



Relationship between body size and certain breeding behavior in selected species of Elasmobranchs off Mumbai

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Received: 24 Jun 2011, Accepted: 23 Nov 2012, Published: 28 Dec 2012

Original Article

Abstract

Social organization in elasmobranchs is complex and poorly understood. In India, no specific studies on the behaviour of this resource have been published. Breeding behavior in six species of sharks, two species of skates and three species of rays were deduced from length frequency data in relation to body size and sex. The species of sharks investigated are *Scoliodon laticaudus*, *Rhizoprionodon acutus*, *Carcharhinus macloti*, *Carcharhinus sorrah*, *Carcharhinus limbatus*, *Loxodon macrorhinus* and *Sphyrna lewini*. The species of skates observed were *Rhinobatos annandalei* and *Rhyncobatus djiddensis* and rays were *Himantura imbricata*, *Himantura alcockii* and *Gymnura japonica*. Based on the present observations mating areas, pupping and nursery grounds for juveniles, segregation and aggregation of adults were recorded.

Keywords: *Elasmobranchs, nursery grounds, mating congregation, Mumbai.*

Introduction

Elasmobranchs are the most important by-catch landed throughout the year in shrimp trawlers at Mumbai. Most species of sharks have biological and behavioral characteristics close to sea turtle, large land mammals and birds (Anon, 1996). The attainment of sexual maturity in sharks is a major

developmental milestone which has a large impact on their distribution, behavior and biology. Matured males and females may come together only to mate, resulting in movement that may range from small-scale aggregation of dispersed individual to long-range migration (Francis and Duffy, 2005). Suda (1953) reported several patterns of segregation among blue shark, *Prionace glauca*, based on the size of sharks, dominance of females in the population etc.

In India no specific studies on the behaviour of this resource especially breeding behavior has been published. Since this resource is a by-catch there is great difficulty in obtaining accurate species-wise, sex-wise, length-wise catch statistics. Bonfil *et al.* (1990) utilised length frequency data to describe population structure of shark species from Yucatan and Mexico. The objective of the present study is to provide baseline information about some breeding behavior of selected elasmobranch species based on their sex-wise body size data, which can be used for future studies.

Material and methods

Length frequency data of six species of sharks, two species of skates and three species of rays were collected and breeding behavior was deduced from this data in relation to body size and sex. The species of sharks investigated were *Scoliodon*

laticaudus, *Rhizoprionodon acutus*, *Carcharhinus macloti*, *C sorrah*, *C.limbatus*, *Loxodon macrorhinus* and *Sphyrna lewini*. The species of skates observed were *Rhinobatos annandalei* and *Rhyncobatus djiddensis*. The species of rays considered were *Himantura imbricata*, *H. alcockii* and *Gymnura japonica*. The data was collected from trawlers operating from New Ferry Wharf which is a major fish landing centre of Mumbai during 1999-2005 which formed the basic material for this study. The boats were operated at 70-80 km off Mumbai coast at a depth of 30-60 m. Field trips were carried out once a week to New Ferry Wharf and measurements were taken as described in CMFRI Manual (1995). The species constituted in these groups were identified, measurements were taken from caudal lobes for sharks and skates and disc width for rays. Sample size for different species is given in Table.1 Males were considered to be fully matured when the claspers were completely calcified (Pratt, 1996). Reproductive stages of females were assessed as: immature (ovary only as loose cells and oviduct thin and slender), mature (ripe ovarian eggs or large yolked eggs and distended uterus) and pregnant (embryo in the uteri).

Results and discussion

Sharks

***Scoliodon laticaudus*:** Among sharks, *S. laticaudus* was the most dominant species with 50-80% as far as shark landings are concerned. The abundance of females above 15 cm and 16-25 cm clearly indicated sexual segregation (Table 1) but sex-ratio of 294 embryos was 1:1. The almost equal sex-ratio in 26-35 cm and 36-46 cm length class coincided with modal class and size at first maturity for males at 34 cm and females at 36 cm, indicating congregation for mating and pupping. The presence of more females in 46-55 cm and 56-65 cm suggested the presence of this length class in the reproductive population. Nakano and Seki (2003) noticed

segregation by sex in *Prionace glauca* in the nursery grounds, where immature females were dominant. Hazin et al. (2002) noticed large numbers of gravid individuals of *Carcharhinus acronotus* in catches off northeastern Brazil and inferred probable reproductive migration of this species.

***Carcharhinus macloti*:** The dominance of males in 26-35 cm and 66-75 cm length group and females in 36-45 cm and 56-65 cm length class (Table 1) suggested segregation habit in this species. Segregation by sex and size are commonly exhibited by elasmobranchs (Springer, 1967). An equal sex-ratio of sub-adults in 46-55 cm length group, coincided with modal length at 55 cm for males and 50 cm for females indicated congregation in the study area. Mature males were observed at 77 cm and females at 83 cm. Both the sexes in 76-85 cm length group comprised mostly of adults with almost equal sex-ratio and modal class at 80 cm which indicated aggregation for mating and pupping. This was further supported by the predominance of mature females in 86-95 cm length class in the fishing ground.

***Rhizoprionodon acutus*:** Males of new born to adult stages were predominant up to 66-75 cm and subsequently adult females from 76-85 cm (Table 1). The modal classes for males and females were 75 cm and 80 cm respectively. The smallest size of mature male and female was 67 cm and 75 cm respectively. Moreover, an increasing proportion of immature females from 36-45 cm length class to 86-95 cm length class were noticed. The results obtained herein indicate that females of all the stages of this species might be congregating forming nursery grounds for mating and breeding. Bonfil et al. (1990) noticed all developmental stages from new born to large adults of *Rhizoprionodon teraenovae* in Yucatan's fishing grounds and suggested that the entire banks of Campeche support a major breeding population of this species.

Table 1. Sex-wise length range, modal size, length at maturity and sex-ratio of sharks from Mumbai waters

Species	Total number examined (male and female)	Size range (cm)		Dominant modes (cm)		Lowest length of maturity (cm)		Overall sex-ratio	Length-wise sex-ratio of sharks								
		Male	Female	Male	Female	Male	Female		<15	16-25	26-35	36-45	46-55	56-65	66-75	76-85	86-95
<i>S. laticaudus</i>	3720	16-62	16-64	34, 42	36, 48	34	36	1:1.1	1:1.7	1:1.4	1:0.9	1:0.8	1:4.4	1:1.8			
<i>R. acutus</i>	306	30-90	40-115	75	80	67	75	1:1.5		3:1	1:0.3	1:0.4	1:0.5	1:0.7	1:4	1:3	
<i>C. macloti</i>	554	30-99	39-98	55, 80	50, 80	77	83	1:0.9		1:0.3	1:2.7	1:1	1:2	1:0.7	1:0.8	1:3.5	
<i>L. macrorhynchus</i>	112	70-90	65-80	80		79		1:0.04						0:1	1:0.1	1:0.01	2:0
<i>C. sorrah</i>	476	50-220	56-235	75, 135	75, 115	132	235 pre	1:1.7	1:0	1:1.2	1:1.1	1:7	6:0.2				
				215	165												
<i>C. limbatus</i>	233	55-230	60-265	90	95, 145	171	293 pre	1:1.2		1:1	1:2	1:1.3	1:2	0:1			
<i>S. lewini</i>	731	50-235	45-259	55	55	190	246 pre	1:1.3	1:1	1:1.2	1:4	1:0.2	2:0.5	0:1			

***Loxodon microrhinus*:** Dominance of males in all the size groups, decrease in proportion of immature females and imbalance in sex-ratio (Table 1) indicated sexual segregation of the species. Anderson and Ahamed (1993) observed remarkable sexual and size segregation in this species from Maldives waters. Buencuerpo and Moron (1998) noticed increased number of males (1M:0.6F) based on the studies on sexual segregation in *Isurus oxyrinchus*.

***Carcharhinus sorrah*:** Mature males measured 132 cm and pregnant females 235 cm in the present study. Setna and Sarangdhar (1949) reported the length of *C. sorrah* as 60 cm and adult females as 120 cm. Devadoss (1988) noted length of mature males at 115 cm and females at 120 cm. Length of new born of *C. sorrah* in the present observation was less than 50 cm and the mode of immature specimens for both the sexes was 75 cm, which coincided with equal sex-ratio in 51-100 cm (Table 1), attributing neonates/juveniles congregation in the fishing ground. Mature males had a mode at 135 cm and females at 115 cm. Equal sex-ratio in 101-150 cm suggested that both the sexes might be aggregating in sampling areas for mating and pupping. High proportion of mature females in 151-200 cm indicated breeding aggregation and later on less proportion of females in 201-250 cm suggested segregation in the fishing grounds.

***Carcharhinus limbatus*:** Smallest mature male measured was 171 cm and pregnant female was 293 cm. Appukuttan and Nair (1988) recorded the range of gestating mother from 89 to 155 cm. The overall sex-ratio of *C. limbatus* was almost equal (Table 1) probably due to schooling behavior of this species as reported by Castro *et al.* (1999). The modal class for immature males was 90 cm and that of females was 95 cm, which coincided with equal sex-ratio for the species in 51-100 cm suggesting congregation habit of juveniles in the inshore waters. Branstetter (1987a) reported that the young ones of *C. limbatus* utilize low beaches and bay areas as nursery ground. *C. limbatus* pups are born at 50-60 cm and they use the relatively unprotected littoral zones as nurseries (Snelson and William, 1981). Second modal class for females

was 145 cm and predominance of females in all the size groups from 101-150 cm to 201-250 cm could be attributed to the entry of more females in fishing ground for mating and pupping. Further, these females might be migrating to the fishing grounds probably for breeding. The presence of only females at the higher length below 300 cm in the present study indicated differential growth rate as well as a larger asymptotic size for females, as observed in other selachians (Pratt and Casey, 1983; Casey *et al.*, 1985).

***Sphyrna lewini*:** Specimens above 50 cm and free swimming young ones at 51-100 cm with almost equal sex-ratio and modal class of both the sexes at 55 cm indicated that the fishing ground might be serving as nursery areas for this species (Table 1). Devadoss (1988) reported length at birth for this species as 42-65 cm. Bonfil *et al.* (1990) observed modal size of *Sphyrna tibura* at 60 cm for both the sexes. Castro (1993) noted nursery grounds for this species in shallow coastal waters. The variation in sex-ratio from 101-150 cm to 201-250 cm was probably due to segregation habit in adult males and females during certain phase of life cycle as observed for this fish by Compagno (1984). Devadoss (1988) reported size of mature males at 140-165 cm and females at 200 cm. According to Klimley (1981) and Branstetter (1987b), mature specimens of *S. lewini* occupy offshore waters more commonly than coastal waters.

Skates

***Rhinobatos annandalei*:** Mature males were recorded from 50 cm and females 60 cm onwards in the present observations. Smallest free-swimming *R. annandalei* was measured at 223 mm. The size ranges of 43 embryos range from 152 to 200 mm and male to female ratio was 1:0.9. Neonates/juveniles of this species exhibited a sex-ratio in unity at 21-30 cm indicating that the fishing grounds could possibly be a pupping ground (Table 2). Further, increasing presence of females from 31-40 cm to 61-70 cm and occurrence of only mature females above 71-80 cm indicate that the females may probably be moving in to the fishing grounds for mating and breeding. According to Smith (1961) fair number of mature

Table 2. Sex-wise length range, modal size, length at maturity and sex-ratio of skates from Mumbai waters

Species	Total number examined (male and female)	Size range (cm)		Dominant modes (cm)		Lowest length of maturity (cm)		Overall sex ratio	Length-wise sex-ratio of skates						
		Male	Female	Male	Female	Male	Female		21-30	31-40	41-50	51-60	61-70	71-80	81-90
<i>R. annandalei</i>	365	30-74	27-85	60	65	50	59	1:2	1:1	1:0.4	1:0.6	1:0.8	1:3.4	0:76	0:3
										40-50	51-100	101-150	151-200	201-250	>300
<i>R. djiddensis</i>	606	41-225	47-260	55, 80	55, 80	132	182	1:1.2	1:1	1:1.2	1:0.7	1:1.4	1:21	0:4	
				130, 145	115, 165										
				160	180, 230										

Table 3. Sex-wise length range, modal size, length at maturity and sex-ratio of rays from Mumbai waters

Species	Total number examined (male and female)	Size range (cm)		Dominant modes (cm)		Lowest length of maturity (cm)		Overall sex-ratio	Length-wise sex-ratio of rays					
		Male	Female	Male	Female	Male	Female		<10	11-20	21-30	31-40		
									21-40	41-60	61-80	81-100	>100	
<i>H. imbricata</i>	731	10-28	10-32	23	23	20	22	1:1.4	1:1	1:0.9	1:1.5	0:3		
<i>H. alcockii</i>	1058	20-96	20-120	36, 52	28, 56	58	63	1:1.7	1:1.1	1:1.2	1:1	1:36	0:25	
				72	88									
<i>G. japonica</i>	268	23-90	28-106	36, 56	36, 88	44	48	1:1.5	1:1.1	1:0.3	1:2.8	1:34	0:14	

females of *Rhinobatos annulatus* aggregated in estuaries for pupping.

***Rhyncobatus djiddensis*:** Mature males measured at 132 cm, females at 182 cm and pregnant females at 210 cm in the present observations. The largest embryo was 422 mm. The free living *R. djiddensis* had a sex-ratio of 1:1 (40-50 cm), while juveniles had 1:1.2 (51-100 cm) and this coincided with the modal classes for both the sexes at 55 and 80 cm (Table 2). Further, sex-ratio of 29 embryos was 1M : 0.9F, which suggested fishing grounds as breeding and nursery areas. Day (1878) recorded large numbers of young ones of this species in the fish catches along the Coromandal coast. The proportion of females showed increase from sub-adults (101-150 cm) to adults (201-250 cm) indicating the movement of females probably for mating and breeding in the fishing ground. The lack of males and the presence of only adult females below 300 cm probably indicated the results of differential growth rate.

Rays

***Himantura imbricata*:** This ray is landed throughout the year in New Ferry Wharf, Mumbai. The free-swimming young ones were at 95-100 mm and size of full grown embryo was in 65-99 mm. New born/neonates of both the sexes were in almost equal proportion above 10 and 11-20 cm (Table 3). However unequal sex-ratio was observed in *Isurus oxyrinchus* by Fancis and Duffy (2005). The predominance of mature females in 21-30 cm coincided with the maturity and modal size of the species. Moreover, presence of only mature females in 31-40 cm suggested entry of more females in fishing grounds for mating and breeding.

***Himantura alcockii*:** This is the most dominant ray species contributing 40-55% towards the ray landings in Mumbai waters. *H. alcockii* exhibited sex-ratio in unity from new born/neonates (21-40 cm) to large adults (61-80 cm). Size of embryos ranged from 132 to 280 mm and sex-ratio was 1:0.7. The modal classes for males were 36, 52, and 72

cm and for females it was 28 and 56 cm (Table 3). The length at maturity for males was 58 cm and for females it was 63 cm and the results in the present studies indicate that this species might have completed its life cycle from mating to pupping in the fishing grounds. High proportion of females in 81-100 cm coincided with modal size at 88 cm and presence of only females in below 100 cm indicated that the females might be migrating in to fishing grounds for breeding activities. The length of embryos in 49 pregnant females examined during different months ranged between 25 to 280 mm. Generally rays use coastal and estuarine areas for breeding and they form nursery grounds (Pratt and Casey 1983).

***Gymnura japonica*:** The almost equal sex-ratio coincided with modal classes of both the sexes at 36 cm in 21-40 cm. Sex-ratio of embryos from 6 pregnant females was 1:1.3 and size ranged between 15 cm and 32 cm. The size of free-swimming young ones was 26 cm. The results suggested that the females might be pupping their young ones in the fishing grounds. There is a change in sex-ratio of sub-adult/adults from 1: 3 (41-60 cm) to large adults 1:34 (81-100 cm). Modal value for females at 88 cm and presence of only mature females at higher length groups suggest the fact that females might have come to the fishing area for mating and breeding. Similarly, James (1966) also noticed females in large numbers of *G. poecilura* at Palk Bay and Gulf of Mannar

Acknowledgements

The authors are grateful to Dr. G. Syda Rao, Director, C.M.F.R.I., Kochi, Dr. E. Vivekanandan, Head, D.F.D., Kochi and Dr. V. D. Deshmukh, Principal Scientist and S.I.C., Mumbai for their encouragements.

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