Reproduction of the Sandbar Shark, *Carcharhinus milberti,* in the East China Sea

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Abstract   The sandbar shark, *Carcharhinus milberti* (Müller and Henle) taken from the East China Sea, includes 2 to 10 embryos with an average of 6.0 and a mode of 6.   More than 80% of gravid females contain 5, 6, 7, and 8 embryos.   Marked difference cannot be seen in the number of embryos between the left and right uterus.   The ratio of males to females in the embryos is about 1 : 1 as a whole, although the ratio differs by litter.   The length at birth is usually 65 cm to 75 cm in total length.   Season of birth is estimated to be between June and July since near full-term embryos appear at that time.   The gestation period is guessed to be 10 to 12 months.

One of the members of the genus *Carcharhinus* (Carcharhinidae, Lamniformes) taken from the East China Sea is called "yaji-buka" by fishermen of Kyushu, Japan.   This shark was first reported from Formosa as *Carcharinus* sp. (*gangeticus*?) by Nakamura (1936).   Later, it was included in the synonymy of *Carcharhinus melanopterus* by Chen (1963)*. However, the shark discussed here differs from *C. gangeticus* or *C. melanopterus* in having prominent mid-dorsal ridge and notably high first dorsal fin.   According to the key to the genus *Carcharhinus* by Garrick and Schultz (1963), this shark falls into *C. milberti* (Müller and Henle).   The characteristics of the shark also agree with those of *C. milberti* described by Bigelow and Schroeder (1948: 368–378).   Therefore, this shark is tentatively identified as *C. milberti.*

C. milberti is one of the most abundant sharks in the East China Sea (Taniuchi and Hiyama, 1966).   Various sizes of males and females are taken in large numbers there. Gravid females are also taken from the area almost all the year round.   Particularly, females caught in early summer contain large

embryos which are connected with the uterine wall of the mother through yolk sac placenta.

The present study deals with the number of embryos per litter, sex ratio and size of embryos, season at birth, and gestation period of this species in the East China Sea.

Material

Counts and measurements on embryos and free-swimming individuals of *C. milberti* were made at the fish markets of Tobata, Nagasaki, and Kushikino during the years 1966 to 1967.   Adult females were caught in the southern part of the East China Sea mainly by bottom long line and partly by floating long line.

Results

Number of embryos

The number of embryos per litter ranges from 2 to 10 (Table 1).   Since cumulative frequencies plotted on the probability paper is almost straight line, the frequency distribution is nearly bell-shaped curve (normal distribution).   The average number of embryos per litter is 6.0 and the mode is 6.   Gravid females containing 5, 6, 7, and 8 embryos constitute 74 out of 91 examined.

Although all females contain less than 10 embryos in the present study, one female

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* The description and figures indicate that Chen's specimen should rather be identified as *C. limbatus* than *C. melanopterus*, judging from the number and shape of the teeth and shape of the snout.

Table 1. Frequency distribution of the number of embryos per litter in *C. milberti* taken from the East China Sea.

No. of embryos	2		3		4					5					6						7						8						9		10		Total
male	2	0	1	2	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	5	2	3	4	5	6	7	0	1	2	3	4	5	2	7	3	7	256
female	0	2	2	1	4	3	2	1	0	5	4	3	2	1	6	5	4	3	2	1	5	4	3	2	1	0	8	7	6	5	4	3	7	2	7	3	293
No. of litters	1	1	3	2	1	1	2	1	1	2	1	9	4	4	1	3	8	8	3	1	4	4	2	4	1	1	1	1	2	3	1	6	1	1	1	1	91
Subtotal	2		5		6					20					24						16						14						2		2		91

carried 7 large eggs (about 30 mm in diameter) in one side of the uterus and 10 small eggs (about 30 mm in diameter) in the other side of the uterus. In another case, a female had 2 embryos (50 cm in total length) in the left uterus and 7 small eggs (10 mm in diameter) in the right. The latter eggs seem to be unfertilized since they are in degenerate condition. It is guessed from the above two facts that the number of eggs included in a single ovary or uterus is not always equal to that of embryos.

Marked difference is not seen in the number of embryos between the left uterus and the right (Table 2). Of 65 litters examined, 31 include equal numbers of embryos in each side of the uterus, and 26 have one more embryo in one side than in the other. Remaining 8 litters show difference more than two between the two sides.

Sex ratio of embryos

Of 549 embryos in the 91 litters, the number of males is 256 and that of females is 293 (Table 1). The ratio of males to females is 1: 1.16. Statistically, however, the null hypothesis that the ratio is 1:1 is not rejected at 5% significant level.

The sex ratio of embryos is markedly different in each litter. Of 91 litters, only 11 have equal numbers of males and females (Table 1). Remaining 80 show a little or more difference in the sex ratio. In an extreme case, 8 embryos included in a litter are all females and no males are found. Furthermore, the sex ratio of embryos shows difference between the sides of the uterus. For instance, of 11 litters containing 8 embryos, 7 possess equal numbers of males and females in the left side of the uterus, whereas none show the ratio of 1:1 in the right side (Table 3).

Table 2. Frequency distribution of the number of embryos in the left and right uterus.

	Number of embryos															Total
Left uterus	1	2	1	2	2	2	3	1	3	4	2	4	4	5	5	
Right uterus	1	0	2	1	2	3	2	4	3	2	4	3	4	3	5	
Frequency	1	1	1	3	3	9	8	1	14	3	2	5	11	1	2	65

Table 3. Number of males and females in each uterus of the mothers containing 8 embryos.

Left uterus			Right uterus			Total	Frequency
No. of males	No. of females	Sub-total	No. of males	No. of females	Sub-total	♂ + ♀	
0	4	4	1	3	4	1 + 7	1
0	4	4	3	1	4	3 + 5	1
0	4	4	0	4	4	0 + 8	1
1	4	5	1	2	3	2 + 6	1
2	2	4	0	4	4	2 + 6	1
2	2	4	1	3	4	3 + 5	2
2	2	4	3	1	4	5 + 3	4

Size of embryos and season at birth

The size frequency distribution of embryos sampled randomly at the end of June indicates that the shark gives birth to young at a limited season. The embryos are of nearly the same size and the histogram does not show poly-modal distribution (Fig. 1). At that time,
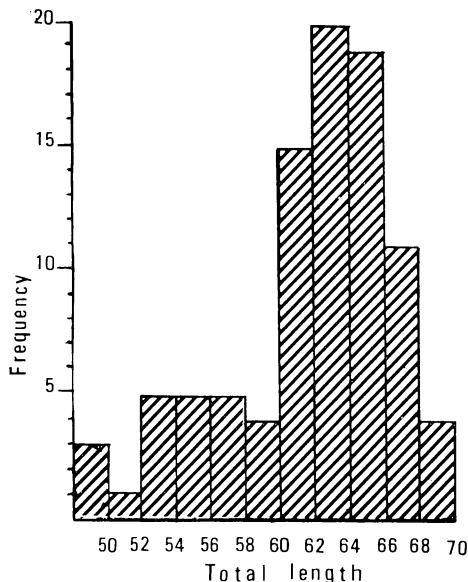

Fig. 1. Length frequency distribution of embryos examined at the end of June. The embryos used here were sampled randomly from gravid females.
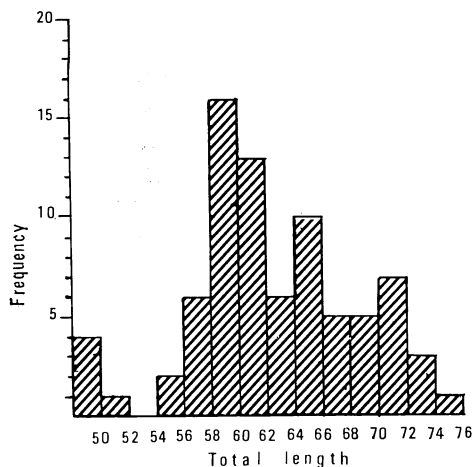

Fig. 2. Length frequency distribution of embryos examined at the beginning of July. The embryos used here were sampled from 12 gravid females.

the maximum length of embryos reaches 68 cm in total length, and at the beginning of July some embryos exceed 70 cm (Fig. 2), while the minimum size of free-swimming young sharks is 69 cm at the beginning of July and young sharks without umbilical scar (70 to 80 cm in total length) are caught in consider-able numbers during the period. Therefore, it is estimated from these facts that the size at birth is between 65 cm and 75 cm in total length. However, there may be considerable variation in the size of newborn sharks because a 64 cm free-swimming juvenile without umbilical scar was caught at the beginning of November.

Season of birth will be estimated by the following three facts: (1) the existence of near full-term embryos in the uteri at the end of June and at the beginning of July; (2) the catch of adult females whose oviducts are spent out at the middle of July; (3) no records of the occurence of large embryos more than 60 cm except early summer. These facts suggest that early summer is season of birth, althuogh no investigation on embryos was made from the end of July to middle of October.

Gestation period

In June and July some females carry eggs ranging from 10 to 30 mm in diameter in the ovaries. These eggs in ovaries may be un-fertilized since Springer (1960) guessed that fertilization occurs after the large eggs leave the ovary. At the same time, some females have large eggs in the uterus, which shows that fertilization will occur soon or has occurred. At the end of October, gravid females contain embryos ranging from 31 cm to 38 cm in total length (Table 4), although one female exceptionally had eggs about 40 mm in diameter. According to Springer (1960), it takes at least about three months for embryos to grow up to 30 mm after fertilization in the Atlantic sandbar shark. The embryos of the shark in the East China Sea examined at the end of October, therefore, would have

Table 4. Length of embryos in October, December, June and July.

Date	No. of specimens	Size range (Total length, cm)	Mean	Standard error
End of October, 1966	25	31.3–37.9	33.3	0.596
Beginning of December, 1967	3	36.8–38.8	37.8	0.607
End of June, 1967	91	44.7–68.2	61.6	0.545
Beginning of July, 1967	78	45.3–74.6	62.1	0.707

been fertilized between June and July, even if different growth rate between the two regions is taken into consideration. Then, embryos grow up to 39 cm at the beginning of December, and most embryos exceed 60 cm in June and July (Table 4). If mating time is between June and August and season of birth is June and July, the gestation period is calculated as 10 to 12 months.

Discussion

Springer (1960) reported that the average number of embryos per litter is 9 with the mode of 10 in *C. milberti* captured off northern Florida. Clark and Schmidt (1965) also showed that the average number of embryos is 8.9 in *C. milberti* of the central Gulf Coast of Florida (calculated from their Table 7). Wheeler (1962) showed that gravid females of *C. milberti* of the Mauritius-Seychelles area have 6 to 11 embryos with an average of 8.3. The result of the present study in the East China Sea differs from the above three in smaller number of embryos per litter. On the other hand, the size at birth is larger in the East China Sea than that in the western Atlantic, where it is 61 cm to 64 cm (Springer, 1960). The size at birth in the Mauritius-Seychelles area is guessed to be approximately 70 to 80 cm, if the growth curve of embryos by Wheeler (1962) is extrapolated and is connected with the size of the smallest juvenile. The size at birth in the East China Sea shows close resemblance to that of the western Indian Ocean. Springer (1960) also pointed out the possibility that the length of new born sharks differs by region even in the western Atlantic. In bony fishes there usually exists large difference in fecun-

dity between populations of a single species by year and region (Nikolskii, 1965). Accodingly, it is reasonable to consider that the difference in the number and size of embryos of *C. milberti* is caused by the difference of the environmental conditions or races rather than by difference of species.

Regarding the sex ratio in the embryos, Springer (1940, 1960) noted that about equal numbers of males and females are produced in *C. milberti*, and Clark and Schmidt (1965) also reported that male/female ratio is 1:1.1. These data coincide with the result of the present study which shows the ratio 1:1.16. Thus, this species is considered to produce about equal numbers of males and females as a whole, although free-swimming sharks frequently show marked seasonal and regional fluctuation in the sex ratio (Springer, 1940, 1960).

Springer (1960) observed that mating season is June and that season of birth is spring to early summer, and hence he estimated that the gestation period is 9 months with range of 8 to 12 months. The estimation of the gestation period given by the present study nearly accords with that of Springer, but mating season and season of birth show slight difference from those in the western Atlantic.

Since mating activity, number of embryos, and growth of embryos are thought to be under large influence of environmental conditions, the differences between regions may be of little imporatnce. However, in case of the East China Sea more detailed investigation will be needed to elucidate the structure of the population.

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東支那海産ヤジブカ, *Carcharhinus milberti* の繁殖生態

谷内　透

東支那海産ヤジブカには一腹あたり 2 尾から 10 尾の胎児がいる. 平均の胎児数は 6.0 で, 6 尾の胎児をもつ雌がもっとも多い. 5 尾, 6 尾, 7 尾および 8 尾の胎児をもつ雌が妊娠雌の 80% 以上をしめる. 左右の子宮間には胎児数において大きな差は認められない. 胎児の雌雄比は全体ではほぼ 1 対 1 であるが, 一腹の胎児の雌雄比は親個体ごとに大きな違いがみられる. 分娩時の胎児の大きさは通常全長で 65 cm から 75 cm である. 分娩期は 6 月と 7 月の間であると考えられる. 妊娠期間は 10 カ月から 12 カ月であると推定される.

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