India Journal of Fishtrits* 3S(3):151-156, September 1991

The behaviour of sharks in captivity

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Received : 6 May 1991

ABSTRACT

Six species of sharks, viz. *Engomphodus taurus* (sand tiger), *Ginglymostoma cirratum* (nurse shark), *Negoprion brtvirostris* (lemon sharks), *Carcharhinus plumbeus* (sand bar), *C. limbatus* (Pacific black tip), and *C. leucas* (bull shark), were selected to understand some patterns of shark's behaviour. The general behavioural patterns like follows, circles and give ways were commonly noted among all the 6 species; however, each species was found to differ from the other. Locomotion in shirk was found to be a combination of anguilliform and crangidform modes. Swimming speed for 6 sharks was measured as distance (cm) travelled per second. Black tip sharks showed highest speed while sand tigers were found to exhibit lowest speed.

Shark species are represented in all the oceans and also in some freshwaters. Sharks are generally known as voracious predators of all oceans. The fear of shark attacks and inadequate facilities to maintain adult sharks in captivity have restricted investigations on them. The available information is mostly anecdotal and deals with occasional encounters or happenings. Several descriptive and empirical approaches to study the behaviour of sharks include investigations based on conceptable framework, constructed on methodologies of philosophies of ethology and experimental psychology (Dempster and Herald 1961, Klausewitz 1962, Springer 1967, Clark 1969, Myrberg *et al.* 1969, Gilbert and Heath 1972, Sciarrotta *et al.* 1972, Johnson and Nelson 1973, Myrberg and Gruber 1974, Hussain 1989).

Studies on structural behaviour of sharks depend entirely on the analysis of location and underlying neuroanatomical basis. It is essential to investigate certain postures and motor patterns that are repeated frequently under the influence of specific situations.

The present study on 6 species of sharks belonging to families Odontaspididae, Orectolobidae and Carcharinidae is a part of the major studies being carried out at University of Miami and Sea world, Orlando, Florida. The major aim of this study is to report some structural behaviour and the swimming speed of the 6 selected sharks.

MATERIALS AND METHODS

Observations were made on 6 species of free-swimming sharks, sand tiger *Engomphodus taurus* (TL, 225 cm; family Odontaspididae), nurse shark *Ginglymostoma cirratum* (TL, 250 cm; family Orectolobidae) and lemon shark *Negoprion brevirostiris* (TL, 237 cm), Pacific black tip *Carcharhinus limbatus* (TL, 103 cm), sand bar *Carcharhinus plumbeus* (TL, 200 cm) and bull shark *Carcharhinus leucas* (TL,

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200 cm) (all family Carcharhinidae). These sharks were kept in the public display tank at Sea world, Orlando, Florida, approximately 9 months prior to the commencement of this experimental study, carried out during July, August, and September 1989.

At the Sea world, Orlando, Florida, the shark display tank was rectangular (38 m x 18.3 m) with a notch in the middle (Fig. 1). The tank was able to hold about 25,000 litre of sea water. The tank was open on three sides with fibre glass windows. It also had a tunnel of fibre glass in the bottom.

The tank was also open from the above from where the animals were fed and most of the observations were made.

The total number of sharks placed in the tank were 32 which included 5 bull sharks, 12 sand bar and sand tiger sharks, 2 lemon sharks, 6 nurse sharks, 2 brown sharks, 3 black tips (one was separated due to injury), and 2 black nose. Some bony fishes, which also included 1 croaker of 50 cm TL, were also present During the present study period no change occurred. Fishes were fed on alternate days, one day for shark and next day for bony fishes. The general behaviour of shark showed no attacks either on bony fishes or on other smaller sharks. For this study individual shark of each species was either marked by the number or by small cut on any of the fins. The same shark was always selected for observation specially when the swimming speed of the animal was recorded. To measure the swimming speed, the tank was divided into small sections/ parts by ropes tied 4 m apart (Fig. 1; R). As soon as the shark touched the rope the stop-watch was pressed and time taken by shark to travel 4 m distance was recorded. These observations were repeated approximately 60 times during various hours of day/night

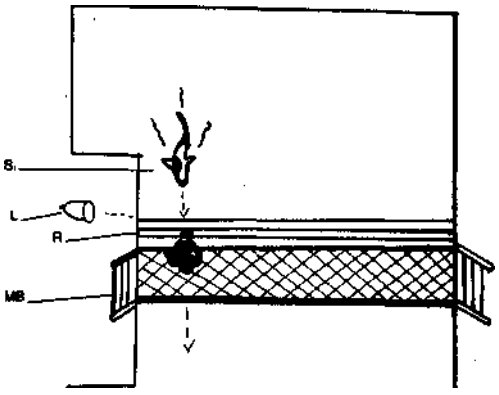

Fig. 1. Outline drawings of teawater tank (shark encounter) at the Sea World, Orlando, Florida, that held the sharks during the present study. L, light; MB, moving bridge; S, shark; R, rope line set

RESULTS

Gruber and Myrberg (1977) categorized sand tigers and nurse sharks in Group 3, (sharks with massive head and tapering sinus body with extremely unequal caudal lobes). The sand tiger sharks are relatively slow movers and are often found in groups of 2 or 3. Present observations revealed that these sharks remained moving most of the time and did not even change their swimming pattern. Other sharks when came face to face were usually made to change their course except the bull shark which being very active, forced the sand tiger to change its course. The sand tigers were found swimming close to the surface with their back out of water (like a hump). They were found patrolling in circles in one half of the tank for a while and then shifting to the other half and continuing circular patterns for quite a while. Changes from one pattern to other occurred often but this shift-over was slow; rapid manoeuvering or rapid change in speed was never noted. The large male

was followed by the other sharks while patrolling. Often, sand tigers were found gulping air from the surface by thrusting mouth out of water (Hussain 1989). During the 3 months observations sand tiger were rarely seen resting on the bottom, and when they reached the bottom they stayed quite a while (approximately 8—12 hr). Jaws snapping (opening and closing) and yawning was often noted in these sharks. It was difficult to note the frequency of yawnings but apparently it was having no relation with the feeding time. During feeding, sand tigers were seen coming out of water to snatch food. To avoid any attack, these sharks were fed by a long fork.

The nurse sharks are known to be sluggish and benthic in habitat. During this study nurse sharks were seen resting at the bottom of the tank. They had almost selected a particular spot and were seen near or at the same spot. After a few hours (4— 6 hr) of rest, they used to come to sufrace and patrol for some time. Such patrolling usually lasted for 20 — 30 min after which the sharks used to go back and stop at the same spot from where it arose.

Tjie frequency of visits to surface increased with the approach of feeding time. Attacks by the nurse sharks on other fishes were rare, at one instance nurse shark was seen swallowing a small reef fish. In a head-on encounter with huge sand tiger and other sharks in the tank, the nurse yielded and changed its course. Following of large nurse sharks by smaller ones was not observed. While resting at the bottom the gills were seen continuously pumping water; no gill puffing or yawning was observed in any nurse shark in the tank. Every nurse shark choosed its own spot usually at the inlets of water, no grouping was noted.

The other sharks (lemon, sand bars, bull sharks, black tip) placed in type Group 2 of Gruber and Myrberg (1977) were of family Carcharhinidae. Lemon sharks were found to be slow swimmers, swimming close together though very often getting separated but again coming close. Sand bar and bull sharks were active, swimming fast mostly close to the surface. The bull sharks were occasionally found dashing and splashing the water when chasing each other or taking a turn near the side wall of the tank. The patrolling of bull, sand bar and lemon sharks was a regular feature. They usually went from one end of the tank to the other. The stronger and bigger male was usually followed by others. Often sand bar and bull sharks were seen with the first dorsal fin out of water steering through the water surface. Black tip sharks preferred deeper waters swimming in a group of 3. The bigger male was followed. Occasional departure from the group by individual was observed but it soon came back and joined the group.

Swimming speed

Out of the 6 species of sharks studied, 4 (black tip, sand bar, bull and lemon sharks) had fusiform shape, while the other 2 (nurse sharks and sand tigers) were having bulky bodies. The mean swimming speed recorded for black tip, sand bar, bull and lemon sharks during the day was 55.66,63.4,59.88, and 42.15 cm/sec respectively, and during night 57.7, 66.48, 60.61 and 61.72 cm/sec respectively (Table 1). The maximum speed (102.56 cm/sec) was recorded for sand bar followed by bull (77.82 cm/sec), black tip (73.93 cm/sec) and lemon shark (61.72 cm/sec). Similarly, the specific speed U/L calculated from mean swimming speed of 4 species was 0.540 (day) and 0.560 (night) for black tip; 0.317 (day) and 0.512 (night) for sand bar; 0.299 (day), 0.303 (night) for bull shark; and 0.177 (day), 0.2434 (night) for lemon shark (Tablel).Mean swimming

Table 1. Maximum, mean and minimum swimming speed and specific swimming speed U/L (cm/sec) for six species of sharks

		A. Bull shark *(Carcharhinus leucasj*	B. Sand tiger *(Engomphodus taurus)*	C. Sand bar *(Carcharhinus plumbeus)*	D. Nurse shark *(Ginglymostoma cirratum)*	E. Pacific black tip *(Carcharhinus limbatus)*	F. Lemon shark *(Negoprion brevirostris)*
TL (cm)		200	225	200	250	103	237
Day speed	Max.	76.62	50.56	88.69	77.97	76.19	**49.14**
	Mean	59.88	39.15	63.4	62.01	55.66	**42.11**
	Min.	48.543	26.84	45.76	31.17	41.753	33.33
Night speed	Max.	77.82	70.67	102.56	76.62	73.93	**61.72**
	Mean	60.61	29.04	66.48	68.02	57.7	53.69
	Min.	40.65	13.249	54.05	58.91	40.6	40
U/L = Specific swimming speed (Day)	Max.	0.3831	0.2247	0.443	0.3188	0.739	0.207
	Mean	0.2994	0.174	0.317	0.248	0.54	0.177
	Min.	0.2427	0.119	0.2288	0.124	0.405	0.14
U/L = Specific swimming speed (Night)	Max.	0.3891	0.314	0.5128	0.306	0.717	0.26
	Mean	0.30305	0.129	0.3324	0.272	0.56	0.2434
	Min.	0.2032	0.0588	0.27025	0.235	0.3941	0.168

speed recorded for the nurse shark was 62.0 cm/sec (day) and 68.0 cm/sec (night) and for sand tiger 39.15 cm/sec (day) and 29.04 cm/sec (night). The maximum speed recorded for the 2 species was 77.97 cm/sec (day) and 76.62 cm/sec (night); and 50.62 cm/sec (day) and 70.67 cm/sec (night). The calculated specific swimming speed U/L from mean swimming speed was 0.248 cm/sec (day) and 0.272 cm/sec (night) for nurse shark and 0.174 cm/sec (day) and 0.129 cm/sec (night) for sand tiger.

Black tip shark was found to be the fastest shark among all the 6 species studied, which usually swam in deep waters but occasionally came to surface. Round-the-clock observations of swimming speed (Fig. 2) revealed a uniform speed (U/L = 0.50) till about 2200 hours but a slight increase was noted (U/L = 0.56), at about 2400 hours, when most of the other sharks slowed down. Probably because of being smallest sized among the shark group in the tank, it gets a chance to be fast when others are slow.

Bull shark was the other species with uniform swimming speed (U/L = 0.3) throughout the day and night. This was an active species moving from one end of the tank to the other. Bull shark was found to be the most energetic maintaining a uniform speed with no signs of exhaustion.

Sand bar appeared to be more active (U/L=0.45) in the afternoon or in the evening and gradually slowed as the night approached. Slowest swimming speed was observed during early morning.

Lemon shark was more slow, even slower than the nurse shark, with U/L 0.20 (day) and 0.26 (night). Slight increase in specific speed, at about mid-night was noted.

Nurse and sand tigers with their bulky bodies were slow moving. Observation on nurse sharks was difficult as they were resting at the bottom most of the time.

Nurse sharks showed low swimming

speed at early morning hours (U/L = 0.2) but as day passed the values increased (U/L = 0.29). Increased activity during night and resting or slow speed during day might be indicating nocturnal feeding habits.

Sand tigers were the slowest sharks among the 6 species studied. The specific swimming speed throughout the day and night was more or less similar to sand bar and nurse sharks, being slower (U/L = 0.174) during early day, but gradually increased in the afternoon (U/L = 0.2) and again going slow at the start of the day.

DISCUSSION

It was significantly observed that behavioural events like follows, circles, hunches and giveways showed marked intraspecific differences. The follows were noted in sand tiger, black tip, sand bars and bull sharks, but not in nurse and lemon sharks. The latter 2 sharks preferred to live alone strolling singly from one end to the other in the tank. Schooling/grouping species followed the rule of going after the more dominant males. Giveway was another important behavioural event but also varied in species. It was observed that dominant shark proceeded straight ahead and the subordinates yielded. The domain sharks among 6 species were bull sharks and sand bars. However, sand tigers did not giveway to these sharks. Hunch and posture in swimming movements were prominent in nurse and sand tiger sharks only.

The pattern of locomotion exhibited by 6 shark species did not indicate a typical anguilliform or crangiform modes. Their swimming could be rated as sub-crangiform, sub-anguilliform or at times sharks combined both the modes enabling their huge bodies to take a sharp turn, as in sand tigers, or to gain higher speed, as in Pacific black tip. It can be suggested that the basic form

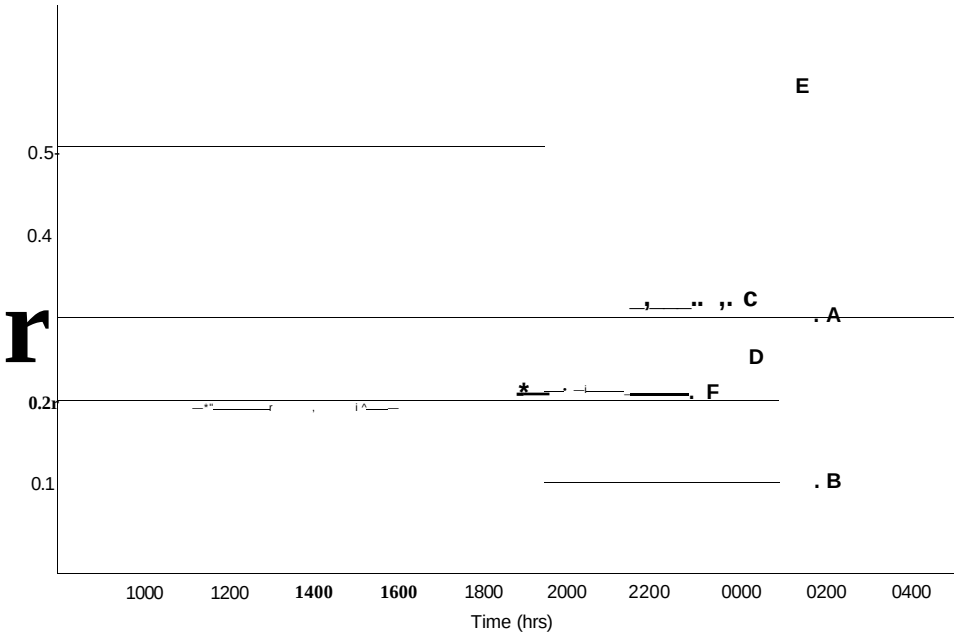

Fig.2. Day and night fluctuations in the mean specific swimming speed of six sharks. A, Bull shark; B, sand tiger, C, sand bar; D, nurse shark; E, Pacific black tip; F, lemon shark.

of propulsive movement in sharks is similar to a bony fish (Gray 1933) and once the speed is attained the sharks body form helps them to advance swiftly.

The specific swimming speed noted by Web and Raymond (1982) for nurse (0.34), lemon (0.47) and black tip shark (0.S8) was slightly higher than that observed in this study (Table 1). The Pacific black tip was considered to be the fastest shark in the present study which confirmed the findings of Web and Raymond (1982).

The present observations thus showed 2 clear patterns of swimming: 1. Sharks which were active 24 hr (black tip, bull and lemon). 2. Sharks which were active at certain time of the day/ night (sand bars, nurse, and sand tigers). These patterns may perhaps be attributed to the feeding time of these species.

ACKNOWLEDGEMENTS

I thank Dr Frank Murru, Director, Sea World, his associate staff members and those who helped me at shark encounter Sea World; USAID and Agency of International Development, New York, for financial help.

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