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Aspects of Reproduction and Food Habits of the Japanese Swellshark *Cephaloscyllium umbratile* from Choshi, Japan

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I examined 356 specimens of the Japanese swellshark caught off Choshi, near Tokyo, Japan. The Japanese swellshark *Cephaloscyllium umbratile* attained maturity at a total length of 861–880 mm size class for males and 921–940 mm for females. All males over 960 mm and females over 1040 mm were mature. The largest male (1140 mm) was only slightly smaller than the largest female (1145 mm). In males, both clasper length and testes weight increased rapidly with the onset of maturity. Occurrence of ripe ova or egg cases in females and presence of semen in the seminal vesicle of males throughout the year, as well as the lack of seasonal changes in male gonad indices indicate that *C. umbratile* does not have a well-defined reproductive season. Food items of the shark consisted of at least 71 prey species, principally fishes. Pacific mackerel and Japanese sardine were the dominant prey. Ten species of Chondrichthyan fishes were also important in their diet.

Swellsharks, Family Scyliorhinidae, are noted for the habit of inflating their abdomens by swelling air or water when disturbed. They are oviparous, laying egg cases with characteristic tendrils. In the case of the eastern Pacific swellsharks *Cephaloscyllium ventriosum* recent studies have treated, diel activity,[1] predation on egg cases,[2] differences in egg case tendril length and reproductive isolation of stocks,[3] dermal denticles in juveniles[4] and bioelectrically-mediated predation.[5] On the other hand, very little has been published on the biology of the Japanese swellshark *C. umbratile*, though it is common in moderately deep water in southern Japan, ranging from Hokkaido to the South China Sea.[6,7] In this paper I present the first documented information on size at maturity, reproductive cycle and food habits of this species.

Springer[8] considers *C. umbratile* Jordan et Fowler, first described on the basis of a specimen from Japan, to be a junior synonym of *C. isabellum* (Bonnaterre), which is common in New Zealand. As he noted, however, variations in proportional dimensions and color patterns found in species of swellsharks make it difficult to determine the validity of closely related species. I tentatively retain the name *C. umbratile*, which is presently used by most Japanese researchers.

Materials and Methods

A total of 365 specimens of the swellshark taken off Chosi, Japan, were examined from 1977 through 1980. The sharks were caught commercially by bottom trawl and longline hook gear in depths of 90 m to 200 m. All the specimens were examined while fresh. Samples were collected in all months except August and September.

Maturity in males was indicated by a combination of the presence of semen in the seminal vesicle and rigidity of claspers, and in females by a combination of the presence of ovarian eggs larger than 10 mm and/or the presence of egg cases in the uteri, and the degree of expansion of uteri. The gonad index for male sharks was calculated as follows:

Gonad index=[testes weight (g)/(total length (mm))^3]$\times 10^8$

No quantitative measurements of food habits were made because most stomachs were full of sea water. Food items were identified to species when possible. The number of stomachs in which one or more individuals of a prey were found was expressed as a percentage of the total of non-empty stomachs.

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Results

Maturity

Table 1 lists the collection by month and sex of Japanese swellsharks sampled. The sharks were collected mainly in the fish market of Choshi. Table 2 gives the length frequency distributions in 20 mm increments of mature and immature individuals. Mature female specimens were nearly twice as numerous as mature males in the specimens examined. The smallest mature males were in the 861–880 mm size class, while the smallest mature females were in 921–940 mm. All males over 960 mm and females over 1040 mm were mature. The modal length of mature males was 941–960 mm, and that of mature females was 1021–1040 mm. Thus, in both aspects the females were around 60–80 mm larger than the males. However, the largest male captured was 1140 mm TL, only slightly smaller than the largest female (1145 mm TL).

The relationship between total length and clasper length is shown in Fig. 1. Claspers grew rapidly as the shark increased in length from 850 mm to 950 mm. This length interval was similar to length at maturity for males. Similarly, the testes showed abrupt increments in weight when the sharks were around 900 mm (Fig. 2). Thus, both clasper lengths and testes weights are closely related to the onset of maturity and hence can be regarded as indices of maturity.

Table 1. Monthly number of specimens examined

	Male	Female	Total
January	10	36	46
February	32	47	79
March	12	22	34
April	44	20	64
May	31	24	55
June	2	8	10
July		1	1
October	1	5	6
November	12	18	30
December	12	17	29
Total	156	200	356

Table 2. Length frequency distributions of immature and mature specimens of *C. umbratile* collected from Choshi

Total Length (mm)	Number of specimens					
	Male			Female		Total
	Immature	Mature	Total	Immature	Mature	
700>	10		10	5		5
701– 720				1		1
721– 740	4		4	5		5
741– 760	2		2	2		2
761– 780	1		1	2		2
781– 800	3		3	1		1
801– 820	2		2	6		6
821– 840	1		1	2		2
841– 860	3		3	6		6
861– 880	3	1	4	4		4
881– 900	1	3	4	4		4
901– 920	4	4	8	2		2
921– 940	2	10	12	2	3	5
941– 960	1	17	18	7	6	13
961– 980		12	12	2	12	14
981–1000		15	15	4	18	22
1001–1020		16	16	1	17	18
1021–1040		11	11	1	36	37
1041–1060		16	16		23	23
1061–1080		9	9		15	15
1081–1100		3	3		6	6
1101–1120					5	5
1121–1140		2	2		1	1
1141–1160					1	1
1161<						
Total	37	119	156	57	143	200

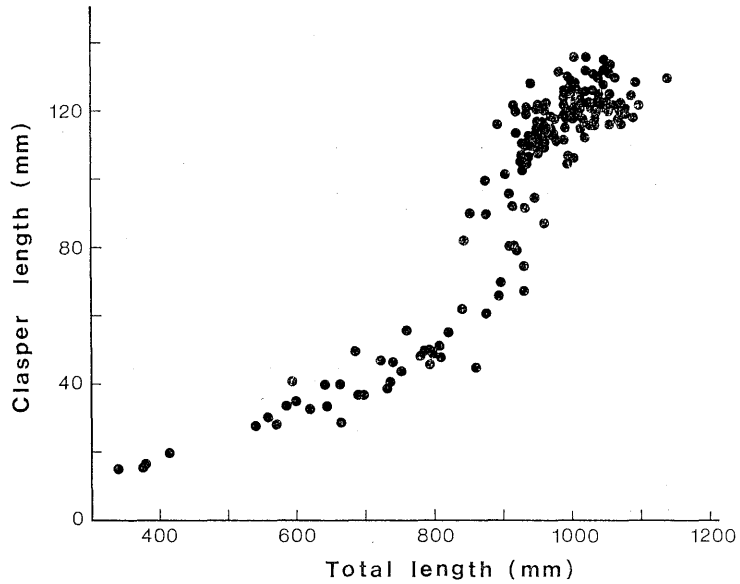

Fig. 1. Relationship between total length and clasper length in *C. umbratile* collected from Choshi.

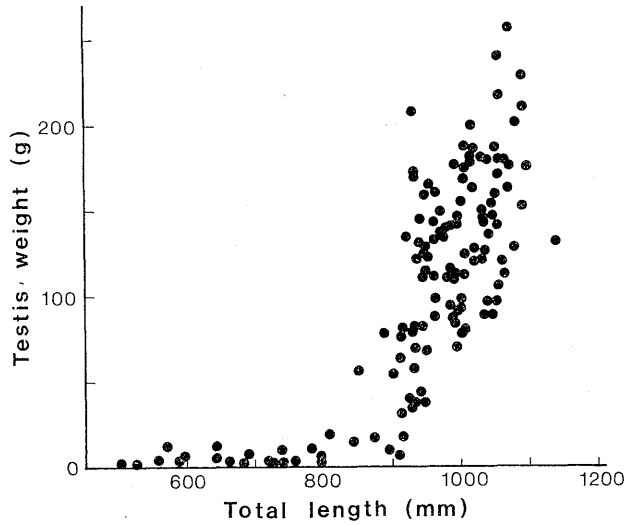

Fig. 2. Relationship between total length and testis weight in *C. umbratile* collected from Choshi.

Reproductive Cycle

As is the case for most sharks, only the right ovary of the Japanese swellshark is functional, the left being vestigial. Ova of various sizes were found in each ovary. About ten ova 35–40 mm in diameter (apparently near the maximum size before ovulation) were found together with numerous ova gradually decreasing in size. The large ova were found during most of the months in which sampling was carried out.

Egg cases were found in both uteri of gravid sharks. They were purse-shaped, about 10–12 cm long and 5.5–7 cm wide, and had long tendrils at each corner. The cases had thick, smooth walls. When they were found between the shell gland and the uterus, the anterior part (near the shell gland) was soft, while the posterior part was rigid. Females carrying egg cases were found in all months that sampling occurred, except in July and October, when only a few specimens were collected (Table 3). Percentage occurrences of pregnant females showed a peak in April (50%) and were lowest in October (0%), January (3.7%) and November (6.3%). Sample numbers were low in April and October, however. Not distinct egg-laying season could be found from my samples.

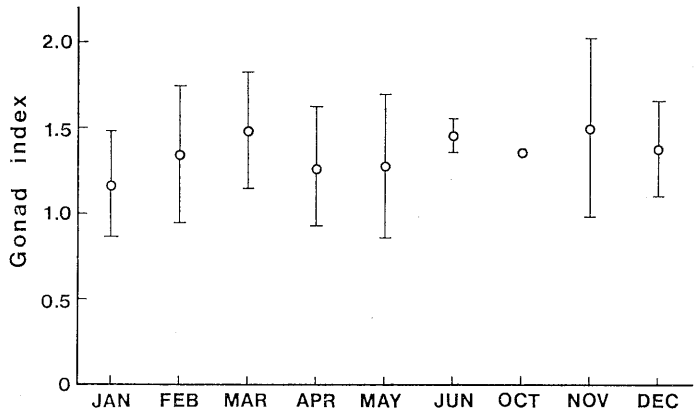

Fig. 3. Monthly gonad index for mature males in *C. umbratile* collected from Choshi. Circle: mean; bar: 95% confidence interval.

Table 3. Monthly percentage occurrence of mature females with and without egg cases in *C. umbratile* collected from Choshi

Month	Number of mature females			Percent frequency
	With egg cases	Without egg case	Total	
January	1	27	28	3.7
February	7	21	28	25.0
March	4	15	19	21.1
April	3	3	6	50.0
May	4	13	17	23.5
June	2	6	8	25.0
October	0	5	5	0
November	1	15	16	6.3
December	4	12	16	25.0
Total	26	117	143	

Mature males seem to possess semen in the seminal vesicle near the cloaca throughout the year. Semen always gushed out freely whenever the seminal vesicle was firmly pressed, indicating the probability that the sharks were capable of reproductive activity throughout the year. The gonad index of mature males (Fig. 3) also illustrates a rather constant and active reproductive state throughout the year. Although the individual indices ranged from 0.80 to 2.01, the average monthly values showed little change, with a maximum average figure of 1.50 in November and a minimum of 1.17 in January. Again, seasonal patterns were not evident.

Thus, it appears that reproductive processes do not occur in regular seasonal cycles in this species, judging from the following facts: either ripe ova occur in the ovary or egg cases occur in the oviduct in almost every month; semen is present in the seminal vesicle throughout most of the year; and males showed no marked changes in monthly gonad index. Since I have no data from July through September, however, the reproductive activity during this period is unknown.

Food Habits

The Japanese swellshark feeds on a wide variety of prey. I found at least 71 prey species in the stomachs. Frequently several kinds of prey were found in one stomach. In one case, 10 fishes of six species (about 20 cm TL) and 15 squids (about 15 cm), were found in a female swellshark 103 cm long. Table 4 lists all the food items that occurred in the stomachs of swellsharks at least three times. Prey species occurring less frequently are treated as "others" in Table 4. The following species are comprised in the "others" category:

Agnatha: *Eptatretus burgeri*

Chondrichthyes: *Cephaloscyllium umbratile*, *Squalus mitsukurii*, *Etmopterus unicolor*, *Centroscyllium ritteri*, and *Chimaera phantasma*

Osteichthyes: *Anago anago*, *Conger myriaster*, *Congriscus megastomus*, *Gymnothorax kidako*, *Ophichthus* sp., *Glossanodon semifasciata*, *Cololabis saira*, *Macrorhamphosus scolopax*, *Gadus macrocephalus*, Macrouridae, *Lophiomus setigerus*, *Halieuteaea stellata*, *Beryx splendens*, *Zenopsis nebulosa*, *Trachurus japonicus*, *Decapterus russellii*, *Coryphaena hippurus* (?), *Leiognathus nuchalis*, *Upeneus bensasi*, *Lateorabrax japonicus*, *Priacanthus boops*, *Nibea mitsukurii*, *Scombrops boops*, *Caprodon schlegelii*, *Sillago japonicus*, *Helicolenus hilgendorfi*, *Sebastes* sp., *Chelidonichthys*

Table 4. Number of specific prey items found in 278 stomachs of *C. umbratile* collected from Choshi. Numerals in parentheses indicate percent occurrence

Food items		
Seaweed	1 (0.1)	
Crustacea		
Isopoda	11 (3.5)	
Bathynomus doederleina		11 (3.5)
Crabs (brachyura)	16 (5.1)	
Unidentified		12 (3.8)
Others		4 (1.2)
Shrimps (Anomura)	2 (0.6)	
Cephalopoda		
Octopoda	6 (2.0)	
Unidentified		5 (1.7)
Others		1 (0.3)
Decapoda	61 (19.1)	
Unidentified		51 (16.5)
Others		10 (3.2)
Pisces		
Agnatha		
Myxine garmani		8 (2.5)
Chondrichthyes		
Galeus nipponensis		3 (0.9)
Scyliorhinus torazame		10 (3.3)
Squalus japonicus		3 (0.9)
Rajidae		3 (0.9)
Narke japonica		3 (0.9)
Egg case: *S. torazame*		5 (1.7)
: Rajidae		5 (1.7)
Others		10 (3.3)
Osteichthyes		
Unidentified		108 (35.1)
Sardinops melanostictus		36 (11.7)
Congridae		8 (2.5)
Myctophidae		4 (1.2)
Synodontidae		3 (0.9)
Trachinocephalus myops		4 (1.2)
Physiculus maximowiczi		20 (6.4)
Chaunacidae		3 (0.9)
Polymixia japonica		3 (0.9)
Scomber japonicus		38 (12.3)
Lepidotrigla abyssalis		3 (0.9)
Callionymidae		7 (2.2)
Suggrundus meedervoorti		3 (0.9)
Scorpaenidae		3 (0.9)
Pleuronectidae		17 (5.5)
Tanakius kitaharai		7 (2.2)
Stephanolepis cirrhifer		3 (0.9)
Navodon modestus		27 (8.8)
Lactoria diaphanus		4 (1.2)
Others		44 (14.3)

spinosus, *Paralichthys olivaceus*, *Pseudorhombus pentophthalmus*, *Pleuronichthys cornutus*, *Liosaccus pachygaster*, and *Fugu* sp.

Cephalopoda: *Paroctopus dofleini dofleini*, *Doryteuthis bleekeri*, and *Loligo japonica*

Crustacea: *Ovalipes punctatus*, *Portunus trituberculatus*, *P. sanguinolentes*, *Pandalus nipponensis*, and *Penaeus japonicus*

Fishes, including hagfish (Agnatha), cartilaginous fishes (Chondrichthyes), and bony fishes (Osteichthyes) made up the bulk of the food of the swellsharks. The three groups accounted for about 88% of the total number of prey items that were identifiable to species. They occurred 395 times, in 278 sharks (of the total of 356 sharks examined) that had identifiable stomach contents; i.e., many stomachs contained more than one species of prey. Fifty species of bony fishes were found, although only 18 of these occurred in more than two stomachs. Mackerel *Scomber japonicus* at 12.3% occurrence, and Sardine *Sardinops melanostictus* at 11.7% were found most frequently. Filefish *Navodon modestus* and brown hakeling *Physiculus maximowiczi* were next in importance, at 8.8 and 6.4%, respectively. It is apparent that active fishes that are good swimmers are not common in the diet.

Cartilaginous fishes occurred frequently as food items of swellsharks. The percentage occurrence was high (13.6%) and represented a relatively large number of species (at least 10 species). The cat shark *Scyliorhinus torazame* and its egg case together were important prey showing 5% occurrence. Noteworthy prey were the normally deep-dwelling lantern shark *Etmopterus* unicolor and whitefin dogfish *Centroscyllium ritteri*, as well as the electric ray *Narke japonica* and two juveniles of the Japanese swellshark.

Cephalopods showed 31% occurrence in the stomach contents. Identification to species was difficult, but the squid *Doryteuthis bleekeri* and species of cuttlefish *Sepia* spp. appeared to constitute the bulk of cephalopods eaten. Octopi were rare, showing up only 2% of the stomach samples. Other minor food items included swimming crabs and even isopods.

Discussion

Studies on other species of sharks like the pointed snout dogfish[10] and star-spotted dogfish[11] indicate that females generally grow to a larger maximum size than males, and also become mature at a larger size. In the case of the Japanese swellshark, males apparently mature at a smaller size than females, but both males and females reach about the same maximum size.

Both also mature at a larger size relative to their maximum length than do the pointed snout dogfish and star-spotted dogfish. Japanese swellshark males mature at approximately 75% and females 80% of their maximum lengths, whereas the pointed snout dogfish and the star spotted dogfish mature at 67% of their maximum length.[10,11] Although the age structure of these animals is not known, the findings suggest that the Japanese swellshark grows very slowly, especially after reaching sexual maturity. Because this shark is abundant in moderately deep water off southern Japan,[6] slow growth may be compensated for by high fecundity and/or a high survival rate of juvenile sharks. Although fecundity was not estimated in this study because the shark was judged to be a multiple spawner, existence of a number of both ripe and unripe ova in the ovary implies high fecundity.

This shark does not appear to have a well defined spawning season or annual reproductive cycle, although it is possible that the spawning season is protracted, lasting seven to eight months from November through at least June (see Table 3). Reproductive data were lacking from July through September. A poorly defined season has also been reported for the lesser spotted dogfish *Scyliorhinus canicula*, which was found to lay eggs throughout the year[12] and to have a very extended spawning period.[13,14] Nakaya* reported that the Japanese catfish *S. torazame* also has no well defined reproductive cycle. Thus, it appears common in scyliorhinid sharks (including *Cephaloscyllium*) for females to lay egg cases throughout the year or to have a partially defined annual cycle with one or two peaks.[15]

The Japanese swellshark preys on a wide variety of marine organisms. However, a high percentage occurrence of fishes indicates that it is primarily piscivorous. The south African swellshark also feeds on a wide variety of prey.[16] In the Eastern Pacific swellshark, food items are bony fishes and probably crustaceans.[17] Compagno[17] hypothesized that the nocturnal activity pattern of this sluggish and weak-swimming shark enables it to catch day-active bony fishes that lie on the bottom at night and are relatively inactive and unresponsive. On the other hand, the Japanese swellshark appears to feed active as well as sluggish prey. Schooling pelagic species such as sardine and mackerel, which live well off the sea floor, occurred frequently in the diet (Table 4).

Another important finding was that this small shark fed on at least 10 species of Chondrichthyan fishes. Even the mako shark, a fast-swimming and voracious species, is not known to consume as many different Chondrichthyans as the Japanese swellshark.[18] In this respect, it compares with large voracious sharks such as the tiger and great white.[17] In contrast, the lesser spotted dogfish, a close relative of the swellshark, feeds mainly on Crustacea, Mollusca, and Polychaeta.[19] Therefore, I have concluded from the diet composition that the Japanese swellshark collected from Choshi is a voracious and opportunistic feeder.

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References

1) D. R. Nelson and R. H. Johnson: *Copeia*, **1970**, 732–739 (1970).
2) C. A. Grover: *Calif. fish Game*, **58**, 191–197 (1972).
3) C. A. Grover: *Copeia*, **1972**, 871–872 (1972).
4) C. A. Grover: *Can. J. Zool.*, **53**, 359–363 (1974).
5) T. C. Tricas: *Copeia*, **1982**, 948–953 (1982).
6) K. Nakaya: *Mem. Fac. Fish. Hokkaido Univ.*, **23**, 1–94 (1975).
7) W. L. Chan: *J. Zool., London*, **148**, 218–237 (1966).
8) S. Springer: *NOAA Tec. Rep. NMFS Cir.*, **422**, 1–97 (1979).
9) Ichthyological Society of Japan: Dictionary of

* K. Nakaya: in "Report of Fisheries Biology of Sharks" supported by Grant in Aid for Co-operative Research from the Ministry of Education, Science and Culture in 1978. pp. 47–59.

Japanese Fish Names and Their Foreign Equivalent, Sanseido, Tokyo, 1981, p. 456.
10) C. Chen, T. Taniuchi, and Y. Nose: *Nippon Suisan Gakkaishi*, **47**, 1157–1164 (1981).
11) T. Taniuchi, H. Kuroda, and Y. Nose: *Nippon Suisan Gakkaishi*, **49**, 1325–1334 (1983).
12) E. Ford: *J. Mar. Biol. Ass. U. K.*, **12**, 468–505 (1921).
13) J. E. Harris: *J. Mar. Biol. Ass. U. K.*, **31**, 269–274 (1952).
14) J. P. Sumpter and J. M. Dodd: *J. Fish. Biol.*, **15**, 687–695 (1979).
15) J. M. Dodd: Am. Zool., **12**, 325–339 (1972).
16) A. J. Bass, J. D. D'Aubrey, and N. Kistnasamy: *Invest. Rep. Oceanogr. Res. Inst., Durban*, **37**, 1–63 (1975).
17) L. J. V. Compagno: *FAO Fish. Synop.*, (125) Vol. 4, pt. 2, 295–305 (1984).
18) C. E. Stiwell and N. E. Kohler: *Can. J. Fish. Aquat. Sci.*, **39**, 407–414 (1982).
19) J. Matallanas: *J. Fish. Biol.*, **20**, 155–163 (1982).

Nippon Suisan Gakkaishi : Formerly *Bull. Japan. Soc. Sci. Fish.*