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Morphology and Taxonomy of *Apristurus longicephalus* (Lamniformes, Scyliorhinidae)

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Abstract Data on the individual variation and changes with growth in proportions and morphology are presented for the poorly known *Apristurus longicephalus*, and compared with those of other species. *A. longicephalus* is concluded to be a distinct species without synonyms, characterized by its long snout, widely separate nostrils, long caudal fin, short abdomen, very sparse teeth, and low number of monospondylous vertebrae. It is a species of small size, maturing at about 42 cm in total length.

The genus *Apristurus* Garman, 1913, is one of the most taxonomically confused shark groups, containing at least 36 nominal species. Springer (1979) made a world revision of the genus, and Compagno (1984) assigned species from other genus, providing additional information. However, despite these recent works, the genus still presents many taxonomic problems.

Nakaya (1975) reviewed the species from Japan and its adjacent waters, but since then many new species from Chinese and Japanese waters have been described with meagre comparative data (Chu et al., 1981; Deng et al., 1983, 1985; Meng et al., 1985; Dolganov, 1985; Chu et al., 1986). Some of these new species are similar to *A. longicephalus* Nakaya, 1975 which was described from a single immature male specimen, caught in Tosa Bay, Kochi Prefecture on Shikoku Island. Only a few specimens of *A. longicephalus* have since been reported from the Okinawa Trough (Nakaya, 1984). Recently, I was able to examine more specimens of *A. longicephalus* from the type locality and from the Okinawa Trough in the East China Sea, and have obtained ontogenetic and variational data on the species.

The purposes of this paper are to present taxonomic and biological information on *A. longicephalus*, comparing with some Japanese species and to discuss this species with closely related members of the genus.

Materials

A. longicephalus: HUMZ (Laboratory of Marine Zoology, Faculty of Fisheries, Hokkaido University) 42399 (holotype of this species, 367.0 mmTL, male), 33°13′N, 133°44.4′E, 610–740 m, May 12, 1972; BSKU (Department of Biology, Faculty of Science, Kochi University) 26358 (274.0 mmTL, male with only one clasper), 26°20.1′N, 124°50.7′E, 1000–1140 m, Jan. 22, 1978; BSKU 26648 (315.0 mmTL, male), 26649 (281.0 mmTL, male), 26650 (282.0 mmTL), 26651 (393.0 mmTL, male), 30°01.8′N, 128°21.9′E, 900 m, Feb. 3, 1978; BSKU 26867 (300.0 mmTL, male), 26868 (413.0 mmTL, male), 29°38.9′N, 127°56.0′E, 750–760 m, Feb. 4, 1978; BSKU 26512 (307.0 mmTL, male), 26°27.8′N, 124°50.9′E, 680–770 m, Jan. 23, 1978; BSKU 28166 (313.0 mmTL, male), 29°03.0′N, 127°16.0′E, 908–915 m, March 16, 1978; BSKU 26455 (330.0 mmTL, male), 25°17.1′N, 124°46.8′E, 910–990 m, Jan. 22, 1978; BSKU 22338 (334.0 mmTL, male), Tosa Bay, depth unknown, May 18, 1972; BSKU 28096 (334.0 mmTL, male), 28097 (390.0 mmTL, female), 28°53.0′N, 127°18.0′E, 820–830 m, March 16, 1978; BSKU 33999 (361.5 mmTL, male), 34000 (413.0 mmTL, male), 30°12.5′N, 128°11.5′E, 600–620 m, Oct. 26, 1979; BSKU 33518 (501.0 mmTL, male), 33519 (411.0 mmTL, male), 33520 (404.0 mmTL, male), 30°12.4′N, 128°17.0′E, 780–810 m, Oct. 26, 1979; BSKU 27596 (423.0 mmTL, male), 28°44.0′N, 127°01.0′E, 610–640 m, March 11, 1978; BSKU 23012 (427.0 mmTL, male), 33°09.0′N, 133°39.6′E, 615 m, Jan. 25, 1975.

Comparative materials—*A. herklotsi*: USNM (U. S. National Museum of Natural History) 93134 (holotype, 326 mmTL), Jolo Sea, southern Philippines.

A. macrorhynchus: ZUMT (Department of Zoology, University Museum, University of Tokyo) 2153 (holotype, 444 mmTL, male), Misaki, Japan. Two other specimens (439 and 482 mmTL) from southern Japan.

A. platyrhynchus: 30 specimens (280–739 mmTL) from southern Japan.

A. japonicus: HUMZ 40082 (holotype, 697 mmTL,

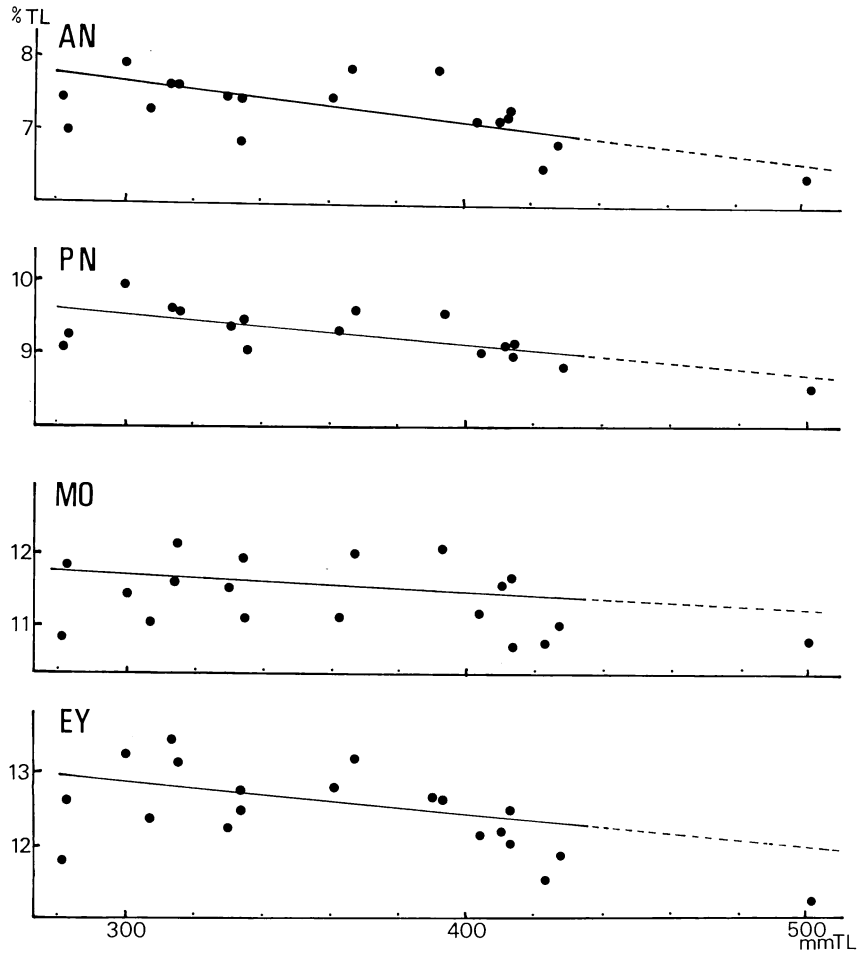

Fig. 1. Ontogenetic changes of the proportional lengths from snout tip to anterior nostril (AN), posterior nostril (PN), mouth (MO), and eye (EY) in *Apristurus longicephalus*.

male), Cape Daito, Chiba, Japan. Eight paratypes (654–711 mmTL) and 6 specimens (468–690 mmTL) from Chiba and southern Japan.

Methods

Body measurements were taken according to the method of Bigelow and Schroeder (1948). Ontogenetic changes were studied by calculating relative growth coefficient b in $y=ax^b$, where y is part length and x is total length. Dermal denticles were counted in a 2×2 mm square area on the skin taken from five parts of the dorsolateral side of the trunk, and they were averaged. I counted only those whose approximate center is included in the square.

Description

Proportional measurements and relative growth coefficients are shown in Table 1.

Body very slender; depth of trunk about equal to its width; depth of caudal peduncle a little more than 2 times its width; caudal axis nearly straight.

Proportional lengths along body axis in head region decreasing with growth (Figs. 1, 2). Head (to 5th gill opening) long, about 1/4 of total length. Snout long and flattened; length nearly 1/2 of head length. Right and left contours of head almost parallel to each other at mouth; head widened at nostrils; snout before nostrils very long, greater than interorbital width and tapering anteriorly; snout tip rather acutely rounded (Fig. 3).

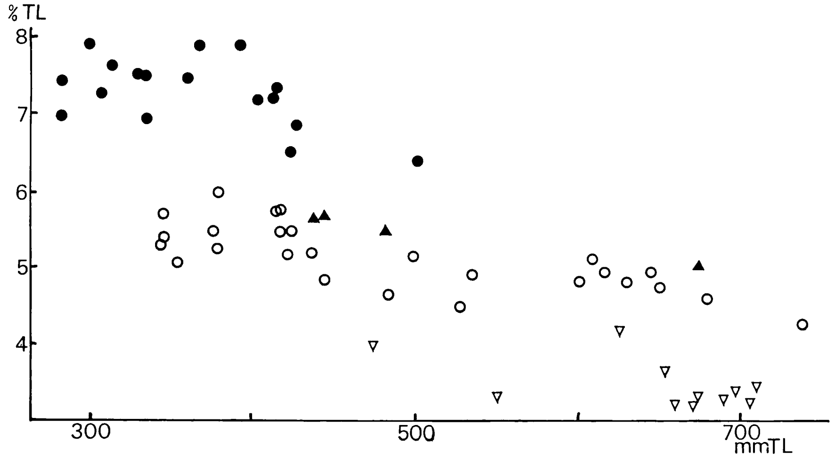

Fig. 2. Ontogenetic change of the proportional lengths from snout tip to anterior nostril in four Japanese species, *Apristurus longicephalus* (solid circles), *A. platyrhynchus* (open circles), *A. macrorhynchus* (solid triangles) and *A. japonicus* (open triangles).

Nostrils large and oblique; interspace between nostrils wide, 1.2 times diameter of nostril or more, and greater than depth of caudal peduncle in most cases. Nostrils separated from mouth by distance of half of interspace between nostrils. Pores of Lorenzini's ampullae small and rather inconspicuous on snout; those on midline of dorsal and ventral sides arranged in a narrow band; those on dorsal side arranged in a few rows anteriorly, but forming a slender elliptical patch posteriorly. Mouth large with well developed labial grooves; the upper groove longer than the lower one, reaching beyond middle of interspace between mouth corner and posterior margin of nostril. Eye moderate with a weak subocular fold; horizontal diameter about half of interorbital length, or about equal to diameter of nostril. Spiracle moderate, behind orbit and slightly below level of horizontal axis of eye. Five small gill openings with 5th, or 4th and 5th gill openings above pectoral base.

Positions of the fins changing with growth; pectoral fin position almost constant, but other fin positions moving posteriorly (Fig. 4). Pectoral fin relatively large; its inner tip reaching behind middle point of interspace between bases of paired fins. Pelvic origin located at anterior 2/5 of total length. Distance between origins of pectoral and pelvic fins increasing with growth, and when maximum about equal to length from snout tip to spiracle, but generally shorter than that; in-

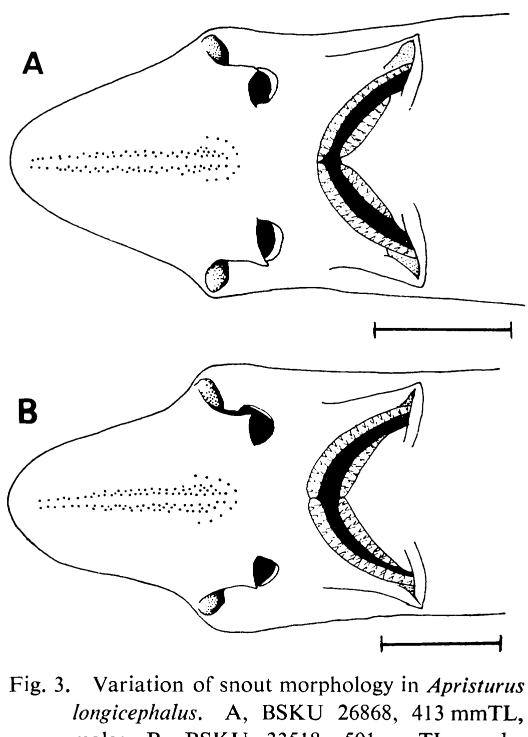

Fig. 3. Variation of snout morphology in *Apristurus longicephalus*. A, BSKU 26868, 413 mmTL, male; B, BSKU 33518, 501 mmTL, male. Scales are 2 cm.

terspace between bases very short, less than length of pectoral fin base. First dorsal fin much smaller than 2nd dorsal fin; its size half or less than the 2nd; origin above posterior end or posterior half of pelvic base (just behind pelvic base in one specimen); posterior end of 1st dorsal base above or a little behind origin of anal fin. Second dorsal fin origin above middle of anal base; posterior end of base before posterior end of anal base (above posterior end of anal base in one specimen);

Table 1. Proportional measurements, counts and relative growth of *Apristurus longicephalus*. Measurements are shown in percent of total length. *RGC: Relative growth coefficient b in $y=ax^b$, where y is part lengths, and x is total length. **Average counts in a 2×2 mm square. P, positive allometry; N, negative allometry.

	Holotype	Other specimens	Relative growth (RGC)*
Total length (mm)	367.0	274.0–501.0	
Snout tip to:			
anterior nostril	7.9	6.4–7.9	N (0.823)
posterior nostril	9.7	8.3–10.0	N (0.897)
mouth	12.1	10.7–12.2	N (0.889)
eye	13.2	11.2–13.5	N (0.853)
1st gill opening	22.3	19.0–22.4	P (1.016)
5th gill opening	26.1	22.7–26.7	N (0.926)
1st dorsal origin	45.8	42.0–47.1	P (1.149)
2nd dorsal origin	55.6	54.0–59.1	P (1.111)
anal origin	48.4	46.1–49.8	P (1.091)
lower caudal origin	62.7	61.2–65.7	P (1.074)
pelvic origin	38.8	35.4–41.2	P (1.069)
pectoral origin	25.8	22.9–25.8	N (0.979)
Head width (at mouth corner)	10.4	8.6–10.9	
Horizontal diameter of eye	3.0	2.6–3.3	
Mouth width	8.7	6.9–9.2	
Internostril width	4.6	3.7–4.6	
Interorbital width	6.5	5.3–6.5	
Labial fold:			
upper	3.4	3.0–3.9	
lower	2.8	2.3–3.6	
Interspace between:			
1st and 2nd dorsal fins	6.1	6.5–8.8	P (1.197)
pelvic and caudal fins	17.2	18.0–21.3	P (1.160)
nostril to mouth	2.3	1.7–2.4	
Distance between:			
origins of paired fins	14.8	13.6–16.5	P (1.183)
First dorsal fin:			
vertical height	1.6	1.4–1.9	
base length	4.7	3.7–5.5	
Second dorsal fin:			
vertical height	2.4	2.2–2.8	
base length	6.3	4.4–6.6	
Anal fin:			
vertical height	2.8	2.7–3.6	
base length	14.6	14.7–16.8	
Caudal fin:			
lower caudal origin to tip	36.5	34.1–38.6	N (0.821)
Teeth:			
upper	36	36–44	
lower	31	31–41	
Monospondylous vertebrae	32	30–33	
Dermal denticles**	36.5	22.8–47	

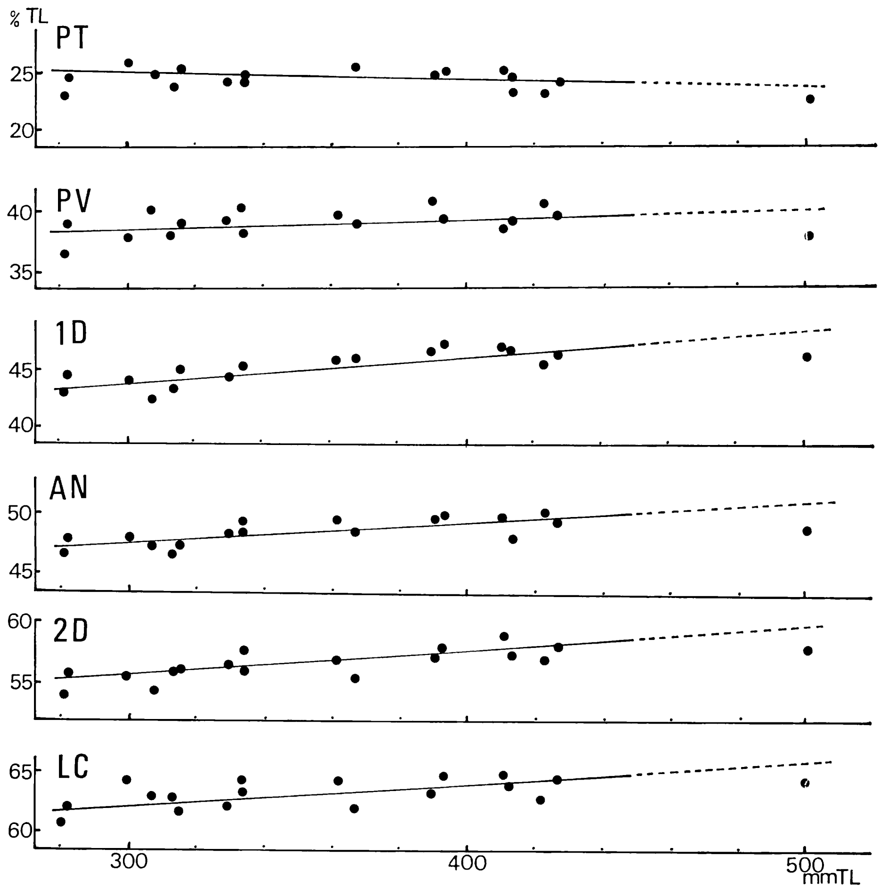

Fig. 4. Ontogenetic changes of the proportional lengths from snout tip to pectoral fin (PT), pelvic fin (PV), 1st dorsal fin (1D), anal fin (AN), 2nd dorsal fin (2D) and lower caudal fin (LC) in *Apristurus longicephalus*.

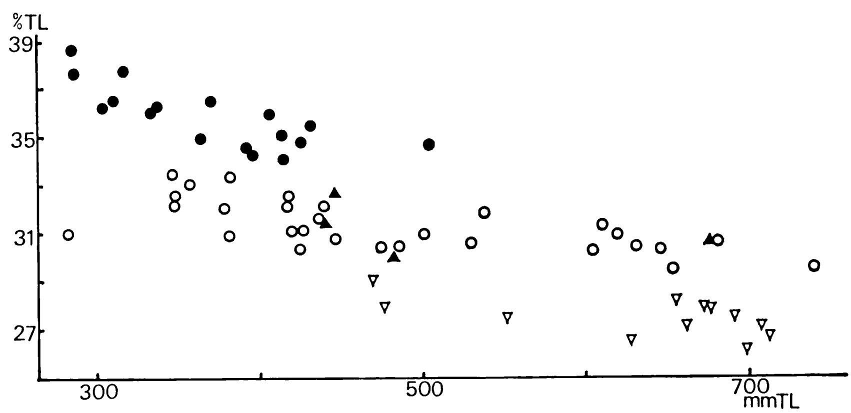

Fig. 5. Ontogenetic changes of the caudal fin lengths in four Japanese species, *Apristurus longicephalus* (solid circles), *A. platyrhynchus* (open circles), *A. macrorhynchus* (solid triangles) and *A. japonicus* (open triangles).

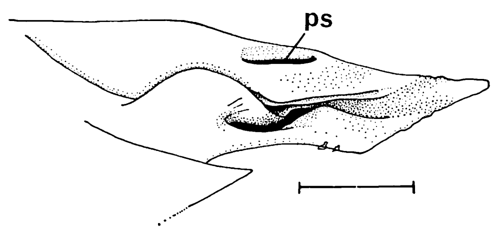

Fig. 6. Clasper from a mature male of *Apristurus longicephalus*, BSKU 33518, 501 mmTL. PS, pseudosiphon. Scale is 0.5 cm.

free rear tip reaching beyond lower caudal origin. Anal fin low with moderately long base; its origin at or a little before posterior end of 1st dorsal fin base; posterior end of base behind that of 2nd dorsal fin (below posterior end of 2nd dorsal base in one specimen); outer margin almost straight. Caudal fin measured from lower caudal origin to tip longer than 1/3 of total length, getting shorter with growth (Fig. 5); its lower anterior corner not expanded; a distinct subterminal notch present. Caudal fin and anal fin separated only by a notch.

Clasper of the largest specimen (501 mmTL; Fig. 6) robust, but short and reaching only to origin of anal fin; tip pointed; pseudosiphon large; clasper groove smooth without denticles or hooks. Dorsal side of clasper smooth, but a few denticles present on outer dorsal surface of clasper. Clasper in specimens smaller than 413 mmTL very short, about 1% TL; specimens larger than 423 mm TL having developed stiff claspers of nearly 4% TL (Fig. 7).

Dermal denticles on body small, weak and velvety to touch; each denticle on dorsolateral surfaces of trunk with three cusps and a strong central ridge (Fig. 8). Denticles on dorsal margin of caudal fin normal and not enlarged. Dermal denticles more slender, weaker and less numerous in small individuals than in the larger ones. Average number of dermal denticles in a 2×2 mm square area 22.8 to 47 on dorsolateral side of trunk (Fig. 9). Central ridges more conspicuous in the adults.

Teeth small but relatively wide with a large central cusp and one to three small blunt lateral cusps on both sides of central cusp; tooth numbers low; number of vertical rows along entire jaw 36 to 44 (36 in the holotype) on upper jaw, 31 to 41 (31) on lower jaw; number of the vertical rows relatively constant during growth (Fig. 9); only two or three series functional.

Number of monospondylous vertebrae 30 (1 specimen), 31 (12 specimens), 32 (holotype and 6 other specimens), or 33 (1 specimen).

Gonads very small and undeveloped in smaller male specimens less than 413 mm TL, but large and well developed in the larger males. The only female (390 mm TL) having a small undeveloped ovary.

Egg cases unknown.

Color of upper and lower surfaces of body and fins uniformly brownish or blackish brown; anterior margins of fins blackish; inside of mouth black.

Distribution. Tosa Bay and East China Sea.

Discussion

The elasmobranch fishes have few countable characters, hence the identification of taxa depends on the use of proportional measurements, relative positions of structures such as fins, and general shape of the body, which are apt to vary

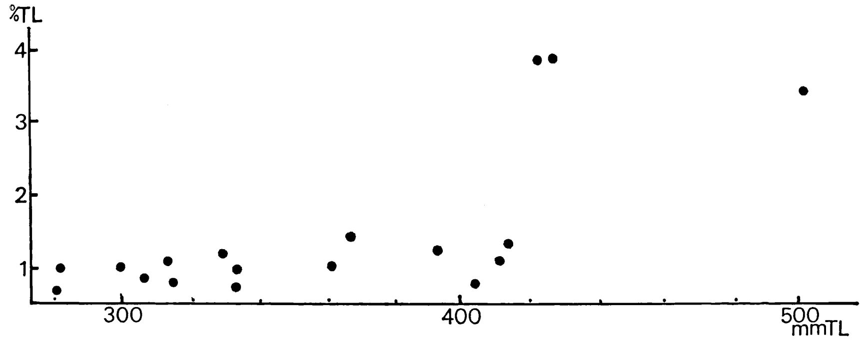

Fig. 7. Clasper development in *Apristurus longicephalus*.

individually, sexually and ontogenetically. Such variation is present in *Apristurus*, but little is known about it because most of the species were described from very few specimens, and additional specimens have been poorly reported. In addition, there are difficulties caused by the softness of the body, and the abdomen is often shrunk so much on fixation that specimens of the same species sometimes look extremely different. Because of these problems, appropriate consideration and discussion on the identity or synonymy of species have been very difficult, and have not yet been realized. In fact, recent revisional works (Nakaya, 1975; Springer, 1979; Cadenat and Blache, 1981; Compagno, 1984) only give the description of nominal species, and/or suggest possibilities of some synonym relationships.

In current shark taxonomy, measurements of specimens are usually summarized as ranges of proportional dimensions by showing minimum and maximum data, and these ranges are directly used in taxonomic discussion. However, as proportional dimensions often change positively or negatively with growth, it is better to analyze that change and to compare the values or patterns of the change between species or species groups. Such values and patterns are, of course, species-specific, and hence allow the comparison which may produce results that cannot be reached by comparison of simple linear ranges. In addition, they provide a basis for deeper taxonomic discussion by inferring growth change in species for which there are as yet few data.

As generally seen in the family Scyliorhinidae (Bass et al., 1975), and in other shark groups (Garrick, 1960; Hubbs et al., 1967; Bass, 1973), the relative lengths along the body axis from the snout tip to points in head region shorten with growth; such shortening is also true for *A. longicephalus* (Fig. 1, Table 1). Despite this negative growth, a long snout is one of the distinctive characters of *A. longicephalus* throughout life. In particular, the snout length in front of the anterior nostril is far longer than that in any other Japanese species (Fig. 2), and it is always longer than the interorbital width. However, some species from the western Pacific, such as *A. herklotsi*, *A. abbreviatus*, *A. xenolepis*, *A. longianalis*, *A. longicaudatus*, *A. micropterygeus* and *A. brevicaudatus*, also have equally long snout.

The positions of the fins, except the pectoral fin, move posteriorly with growth (Fig. 4, Table 1). The pectoral fin position is either stable or moves relatively forward with growth, and the distance between the origins of pectoral and pelvic fins, or

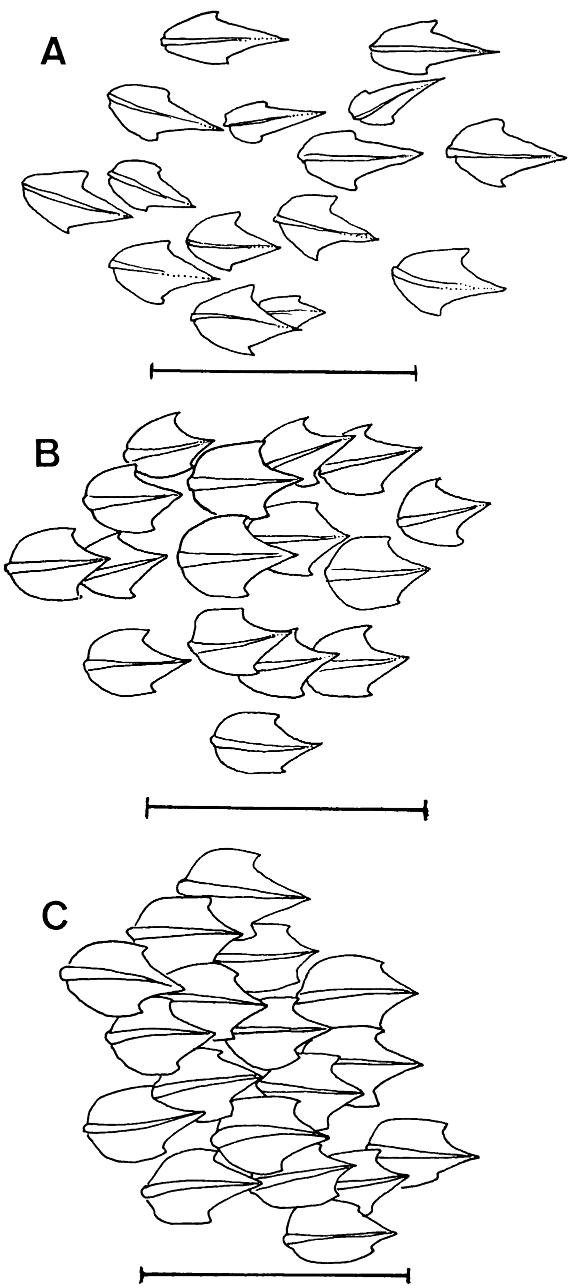

Fig. 8. Dermal denticles of *Apristurus longicephalus*. A, BSKU 26649, 281 mmTL; B, HUMZ 42399, holotype, 367 mmTL; C, BSKU 33518, 501 mmTL. Scales are 1 mm.

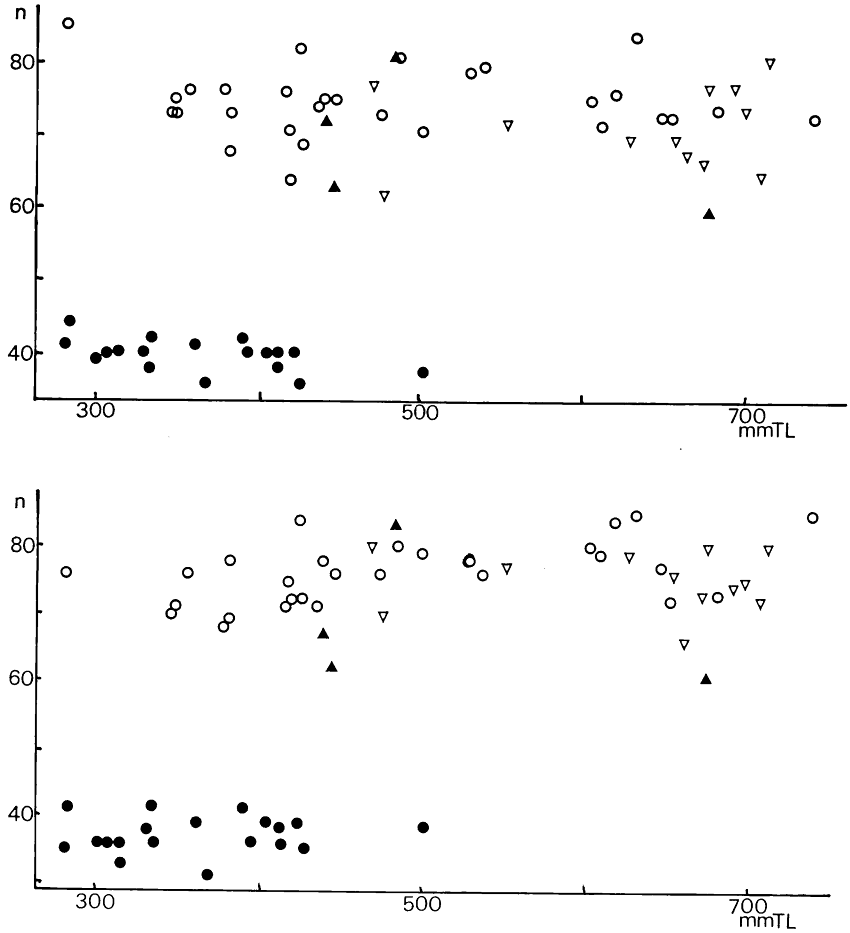

Fig. 9. Ontogenetic changes of the number of vertical rows of teeth on upper (above) and lower (below) jaws in four Japanese species, *Apristurus longicephalus* (solid circles), *A. platyrhynchus* (open circles), *A. macrorhynchus* (solid triangles) and *A. japonicus* (open triangles).

the abdominal length, becomes longer with growth. Despite this tendency, the abdominal length is always very short, and this is a distinctive character of the present species. Generally, abdominal length varies greatly in the species of *Apristurus* (Nakaya, 1975; Springer, 1979; Compagno, 1984), and western North Pacific species at least can be grouped into long- and short-abdomened species. In this context, *A. longicephalus* is a member of the latter group. The positions of fins, other than the pectoral, relative to each other do not change much throughout life, but there is some variation. The first dorsal origin is usually located above the pelvic base, but it is behind the posterior end of the pelvic base in a few individuals. This fin relation is sometimes important as a key character, but it is necessary to use it with care in closely related species, because of the presence of such variation and the ill-defined origin of the fin.

Apristurus longicephalus is also characterized by having an elongate caudal fin, the longest in Japanese species (Fig. 5). Caudal fin acutely shortens with growth, but length of the fin from lower caudal origin to tip is always longer than 34% TL in my specimens, including adults. This means that *A. longicephalus* has a very long caudal fin throughout life, exceeding 1/3 of total length. Available data show that *A. herklotsi, A. abbreviatus, A. xenolepis, A. longianalis, A. longicaudatus, A. micropterygeus* and *A. brevicaudatus* also have equally long caudal fins (Fig. 10).

One of the remarkable characters of *A. longi-*

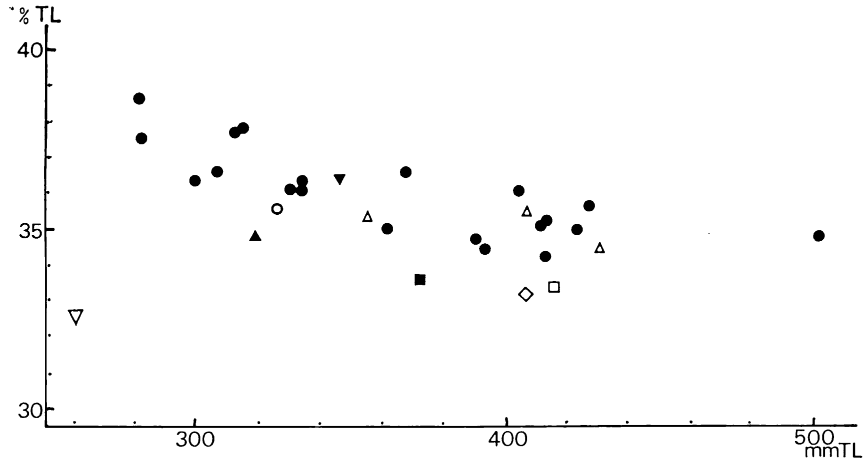

Fig. 10. Comparison of the caudal fin length in *Apristurus longicephalus* (solid circles), *A. herklotsi* (open circle), *A. abbreviatus* (open triangles), *A. xenolepis* (open square), *A. investigatoris* (open inverted triangle), *A. micropterygeus* (solid square), *A. longianalis* (solid inverted triangle), *A. longicaudatus* (solid triangle) and *A. brevicaudatus* (diamond). Measurements for the last four species are taken from the original figures.

cephalus is the sparsity of the teeth, those being only 36 to 44 (mostly around 40) vertical rows of teeth on upper jaw and only 31 to 41 (mostly 36 to 40) on the lower jaw. Available data indicate that this species has the fewest number of teeth on both jaws in the genus. The number of vertical rows of teeth does not seem to change with growth in this species, and other Japanese species also have relatively stable tooth numbers throughout life (Fig. 9). Though Springer (1979) did not use tooth number in his revision, it is apparent that this is a useful taxonomic character.

The number of monospondylous vertebrae in *A. longicephalus* ranges from 30 to 33. Considering the wide range of monospondylous vertebral number in the genus (28–46) and known individual variation of 4 to 6 vertebrae in a single species of this genus (Springer, 1979), this is a useful taxonomic character, though data for many species are still lacking. Compared with available data of other species (Springer, 1979), the vertebral numbers of *A. longicephalus* indicate that it is one of the species with low vertebral numbers.

Judging from the condition and development of the clasper (Fig. 7) and testes, male individuals of *A. longicephalus* appear to become mature around 420 mm TL. The only female in this study was 390 mm and no large ova were present in her ovary. Therefore, the minimum size at maturity of *A. longicephalus* appears to be around 42 cm TL, at least in male. My unpublished data show that other Japanese species become mature at larger sizes, hence these facts suggest that *A. longicephalus* is a small-sized species among them.

Dermal denticle counts (Table 1, Fig. 11) in *A. longicephalus* are relatively constant in individual specimens, but there is a tendency for them to increase with growth until maturation, when they become relatively constant. The only female in the sample has about the same density of dermal denticles as the males. Though I do not give the data of other species to compare, some species apparently have sparser or denser distribution of dermal denticles. Therefore, the number of dermal denticles in a unit area may be used as a countable character.

As discussed above, *A. longicephalus* has several distinctive characters, but some western Pacific and Indian species are very similar, i.e. *A. herklotsi* Fowler, 1934 from the Philippines, *A. investigatoris* Misra, 1959 from the Andaman Sea, *A. abbreviatus* Deng, Xiong et Zhan, 1985 from the East China Sea, *A. xenolepis* Meng, Chu et Li, 1985, *A. brevicaudatus* Chu, Meng et Li, 1986, *A. micropterygeus* Meng, Chu et Li, 1986, *A. longianalis* Chu, Meng et Li, 1986 and *A. longicaudatus* Li, Meng et Chu, 1986, all from the South China Sea.

A. longicephalus resembles *A. investigatoris* in

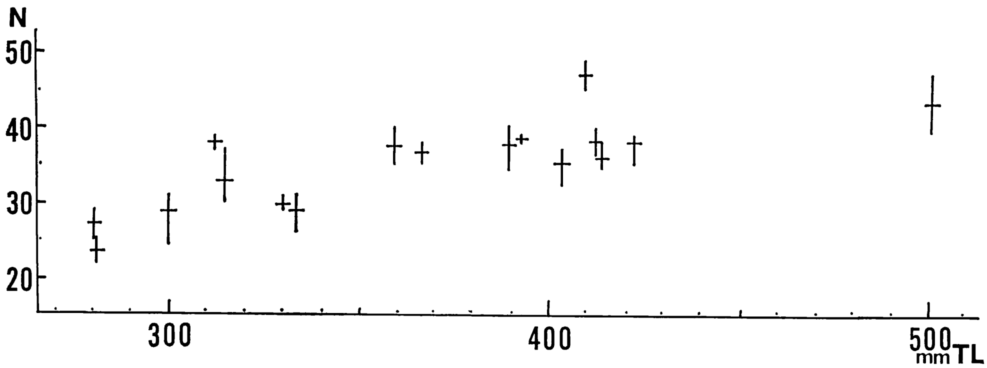

Fig. 11. Ontogenetic change of the number of dermal denticles in a 2×2 mm square in *Apristurus longicephalus*. Horizontal bars indicate the mean.

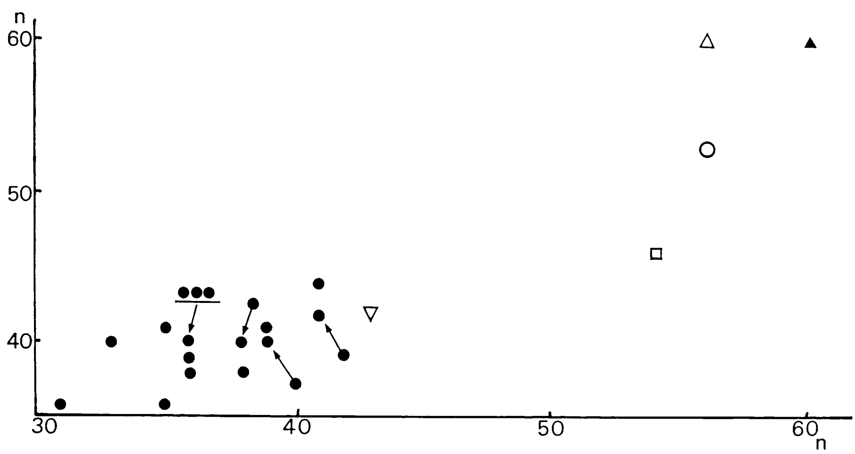

Fig. 12. Interrelation of the number of vertical rows of the upper (Y axis) and lower (X axis) teeth in *Apristurus longicephalus* (solid circles), *A. herklotsi* (open circle), *A. abbreviatus* (open triangle), *A. xenolepis* (open square), *A. investigatoris* (open inverted triangle), and *A. longicaudatus* and *A. brevicaudatus* (solid triangle).

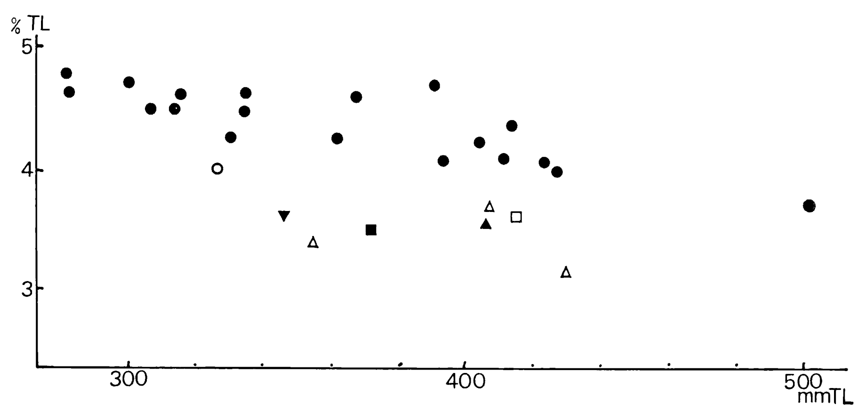

Fig. 13. Comparison of the internostril widths in *Apristurus longicephalus* (solid circles), *A. herklotsi* (open circle), *A. abbreviatus* (open triangle), *A. xenolepis* (open square), *A. micropterygeus* (solid square), *A. longianalis* (solid inverted triangle), *A. brevicaudatus* (solid triangle) and *A. longicaudatus* (open inverted triangle). Measurements for the last four species are taken from the original figures.

having very short abdomen, and sparse teeth on both jaws (Fig. 12), but *A. investigatoris* has a very short caudal fin (less than 30% TL) even at 260 mm TL. Judging from the values for ontogenetic change in the caudal fin (Fig. 10), *A. longicephalus* of 260 mm TL could be expected to have a much longer caudal fin of about 38% TL. The snout is also shorter in *A. investigatoris* (6.2% TL) than in *A. longicephalus*.

On the other hand, *A. herklotsi* and the six species from the East and South China Seas cited above have very long caudal fins, almost the same as that of *A. longicephalus* (Fig. 10). These species are also similar to *A. longicephalus* in having very long snouts and short abdomens. The teeth of these species are, however, more numerous, and the numbers of vertical rows are outside the range of *A. longicephalus* (Fig. 12; 76–80 rows on both jaws in *A. longianalis* and ca. 72 rows in *A. micropterygeus*). In addition, internostril space is apparently wider at any stages of growth in *A. longicephalus* than in *A. herklotsi* and these Chinese species (Fig. 13).

Conclusively, *A. longicephalus* is a distinct species without synonyms, and characterized by the following features: long snout before nostril which is greater than interorbital width, wide internostril space which is more than 1.2 times the nostril diameter, 1st dorsal origin on pelvic base in most specimens, long caudal fin more than 1/3 of total length, short distance between origins of paired fins which is always much shorter than length from snout tip to 1st gill opening, very sparse teeth, with less than 44 vertical rows on upper and 41 on lower jaw, and 30 to 33 monospondylous vertebrae.

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テングヘラザメの形態および分類

仲谷一宏

ヘラザメ属は深海性トラザメ類で，少なくとも 36 種が知られ，特に東シナ海，南シナ海を含む西部北太平洋海域からはその多くが報告されており，その分類は極めて困難になっている．テングヘラザメ *Apristurus longicephalus* Nakaya は土佐湾などからわずか数個体が知られ，その特徴や近縁種との関係があまり明らかではなかった．しかし，近年，比較的多くのテングヘラザメの標本を入手することができたため，本種の特徴を明確にし，さらに日本近海産種および近縁種との分類学的関係を明らかにするために，これらの標本に基づいて，本種の個体変異，性的二型，成長による外部形態の変化を考察した。その結果，本種は鼻孔より前の吻部が非常に長く，その長さは両眼間隔幅より長いこと，両鼻孔間は幅広く，その幅は鼻孔径の 1.2 倍以上あること，尾鰭が非常に長く，成体でも全長の 3 分の 1 以上あること，胸鰭腹鰭間が短いこと，歯が極めてまばらで，上顎歯は 44 列，下顎歯は 41 列以下であること，腹椎骨数は 30–33 個であることなどで特徴づけられることが明らかになった．本種はフィリピンから記載された *A. herklotsi*, 東シナ海の *A. abbreviatus*, 南シナ海の *A. xenolepis* など 7–8 種に類似するが，上記の形質で明瞭に区別できる．なお，本種のシノニムはない．

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