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Sexual Dimorphism Found in Teeth of Three Species of Moray Eels

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Abstract Sexual dimorphism was found in the number of teeth on the jaws of *Gymnothorax richardsoni* and in the shape of teeth of *Echidna nebulosa* and *E. polyzona*. Males of *G. richardsoni* have fewer teeth than females. Males of two species of *Echidna* have sharper teeth than females.

Teeth on the jaws and prevomer have been treated as an important diagnostic character for the classification of genera and species of moray eels. On the other hand this character has been used with some difficulties in the identification. Some authors have noted variations with growth in this character (Günther, 1870; Weber and de Beaufort, 1916; Herre, 1923; Schultz, 1943, 1953; Gosline and Brock, 1960; Smith, 1962; Chen and Weng, 1967; Blache, 1967a, b, c, d). During the examination of the validity of teeth as a diagnostic character, I found that some variations are due to sexual dimorphism. Among available species, with enough mature adult specimens, this phenomenon was found in the teeth on jaws of *Gymnothorax richardsoni, Echidna nebulosa,* and *E. polyzona*. These three species are common in the shallow waters of the Ryukyu Islands.

Methods

All species belonging to the Muraenidae have teeth on the premaxillo-ethmo-prevomer, the maxillary, and the mandible (Fig. 1). In the Anguilliformes the premaxillo-ethmo-prevomer is a single complex into which the premaxillary, the ethmoid, and the prevomer are fused. The toothed area of this bone is divided into two parts, the anterior plate and the posterior shaft. I call the former premaxillary plate which is a synonym of the intermaxillary (plate) of some authors (cf. Weber and de Beaufort, 1916; Herre, 1923; Schultz, 1943; Smith, 1962; Chen and Weng, 1967; McCosker and Randall, 1982), and the latter prevomer.

Regarding the tooth counts, shed teeth were included when holes were present in the skin and the replacement teeth (Blache, 1967a, b, c, d, e) were visible under the skin near the holes (Figs. 4, 5, and 6).

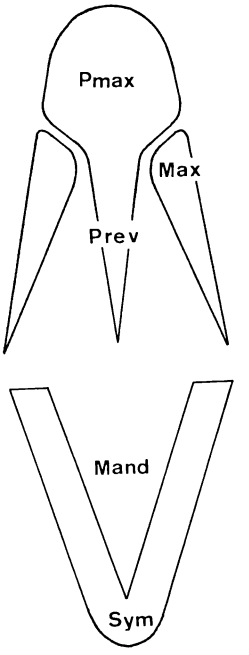

Fig. 1. Arrangement of teeth. Mand, mandible; Max, maxillary; Pmax, premaxillary; Prev, prevomer; Sym, symphysis.

Sex was determined by the direct examination of gonads.

Specimens are deposited in the Department of Fisheries, Faculty of Agriculture, Kyoto University (FAKU); the Seto Marine Biological Laboratory, Kyoto University (SMBL-F); and the Department of Marine Sciences of the University of the Ryukyus (URM-P).

Results

Gymnothorax richardsoni (Bleeker)
(Figs. 2A, 3, 4)

Materials examined. Male: FAKU 51386, 230.0

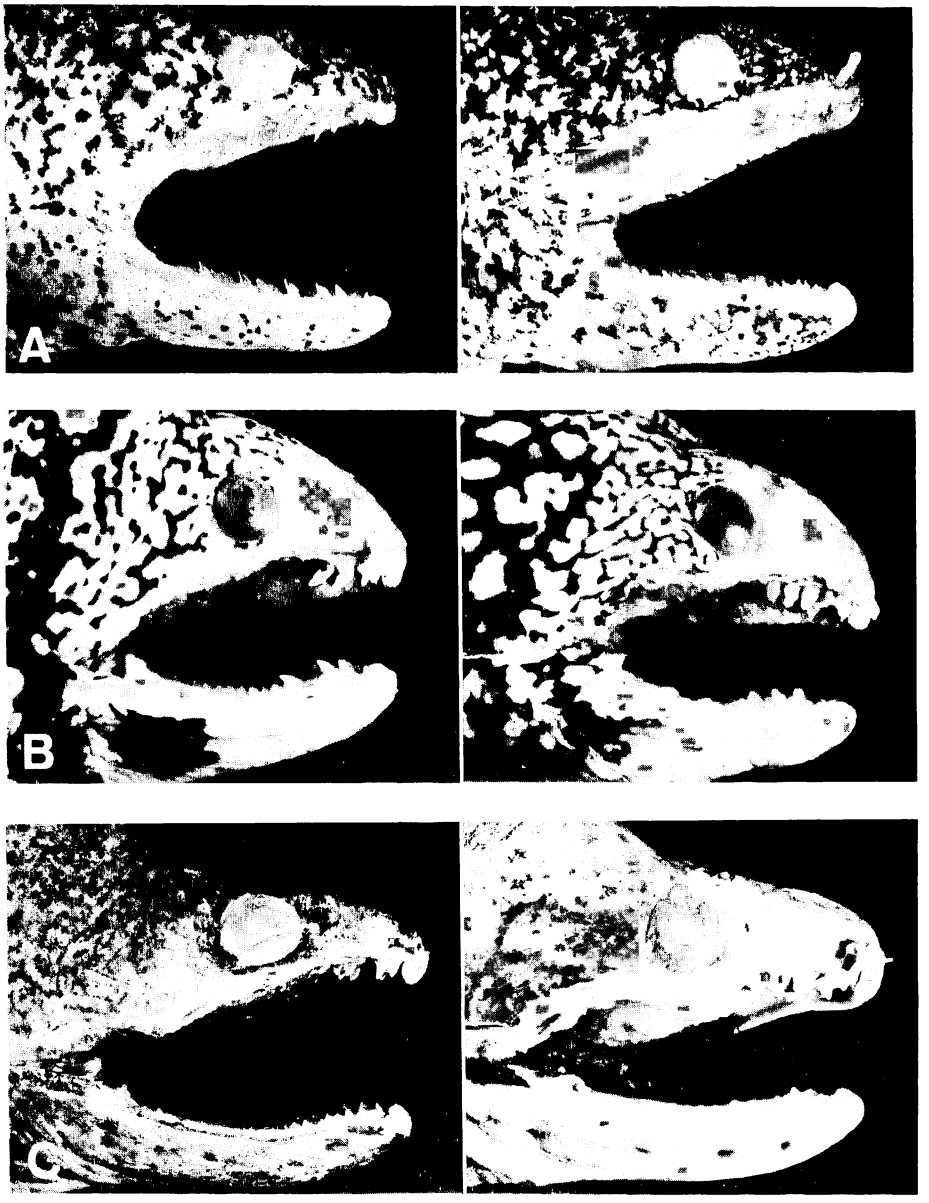

Fig. 2. Right lateral view of head. A, *Gymnothorax richardsoni*: left, male, 253.2 mm TL; right, female, 294.1 mm TL. B, *Echidna nebulosa*: left, male, 557.3 mm TL; right, female, 615.5 mm TL. C, *Echidna polyzona*: left, male, 628.2 mm TL; right, female, 600.5 mm TL. Upper and lower lips were removed.

mm total length (TL), July 15, 1982, Yakata, Okinawa I.; FAKU 51388, 303.0 mm TL, Aug. 9, 1982, Sesoko I., near Okinawa I.; FAKU 51389, 302.5 mm TL, Aug. 31, 1982, Tonoshiro, Ishigaki I., Ryukyu Is.; FAKU 100580, 100584, 100585–100588, 100592, 100593, 100597, and 100599, 222.3–285.2 mm TL, July 20, 1982, Yakata, Okinawa I.; URM-P 0571, 0575, and 0576, 174.6–256.1 mm TL, Sept. 3, 1979, Yakata, Okinawa I.; URM-P 1813, 233.9 mm TL, May 31, 1978, Yagaji, Okinawa I.

Female: FAKU 51385 and 51387, 157.2 and 309.9 mm TL, July 15, 1982, Yakata, Okinawa I.; FAKU 100581–100583, 100589–100591, 100594–100596, 100598, and 100600–100604, 149.9–313.8 mm TL,

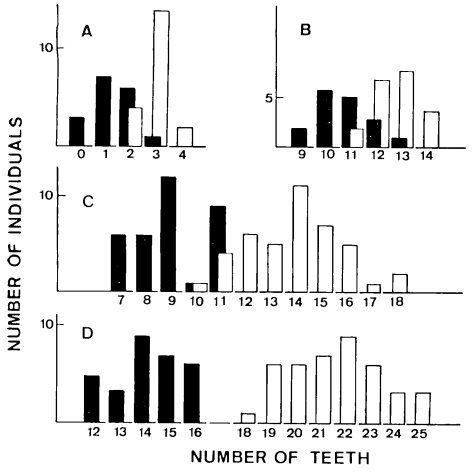

Fig. 3. Number of teeth on jaws in *Gymnothorax richardsoni*. A, medial teeth of premaxillary plate; B, peripheral teeth of premaxillary plate; C, maxillary teeth; D, mandibular teeth. Solid column, male; open column, female. Number of individuals of maxillary and mandible are total of left and right sides.

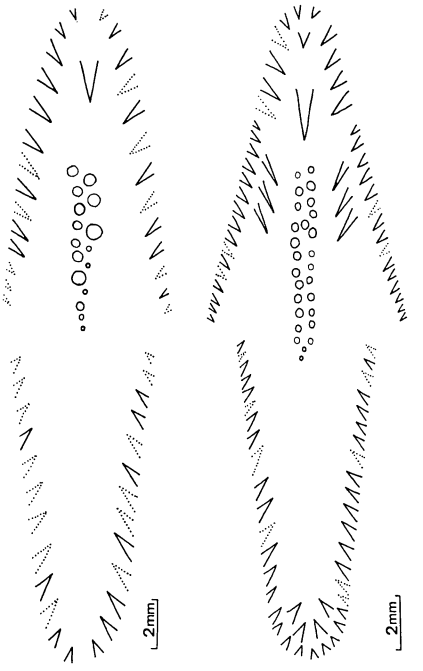

Fig. 4. Dentition of *Gymnothorax richardsoni*: left, male, 285.2 mm TL; right, female, 294.1 mm TL. Dotted line, shed tooth.

July 20, 1982, Yakata, Okinawa I.; URM-P 0572–0574, 219.0–242.5 mm TL, Sept. 3, 1979, Yakata, Okinawa I.

Description. Sexual dimorphism is mainly found in the number of teeth. In every part, teeth of females are more numerous than males (Fig. 3). This difference is conspicuous in mandible and maxillary; especially, in the mandible there is no overlapping in the ranges of the number of teeth between males and females (Fig. 3D).

Premaxillary plate. Male: peripheral series with 9–13 sharp teeth; along midline on premaxillary plate 0–3 (mostly 1–2) fangs present; when 2–3 teeth present, anterior teeth short. Female: peripheral series with 11–14 teeth, some anterior teeth small and somewhat blunt, other lateral teeth sharp; along midline of premaxillary plate 2–4 (mostly 2–3) fangs present, anterior short, posterior long; when 4 teeth present, arranged in irregular two rows.

Maxillary. Male: 7–11 sharp teeth in a single row. Female: teeth in two rows except in a 309.9 mm TL specimen (teeth of this specimen in a single row); outer row with 10–18 sharp teeth which are smaller than peripheral teeth of premaxillary plate, compared with the condition of males; inner row located anteriorly with 1–4 depressible sharp teeth which are slender and longer than those of outer row.

Prevomer. In both sexes, teeth small and blunt, in two rows or an irregular single row.

Mandible. Male: 12–16 sharp teeth in a single row. Female: teeth in a single row except near symphysis with an additional inner row: outer row with 18–25 teeth, some of them near symphysis small and blunt, other teeth sharp; inner row with 1–2 somewhat larger teeth.

Echidna nebulosa (Ahl)
(Figs. 2B, 5)

Materials examined. Male: FAKU 51442 and 51447, 615.0 and 625.5 mm TL, Sept. 5, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51444, 616.4 mm TL, Sept. 4, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51445 and 51450, 602.0 and 596.3 mm TL, Sept. 2, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51446, 557.3 mm TL, Aug. 6, 1982, Sesoko I., near Okinawa I.; FAKU 51449, 488.0 mm TL, Aug. 22, 1982, Sesoko I., near Okinawa I.; FAKU 51454, 432.5 mm TL,

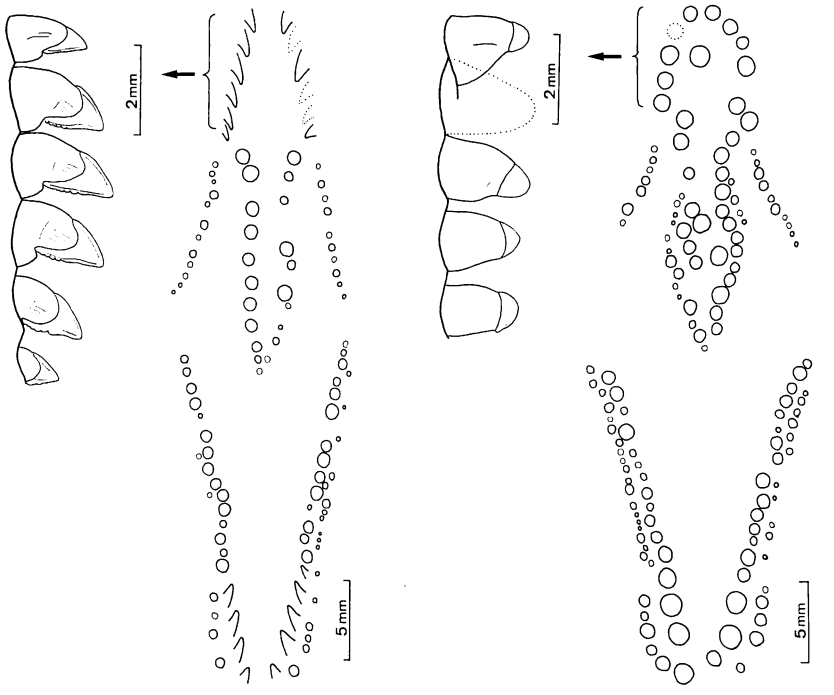

Fig. 5. Dentition of *Echidna nebulosa*: left, male, 602.0 mm TL; right, female, 615.5 mm TL. Dotted line, shed tooth.

Aug. 18, 1982, Sesoko I., near Okinawa I.; FAKU 51475, 627.0 mm TL, Aug. 6, 1980, Tonoshiro, Ishigaki I., Ryukyu Is.; FAKU 102834, 596.3 mm TL, Aug. 31, 1982, Tonoshiro, Ishigaki I., Ryukyu Is.; URM-P 0808, 472.0 mm TL, June, 1976, Urasoe, Okinawa I.; URM-P 0862, 513.0 mm TL, Jan. 6, 1974, Minatogawa, Okinawa I.; SMBL-F 73352, 477.0 mm TL, July, 1973, Yaeyama Is., southern part of Ryukyu Is.

Female: FAKU 51440 and 51443, 557.3 and 615.5 mm TL, Sept. 5, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51441, 446.8 mm TL, Aug. 8, 1982, Motobu, Okinawa I.; FAKU 51448, 463.0 mm TL, Aug. 9, 1982, Sesoko I., near Okinawa I.; FAKU 51451 and 51452, 519.0 and 568.9 mm TL, Sept. 1, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51453, 574.4 mm TL, Sept. 2, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 102833, 646.5 mm TL, Aug. 31, 1982, Tonoshiro, Ishigaki I., Ryukyu Is.; SMBL-F 73351, 554.0 mm TL, July, 1973, Yaeyama Is., southern part of Ryukyu Is.

Description. Sexual dimorphism is mainly found in the shape of teeth on the premaxillary plate. Males are characterized by having the peripheral series of the premaxillary plate with sharp teeth and the medial part without teeth. Moreover, in males, the tooth crown of each tooth is serrated posteriorly. In females all the teeth of the premaxillary plate are conical, and the conical teeth are always present in the medial part.

Premaxillary plate. Male: peripheral series with 11–12 sharp teeth; 5–6 teeth in each side making a rather straight row, anterior teeth slightly smaller; tooth crowns of peripheral sharp teeth inclined posteriorly and compressed, some of these teeth in specimens longer than 477.0 mm TL with serrated posterior edge, tooth root of peripheral sharp teeth with a large posterior lobe; in large adult male specimens longer than 596.3 mm TL, medial part of premaxillary plate without teeth, and in specimens shorter than 557.3 mm TL with 1 or 2 blunt teeth. Female: peripheral series with 11–12 conical teeth, making a U-shaped row; medial part with 1–2 blunt conical teeth, even in specimens over 600 mm TL (the largest specimen with teeth in this part, 646.5 mm TL).

Maxillary. Male: 7–12 small sharp teeth and conical ones in a single row; tooth crown of some

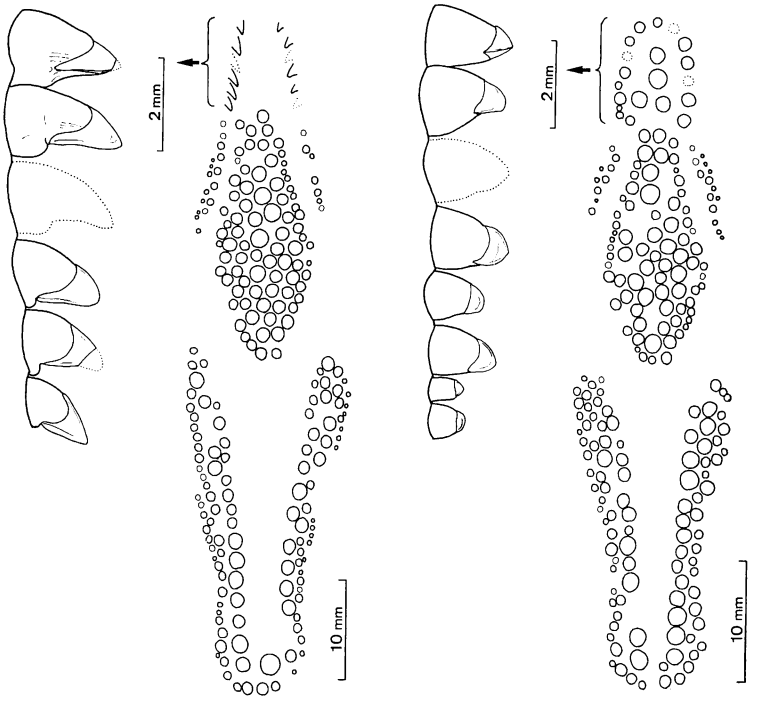

Fig. 6. Dentition of *Echidna polyzona*: left, male, 628.2 mm TL; right, female, 600.5 mm TL. Dotted line, shed tooth.

sharp teeth with faintly serrated posterior edge. Female: 7–12 small blunt teeth also in a single row.

Prevomer. In both sexes large conical teeth almost in two rows; in some specimens two rows widely separated laterally in the middle parts and some large conical teeth present in the interspace of the rows; this tendency is observed more often in females.

Mandible. Male: teeth in about two rows; some inner teeth near symphysis large and sharp, some of these teeth in specimens longer than 557.3 mm TL with serrated posterior edge, the other inner teeth conical; outer teeth very small and conical, and the tooth row mostly shorter than inner tooth row and found in anterior half of the mandible, sometimes restricted to near symphysis, but in some specimens in entire mandible. Female: teeth also in about two rows; all inner teeth conical, anterior large, posterior small; outer teeth very small and conical, mostly these teeth found in entire mandible and sometimes in anterior half of the mandible.

Echidna polyzona (Richardson)
(Figs. 2C, 6)

Materials examined. Male: FAKU 51457, 628.2 mm TL, June 22, 1982, Ishikawa, Okinawa I.; FAKU 51461 and 51462, 536.8 and 647.5 mm TL, Sept. 5, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51463 and 51466, 514.4 and 527.5 mm TL, Sept. 2, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51464, 593.5 mm TL, Sept. 1, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51465 and 51470, 590.4 and 433.8 mm TL, Sept. 4, 1982, Haimi, Iriomote I., Ryukyu Is.; SMBL-F 73348, 363.2 mm TL, July, 1973, Yaeyama Is., southern part of Ryukyu Is.

Female: FAKU 51458, 600.5 mm TL, July 16, 1982, Yagaji, Okinawa I.; FAKU 51459, 605.8 mm TL, July 17, 1982, Yagaji, Okinawa I.; FAKU 51460, 573.6 mm TL, July 19, 1982, Inbu, Okinawa I.; FAKU 51467, 527.8 mm TL, Sept. 4, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 51468 and 51469, 382.6 and 405.6 mm TL, Sept. 5, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 102837, 614.0 mm TL, Sept. 4, 1982, Haimi, Iriomote I., Ryukyu Is.; FAKU 102838, 543.0 mm TL, Sept., 1982, Haimi, Iriomote I., Ryukyu Is.

Description. Sexual dimorphism is mainly found in the shape of teeth on the premaxillary

plate. Males are characterized by having the peripheral series of the premaxillary plate with sharp teeth and the medial part without teeth. Females are characterized by the fact that all teeth of the premaxillary plate are conical, and conical teeth are always present in the medial part.

Premaxillary plate. Male: peripheral series with 11–12 sharp teeth, 5–6 teeth in each side, making almost a straight line; tooth root with a large posterior lobe and tooth crown without serration; in large adult specimens, longer than 593.5 mm TL, medial part of premaxillary plate without teeth, and in specimens shorter than 590.4 mm TL with 1 or 2 conical teeth; exceptionally a 363.2 mm TL specimen without teeth in this part. Female: teeth of the premaxillary plate conical; both peripheral and medial rows of teeth irregular and making a tooth patch which continues to prevomerine tooth patch.

Maxillary. Teeth of both sexes conical and in 1–2 rows, inner large, outer small, some teeth of male often small canines.

Prevomer. All teeth of both sexes conical or molar-like, making a pear-shaped tooth patch.

Mandible. All teeth of both sexes conical, arranged in 2–3 rows anteriorly, 2–6 wide rows posteriorly, inner teeth large, outer teeth small.

Discussion

The shape and arrangement of the teeth on the jaws and prevomer have been used as important diagnostic characters for the classification of genera and species in the moray eels. But this character has been used with some difficulties in identification. These difficulties seem to be due to changes with growth as mentioned by some authors (Günther, 1870; Weber and de Beaufort, 1916; Herre, 1923; Schultz, 1943, 1953; Gosline and Brock, 1960; Smith, 1962; Chen and Weng, 1967; Blache, 1967a, b, c, d). These authors, however, have not mentioned sexual dimorphism in these characters. The results of this study suggest that some of the changes with growth mentioned by these authors are due to the differences arising from the sexual dimorphism.

Herre (1923) and Schultz (1953) stated that the inner teeth of the maxillary in *G. richardsoni* (Herre, numerous specimens, 150–322 mm TL; Schultz, 5 specimens, 135–300 mm TL) become fewer or disappear with growth, and further Herre (1923) found the reduction of outer teeth in number (12–14 to 5, 6, or 8). The largest female specimen of this species examined here (313.8 mm TL) has 14 outer and 1 inner teeth in the left side and 14 and 2 in the right side. This suggests that the reduction of the maxillary teeth with growth are not found in females. These authors did not check the sex, and this species matures at less than about 25 cm TL (Hatooka and Yoshino, 1982). Taking these facts into consideration, the smaller specimens of Herre (1923) and Schultz (1953) may be females and the larger specimens may be males.

Schultz (1953: 100) suggested that the median row of premaxillary teeth may disappear in very large eels of *Echidna*. Gosline and Brock (1960: 103, fig. 148c, d) illustrated that in the medial part of the premaxillary plate, a 5-inch *E. polyzona* has some teeth but a 20-inch specimen has no teeth. In this study, the larger males of *E. nebulosa* (596.3–627.0 mm TL) and *E. polyzona* (593.5–647.5 mm TL and one 363.2 mm TL exceptional specimen) have no teeth in the middle part of the premaxillary plate, while the smaller males of *E. nebulosa* (432.5–557.3 mm TL) and *E. polyzona* (433.8–590.4 mm TL), and all the female specimens have conical teeth in this part. The largest size of females in *E. nebulosa* is 646.5 mm TL and that of *E. polyzona* is 614.0 mm TL, and these values are about the same as that of each male. These results suggest that the teeth on the middle part of the premaxillary plate disappear with growth in males of each species and the absence of teeth in this part is peculiar to large males. Unsatisfactory suggestions given by the previous authors may be due to lack of examination of the sex and of enough large materials (materials of Schultz are mostly less than 40 cm TL).

Some recent authors have divided *Gymnothorax* into two genera (*Gymnothorax* and *Lycodontis*) on the basis of the presence or absence of the serration found in the edge of the tooth crown (Smith, 1962: 429; Blache, 1967e: 1696; Böhlke, 1977: 3, 1981: 3). They have insisted that the species with serrated teeth should be included in *Gymnothorax* and those with smooth teeth in *Lycodontis*; at that time, the serrated teeth were considered to be unique to *Gymnothorax* (*sensu* Smith, 1962; Blache, 1967e; Böhlke, 1977, 1981).

On the other hand, the serration of teeth was observed in the larger males of *Echidna nebulosa*, which shows that the serration is not a unique character in *Gymnothorax* (*sensu* Smith, 1962; Blache, 1967e; Böhlke, 1977, 1981). A discussion about the problem between *Gymnothorax* and *Lycodontis* is beyond the scope of this study. The sexual dimorphism found in the jaw teeth, however, may give us a clue to clarify confused classification in this family, so the intensive and extensive reexamination of the character is needed.

Acknowledgments

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ウツボ科魚類3種の顎歯にみられる性的二型

波戸岡清峰

ウツボ科魚類において顎歯の形態，配列様式は重要な分類形質となるが，その顎歯に性的二型のあることがアラシウツボ属 *Echidna* 2種，ウツボ属 *Gymnothorax* 1種において観察された．

アラシウツボ属のクモウツボ *E. nebulosa* とシマアラシウツボ *E. polyzona* では歯の形態に差異が認められる．これら2種の雄は前上顎骨板周辺列の歯が鋭い．またクモウツボの雄ではこの部分の歯および下顎前部の歯に顕著な鋸歯状部を持つ．一方，両種の雌は鈍い円錐状である．

ウツボ属のモバウツボ *G. richardsoni* では歯列数，歯数に差異が認められる．この種の雄の主上顎骨歯は1列をなすが，雌では前方で2列をなす傾向があり，その外列歯数および下顎歯数は雄では少ないが雌では多い．

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