J. mar. biol. Ass. India, **46** (2) : 178 - 184, July - Dec., 2004

Distributional record and biological notes on two deep-sea sharks, *Centrophorus acus* Garman and *Squalus megalops* (Macleay), from Andaman waters

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Abstract

Two deep-sea squaliform dogfishes *Centrophorus acus* Garman and *Squalus megalops* (Macleay), have been recorded from Andaman waters, the former for first time from the entire Indian Ocean and the latter from the eastern Indian Ocean. Both the species were collected from the catches of vertical hand lining off southwest coast of South Andaman Islands at depths between 200 and 400 metres during 1988 to 1992. The morphometric characters were compared with the description of Compagno (1984) for confirming the identity of the two species. *C. acus* was found to be a prolonged and continuous breeder and is ovo-viviparous. Only the left ovary and uterus are functional and each gravid female contained mostly one developing embryo or foetus at a time. The age, growth and length-weight relationship of *C. acus* was worked out. *S. megalops* also is ovo-viviparous and both right and left ovaries and uteri are functional. Each gravid female was found to bear 5 to 7 embryos/foeti shared in the uteri. These sharks are commercially important due to their high liver oil and squalene content. The targeted fishing of sex-segregated population of *C. acus*, having a very low fecundity, warrants monitoring for conservation and regulation of the fishery.

Key words: Deep sea sharks, distribution, biology, fishery, Andamans

Introduction

The seas around the Andaman and Nicobar group of islands comprising an area of 0.6 million sq.km^2 constitute nearly 30% of the total Exclusive Economic Zone (EEZ) of India. The area offers excellent potential for exploiting vast oceanic and deep-sea fishery resources. Among them the coastal and pelagic sharks form an important group and are exploited by the local fishermen. The annual average catch is 800 t which constitutes 3% of the total marine fish production in this island territory (Krishnamurthy and Soundararajan, 1999). Information on deep-sea shark fishing is very limited. The observation during 1988-92 revealed that there was a small-scale fishery for deep-sea sharks targeting two squaliform dogfish species, *Centrophorus acus* Garman (needle dogfish) and *Squalus megalops* (Macleay) (shortnose spurdog). This is the first record of the distribution of the former species from the entire Indian Ocean and latter in eastern Indian Ocean. The results of the observations on their biological characteristics also are discussed.

Material and methods

Weekly observations were made on the landings of deep-sea sharks and the specimens were measured and weighed. Information was collected on size distribution, length-weight relationship, and breeding habits. The stomach content, if any, conditions of functional gonad and uterus of females and number and stage of development of embryos were also observed. Detailed morphometric data on *C. acus* (five females of 924-1007 cm and 4 males of 808-891 cm) and *S. megalops* (females of 709-827 cm were used for precise identification of the two species. The length-weight relationship has been estimated based on the measurements taken randomly and separately for female and male sharks at the landing centre. Peterson method adopted by Krishnamoorthi and Jagadis (1986) for estimating the age and growth of the gray dog shark, *Rhizoprionodon (Rhizoprionodon) acutus* of Madras waters has been followed, for applying the Bertalanffy's growth equation as modified by Holden (1974, 1977).

Fishing methods

Fishing was done using vertical longline, carrying 300 to 450 angled hooks, operated at a depths between 200 and 600 m, in areas adjoining continental and insular shelves off south-eastern coast of South Andaman. One or two small dugout canoes (10m OAL), fitted with diesel-powered 8HP engine (inboard), were used for fishing. These units leave the shore by noon and reach the fishing ground within three hours. The fishermen go to specifically identified grounds to fish the sexually segregated population of sharks. The soaking time of the gear is 3-4 hours. The catches were landed in the night. Some fishermen leave at midnight for fishing in the early hours and returned to shore in the morning. Mostly lesser sardines or squids were used as bait to hook the sharks.

The gear, which is highly selective, predominantly targeted *C. acus*, because of its large body and liver volume. *C. acus* and *S. megalops* formed the deep sea shark catches during the entire period of observation. The data on deep-sea shark fishery, collected during 1988-1992, are given in Table 1. Occasionally, one or two chimaeroids, miscellaneous deep-sea fishes and crabs were also caught. The sharks brought to the landing centre and kept in cold storage are cut open to remove the liver.

Results

Diagnostic features and distribution

Centrophorus acus Garman : Snout flattened, narrowly parabolic and moderately long. Head about 1/4 of the total length and with short nasal flaps, anteriorly. Gill openings moderately broad, increasing in width posteriorly. First dorsal fin relatively low and long and second dorsal fin nearly 2/3 of the first dorsal at base as well as of the length and 3/4 of the height. Both dorsal fins with strong and grooved spines anteriorly. First dorsal origin is over pectoral fin inner margin and the insertion is well in front of the

Table 1. *Details of deep-sea shark fishery in Andaman waters, 1988-1992*

Month	Fishing days	Total units	Total catch (kg)	CPUE (kg)
Jan.'88	1	1	44	44
Feb.	8	8	496	62
Mar.	12	17	749	44
Apr.	4	5	519	104
Oct.	13	15	1643	110
Nov.	5	6	669	112
Dec.	2	2	154	77
Aug.'90	4	7	655	94
Sep.	2	3	113	38
Jan.'91	13	17	805	47
Feb.	6	6	152	25
Mar.	17	17	606	36
Apr.	6	7	157	22
May	14	16	567	35
Oct.	7	8	357	45
Dec.	3	3	185	62
Jan.'92	2	2	52	26
Feb.	14	14	473	34
Mar.	6	6	295	49

pelvic origin and closer to pectoral base. Second dorsal origin is over inner margins of pelvic fins. Free rear tips of pectoral fins extended into moderately elongated, narrow angular lobes reaching the level or slightly past first dorsal fin origin. Caudal fin asymmetrical with long upper and short lower lobes. The post-ventral margin of caudal fin weakly notched and with weak folds. Colour: dark gray and brown above with slightly lighter lower side.

Distribution: So far known only from Western North Pacific (Japan-southeastern Honshu) and Gulf of Mexico in Western Atlantic (Compagno, 1984). Present record extends the distribution to Eastern Indian Ocean – Bay of Bengal, Andamans, India. The habitat of the species is little known (Compagno, 1984). The catches showed clear-cut indication of sexual segregation and was caught from 200-400m depth.

Squalus megalops (Macleay): The two dorsal fins, with ungrooved spines. The spine of first dorsal shorter than the anterior margin of dorsal fin and finbase. It lies anterior to rear tips of pectoral fins, which are falcate. Posterior margins of pectoral fins moderately concave. The midpoint of pelvic bases lies closer to first dorsal base than second dorsal. The caudal fin narrow with a long ventral lobe and strongly notched post-ventral margin. No sub-terminal notch on caudal fin. An upper pre-caudal pits and lateral keels on caudal peduncle. Anal fin absent. Colour: Body gray to dusty brown above, becoming lighter below. No spots or blotches on body. Dorsal fins with black edges.

Distribution: *S. megalops* has been recorded from Eastern Atlantic, Western Indian Ocean and Western Pacific (Compagno, 1984). The present record indicates the continuity in distribution from Western Indian Ocean to Western Pacific as the species has been recorded now in Eastern Indian Ocean also. *S. megalops* has been found to occur on the

inter-continental shelves and upper slopes at a depth of 50 - 730 metres. In the present record it was caught at depths between 200-300 metres.

Biological notes

C. acus: The size of females ranged from 444 mm to 1108 mm in length (wt. 0.5kg to 7.3kg) and males from 790 mm to 875 mm (wt. 2.5kg to 3.6kg). The length-weight relationship expressed by equation: $W = aL^b$, in which 'a' and 'b' are constants, is as follows:

$$\text{Log } W = -4.8797 + 2.87 \log L$$

The proportion of liver weight to body weight in females and males of different size groups of *C. acus* is given in Table 2.

It was found that the liver ratio to body weight was higher (25% to 26%) in males compared with females (18% to 22%). The oil was extracted from liver by boiling and decanting. Oil formed 17% of the liver weight and one litre of oil weighed 850g. The stomachs of the hooked sharks were mostly empty but occasionally contained fish or squid remains.

The examination of females for gonad maturity, fecundity and intra-uterine embryonic development indicated that *C. acus* is a prolonged, breeder. Many females contained free intra-uterine embryos or foeti in various developmental stages. Only the left ovary and left uterus were found to be functional. Each gravid female had only one developing embryo or foetus at a time, with rare exceptions of two foeti in few specimens. There is a direct relationship between the sizes of developing ovum in the ovaries and the foetus in the uterus. When the uterus contains a fertilized egg or an embyo in

Table 2. *Liver weight percentage of* C. acus

Range (cm)	Female			Male		
	Avg. body wt (kg)	Avg. Liver wt. (kg)	%	Avg. body wt. (kg)	Avg. liver wt. (kg)	%
60-65	1.3	0.1	5.6	-	-	-
65-70	1.8	0.1	5.1	-	-	-
70-75	2.5	0.2	8.8	2.5	0.6	25.2
75-80	1.3	0.1	7.8	3.0	0.8	25.6
80-85	3.0	0.6	18.3	2.9	0.7	25.4
85-90	4.5	1.0	21.0	3.2	0.8	25.6
90-95	5.1	1.1	22.1	-	-	-
95-100	5.5	1.3	22.4	-	-	-
100-105	6.0	1.3	22.1	-	-	-
105-110	6.7	1.4	21.7	-	-	-

the early stage of development, the average size of the largest ovum in the ovary of the respective female was 33.5 mm. The size of the largest ovum and intra-uterine embryos were 44.2 mm (10-99mm), 61.2 mm (100-199mm) and 61.4mm (200-299mm). There was a corresponding increase in the size of the ovum to 78 mm when embryos reached the size range of 350-399 mm which is almost ready for release. The maximum size of the ovum observed in the present study was 93mm. It is observed that by the time the baby shark is released, the ripe ova start developing in the uterus. The females appear to breed throughout their life span. It was found that the largest female that occurred in catches measured 1108mm in length and was bearing a fully developed foetus (400mm) ready for release. The yolk sac had been fully absorbed by this time and only umbilical scar was visible on the ventral side of the foetus (Fig. 1). The largest foetus measured 404mm and the smallest free female encountered in the catch was 444 mm with an indistinct umbilical scar. From this, t it could be assumed that the young ones are released from mother sharks when the baby sharks reach the sizes between 404 and 440mm. Even though, the catches from a particular fishing ground are showing sexual segregation, examination of developed foeti showed almost equal sexual ratio.

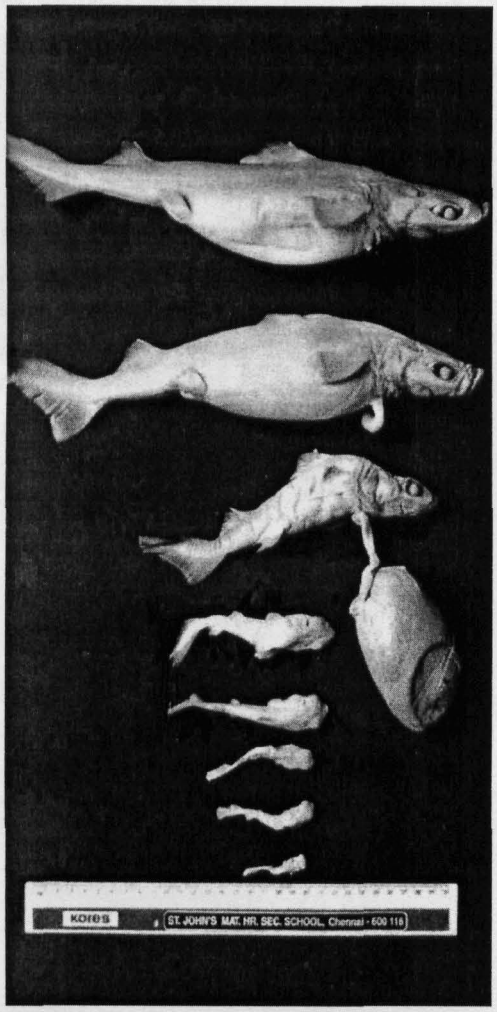

Fig. 1. *Different intra-uterine developmental stages of* C. acus *(the free yolk sac in one of the foetus is kept intact*

S. megalops: The catches comprised only of females. The sizes ranged from 62.5 to 76.6cm in length (wt. 1.3 to 2.8kg). Compared to *C.acus* the liver was smaller forming about 8% of the body weight. This species also is ovo-viviparous and both the right and left ovaries and uteri are functional. Each gravid female was observed to have 5 - 7 embryos/foeti in the uteri. Similar to *C. acus*, in *S. megalops* also equal number of ova develop along with growing foeti indicating continuous breeding habit. The maximum size of the foetus, observed in advanced stage of development in the uteri, was 132 mm,

which still retained a very small yolk sac. The size of young one at birth was above 150 mm. The sexes were in equal ratio, at random, in the uteri.

According to Holden (1977), $T = t_o$ for selections should be so adjusted that k is between 0.1 and 0.2 which is the range for most selachians. With the same approach of Krishnamoorthi and Jagadis (1986), the values of L_∞ and size at birth were estimated. The maximum size recorded for *C. acus* was 1108 mm. Hence the value of L_{max} was fixed by rounding off the maximum recorded size to 1100 mm. Similarly, the recorded maximum size of intra-uterine foetus was 404 mm and the minimum size of just released young one was 444 mm. Hence the size at birth was determined as 420 mm by taking the average of the above two values. Using the values of maximum length as 1110 mm and the size at birth as 420 mm the gestation period was estimated applying the modified Bertalanffy's equation as follows:

$$l_t = 420 = 1110\ (1 - e^{-0.2T})$$

$$e^{-0.2T} = 1 - 0.37 = 0.6216$$

$$0.2T = \log_e 1/0.6216 = 0.4754$$

$$\therefore T = 0.4754 / 0.2 = 2.37 \text{ yr}$$

The value of 2.37 yr is taken as the gestation period ($T = t_o$). The gestation period in sharks have been reported to vary from a few months (*Lamna* spp.) to 2 years and more (*Squalus* spp.) (Compagno 1984). In Indian waters, the gestation period for *Scoliodon laticaudus* has been estimated as 1.2 years (Prabhakaran Nair, 1976) and for *Rhizoprionodon acutus* as 1.78 years (Krishnamoorthi and Jagadis, 1986). Hence it may be safely assumed from the above analysis that the gestation period in *C. acus* is around two years. The von Bertalanffy's growth equation for *Centrophorus acus* can be written as:

$$l_t = 1100\ (1 - e^{-0.2\ (t + 2.3771)})$$

Similarly, in *S. megalops*, using the estimated size at birth as 150mm and the maximum length attained being 770mm, following values (von Bertalanffy) were obtained:

$$150 = 770\ (1\text{-}e^{0.2T})$$

$$e^{0.2T} = 1\text{-}0.19 = 0.80$$

$$0.2T = 0.21 \text{ or}$$

$$T = 1.08$$

Hence the gestation period of *S. megalops* can be taken as 1.08 years.

The von Bertalanffy's growth equation for *S. megalops* can be written as:

$$l_t = 770\ [\ 1\text{-}e^{-0.2(t+1.0834)}].$$

The graphical representation of both the above mentioned age and growth equations of *C. acus* and *S. megalops* is depicted in Fig. 2.

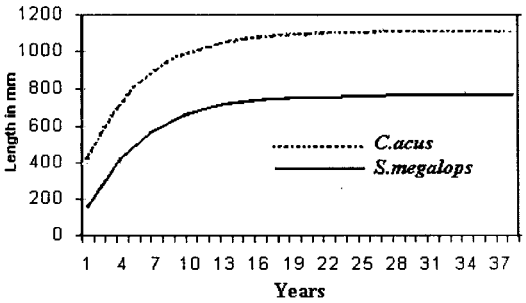

Fig. 2. *Age and growth curve of* C.acus *and* S.megalops

Discussion

Japanese had been fishing in Andaman seas during the early part of the last century. Since the liver is rich in squalene the Japanese have shown great interest to reach far off areas as Andaman Sea to exploit these deep-sea sharks. The squalene extracted from the liver oil has many pharmaceutical uses. In the post-independent era, the deep-sea sharks were first fished from the continental slope off Andamans in 1984 (Mustafa,1986). The fishing had revealed that the *Centrophorus* spp. occur in the upper continental slope in the depth range of 300 – 800 m and maximum yields could be obtained at 360 – 450 m. In Andamans, the deep-sea sharks were exploited by a few enterprising fisherman intermittently during 1988 and 1992. The monthly catches ranged from 44 kg to 1643 kg at a varying CPUE of 2 kg and 44 kg. In general, the catches have been good in March and October. According to Mustafa (1984) the hooking rate, during the surveys in 1984, was 18% and the average yield per 100 hooks was 94 kg. The hooking rates in the fishery, reported in the present study, varied between 1 - 14%.

The resource, if exploited under strict monitoring and regulation, will facilitate export of liver oil from Andamans. Monitoring is essential as the fishermen target the females. Further, the fecundity of these sharks is low. It has been postulated that around 4000 tonnes of deep-sea dogfish sharks can be exploited annually (Mustafa, 1986). However, proper assessment of resource dynamics is essential before venturing to regular exploitation and it would be possible only when controlled fishery is promoted and feedback information is analyzed for planning sustainable exploitation.

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