

日本各地で採集したトラザメScyliorhinus torazameの成熟全長の地理的変異

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Geographic Variation of Maturity Size of the Cloudy Catshark, *Scyliorhinus torazame*, in Japan

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Abstract

The present study provides information on the geographic variation in maturity size of the cloudy catshark, *Scyliorhinus torazame*, in Japan. A total of 133 from Aomori Prefecture, 114 from Fukushima Prefecture, 88 from Ibaraki Prefecture and 87 from Tsushima Island were used for the present research. Size at sexual maturity in females was considered to be over 370mm TL in Aomori, range of 330-390mm TL in Fukushima, over 350mm TL in Ibaraki and over 330mm TL in Tsushima specimens. Size at sexual maturity in males was considered to be over 390mm TL in Aomori, over 350mm TL in Fukushima and under 330mm TL in Tsushima specimens. Size at sexual maturity of the cloudy catshark tended to become larger with the decline of water temperature. Size difference of egg capsules in the cloudy catshark was not observed by location.

Catsharks belonging to the genus *Scyliorhinus* consist of 2 species around Japan, *S. torazame* and *S. tokubee*. These 2 species inhabit the upper continental slope in Japan and are incidentally caught with commercial trawl, stationary net, bottom gill net and bottom long-line fishing. However, they are usually discarded. The cloudy catshark (*S. torazame*) accounted for 40% of discarded fish in Yamaguchi Prefecture (TAKAGI, 1994). In addition, the cloudy catshark causes damage to fisherman as its hard scales injure other fish that are netted. Information on the biology of the cloudy catshark is important in order to evaluate its influence on other aquatic organisms and utilize it as a resource in the future.

In Japanese waters, scyliorhinid sharks including species of *Scyliorhinus* have been studied slightly on their taxonomy (NAKAYA, 1975; TACHIKAWA and TANIUCHI, 1987; SHIRAI, et al., 1992), reproduction (KUDO, 1959; MAKIHATA, 1984; TANIUCHI, 1988; HORIE and TANAKA; 2000) and feeding habits (TANIUCHI, 1988; HORIE and TANAKA, 2000) in

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spite of there being 17 species, making it the third most numerous group among Japanese shark families. Biological information of *S. torazame* is merely limited to classification (NAKAYA, 1975 ; SPRINGER, 1979 ; COMPAGNO, 1984). The reproductive mode of the catshark is known to be oviparity. There have not been specific studies on reproduction. This study provides information on the geographic variation in maturity size of the cloudy catshark in Japan.

MATERIALS AND METHOD

A total of 133 (72 female and 61 male) from Aomori Prefecture, 114 (41 female and 73 male) from Fukushima Prefecture, 88 (80 female and 8 male) from Ibaraki Prefecture and 87 (49 female and 38 male) from Tsushima Island were used for the present study (Table 1).

Table 1. Sampling location, date, range of total length and number of specimens in this study

	Aomori		Fukushima		Ibaraki		Tsushima	
Location	41° 15' - 25N 141° 30' - 40E		37° 00' - 10N 141° 00' - 10E		36° 15' - 25N 140° 30' - 40E		34° 30' - 40N 138° 10' - 20 E	
Date	October 1998 - June 1999		October 1998		September 1998		August 1998	
Sex	Female	Male	Female	Male	Female	Male	Female	Male
Total length (mm)	145 - 475	156 - 506	120 - 464	255 - 453	319 - 472	391 - 471	290 - 434	308 - 432
Number	72	61	41	73	80	8	49	38

In Aomori Prefecture, discarded cloudy catsharks were sampled at Hachinohe fish market. The cloudy catsharks were caught by commercial bottom trawlers off Shiriyazaki (41°15'~25'N, 141°30'~40'E) between October, 1998 and June, 1999.

The other cloudy catsharks were collected by commercial bottom trawlers off Hisanohama (37°00'~10'N, 141°00'~10'E) in Fukushima Prefecture on October, 1998, off Shiraiso (36°15'~25'N, 140°30'~40'E) in Ibaraki Prefecture on September, 1998 and off Tsushima Island (34°30'~40N, 138°10'~20'E) on August, 1998.

The specimens were frozen and carried to the laboratory. After thawing, total length (TL), body weight (g), gonad weight, ovum diameter (OD), ovum weight, maximum width of uterus and shell gland, clasper length and maximum width of left sperm sac were measured, and the calcification of the clasper and the existence of sperm in the sperm sac were observed. The cloudy catshark is an oviparous species, and possesses oviducts to maintain an egg capsule shortly. In this study, the oviduct gives a word of uterus in the same way as in viviparous sharks. The egg capsule was measured in length, excluding tendrils, and maximum width. The egg in the capsule was weighed.

Sexual maturity of female was assessed using the following criteria, based on examination of numerous specimens :

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- 1) Immature-The ovary is thin and has no yolky ova. The shell gland is small and the same color as the oviduct in front of the shell gland. The uterus is slender and as narrow as the oviduct.
- 2) Mature-The ovary has large yolky ova. The shell gland is well-developed and more brownish than the oviduct. The uterus is thicker than the oviduct.

Sexual maturity of males was assessed using the following criteria.

- 1) Immature-The clasper is short, soft and not calcified. No sperm exists in the sperm sac.
- 2) Mature-Stem cartilage of the clasper becomes hard or calcified. Sperm exists in the sperm sac.

RESULTS

Size at sexual maturity

Only the right ovary was functional in all female cloudy catsharks. Both right and left testes were functional in all male cloudy catsharks.

1 Aomori Prefecture

Female sharks matured completely over 402mm TL. They possessed well-developed reproductive organs; a uterus over 7.2mm in width, shell gland over 15.7mm in width and ovary over 7.12g (Fig. 1). The uterus, shell gland and ovary began to develop at 350mm TL. As a shark of 372mm TL possessed a well-developed uterus of 7.5mm in width, shell gland of 14.6mm in width and ovary of 5.99g with large yolky ova, the shark completely matured. However, a shark of 402mm TL possessed a uterus of 2.0mm in width, shell gland of 6.6mm in width and ovary of 1.46g. Though the ratio of mature females in the range of 350-370mm TL was only 11%, that in the range over 370mm TL was over 80% (Table 2).

Table 2. Number of immature and mature catsharks by the class for female and male

Length(mm)	Aomori			Fukushima			Ibaraki			Tsushima		
	Immature	Mature	%	Immature	Mature	%	Immature	Mature	%	Immature	Mature	%
Female												
<310	32	0	0	8	0	0	0	0	0	4	0	0
-330	6	0	0	3	0	0	4	0	0	2	2	50
-350	4	0	0	1	2	67	1	0	0	1	9	90
-370	8	1	11	3	4	57	2	3	60	1	17	94
-390	0	3	100	3	3	50	0	10	100	0	9	100
-410	1	4	80	0	9	100	0	9	100	0	2	100
410≤	0	13	100	0	5	100	0	51	100	0	2	100
Male												
<290	17	0	0	2	0	0	0	0	0	0	0	0
-310	5	0	0	3	0	0	0	0	0	1	0	0
-330	5	0	0	6	0	0	0	0	0	0	0	0
-350	2	0	0	5	1	17	0	0	0	0	4	100
-370	4	1	20	1	8	89	0	0	0	0	9	100
-390	7	0	0	2	20	91	0	0	0	0	14	100
-410	1	3	75	1	16	94	0	1	100	0	6	100
410≤	0	16	100	0	8	100	0	7	100	0	4	100

% Indicates the rate of mature sharks in the class.

Male sharks matured completely over 409mm TL. They possessed well-developed reproductive organs ; a sperm sac over 3.0mm in width including sperm, a calcified clasper over 63mm in length and well-developed testes over 4.88g (Fig 1). The clasper and testes began to develop at 340mm TL. As a shark of 395mm TL possessed a sperm sac of 3.2mm in width including sperm, a calcified clasper of 67mm in length and well-developed testes of 7.75g, the shark completely matured. However, a shark of 409mm TL possessed a sperm sac of 4.6mm in width without sperm, little calcified clasper of 37mm in length and testes of 2.58g. No mature male was observed under 390mm TL (Table 2). The ratio of mature males in the range of 390-410 mm TL was 75%, and males in the range over 410mm TL were all mature.

2 Fukushima Prefecture

Female sharks matured completely over 386mm TL. They possessed well-developed reproductive organs ; a uterus over 5.7mm in width, shell gland over 13.1mm in width and ovary over 8.70g (Fig. 2). The uterus, shell gland and ovary began to develop at 300mm TL. As a shark of 331mm TL possessed a well-developed uterus of 8.7mm in width, shell gland of 14.6mm in width and ovary of 2.60g with large yolky ova, the shark completely matured. However, a shark of 386mm TL possessed a uterus of 4.7mm in width, shell gland of 9.2mm in width and ovary of 2.10g. No mature female was observed under 330mm TL (Table. 2). The ratio of mature females in the range of 330-350mm TL was 67%, and females in the range over 390mm TL were all mature.

Male sharks matured completely over 390mm TL. They possessed well-developed reproductive organs ; a sperm sac over 2.7mm in width including sperm, a calcified clasper over 59mm in length and well-developed testes over 4.30g (Fig. 2). As a shark of 338mm TL possessed a sperm sac of 3.4mm in width including sperm, a calcified clasper of 61mm in length and well-developed testes of 3.70g, the shark completely matured. However, a shark of 390mm TL possessed a sperm sac of 2.7mm in width without sperm, little calcified clasper of 53mm in length and testes of 4.42g. Though the ratio of mature males in the range of 330-350mm TL was only 17%, that in the range of 350-370mm TL was 89% (Table 2).

3 Ibaraki Prefecture

Female sharks matured completely over 374mm TL. They possessed well-developed reproductive organs ; a uterus over 6.9mm in width, shell gland over 13.5mm in width and ovary over 4.39g (Fig. 3). As a shark of 374mm TL possessed a well-developed uterus of 7.4mm in width, shell gland of 15.5mm in width and ovary of 7.92g with large yolky ova, the shark completely matured. However, a shark of 374mm TL possessed a uterus of

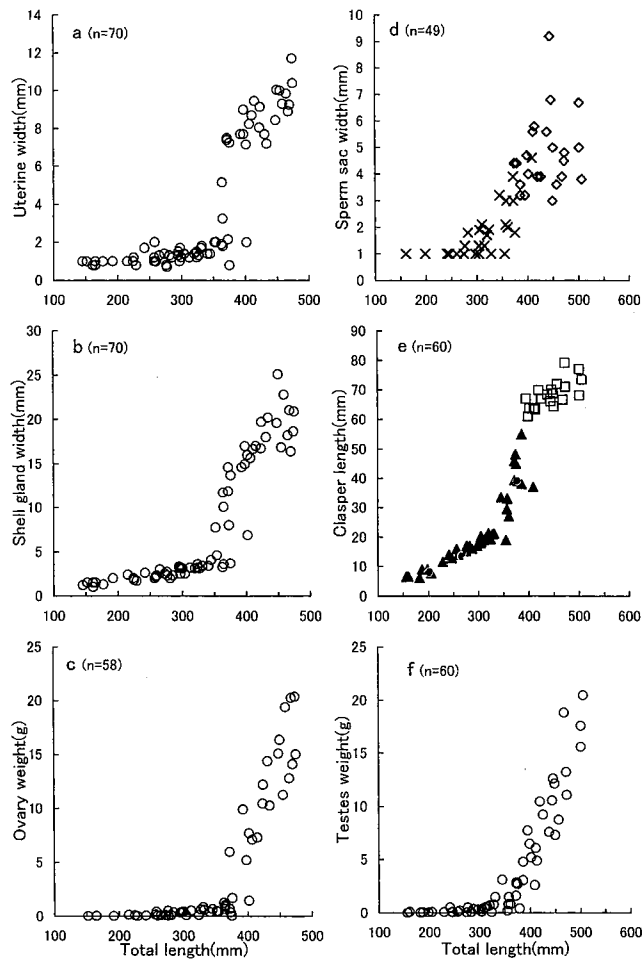


Fig. 1. Relationships of total length to maximum width of uterus (a), maximum width of shell gland (b), ovary weight (c), sperm sac width (d), clasper length (e) and testes weight (f) in Aomori. Sperm in sac (\diamond) and no sperm in sac (\times); calcified clasper (\square) and soft and not calcified clasper (\blacktriangle).

5.6mm in width, shell gland of 12.3mm in width and ovary of 1.92g. No mature female was observed under 350mm TL (Table. 2). The ratio of mature females in the range of 350-370mm TL was 75%, and females in the range over 390mm were all mature.

All investigated male sharks matured. They possessed well-developed reproductive organs; a sperm sac over 2.7mm in width including sperm, a calcified clasper over 58mm in length and well-developed testes over 7.05g (Fig. 3).

4 Tsushima Island

Female sharks matured completely over 364mm TL. They possessed well-developed

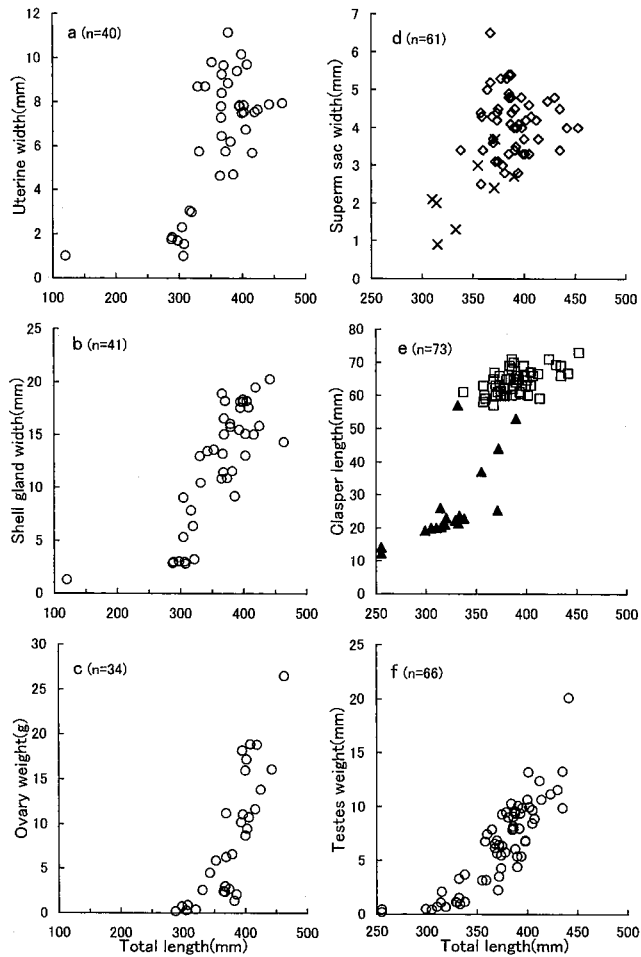


Fig. 2. Relationships of total length to maximum width of uterus (a), maximum width of shell gland (b), ovary weight (c), sperm sac width (d), clasper length (e) and testes weight (f) in Fukushima. Sperm in sac (\diamond) and no sperm in sac (\times); calcified clasper (\square) and soft and not calcified clasper (\blacktriangle).

reproductive organs; a uterus over 7.2mm in width, shell gland over 15.4mm in width and ovary over 6.80g (Fig. 4). As a shark of 322mm TL possessed a well-developed uterus of 8.5mm in width, shell gland of 16.6mm in width and ovary of 8.88g with large yolky ova, the shark completely matured. However, a shark of 364mm TL possessed a uterus of 6.2mm in width, shell gland of 12.5mm in width and ovary of 6.60g. No mature female was observed under 310mm TL (Table. 2). The ratio of mature females in the range of 310-330mm TL was 50%, and that in the range over 330mm was over 90%.

Male sharks matured completely over 338mm TL. They possessed well-developed reproductive organs; a sperm sac over 2.7mm in width including sperm, a calcified clasper

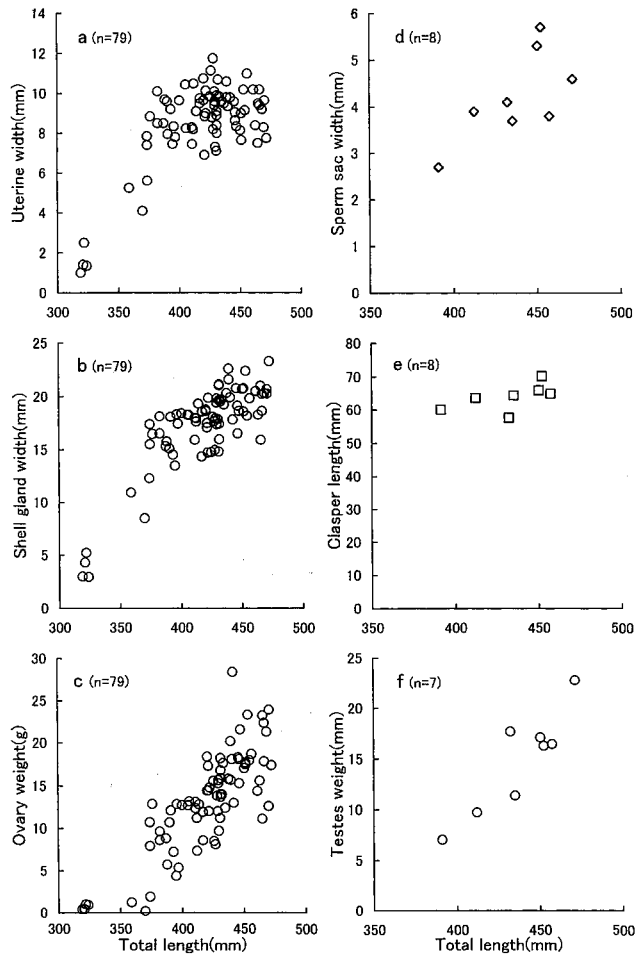


Fig. 3. Relationships of total length to maximum width of uterus (a), maximum width of shell gland (b), ovary weight (c), sperm sac width (d), clasper length (e) and testes weight (f) in Ibaraki. Sperm in sac (\diamond); calcified clasper (\square)

over 55mm in length and well-developed testes over 3.8g (Fig. 4). Males in the range of 330mm TL were all mature.

Ovum and egg capsule

1 Ovum

Mature female sharks possessed several sizes of yolky ova. Maximum diameter and weight of the ovum were 16.1mm in diameter and 2.30g in Aomori, 15.1mm in diameter and 2.17g in Fukushima, 16.4mm in diameter and 2.10g in Ibaraki and 16.2mm in diameter and 2.36g in Tsushima specimens (Fig. 5).

Ovum weight (OW) increased exponentially with ovum diameter (OD) according to

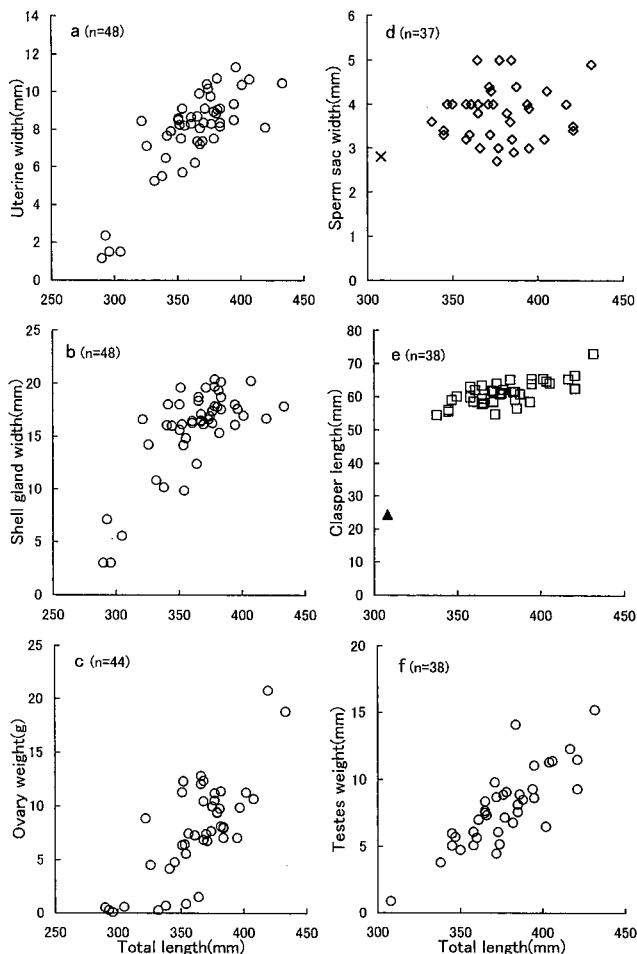


Fig. 4. Relationships of total length to maximum width of uterus (a), maximum width of shell gland (b), ovary weight (c), sperm sac width (d), clasper length (e) and testes weight (f) in Tsushima. Sperm in sac (\diamond) and no sperm in sac (\times); calcified clasper (\square) and soft and not calcified clasper (\blacktriangle).

the following regression equations (Fig. 5).

Aomori Prefecture: $OD = 5.11 \times OW^{2.98} \times 10^{-4}$ ($r = 0.988$).

Fukushima Prefecture: $OD = 5.94 \times OW^{2.98} \times 10^{-4}$ ($r = 0.986$).

Ibaraki Prefecture: $OD = 5.17 \times OW^{2.98} \times 10^{-4}$ ($r = 0.980$).

Tsushima Island: $OD = 6.60 \times OW^{2.89} \times 10^{-4}$ ($r = 0.971$).

No significant difference in degree of curve by location was observed ($P > 0.05$). No significant difference in curve by Aomori Prefecture, Ibaraki Prefecture and Tsushima Island was observed ($P > 0.05$), however, the curve of Fukushima Prefecture differed significantly from other locations (Aomori Prefecture; $F_{cal} = 28.13$, Ibaraki Prefecture;

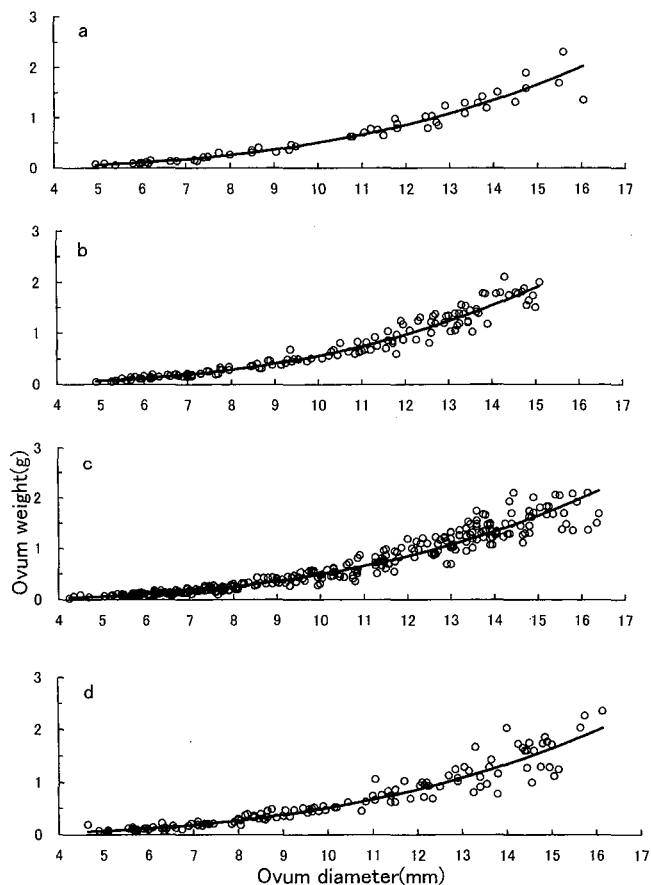


Fig. 5. Relationship between ovum diameter and ovum weight in Aomori
 (a) $[OD=5.11 \times OW^{2.98} \times 10^{-4} (r=0.988, n=51)]$, Fukushima
 (b) $[OD=5.94 \times OW^{2.98} \times 10^{-4} (r=0.986, n=132)]$, Ibaraki
 (c) $[OD=5.17 \times OW^{2.98} \times 10^{-4} (r=0.980, n=300)]$ and Tsushima
 (d) $[OD=6.60 \times OW^{2.89} \times 10^{-4} (r=0.971, n=127)]$.

$F_{cal}=50.13$, Tsushima Island ; $F_{cal}=16.63$, $P<0.01$).

2 Egg capsule

Seven sharks among 21 mature females in Aomori specimens possessed an egg capsule in each uterus, and one female was forming an egg capsule in each shell gland. Minimum size of the shark with egg capsules was 398mm TL. Egg capsules ranged from 46.1 to 58.8mm in length and averaged 51.8mm in length (Fig. 6), and from 17.9 to 22.2mm in width and averaged 19.8mm. Average weight of egg in egg capsule was 1.59g, ranging from 1.26 to 2.07g. Diameter of ova over 1.59g, average weight of egg in the egg capsule, was over 14.7mm.

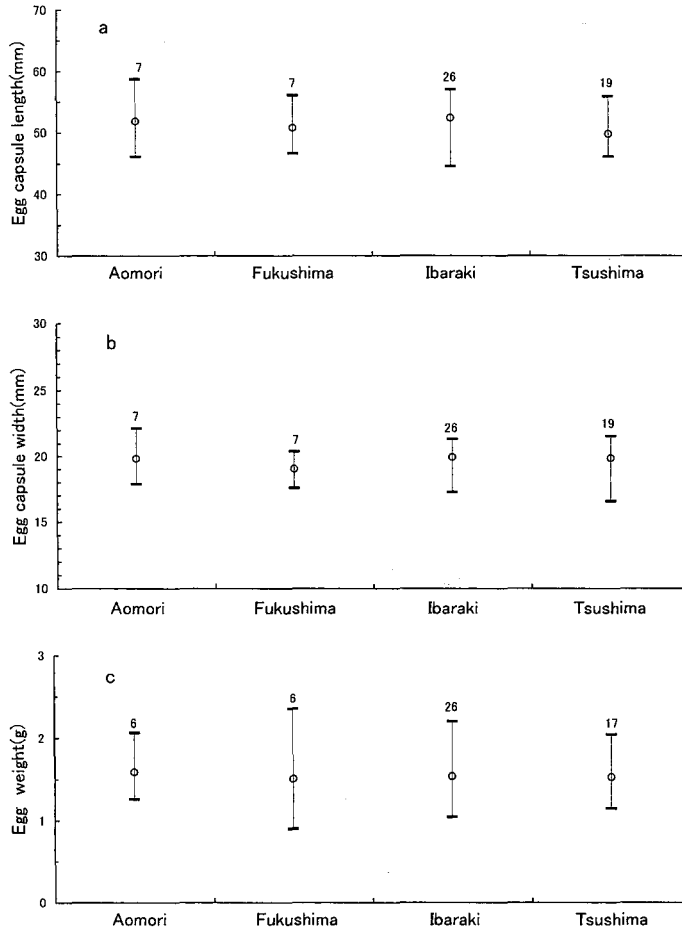


Fig. 6. Average of egg case length (a), maximum width of egg capsule (b) and egg weight in egg capsule (c) by locations. Symbols and extent bars indicate average and range. Number of egg capsules was indicated at the top of the bar.

Seven sharks among 73 mature females in Fukushima specimens possessed an egg capsule in each uterus. Minimum size of the shark with egg capsules was 369mm TL. Egg capsules ranged from 46.6 to 56.0mm in length and averaged 50.7mm in length (Fig. 6), and from 17.6 to 20.4mm in width and averaged 19.0mm in width. Average weight of egg in egg capsule was 1.51g, ranging from 0.91 to 2.35g. Diameter of ova over 1.51g, average weight of egg in egg capsule, was over 13.3mm.

Twenty-six sharks among 54 mature females in Ibaraki specimens possessed an egg capsule in each uterus. Minimum size of sharks with egg capsules was 374mm TL. Egg capsules ranged from 44.6 to 57.0mm in length and the average 52.4mm in length (Fig. 6), and from 17.3 to 21.4mm in width and averaged 19.9mm in width. Average weight of egg in egg capsule was 1.54g, ranging from 1.05 to 2.20g. Diameter of ova over 1.54g, average

Geographic variation of maturity size of the cloudy catshark, *Scyliorhinus torazame*, in Japan weight of egg in egg capsule was over 14.8mm.

Nineteen sharks among 37 mature females in Tsushima specimens possessed an egg capsule in each uterus. Minimum size of sharks with egg capsules was 341mm TL. Egg capsules range from 46.1 to 55.9mm in length and the averaged 49.8mm in length (Fig. 6), and from 16.6 to 21.6mm in width, and averaged 19.8mm in width. Average weight of egg in egg capsule was 1.53g, ranging from 0.91 to 2.35g. Diameter of ova over 1.53g, average weight of egg in egg capsule was over 14.5mm.

DISCUSSION

Size at sexual maturity in female was considered to be over 370mm TL in Aomori Prefecture, range of 330–390mm TL in Fukushima Prefecture, over 350mm TL in Ibaraki Prefecture and over 330mm TL in Tsushima Island. Size at sexual maturity in male was considered to be over 390mm TL in Aomori Prefecture, over 350mm TL in Fukushima Prefecture and under 330mm TL in Tsushima Island. Size at sexual maturity in fish is generally known to change according to the population size and their environmental conditions. Size at sexual maturity of *Mustelus manazo* tended to become larger with the decline of water temperature in their habitats (YAMAGUCHI et al., 2000). Each size at sexual maturity of *Galeus eastmani* and *G. nipponensis* in the same habitat differed causing the difference of water temperature between two periods examined (HORIE and TANAKA, 2000). The water temperature was high in order of Tsushima Island, Chiba and Aomori Prefecture (FISHRIES EXPERIMENT STATION OF AOMORI PREFECTURE, 1997a, 1997b 1998, 1999, 2000 ; FISHRIES EXPERIMENT STATION OF CHIBA PREFECTURE, 1996, 1997 ; FUKUOKA FISH AND MARINE TECNOLOGY RESEARCH CENTER, 1997, 1998, 1999, 2000) (Table 3). Size at sexual maturity of the cloudy catshark tended to become larger with the decline of water temperature. The change of maturity size in the cloudy catshark may be caused by the change of physical environments. However, further investigation, collecting both biological and environmental information, will be required to elucidate the variations.

Size of egg capsule in *Cephaloscyllium ventriosum*, belonging to Scyliorhinidae, differed by population, namely locality (GROVER, 1972). Size difference of egg capsules in the cloudy

Table 3. Water temperature at 100m in depth by locations

	Aomori*	Chiba**	Tsushima***
	40° 36.6N, 139° 40.0E	35° 30.0N, 141° 11.0E	34° 15.6N, 130° 14.3E
Date	March, 1995 – June, 1999	April, 1995 – March, 1997	January, 1995 – March, 1999
Minimum water temperature(°C)	4.5	8.3	13.7
Maximum water temperature(°C)	17.4	20.5	21.9

*From FISHERIES EXPERRIMENT STATION OF AOMORI PREFECTURE (1997a, 1997b 1998, 1999, 2000).

**From FISHERIES EXPERRIMENT STATION OF CHIBA PREFECTURE (1996, 1997). Chiba located near Fukushima and Ibaraki Prefecture.

***From FUKUOKA FISH AND MARINE TECHNOLOGY RESEARCH CENTER (1997, 1998, 1999, 2000).

catsharks, however, was not observed by location. The cloudy catsharks in all locations were considered to ovulate with ovum of about 14mm in diameter and about 15g in weight. In the oviparous cloudy catshark, embryonic growth in the egg capsule until hatching depends solely on the nutriment of ovum. Embryonic growth in *Scyliorhinus canicula* became fast with the increase of water temperature, however, increase of water temperature had no effect on size at hatching (THOMASON et al., 1996). Though size at hatching in the cloudy catshark was considered not to have differed by location in Japan, the period of embryonic growth until hatching may be different. In *M. manazo* of viviparous species, size at birth differed by location, and the pregnancy period in Aomori Prefecture, being the lowest water temperature, was longer than other locations (YAMAGUCHI et al., 2000). The cloudy catshark may be different from *M. manazo* by a difference of reproductive mode.

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[要 旨]

日本各地で採集したトラザメ *Scyliorhinus torazame* の
成熟全長の地理的変異

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本研究は、日本各地で採集したトラザメの成熟全長の地理的変異を報告する。青森県沖で採集した133個体、福島県沖で採集した88個体、茨城県沖で採集した87個体、対馬沖で採集した87個体のトラザメを使用した。メスの成熟全長は、青森で全長370mm以上、福島で330-390mm、茨城で350mm以上、対馬で330mm以上でと考えられた。オスの成熟全長は、青森で390mm以上、福島で350mm以上、対馬で330mm以下でと考えられた。成熟全長は環境水温が低くなるほど大きくなる傾向が見られた。メスの輸卵管内に観察された卵殻の大きさに海域による相違はなかった。