occur throughout the year in both hooks and line and drift net, the yield fluctuated between months. The picture emerges out of this study on the seasonal landings in hooks and line is that the species has two peak occurrence in December-March and September. The high catch of December-March period coincides with the breeding season of the species (Vasudevappa and James, 1980) and is also related to the period of southward migration (James *et al.*, 1987). The second

TABLE 4. *Gearwise catch (kg), effort and catch per effort (kg) of* T. dussumieri *at North Kerala during* 1979-1984

Year	Hooks and line			Drift net			Trawl net			All gear total		
	Catch	Effort	C/E	Catch	Effort	C/E	Catch	Effort	C/E	Catch	Effort	C/E
1979	143,112	2047	69.9	93,591	3462	27.0	24,714	8370	3.0	261,417	13879	18.8
1980	158,254	2270	69.7	138,343	3864	35.8	11,473	8596	1.3	308,070	14730	20.9
1981	101,482	2066	49.1	68,453	4170	16.4	—	—	—	169,935	6236	27.3
1982	75,702	1896	39.9	34,385	4907	7.0	—	—	—	110,087	6803	16.2
1983	33,126	1640	20.2	24,492	3414	7.1	—	—	—	57,618	5054	11.4
1984	83,590	1422	58.8	22,410	2733	8.2	—	—	—	106,000	4155	25.5
Average	99,211	1890	52.5	63,612	3758	16.9	6,031	2828	2.1	168,855	8476	19.9

As the catch of *T. dussumieri* went down, the effort expended also decreased. The decline in the catch was due to the lesser availability of the species in the fishing ground. Availability is mostly affected by changes in seasonal patterns of migration consequent on climatic conditions, water temperature, sea surface drifts and monsoonal effects. But above all, the normal migration of this species in the south and north directions is seriously hampered by mass harvest with the help of purse seines along Mangalore - Goa in the north and Cochin in the south, of the presently studied fishing grounds. This indiscriminate harvest by purse seine not only affected the regular migrations, but also the normal recruitment as a result of destruction of brooders.

peak occurrence in September is the time when the adult stock reaches this fishing ground in the course of northward migration. In the drift net catches also a similar seasonal trend is noticed, with the crests in January and September. A large proportion of the catch of drift net in the breeding months of December-March consisted of female spawners and gestating males.

The monthly catch data for 1979-1984 showed that in hooks and line about 55% of the *T. dussumieri* landing was during the breeding season. Similarly in the drift net about 50% of the catch was in December-March period (Table 5 and 6).

TABLE 5. *Monthwise hooks and line catch (kg) of* T. dussumieri *for 1979-1984 and its percentage in total catfish*

	1979	1980	1981	1982	1983	1984	Average	Percentage
January ..	9347	26214	8820	—	3119	40	7923	45.2
February ..	6582	43654	35037	8393	4205	35676	22258	59.9
March ..	27755	4123	12593	8540	5490	18517	12836	74.2
April ..	19035	4444	10444	—	7431	14438	9299	72.4
May ..	14486	3784	10643	1581	6813	1297	6434	36.1
June ..	1896	—	274	10170	—	—	2057	45.5
July ..	18	610	503	—	—	—	189	15.9
August ..	6632	6885	828	9400	610	4828	4864	37.9
September ..	9024	31536	4907	15268	582	5200	11086	15.9
October ..	11456	6795	2490	93	4320	3523	4780	9.2
November ..	10565	9830	9837	892	435	39	5266	11.4
December ..	26316	20380	4981	7181	175	32	9844	29.1

TABLE 6. *Monthwise drift net catch (kg) of* T. dussumieri *for 1979-1984 and its percentage in total catfish*

	1979	1980	1981	1982	1983	1984	Average	Percentage
January ..	12324	37740	23097	4362	3684	111	13553	75.1
February ..	29365	1178	2807	2542	5479	2938	7385	84.9
March ..	4893	5097	2620	2289	1783	1048	2938	91.9
April ..	477	443	1493	36	3258	190	983	83.5
May ..	312	759	1706	213	2192	—	864	64.4
June ..	34	—	315	840	—	—	198	31.8
July ..	—	2502	544	—	—	2598	941	46.5
August ..	5192	5163	2321	2100	1370	999	2858	52.7
September ..	11471	22718	13163	3869	2640	8523	10397	36.9
October ..	15861	19630	9086	5081	3947	5078	9781	53.9
November ..	1334	22059	6976	2113	149	771	5567	52.8
December ..	12328	21055	4326	10900	288	155	8175	63.6

TRENDS IN CPUE

The annual catch rate (cpue) of *T. dussumieri* in the hooks and line fluctuated from 69.9 kg (1979) to 20.2 kg (1983) with a diminishing trend in abundance. Similarly in the drift net the cpue ranged from 35.8 kg (1980) to 7.0 kg (1982) with a downward trend. The catch rate in trawl net also showed decreasing trend from 3 Kg (1979) to 1.3 kg (1980). The seasonal (monthly) catch rate showed high values during February-March in both looks and line and drift net.

TOTAL MORTALITY ESTIMATES

Table 7 summarises the estimates of total mortality by using the formula (1) and also the estimates derived from catch curve. *T. dussumieri* are fully vulnerable to both hooks and line and drift net by age 5. Annual total mortality estimates, worked out with the formula (1) and from the catch curves, therefore, were based on fishes of age 5 and older. The points that represent the descending right limb of catch curve for the years 1979-1984 and the mean (Fig. 4) alone were taken into

TABLE 7. *Catch in numbers of* T. dussumieri *per 1000 units effort during 1979-1984 and Z values*

Year		Age in years 1	2	3	4	5	6	7	8	Z_t = loge No— log eN_t)	Z (catch) curve
1979	..	218	528	1251	4402	3898	2480	1310	95	1.2381	1.18
1980	..	13140	5844	1236	3385	4706	4494	782	77	1.3709	1.41
1981	..	10	1027	1731	3856	3727	1566	272	3	2.3749	2.31
1982	..	—	171	878	1014	2239	1233	258	—	1.0804	1.08
1983	..	—	49	367	718	575	230	221	27	1.0195	0.93
1984	..	—	4643	238	1993	3687	1804	945	250	1.0673	1.20
Mean	..	2228	2044	950	2561	3139	1968	631	59	1.3585	1.41

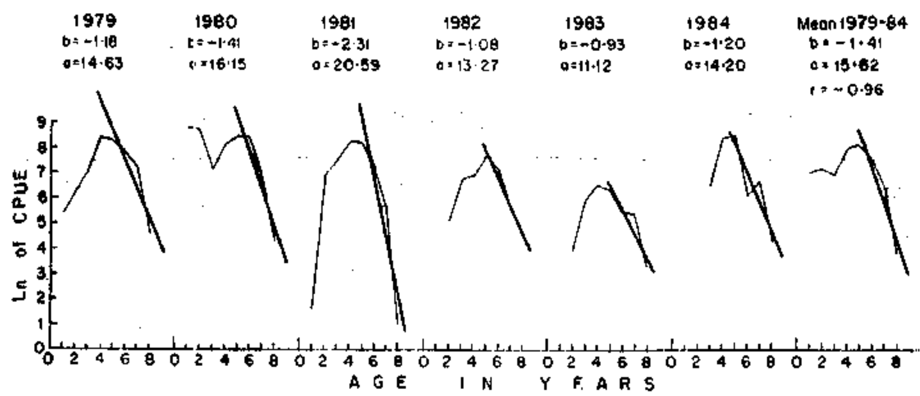

Fig. 4. Catch curve of *T. dussumieri*.

account for fitting the regression. In the regression the value of 'b', with sign changed, provided the estimate the total mortality (Z). The values of Z derived by using the formula (1) ranged from 1.02 (1983) to 2.37 (1980), with a mean of 1.36 ; whereas the Z values estimated by catch curve varied from 0.93 (1983) to 2.31 (1980), with a mean of 1.41. The cohort analysis for the estimation of Z (Table 8) gave a value of 1.50 with no apprecia-

TABLE 8. *Estimation of Z by Cohort analysis*

Age		Total No. caught	Total No. in sea (N)	Z	F	Average No. in sea
1	..	8616	117770	0.2635		103526
2	..	9889	90491	0.3074		77905
3	..	4103	66543	0.2499		58880
4	..	12755	51829	0.4938		40901
5	..	11154	31632	0.6676	0.3976	23077
6	..	10754	16226	1.4799	1.2099	8468
7	..	2996	3694	2.3651	2.0951	1415
8	..	218	347			
Average	..			1.5042	1.2342	

ble change from the values derived from other methods.

Natural Mortality

The value of M estimated by using the multiple regression formula (2) derived by Pauly (1980) gave M value of 0.31. As catfishes have a peculiar type of parental care *viz.* oral incubation, the chances of natural mortality during the egg/larval stage are almost negligible and any mortality which may occur by way of predation during the juvenile period is also remote because of the conspicuous pungent spines. Therefore, in view of its peculiar breeding nature and other biological characters, the natural mortality derived by above methods may be an over estimated value and far from truth. In these circumstances, it is more reliable to assume that under no exploitation 99% of the fish die when they reach 95% of $L\infty$; then the value of M is 0.18 with a low growth coefficient.

Fishing Mortality

The fishing mortality is estimated from the relationship $Z = M + F$. The fishing mortality (F) of *T. dussumieri* in the fishing grounds off North Kerala during the period 1979-1984 ranged from 0.75 in 1983 to 2.13 in 1981 with an average of 1.23.

Yield Per Recruit

The vital parameters used for constructing the yield per recruit curves of *T. dussumieri* are given in Table 9. The yield per recruit at different values of fishing mortality were calculated for various values of age at capture (tp') from 2 to 6 years keeping the natural mortality constant at 0.18 (Fig. 5). The Y/R of *T. dussumieri* at the present age at first capture of 2.3 years has the maximum value of 765 g when F=0.3; whereas the present F is 1.23. The Y/R values when ploted against various tp' from 2 to 6 (Fig. 6) keeping the value of F constant shows that with the present rate of fishing (F=1.23) the Y/R steadily

Table 9. *Population parameters used for* T. dussumieri *off North Kerala*

Age at recruitment	..	tp	1 year	Both in hooks and line and drift net
Age at first capture	..	tp'	2.3 years	
Maximum age in years	..	t max	23.4 years	
Age at 0 length	..	to	—1.61	
Exponent of length-weight relationship	..	b	2.647324	
Maximum length	..	$L\infty$	120.6 cm	88 cm observed
Maximum weight	..	$W\infty$	10.882 kg	
Growth coefficient	..	K	0.1203	
Total instantaneous mortality	..	Z	1.41	
Natural mortality	..	M	0.18	
Fishing mortality	..	F	1.23	
Annual mortality	..	*a*	0.75	

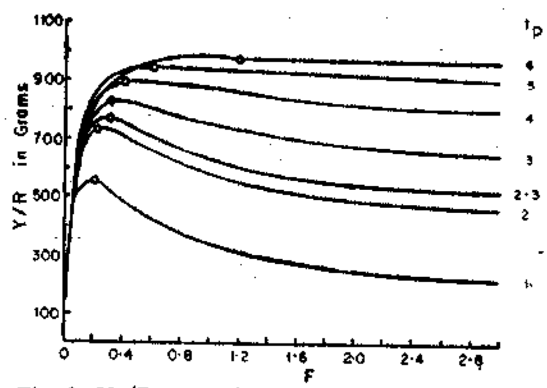

Fig. 5. Yw/R curve of *T. dussumieri* at different values of F keeping t_p' constant with M = 0.18.

increases with increase in 'tp'. It may be clearly seen from the figure that an increase of fishing mortality would not increase the yield per recruit. In order to get the maximum yield per recruit at the existing exploitation at

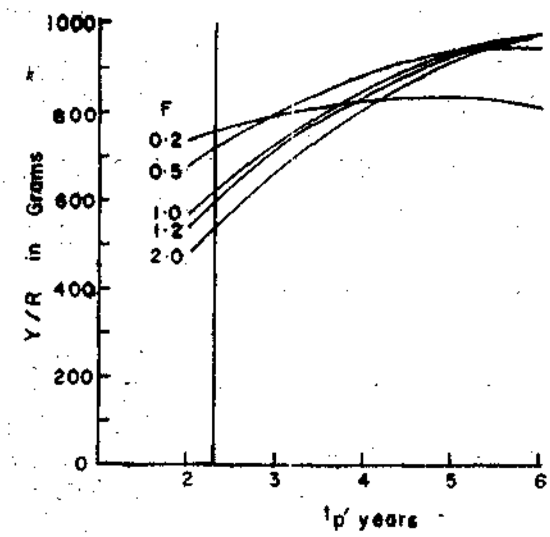

Fig. 6. Yw/R of *T. dussumieri* at different values tp' keeping F constant.

age 2.3 years, the present effort has to be brought down to 25% of the present average effort. The next possibility to increase the Y/R is by increasing the tp' to 4-6 years by alteration in the gear employed for its fishing or change the area of fishing to outershelf.

Estimation of Total Stock and Standing Stock

The total stock and standing stocks of *T. dussumieri* in the fishing grounds off North Kerala were estimated for different years from 1979-1984 (Table 10). The exploitation rate varied from 0.49 (1983) to 0.76 (1981) with a mean of 0.65. The total stock or the biomass (Y/*u*) in the fishing ground fluctuated from 466.7 t (1980) to 117.6 (1983) and the average was 259.8 t. The standing stock (Y/F) ranged from 261.4 t (1979) to 68.6 t (1983) with a mean of 141. 9 t and the annual average yield is 16.0% more than the average standing stock. The study of the stock position in North Kerala waters showed slight over fishing of *T. dussumieri*, which is in agreement with the observations on the same species from Veraval, where the annual average yield was 52.7% more than the average standing stock (Anon., 1987).

Discussion

Tachysurus dussumieri is long lived (t max = 23.4 years) and displays a slow, steady rate of growth, reflecting the type of environment in which it occurs. The growth coefficient K =0.1203 compared with other sympatric species indicates a slower rate of growth than

Table 10. *Estimation of total stock, standing stock and catch (in tonnes) of* T. dussumieri

Year	Catch (t)	Z	F	M	μ	Total stock (t) Y/μ	Standing stock (t) Y/F
1979 ..	261.4	1.18	1.00	0.18	0.59	443.1	261.4
1980 ..	308.0	1.41	1.23	0.18	0.66	466.7	250.4
1981 ..	169.9	2.31	2.13	0.18	0.76	223.6	79.8
1982 ..	110.1	1.08	0.90	0.18	0.55	200.2	122.3
1983 ..	57.6	0.93	0.75	0.18	0.49	117.6	68.6
1984 ..	106.0	1.20	1.02	0.18	0.60	176.7	103.9
Mean ..	169.9	1.37	1.19	0.18	0.65	259.8	141.9

T. thalassinus (Anon., 1987), *T. platystomus* (Menon, 1984) and *T. sona* (Singh and Rege, 1968). *T. dussumieri* is highly mobile and undertakes long courses of migration and lives in different types of unstable environments (depending on the changes of monsoon, etc.). They are unable to expend more energy on growth compared to species which do not migrate extensively like *T. thalassinus* (K=0.36), *T. sona* (K = 0.35), *T. platystomus* (K = 0.35) and *Osteogeneiosus militaris* (K = 0.78). The L_∞ and W_∞ of *T. dussumieri* in the North Kerala waters showed slightly higher values than the estimates from Veraval (Anon., 1987).

Assessment of the resources of important species of catfishes along Indian coastal waters showed that the stocks of *T. thalassinus*, *T. tenuispinis*, *T. dussumieri* and *T. serratus* are under heavy fishing pressure. The study indicated that in order to obtain maximum sustainable yield from these stocks, either the fishing intensity has to be lowered keeping the present size at first capture (lc) constant or the size at first capture should be increased at the existing level of fishing effort inputs (Anon., 1987) the latter proposition may not be possible due to non-selectivity. Dan (1981) found that the yield per recruit of *T. tenuispinis* along the northeast coast of India attained the maximum value at a fishing mortality of 0.3 and the then prevailing fishing mortality was between 0.58 to 0.96. *T. tenuispinis* and *T. thalassinus* together constituted the entire catfish fishery of northeast coast in equal proportions till late 1970's. But the percentage contribution of *T. tenuispinis* gradually declined and by 1984 and 1985, it almost disappeared from these fishing grounds. Whereas *T. thalassinus* continued to sustain a regular fishery (about 98%) in this region. This is because of the less migratory habit of *T. thalassinus* and poor exploitation on brooders and spawners. On the other hand, *T. tenuispinis* undertakes long courses of migrations and there was high fishing mortality of brooders and spawners along Karnataka - Goa region from 1979-1985 periods. Thus, the recruitment overfishing suffered by the stock along these spawning grounds had its impact on future recruitment which was felt all along the coast. This may be the reason for the sudden fall in the catches of *T. tenuispinis* along the east coast too. The decline of *T. dussumieri* landing along the North Kerala Coast may also be the result of such poor recruitments and high exploitation of brooders and spawners (Muthiah and Syda Rao, 1985). Thus it is very clear that over exploitation, affecting recruitment or growth at any fishing centre along the coast will have a far reaching effect on the total stock.

The present study on the stock assessment of *T. dussumieri* along North Kerala very clearly agrees with the earlier findings from Veraval. *T. dussumieri* at Veraval had high exploitation rate (0.91), when the Y/R was only 216 g; whereas the maximum Yw/R of 475 g was at an exploitation rate of 0.5 (Anon., 1987). At Veraval, *T. dussumieri* fishery (mainly by trawlers and gill nets) yielded an average (1981-1982) 438 t, which was about 53% more than the average standing stock (207 t) with an average exploitation rate of 0.82, indicating over exploitation. The relatively high fishing mortality (F=2.12) was due to high exploitation of less than one year old fish by trawlers. Therefore, the over exploitation at Veraval may be largely because of growth over fishing rather than recruitment over fishing.

Along the coastal waters off North Kerala with the present fishing mortality of 1.23, the average annual yield (168.9 t) is 16% more than the average annual standing stock (141.9 t). Since the exploitation is mainly confined to the mature and spawned fish stock, the growth over fishing seems to be very negligible and the major reason for the low standing stock and over exploitation is recruitment over fishing, which mostly took place in the spawning grounds off Mangalore - Goa region by purse seines. The impact of this is felt in the North Kerala because of the migratory habit of species. The severe exploitation of brooders and spawners reduced considerably the productivity of the stock not only the level of maximum sustainable yield been surpassed, but also the normal reproduction of the stock has been dangerously interfered with. This condition is very similar to that of *T. tenuispinis* along the northeast coast. The possible solution to overcome this situation lies in strict adherence to managerial policies to curb over exploitation of spawners and brooders by purse seines in the breeding grounds off Karnataka - Goa waters.

REFERENCES

ANONYMOUS 1987. Marine Catfish Resources of India. *C.M.F.R.I. Bull.*, **40**: 70-87.

BEVERTON, R. J. H. AND S. J. HOLT 1957. On the dynamics of exploited fish populations. *Fish Invest. sec.* 11, **19**: 533 p.

CASSIE, R. M. 1954. Some use of probability paper in the analysis of frequency distribution. *Aust. J. Mar. Freshw. Res.*, **5**: 515-522.

DAN, S. S. 1981. Mortality rates and yield per recruits of the catfish *Tachysurus tenuispinis* (Day). *Indian J. Fish.*, **28** (1 & 2): 41-46.

DHULKHED, M. H., S. HANUMANTHARAYA AND N. CHANNAPPA GOWDA 1982. Destruction of eggs of catfish, *Tachysurus tenuispinis* by purse seiners at Karwar. *Mar. Fish. Infor. Serv. T & E Ser.*, **44**: 16-17.

FORD, E. 1933. An account of the herring investigations conducted at Plymouth during the years from 1924-1933. *J. Mar. Biol. Ass. U.K.*, **19**: 305-384.

JAMES, P. S. B. R., V. N. BANDE, N. GOPINATHA MENON AND K. BALACHANDRAN 1987. The catfish resources of southwest coast of India—Prospects and management problems. *C.M.F.R.I. Bull.*, **44** (1): 78-94.

MENON, N. G. 1979. Studies on the biology and fishery of the giant marine catfish *Tachysurus thalassinus* (Ruppell). *Ph.D. Thesis. University of Cochin* (Unpublished).

——— 1984. On the biology of the flat-mouthed catfish *Tachysurus platystomus* (Day) from Mandapam. *Indian J. Fish.*, **31** (2): 293-308.

MUTHIAH, C. AND G. SYDA RAO 1985. Occurrence of *Tachysurus dussumieri* (Val.) with incubating young ones off Mangalore. *Mar. Fish. Inform., Serv., T & E Ser.*, **61**: 14-15.

PAULY, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. Int. Explor. Mer.*, 39 (2): 175-192.

RICKER, E. W. 1958. Handbook of computations for biological statistics of fish populations. *Bull. Fish. Res. Bd. Canada*, **119**: 300 p.

SILAS, E. G., P. PARAMESWARAN PILLAI, M. H. DHULKHED, C. MUTHIAH AND C. SYDA RAO 1980. Purse seine fishery—imperative need for regulation. *Mar. Fish. Infor. Serv. T & E Ser.*, **24**: 1-9.

SINGH, V. D. AND M. S. REGE 1969. Observations on age and growth of *Tachysurus sona* (Ham.), *J. Bombay nat. Hist. Soc.*, **65** (1): 75-87.

SUSEELAN, C. AND K. V. SOMASEKHARAN NAIR 1969. Food and feeding habits of demersal fishes off Bombay. *Indian J. Fish.*, **16**: 56-74.

VASUDEVAPPA, C. AND P. S. B. R. JAMES 1980. Maturity and spawning of marine catfish *Tachysurus dussumieri* (Val.) along the south Kanara coast. *Proc. Indian Nat. Sci. Acad.*, *B* **46** (1): 90-95.

VENKATARAMAN, G. 1960. Studies on the food and feeding relationships of the inshore fishes off Calicut on the Malabar Coast. *Indian J. Fish.*, **7** (1): 275-306.

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol. Bull. Woods-hole*, **90**: 141-147