BIOLOGY AND POPULATION DYNAMICS OF THE GREY DOGSHARK, *RHIZOPRIONODON* (*RHIZOPRIONODON*) *ACUTUS* (RUPPELL), IN MADRAS WATERS

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ABSTRACT

The morphometric ratios of 13 characters of a sample of 105 specimens ranging in size from 144 mm to 826 mm established the identity of the species, *Rhizoprionodon* (*Rhizoprionodon*) *acutus* (Ruppell), supporting the shark fisheries at Madras. The Bertalanffy's growth parameters were: 1 = t_0 = 1.78 yrs; K = 0.2; and L_∞ = 100 cm. *R.* (*R.*) *acutus* attains sizes of 417.3, 522.9, 609.4, 680.2, 738.2, 785.6, 824.5, 856.3, 882.3 and 903.7 mm respectively at ages of 1 to 10 years. The regression equations of length on weight between females and males were not significantly different. Although the overall sex ratio was 1 : 1.34, females were predominant up to the size group of 60-70 cm and during the months of February, March and April. The size and age at maturity were respectively 650 mm and 3.5 yrs; and the l_m/l_∞ ratio was 0.65 in conformity with ratios of other species of the genus *Rhizoprionodon*. With a fecundity of 2 female young and the t_m at 3.5 yrs, the upper limit of instantaneous total mortality rate (Z) was 0.4355, which was comparable with the total mortality rate (0.4407) now being generated. Because recruitment and abundance are directly linked among elasmobranchs, maintenance of a value of Z at 0.4355 is critical for a rational exploitation of the stocks of *R.* (*R.*) *acutus* in the Madras waters. Since the estimated total stock (25 tons|month) and sanding crop (20 tons|month) of *R.* (*R.*) *acutus* are very much in excess of the estimated catches of 2.9 tons| month, there is considerable scope for expansion of the fisheries for *R.* (*R.*) *acutus* in Madras waters, but with caution that the upper limit of Z is continuously monitered so as to ensure maintenance of the present level of recruitment.

INTRODUCTION

As in most fishing centres of the world, there is no organized fishery for chondrichthyan fishes in Madras. Nevertheless, the selachians form a sizeable incidental catch in gill nets, which are chiefly directed toward harvesting fishes like the seer, wolf-herring and ribbonfishes. The bateoid fishes contribute considerably to the trawl fisheries.

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The elasmobranchs in general have attracted relatively less attention of fishery scientists the world over, probably because of the selectivity of gear employed, slow growth rate, late maturity, low fecundity, long gestation period, lack of ctenoid or cycloid scales, cartilagenous hard parts and less consumer acceptability. Consequently, published accounts on biological aspects such as age and growth, feeding habits, reproduction, mortality, etc., are not as numerous as they are on taxonomy. Out of the 77 known publications on this group from India, only one (Prabhakaran Nair 1976) deals with the age and growth, that is of *Scoliodon laticudus*. The remaining studies concern with embryology|development, taxonomy|distributional records, fisheries, feeding, natural products and general aspects.

An attempt, therefore, is made here to obtain information on reproduction, age and growth, etc. and from them the population dynamics of the grey dog-shark, *Rhizoprionodon (Rhizoprionodon) acutus* (Ruppell); which is the chief contributor (by weight) in the catches (80%) at Madras (Annon 81), where the estimated annual gill-net landings of sharks had ranged between 13.8 m.t., the lowest, recorded in 1982-83, and 85.3 m.t., the highest, recorded in 1980-81, during the five year-period from 1979-80 to 1983-84 (5 year-average: 43.7 t).

Material and Methods

The majority (80%) of the specimens were obtained from the biggest landing centre, at Kasimedu, Madras, and these were supplemented with samples obtained from three additional major fish markets, at Saidapet, Chintadripet and Zambazaar. Only the fish in fresh condition were measured and weighed. The total length was measured from the tip of the snout to the tip of the upper caudal lobe and weighed to the nearest 1 mm and 0.5 g, respectively. Classical statistical methods of regression analysis were adopted wherever required, as for example between length and weight. More details are given in the concerned sections.

Results and Discussion

Identity

At the fish-landing centre Kasimedu, Madras, two species dominated the catches, which, until recently, had been misidentified as either *Scoliodon sorrakowah* or *S. palasorrah* (Gunther 1870, Day 1878, Thillayampalam 1928, Setna and Sarangdhar 1946, Misra 1947 and 1959, Munro 1955). A gross examination of the characters such as the position of first dorsal fin in relation to appressed pectorals, the origin of pectoral fins, hyomandibular pores, lower labial furrow, etc., indicated that the sharks considered to be the above species really belonged to another genus, viz., *Rhizoprionodon*. Therefore, in order to establish the true identity of the species, a sample of 105 specimens ranging in size from 144 mm to 826 mm (Average size: 304.8 mm) were examined for 13 important characters as followed by Nair et al (1974) and measured to arrive at their morphometric ratios in percent of total length (Table 1). These ratios were compared with those given by Springer (1964). In 11 characters the present specimens resembled *R.* (*R.*) *acutus,* while in 1 character they resembled *R.* (*R.*) *porosus* and in 5 characters *R.* (*R.*) *terraenovae,* the two closely related species of *R.* (*R.*) *acutus* within the genus *Rhizoprionodon* (Springer 1964). In the light of these observations, the identity of the shark species presently supporting the fisheries at Madras was established as *Rhizoprionodon* (*Rhizoprionodon*) *acutus* (Ruppell).

TABLE 1. *Average proportional dimensions in percent of total length of various species of genus:* Rhizoprionodon *compared with those obtained in the present studies. *from Springer,* 1964.

Characters	Present Studies	*R.* (*R.*) *acutus**	*R.* (*R.*) *terranovae**	*R.* (*R.*) *porosus**	*R.* (*R.*) *longurio**	*R.* (*P.*) *lalandi**	*R.* (*P.*) *oligolinx**
Snout tip to anterior margin of eye	8.0	8.0	7.4	7.3	8.5	8.0	7.4
Snout tip to pectoral Origin	22.3	21.7	21.9	21.2	23.7	21.6	21.3
Internarial distance	5.1	5.0	5.2	5.2	5.0	4.9	4.8
Mouth width	6.1	6.2	7.1	7.1	7.0	6.5	6.9
Head length	19.1	19.0	18.9	18.1	20.6	18.6	17.9
Lower labial furrow length	1.3	1.4	1.5	1.5	1.6	1.4	1.4
Horizontal diameter of eye	2.2	2.3	2.6	2.6	2.4	2.4	2.5
Pectoral base length	5.2	4.9	5.1	4.7	5.1	5.1	5.4
Length of pectoral	13.1	13.1	13.3	13.5	12.7	12.0	12.3
First dorsal base length	9.3	9.3	9.1	8.8	9.2	9.5	9.7
Anal base length	4.7	4.9	4.8	4.4	4.4	4.5	4.9
Length of upper caudal lobe	26.2	25.8	26.0	26.3	24.5	25.1	25.6
Clasper length	4.3	4.2	2.4	2.7	4.6	2.8	6.3
Sample size	105	17	10	10	10	9	10
Size range	144-826	368-820	335-827	323-810	351-792	352-612	272-489

Age and Growth

Age and growth in elasmobranchs have been determined by many methods by various investigators. Among those who used markings on spines, in *Squalus acanthias*, are Soldat (1982) and Nammack et al (1985). Zones occurring in centra were utilized by a number of workers, among whom some of the more recent being Waring (1984), Nakano (1985) and Branstetter and McEachran (1986). The Petersen length-frequency method was adopted by others, for example, Natanson et al (1984), Casey et al (1985) and Nakano (1985). An altogether different approach was that of Yokota (1952), who advanced that the growth of claspers in *Dasyatis akejei* was not continuous but occurred in annual increments. In the present study, the Petersen length-frequency method is adopted as was done for *S. laticaudus* from Bombay waters by Prabhakaran Nair (1976).

The length-frequency polygons drawn for each month for the period from January to December 1984 (Fig. 1), based on 1418 measurements (total length), show only two modes in most months; single modes in April, June and August; and three modes in September and October. The earliest mode 'D' at 25 cm in May, can be traced to a mode at 55 cm in October, registering a progression of 30 cm over a period of 6 months, indicating a growth rate of 5 cm | month. The next mode 'C', at 35 cm in February, can be traced to the mode at 75 cm in December. Since its progression is 40 cm over a period of 11 months, the rate of growth of this mode is 3.6 cm | month. The third mode 'A', at 45 cm in January, can be traced to the mode at 85 cm in October, showing a progression of 40 cm over a period of 10 months. Its rate of growth is 4 cm|month. While mode 'B', at 85 cm in January, can not be traced, the mode 'E', at 35 cm in September, remains stationary even in December, not showing any growth at all. Because the modes 'D', 'A' and 'C' show progressively decreasing growth rates of 5, 4 and 3.6 cm|month, it is tempting to assign these length groups to age classes I, II and III, respectively. Considering the fact that the differences in growth rates between age classes are too little to be of any significance, growth rates now observed are presumably not truthful reflections of growth in *R.* (*R.*) *acutus*, since growth in elasmobranchs, in general, is believed to be slow. The length-frequency method to determine age and growth is, therefore, unsuited unless validated by other methods such as markings on spines, rings on centra, etc. Grant et al (1979) found it 'fundamentally impractical' (p. 634) for assessing the age of *G. australis* (= *G. galeus*). Hence, growth parameters essential for application in studies on population structure and status are estimated, adopting Bertalanffy's growth equation as modified by Holden (1974, 1977), who states:

$$l_{t+T} = L_\alpha \,(1 - e^{-KT}) \text{ where}$$

l_{t+T} = Length at birth,

$L\alpha$ = Lmax = Maximum observed length,
K = Growth coefficient and
T = t_0 = Gestation period.

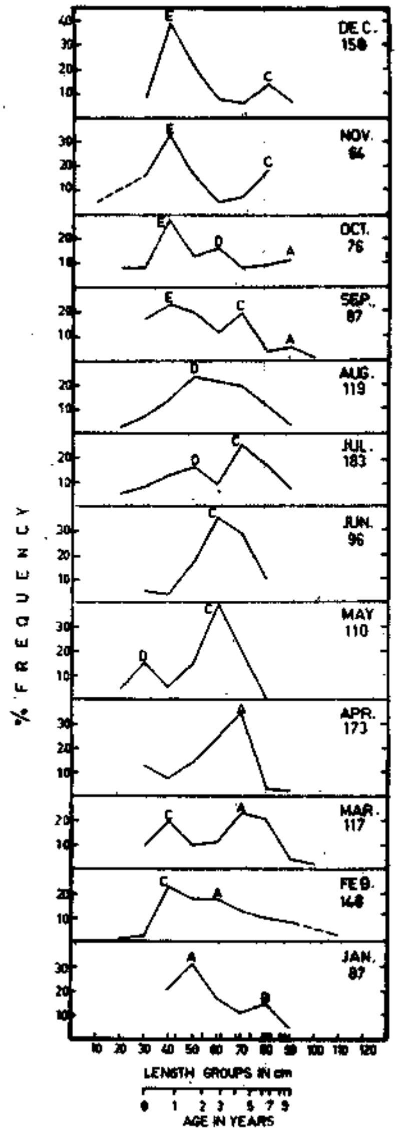

FIG. 1. Length-frequency polygons in the grey dog shark, R. (R.) *actus* during 1984 (Jan.-Dec.). The numbers in each month indicate the sample size.

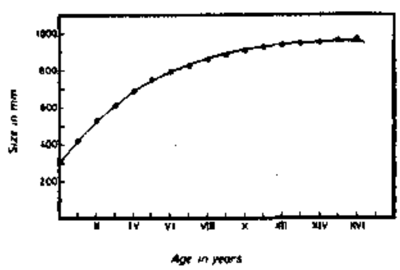

FIG. 2. Growth curve in the grey dog shark, R. (R.) acutus.

He further states that $T = t_0$ should be so adjusted that K is between the values of 0.1 and 0.2 which is the range for most selachians.

It is observed from the length-frequency data that the maximum size recorded (108 cm) in February 84 belonged to the size group 100-110 cm. Hence, the lower limit of this group, i.e. 100 cm, is taken as the $L_\infty = L_{max}$ for *R.* (*R.*) *acutus*. Springer (194) has, however, noted 722 mm as the maximum size for this species and regarded the size 940 mm as doubtful. But a record of five specimens in the size group of 100-110 cm in February 84, in the present study, establishes that the species grows beyond 940 mm, the size considered doubtful by him. Compagno (1984) states that most adults are less than 1.1 m, though exceptionally males might grow up to 178 cm and females up to 165 cm.

The length-frequency data are, however, not useful to determine the size at birth, although specimens in sizes less than 40 cm were present in the samples in most of the months from February to December 1984. All such samples (180 Nos.) are, therefore, reclassified into 50-mm-size groups up to the maximum size group of 350-400 mm, and the frequency distribution with respect to those with umbilical cord and umbilical scar prominent, trace or absent, which was the case in all the specimens measuring above 400 mm (Table 2), is worked out. The maximum size group of those in which the umbilical scar was still present and the cord was totally absent (considered to have been just released)

TABLE 2. *Sizewise percentage distribution of embryos in relation to umbilical cord and scar in the grey dog-shark,* R. (R.) acutus.

	Size group in mm							Size of Sample
	50-100	100-150	150-200	200-250	250-300	300-350	350-400	
Umbilical Cord								
Present	6.8	13.7	17.8	21.9	31.5	8.3		73
Umbilical Scar								
Prominent				7.1	78.6	10.7	3.6	56
Trace					35.6	55.6	8.8	45
Absent					33.3	50.0	16.7	6
Both Cord & Scar	2.8	5.5	7.2	11.1	47.3	22.2	3.9	180

belongs to the size group 300-350 mm; and the lower limit of this group, i.e. 300 mm, is taken as representing the size at birth. Compagno (1984) reports the corresponding size to be between 25 and 39 cm.

The two values having thus arrived at (i.e. the maximum length = 1000 mm and the length at birth = 300 mm), the gestation period ($T = t_o$) is estimated by the Bertalanffy's modified equation as follows:

$$300 = 1000\,(1 - e^{-0.2T})$$

$$e^{-0.2T} = 1 - 300/1000 = 0.7$$

$$0.2T = \log_e 1/0.7 = 0.3567$$

$$\therefore T = 0.3567/0.2 = 1.78 \text{ yrs.}$$

The values less than 1.78 years such as 1 year or 1.5 years give K values of 0.3445 and 0.23, respectively, which are higher than the range normally expected for selachians (0.1-0.2). Hence, the value of 1.78 years is accepted as the gestation period ($T = t_o$). which compares well with the values so far derived for other selachians; as for example 2 years for *S. acanthias* (Ford 1921), 1.2 years for *S. laticaudus* (calculated from published data; Prabhakaran Nair 1976); 1 year for *C. milberti* (Wass 1973), and 1.3 years for *G. australis* (Grant et al 1979).

The Bertalanffy's growth equation for *R. (R.) acutus* can now be stated as follows:

$$l_t = 1000\,(1 - e^{-0.2\,(t+1.78)})$$

On the basis of this equation, *R. (R.) acutus* attains sizes of 417.3, 522.9, 609.4, 680.2, 738.2, 785.6, 824.5, 856.3, 882.3 and 903.7 mm respectively at ages from 1 to 10 years and reaches the maximum size (1000 mm) at an age of about 20 years. (Fig. 2 depicts the growth curve of *R. (R.) acutus.*)

A reexamination of the length-frequency polygons in the light of these estimated sizes at ages reveals that the various modes in any month belong to year classes different from those of the preceding or the succeeding months. The grey dog-shark fishery at Madras is, therefore, mainly supported in each month by two year-classes while the older year classes are less distinct, may be because of the selectivity of the gear employed or the existence of an acute sense of territoriality, a behaviour not uncommon among selachians (Springer 1967, Johnson and Nelson 1973).

Length-Weight Relationship

Based on the observations on lengths (cm) and weights (g) of 83 males and 97 females ranging in size from 19 to 87.5 cm and in weight from 19 to

4000 g, the length-weight rtlationship, separately for males and females, was fitted to the allometric equation: $W = aL^b$, and the values of the constants a and b were estimated by the least square method. The equations are:

Male: $\text{Log } W = -1.9551 + 2.80 \log L$

Female: $\log W = -2.1460 + 2.95 \log L$

An Analysis of covariance reveales that the difference between the two b values, of males and of females, is not significant at 5% level with 13 d.f. The length-weight equation of data pooled for the males and females is:

$\log W = -2.1007 + 0.9873 \log L$

with a very high Coefficient correlation value of 0.9873. The scatter diagram between length and weight with the best-fit line is shown in Fig. 3.

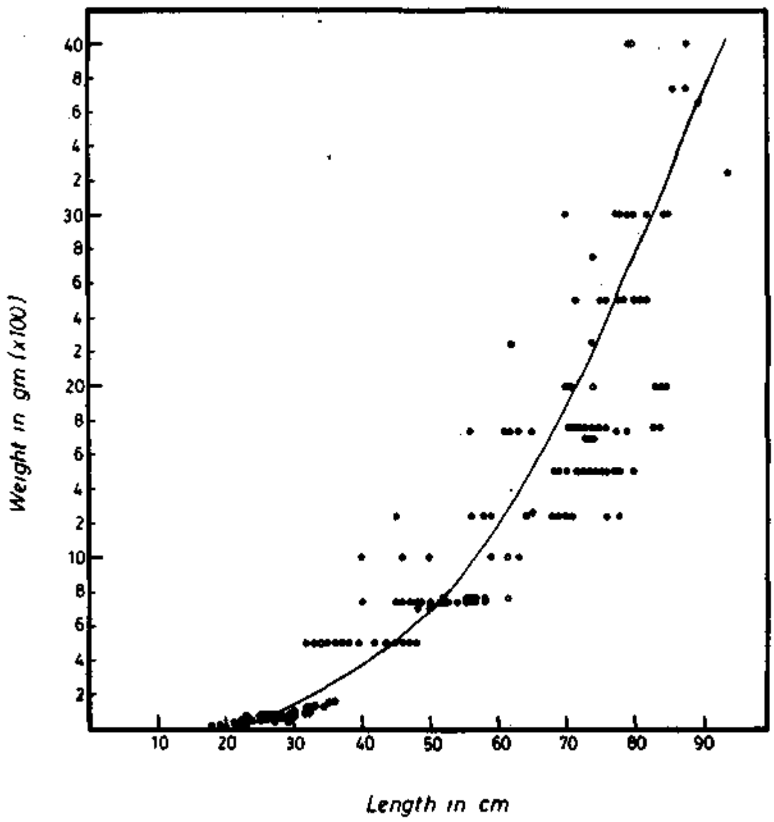

FIG. 3. Length-weight relationship in the grey dog shark, *R.* (*R.*) *acutus*.

Reproduction

A knowledge of the size (age) at maturity, the number of female embryos produced by each adult and the sex ratio is very important to understand the population dynamics of elasmobranchs, since stock and recruitment among them are more directly related than they are among teleosteans (Holden 1977).

Size at maturity: Commencing with the month of May, when specimens in the smallest size range (10-20 cm) were observed, adult females above 600 mm were examined to see if they were bearing embryos. If they were bearing, the number of embryos present in each adult and their sizes were taken (Table 3).

TABLE 3. *Average size and number of embryos in relation to adult size in the grey dog shark,* R. (R.) acutus.

Sl.		Size (mm)		No. of Embryos			Functional
No.	Date	Adult	Embryo	Right Uterus	Left Uterus	Both Uterii	Ovary
1	18-09-84	656	264.8	1	3	4	
2	06-11-84	679	99.0	1	2	3	
3	11-07-84	685	172.5	2	2	4	
4	30-11-84	694	135.5	3	3	6	
5	22-06-84	698	75.0	0	2	2	
6	07-05-84	721	175.4	2	3	5	
7	15-01-84	722	152.0	0	1	1	Right
8	24-07-84	738	180.0	2	3	5	
9	21-06-84	782	208.8	1	3	4	
10	30-11-84	800	312.0	1	1	2	Right
11	11-03-85	802	320.7	0	3	3	Right
12	20-07-84	815	253.5	2	2	4	
13	08-02-85	815	362.0	1	1	2	Right
14	30-05-84	818	231.0	1	3	4	
15	03-08-84	826	108.3	1	2	3	
16	24-10-84	845	342.3	1	3	4	
17	19-12-84	848	318.3	0	3	3	Right
18	30-09-84	868	306.8	2	3	5	
19	19-10-84	876	253.4	2	3	5	
20	12-01-85	885	283.5	2	2	4	Right

In the specimens measuring less than 656 mm embryos were not observed. It seems reasonable, therefore, to conclude that in *R.* (*R.*) *acutus* the minimum size at maturity in females may be at 650 mm and the l_m/L_∞ ratio at 0.65. A size of l_m = 600 mm reported for this species by Springer (1964) appears to be low, because the l_m/L_∞ ratio (600|722 = 0.83) is higher than that suggested (0.77) by Holden (1974) for elasmobranchs. Furthermore, other species in this genus reported so far (Springer 1964) indicate a l_m/L_∞ ratio ranging from 0.61 to 0.64. If a value of 0.77 is accepted, then the size at maturity in *R.* (*R.*) *acutus* would work out to 770 mm. But the present studies have shown that adults only in the size of 656 mm and above had embryos. Perhaps the l_m/L_∞ ratio in this genus is around 0.64. A value of 0.51 for the l_m/L_∞ ratio has been suggested for tropical elasmobranchs by Devaraj (1983). On the basis of this value, the l_m value for *R.* (*R.*) *acutus* would work to 510 mm, which is clearly too low to permit acceptance. Compagno (1984) reports a l_m between 68 and 72 cm for males and 70 and 81 cm for females. The age corresponding to the size of 650 mm, as estimated by the Bertalanffy's growth equation for the species, is 3.5 years (*vide infra*). The value of t_m (3.5 years) is a departure from the range of 7-10 years suggested by Holden (1974) for sharks, but comparable with that reported for *C. milberti* (t_m = 3 years) (Wass 1973).

Fecundity: Among 20 specimens observed, the minimum number of embryos recorded was 1, in a specimen measuring 722 mm, and the maximum was 6, in a specimen measuring 694 mm (Table 3). Three specimens, measuring 698, 800 and 815 mm, had 2 embryos each. The specimens measuring 721, 738, 858 and 876 mm, each had 5 embryos, while seven specimens, measuring 656, 685, 782, 815, 818, 845 and 885 mm, had 4 embryos each. But four specimens, measuring 679, 802, 826 and 848 mm, each had only 3 embryos. There is, thus, no relationship between the size of the adult and the number of embryos present. Considering the length at birth to be 300 mm, full-term pups were found invariably in adults measuring 800 mm and above. Among 11 such specimens examined, however, there was no correlation between the average size of the embryo and the absolute size of the adult. These results are in contrast with that observed either in the smooth dog-shark, *Eridacnis radcliffei* Smith (Nair and Appukuttan 1974), or in the Japanese dog-fish, *Mustelus manazo* (Teshima et al 1971).

As in *Mustelus manazo* (Teshima et al 1971) and *C. milberti* (Wass, 1971), in *R.* (*R.*) *Acutus* also only the right ovary was functional. Mahadevan (1940), however, reported that both the ovaries were functional in *S. walbheemi* (= *R.* (*R.*) *acutus*); *S. palasorrah* (= *R.* (*P.*) *oligolinx*) and *S. sorrakowah* (= *S. laticuada*). Invariably, the number of embryos in the left uterus was more than in the right unlike in *C. milberti* (Wass 1973), and, on an average, an adult *R.* (*R.*) *acutus* produced 4 embryos during each pregnency.

TABLE 4. *Monthwise and sizewise distribution of the number of females to each male in the grey dog shark,* R. (R.) acutus. *Figures in parantheses indicate the number when only one sex was present. M = Male; F = Female.*

Month	Sample Size	Size groups in cm										All Groups
		10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	
Jan	86			1.71	1.60	1.00	3.50	0.38	(4F)	(1F)		1.46
Feb	171	(2F)	1.00	3.86	5.50	3.67	3.83	3.00	3.25		4.00	3.75
Mar	120		1.50	2.63	1.20	1.46	5.00	1.50		(2M)		2.00
Apr	173		0.83	0.75	3.17	1.00	2.63	1.67	(4F)			1.62
May	126	1.50	1.83	2.00	3.00	0.91	1.75	0.50	1.33			1.55
Jun	96		1.50	3.00	4.33	0.79	1.15	0.80				1.23
Jul	161		(1M)	1.08	1.50	2.20	0.25	0.35	0.08			0.59
Aug	117		1.00	2.20	2.11	2.57	0.29	0.17	1.00			1.09
Sept	83		2.67	1.50	3.25	1.50	0.06	0.50	(4F)	(1F)		1.24
Oct	76	1.00	1.00	1.44	2.00	1.00	0.20	(7M)	1.00			0.90
Nov	64		1.50	1.00	1.25	1.50	0.33	0.50		(1F)		1.00
Dec	158		1.00	1.44	0.84	1.20	1.25	1.19	2.00			1.19
All Months	1431	1.60	1.25	1.65	1.99	1.35	1.02	0.82	1.53	1.50	4.00	1.34

Sex ratio: The monthwise and sizewise distributions of sex ratio of 1431 specimens observed during the period January-December 1984, are given in Table 4. A chi-square test indicates that the differences noticed in the ratios are significant at 1% level with 99 d.f. The overall male-female ratio being 1 : 1.34, females predominated, in all size groups, appreciably so in the period from February to April. Since specimens less than the length at birth (300 mm) were encountered in most months of the year, the departure in the sex ratio noticed in the months of February, March and April is not conclusively indicative of the spawning season in *R.* (*R.*) *acutus*.

Population Dynamics

Assessing the effect of fishing on the stocks of ovoviviparous dog shark, *S. acanthias*, Holden showed that 'the female part of the stock must be given considered protection if recruitment is not to be affected' (Holden 1974, p. 132).

TABLE 5. *Monthwise total mortality rate* (Z) *estimated by the method of Ssentongo & Larkin* ($Z_{S\&L}$) *and Beverton & Holt* ($Z_{B\&H}$. ($L\alpha$ = 100 cm; lc = 30 cm; yc = 0.3567; and K = 0.2).

Month	Sample Size	$\bar{l}$	y	$Z_{S\&L}$	$Z_{B\&H}$	No. of Units (f)
Jan	87	53.28	0.7610	0.4890	0.4014	224
Feb	148	54.73	0.7925	0.4558	0.3661	343
Mar	117	55.60	0.8119	0.4356	0.3469	426
Apr	173	53.09	0.7569	0.4969	0.4063	286
May	110	48.18	0.6574	0.6591	0.5701	402
Jun	96	55.73	0.8149	0.4320	0.3441	352
Jul	183	54.51	0.7877	0.4615	0.3712	223
Aug	119	52.14	0.7369	0.5217	0.4323	545
Sep	87	47.76	0.6493	0.6757	0.5883	421
Oct	76	48.42	0.6620	0.6461	0.5600	441
Nov	64	44.69	0.5922	0.8356	0.7530	—
Dec	158	47.97	0.6533	0.6701	0.5791	—
All Months	1418	51.85	0.7214	0.5480	0.4407	3663

Holden (1974) has derived an equation to determine, when the estimates of age at maturity and of fecundity are available, the upper limit of the instantaneous total mortality rate (Z) at which recruitment is maintained at a constant level, the equation being $Z = x\, e^{Zt_m}$, where x = average number or female young produced and t_m = age at maturity.

It has been proposed earlier that in *R.* (*R.*) *acutus* the age at maturity is 3.5 years and the fecundity is 4 per adult. Since the overall sex ratio is almost equal, the average number of young females produced would be 2. The estimated upper limit of the total mortality rate (Z) would then be: 0.4355.

Adopting the methods of Ssentongo and Larkin (1973): $Z = K(n|n + (1|\bar{y}\text{-}yc)$; and Beverton and Holt (1957): $Z = K(L_\infty\text{-}\bar{l}|\bar{l}\text{-}lc)$, the rates of total mortality (Z) now being generated are estimated at 0.5080 and 0.4407, respectively (Table 5). The respective rates of natural mortality (M) are estimated at 0.3882 and 0.2982 and the catchability coefficient (q) at 0.0003796 and 0.0003834 following the method of Widrig (1954): Z = M + qf, where qf. = F. Since fishing mortality (F) = Z – M, the rates of fishing mortality respectively are: 0.1598 and 0.1425. From the estimated rates of total mortality (Z = 0.4407) and fishing mortality (F = 0.1425) obtained from the method of Beverton and Holt (1957), the rate of exploitation (U) is estimated at 0.1152 following the method of Cushing (1968): $U + F/F + M\ (1 - e^{-F+M})$. Since total stock (Y) = C|U and standing crop (Y) = C|F where C = estimated catch, the total stock and standing crop of *R.* (*R.*) *acuts* in the Madras waters are 25 and 20 tonnes per month for a catch (C) presently at 2.9 tonnes per month (5 year average). Since the current rate of total mortality (0.4407) and the upper limit of total mortality rate (0.4335) at which recruitment is maintained are comparable, and are more or less equal, there is scope for stepping up of the exploitation of *R.* (*R.*) *acutus* in Madras waters, but with caution that the upper limit of Z is continuously monitored so as to ensure maintenance of the present level of recruitment.

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