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Redescription of a Poorly Known Stingray, *Dasyatis laevis* (Chondrichthyes: Dasyatidae), with Notes on Some Biological Aspects in Ariake Sea, Japan

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The poorly known dasyatid stingray *Dasyatis laevis* Chu, 1960 is re-described on the basis of a single syntype and 18 recently collected specimens from Ariake Sea, Japan, and the East China Sea. Sexual dimorphism and growth-related variation in taxonomic characters are considered, and life history characteristics, such as distribution and size at maturity, are clarified on the basis of an additional 464 specimens.

Key Words: Dasyatidae, Yantai Stingray, *Dasyatis laevis*, redescription, size at maturity.

Introduction

Dasyatis Rafinesque, 1810, one of seven genera of stingrays belonging to the family Dasyatidae, is characterized by a long, whip-like tail, a tail spine, and a ventral tail fold that terminates before the tail tip. The genus includes approximately 36 species (Gomes *et al.* 2000; Compagno 2005; Last and White 2008a, b; Last and Stevens 2009), eight of which are distributed in Japanese waters (Aonuma and Yoshino 2000).

Dasyatis laevis Chu, 1960 was described on the basis of six specimens obtained from the Shanghai Fish Market, Dongfushan, and Huaniao, China. The first Japanese record of *D. laevis*, from Tachibana Bay, Nagasaki Pref., was reported by Yamada and Irie (1989), but no morphological details were given. Subsequently, Furumitsu *et al.* (2006) noted that *D. laevis* is also distributed in Ariake Sea, Japan, having long been misidentified there as *D. akajei* (Müller and Henle, 1841) owing to the morphological similarity of the two species. In fact, Nishida and Nakaya (1990) had earlier noted the potential for confused identifications within *Dasyatis*, owing to individual, sexual, and ontogenetic variation. Within recent years, many specimens of both *D. laevis* and *D. akajei* have been collected in coastal areas off western Kyushu, Japan.

Chu (1960) did not indicate the repository of his syntypes, but one of the numbered specimens (154,103-8 (4)) was found in 2006 in the East China Sea Fisheries Research Institute of the Chinese Academy of Fishery Sciences in Shanghai. This specimen has subsequently gone missing there (see Remarks), and as the remain-

ing five syntypes could not be traced at all, we assume they have been lost. Based on the temporarily located syntype and the other specimens examined in this study, *D. laevigata* is redescribed herein, with special attention paid to individual, sexual, and ontogenetic variation. Biological data on the distribution and size at maturity of *D. laevigata* are also presented, and comparisons are made with related western North Pacific dasyatid species.

Material and Methods

Methods and terminology for counts and measurements follow Compagno and Roberts (1982, 1984) and Nishida and Nakaya (1988a), except for the following: pre-ventral tail fold length—distance from snout tip to anteriormost point of ventral tail fold; amphioral snout length—distance from snout tip to posteriormost point of mouth; pectoral fin anterior margin—distance from snout tip to outermost margin of disc; pectoral fin posterior margin—distance from posteriormost point of disc to outermost margin of disc. Disc width (DW) is considered as the standard measure of size in this study. Counts of radial cartilages and vertebrae, as well as observations of the pelvic girdle, were made using soft X-rays, following Compagno and Roberts (1982) and Nishida (1990). Unstained clasper skeletons were observed after flesh removal following Taniuchi and Ishihara (1990). Snout angle measurement and tooth counts follow Stehmann (1981). Pelvic girdle terminology and clasper terminology follow Nishida (1990) and Taniuchi and Ishihara (1990), respectively. Tooth rows, intestinal spiral valve turns, radial cartilages, and vertebrae of the female syntype were not counted before the specimen was misplaced, nor could the pelvic girdle be examined. In addition to this syntype, 18 specimens collected off western Kyushu, Japan, were used to redescribe *D. laevigata*. These 18 specimens were deposited in the National Museum of Nature and Science, Tokyo (NSMT). An additional 464 unregistered specimens (collected from Ariake Sea, Amakusa Sea, and Nomozaki, western Kyushu, Japan during 2003–2008) used for the “Biological Data” section, including estimation of size at sexual maturity and documentation of variation in the ratio of clasper length to DW and other morphological and morphometric characters, were later discarded. Maturity stages were assigned according to the degree of development of the testes and claspers in males, and ovaries and uteri in females, following Braccini and Chiaramonte (2002), as follows. Males: 1) immature, testes and claspers undeveloped; 2) sub-adult, testes becoming lobular, vas deferens beginning to thicken and coil, clasper elongated and flexible, not calcified; and 3) mature, testes and seminal vesicle fully developed, vas deferens fully developed and coiled, sperm may be present, claspers calcified. Females: 1) immature, ovary comprising white, undifferentiated tissue, uterus thin; 2) sub-adult, ovary carrying small, immature, opaque oocytes, uterus becoming thickened; and 3) mature, ovary containing ova with yolk, uterus fully developed and possibly with eggs or embryos.

Comparative specimens. *Dasyatis akajei*: NSMT-P 91833–91854. *Dasyatis iizuensis*: NSMT-P 91829–91832.

Taxonomic Account

Dasyatis laevis Chu, 1960

[English name: Yantai Stingray Japanese name: Shiro-ei]

(Figs 1–5)

Dasyatis laevis Chu, 1960: 170–172, figs 160–162 (purchased at the Shanghai Fish Market, Dongfushan, and Huaniao, China); Chu *et al.* 1963: 65–66, fig. 52 (northern part of the East China Sea, the Shanghai Fish Market, Wenzhou Waihai, Shitang, and Sansha, China); Yamada and Irie 1989: 24 (Tachibana Bay, Nagasaki Pref., Japan); Nishida and Nakaya 1990: 341–342 (followed Chu (1960)); Chen and Joung 1993: 85 (Taiwan); Aonuma and Yoshino 2000: 182; Zhu and Meng, 2001: 420–422, fig. 220 (followed Chu (1960)).

Dasyatis laevis: Furumitsu *et al.* 2006: 32–34, figs 1, 2, 4; Furumitsu 2009: 25–28, fig. 14.

Specimens examined. *Syntype*: 154,103-8 (4) (Fig. 1) (formerly deposited in the East China Sea Fisheries Research Institute of the Chinese Academy of Fishery Sciences in Shanghai, examined in April 2006, but lost in December 2009), female, immature, 446 mm TL, 205 mm DW, Huaniao, China, 2 June 1956.

Comparative non-type specimens (all from Japan): NSMT-P 91808, immature male, 221 mm DW, off Mogi, Tachibana Bay, Nagasaki Pref., 8 February 1967; 91809, mature female, 292 mm DW, off Tara, Ariake Sea, Saga Pref., 28 June 2004; 91810, mature male, 237 mm DW, same as 91809; 91811, immature female, 128 mm DW, East China Sea, off Nomozaki, Nagasaki Pref., 16 July 2004; 91812, immature male, 124 mm DW, same as 91811; 91813 (Fig. 2A, B), mature male, 225 mm DW, off Shimabara, Ariake Sea, Nagasaki Pref., 3 May 2005; 91814, sub-adult male, 203 mm DW, same as 91813, 24 September 2005; 91816, immature male, 177 mm DW, same as 91813, 16 November 2005; 91817, immature female, 260 mm DW, off Higashi-yoka, Ariake Sea, Saga Pref., 12 May 2006; 91818 (Fig. 2C, D), mature female, 303 mm DW, same as 91817; 91819, immature female, 264 mm DW, same as 91817; 91820, sub-adult

Fig. 1. *Dasyatis laevis*, syntype, 205 mm DW, immature female, 154,103-8 (4). A, Dorsal view; B, ventral view. Scale bars: 50 mm.

Fig. 2. *Dasyatis laevigata*. A, B, NSMT-P 91813, 225 mm DW, mature male; C, D, NSMT-P 91818, 303 mm DW, mature female. Scale bars: 50 mm.

male, 224 mm DW, same as 91817; 91821, mature male, 226 mm DW, same as 91817; 91822, immature male, 120 mm DW, same as 91817, 13 July 2006; 91823, immature female, 250 mm DW, Amakusa Sea, off Ushibuka, Kumamoto Pref., 17 January 2007; 91824, sub-adult male, 246 mm DW, same as 91823; 93294, mature female, 321 mm DW, off Shimabara, Ariake Sea, Nagasaki Pref., 23 April 2002; and 96557, mature female, 296 mm DW, same as 93294, 17 July 2009.

Diagnosis. This species is distinguished from its congeners by the following combination of characters: disc rhomboid, width 111.5–123.5% of length; snout broadly triangular, angle 108–120°, preorbital length 138.3–182.6% of interorbital width; amphioral length 225.0–288.6% of mouth width; internasal distance 51.7–69.6% of prenasal length; body and tail mostly naked; dorsal surface of disc usually naked, sometimes with single row of up to 3 thorns along midline of disc; tail relatively long, slender, whip-like beyond posteriormost spine, tail width 140.5–192.9% of its depth, tail length 135.6–227.1% of precloacal length; ventral tail fold long, slender, its length 35.2–62.1% of DW; preventral tail fold short, 105.0–116.8% of DW; dorsal tail fold elongate, low, much shorter than ventral tail

fold; oral papillae 1–4 (mostly 3); intestinal spiral valve turns 16–18; total pectoral radials 98–103; prespine separate centra 87–96.

Description. Proportional measurements and counts of the syntype and other specimens are given in Tables 1 and 2, respectively. In the following description, measurements and counts are given for the syntype, with ranges for 18 additional specimens in parentheses.

Table 1. Proportional measurements (as % of DW) of *Dasyatis laevis*.

	Syntype 154,103-8 (4) ♀	Non-type specimens (included in the description) 10♂, 8♀ Min-Max Mean		Other materials (not included in the description) 188♂, 276♀ Min-Max Mean	
Snout angle (°)	115	108–120		105–122	
As % of DW					
Total length	213.4	177.2–239.2	208.7	148.1–241.7	203.5
Disc length	81.0	81.4–89.7	84.8	79.1–92.7	85.2
Preventral tail fold length	105.4	105.0–116.8	111.0	101.7–123.2	111.5
1st spine length	17.9	13.1–26.4	21.8	1.6–27.0	19.1
2nd spine length	–	12.6	12.6	4.4–23.1	17.2
Preorbital snout length	16.8	16.6–20.0	18.6	15.6–22.3	18.2
Eye diameter	4.6	3.7–5.5	4.4	3.3–5.5	4.2
Interorbital width	12.1*	9.8–12.5	11.1	10.1–12.5	11.2
Spiracle length	6.4	6.2–8.5	7.1	5.7–9.4	7.2
Interspiracular width	15.6	13.8–16.3	15.4	13.6–16.8	15.2
Snout to greatest width	40.0	37.1–42.2	39.9	32.9–44.2	39.4
Tail base width	6.9	7.7–9.5	8.5	5.4–9.7	7.8
Tail base depth	4.9	4.2–6.1	5.1	3.6–6.2	4.9
Tail length	141.5	101.6–164.2	134.1	74.8–193.9	129.1
Dorsal tail fold length	9.8*	10.8–30.2	21.7	10.0–31.9	21.4
Ventral tail fold length	35.2	41.4–62.1	50.1	30.5–68.5	48.9
Precloacal length	72.3	69.7–79.8	74.5	69.6–83.3	75.1
Ventral head length	38.7	37.5–42.2	40.1	37.4–43.4	40.1
Preoral snout length	19.2	18.8–20.8	20.0	18.6–21.0	19.8
Amphioral snout length	20.9	19.7–22.3	20.9	18.6–22.6	20.7
Pectoral fin anterior margin	61.8	62.2–66.4	63.9	58.2–67.6	63.5
Pectoral fin posterior margin	56.7	53.1–57.6	55.7	48.7–63.5	55.9
Prebranchial length	27.5	27.0–30.4	28.6	25.5–30.8	28.4
Prenarial snout length	14.9	13.0–15.7	14.6	12.4–15.9	14.3
Internarial width	8.1	7.7–9.5	8.8	7.7–10.6	8.8
Nostril length	4.1	3.6–4.6	4.2	3.2–5.0	4.3
Nasal curtain length	5.5	4.4–6.2	5.7	4.4–6.8	5.7
Mouth width	8.6	7.4–9.1	8.3	7.2–9.8	8.3
1st gill slit	2.6	2.0–3.6	2.8	2.0–3.6	2.9
1st interbranchial width	16.6	17.2–20.1	18.6	16.6–21.6	18.7
5th gill slit	1.5	1.5–2.3	1.8	1.4–2.4	1.9
5th interbranchial width	10.7	9.6–12.7	11.5	9.6–15.3	11.7
Clasper length	–	8.3–20.9	15.4	8.0–24.0	16.6
Clasper outer length	–	3.0–12.8	8.3	2.5–14.7	9.3
Clasper inner length	–	5.4–17.8	11.9	4.7–20.4	13.0

* Measurements from photo.

Table 2. Counts for *Dasyatis laevis*.

	Syntype 154,103-8 (4) ♀	Non-type specimens (included in the description) 10♂, 8♀		Other materials (not included in the description) 188♂, 276♀	
		Min-Max	Mean	Min-Max	Mean
Oral papillae	3	1-4	2.9	1-8	3.0
Upper tooth rows	–	34-49	43.4	37-55	43.6
Lower tooth rows	–	35-54	46.1	40-63	47.7
Intestinal spiral valve turns	–	16-18	17.0	15-20	17.7
Total pectoral radials	–	98-103	100.3	99-101	100.6
Propterygial radials	–	40-44	41.9	41-43	41.8
Mesopterygial radials	–	11-16	13.4	12-16	13.9
Metapterygial radials	–	44-47	45.0	42-46	44.9
Pelvic radials (male)	–	19-22	21.0	19-20	19.5
Pelvic radials (female)	–	24-27	26.0	24-26	24.8
Prespine separate centra	–	87-96	91.7	90-98	93.1
1st synarcual free centra	–	3-6	4.1	4-6	4.6
Intersynarcual centra	–	1-4	3.2	3-5	3.8
2nd synarcual + monospondylous	–	26-32	29.8	28-33	29.9
Prespine diplospondylous	–	49-59	54.8	51-57	55.0
Postspine diplospondylous	–	3-14	8.4	4-17	10.4

Disc rhomboid, width slightly broader than length, 123.5% (111.5–122.9%) of length; snout triangular, slightly projecting, angle 115° (108–120°); anterior margin slightly concave; posterior margin of disk slightly convex; outer angles of disc rounded; posterior angles slightly angular. Preorbital snout length 16.8% (16.6–20.0%) of DW; eyes small, eyeball diameter 27.1% (19.6–29.8%) of preorbital snout length, 37.7% (31.4–49.1%) of interorbital width, and 70.7% (52.2–78.7%) of spiracle length; interspiracular width 92.8% (73.2–97.9%) of preorbital snout length.

Mouth weakly arched, width 41.1% (34.6–44.4%) of amphioral snout length; midline of lower jaw with prominent indentation; teeth pavement-like, in quincunx pattern with 34–49 rows in upper jaw and 35–54 in lower jaw in non-type specimens, sexually dimorphic, adult males with pointed teeth in both jaws, females and juvenile males with blunt teeth (Fig. 3A–D); floor of mouth with 3 (1–4) elongate oral papillae. Posterior margin of nasal curtain relatively straight, fringed; longitudinal medial groove absent; nasal curtain length 26.1% (21.9–31.2%) of amphioral snout length; internarial width 38.5% (38.0–46.8%) of amphioral snout length. Ventral head length (VHL) 38.7% (37.5–42.2%) of DW; amphioral snout length 54.1% (48.6–54.1%) of VHL; prebranchial length 71.2% (69.0–72.9%) of VHL.

Gill slits weakly S-shaped, each laterally forming weakly fringed lobe; length of first gill slit 170.5% (125.9–187.4%) of length of fifth gill slit, 29.8% (25.7–44.8%) of mouth width; distance between first gill slits 206.2% (196.1–224.4%) of internasal distance, 43.0% (43.9–49.4%) of VHL; distance between fifth gill slits 133.1% (116.2–145.7%) of internasal distance, 27.8% (24.4–31.4%) of VHL.

Tail relatively long, whip-like, length 174.7% (120.2–199.0%) of disc length. Tail with 1 or 2 spines; 1st spine length 12.6% (8.0–22.5%) of tail length, 2nd spine absent

Fig. 3. Light microscope photographs of lower jaw teeth of *Dasyatis laevigata*. A, Immature female, 208 mm DW; B, immature male, 120 mm DW; C, mature female, 327 mm DW; D, mature male, 261.5 mm DW. Scale bars: 1 mm.

in syntype (10.2% of tail length in 1 of other 18 specimens). Low dorsal tail fold behind posteriormost spine, length 27.8% (23.5–53.0%) of that of ventral tail fold. Ventral tail fold beginning immediately below spine, length 91.1% (104.9–155.6%) of VHL. Preventral tail fold length 130.1% (126.9–134.4%) of disc length. No dorsal or caudal fin.

Pelvic girdle (Fig. 4A, B) thick, anteriorly arched; 2–3 obturator foramina on iliac region; iliac processes moderately long, stout, recurved inwardly; prepelvic processes reduced, lateral ones short, stout, projecting anterolaterally.

Claspers of mature males short, stout (Fig. 4C), length 23.2–24.8% of disc length, oval in cross section, robust basally, tapering distally to blunt point; ventral pseudosiphon well developed, about as long as clasper glans; small flap at top of glans; dorsal pseudosiphon absent; dorsal margin of hypopyle comb-like.

Clasper skeleton composed of basal, axial, and terminal groups (Fig. 4D, E). Basal group comprising basipterygium of pelvic fin, two basal segments (B1 and B2), and beta cartilage; B1 relatively short, stout, B2 relatively long, cylindrical, connecting pelvic basipterygium to clasper axial cartilage; beta cartilage located on dorsal surface of posterior part of B1, all of B2, and anterior half or so of axial cartilage. Terminal group of clasper composed of six cartilaginous components: 1) long axial cartilage located below dorsal terminal 2 cartilage, reaching to posterior tip of clasper, slender distally with blunt tip; 2) dorsal marginal cartilage broad,

Fig. 4. Pelvic girdle (A,B), left clasper (C), and right clasper skeleton (D,E) of *Dasyatis laevigata*. A, Dorsal view, 226 mm DW, mature male (NSMT-P 91821); B, dorsal view, 303 mm DW, mature female (NSMT-P 91818); C, dorsal view, 286 mm DW, mature male; D, E, dorsal and ventral views respectively, 286 mm DW, mature male. Abbreviations: AP, apophyle; AT, accessory terminal cartilage; AX, axial cartilage; B1, B2, basal segments of clasper axis; BE, beta cartilage; CG, clasper groove; DM, dorsal marginal cartilage; DT2, dorsal terminal 2 cartilage; HP, hypophyle; IP, iliac process; LPP, lateral prepelvic process; OF, obturator foramina; PPP, prepelvic process; SF, small flap; VM, ventral marginal cartilage; VPS, ventral pseudosiphon; VT, ventral terminal cartilage. Scale bars: 10 mm

Fig. 5. Dorsal midline thorns in *Dasyatis laevigata*, 296 mm DW, mature female (NSMT-P 96557). Scale bar: 10 mm.

triangular, with strongly concave posterior edge and arched cross-section, forming roof of clasper groove; 3) dorsal terminal 2 cartilage situated on dorsal aspect of clasper glans, long, oval, shield-like, its mediolateral edge comb-like; 4) ventral marginal cartilage short, narrow, with distinctive spatulate anterior projection, firmly attached to axial cartilage laterally; 5) ventral terminal cartilage large, oval-rectangular, with deep, V-shaped posterior notch; and 6) accessory terminal cartilage long, oval, dome-shaped, its outer edge incurved, broadly overlapping dorsal terminal 2 cartilage and ventral terminal cartilage.

Eighteen non-type specimens with 87–96 prespine separate centra, 98–103 total pectoral radials, 24–27 (5 females) and 19–22 (8 males) pelvic radial cartilages, and 16–18 intestinal spiral valve turns.

Dorsal surface of disc entirely smooth in all specimens, except for single mature female (NSMT-P 96557, 296 mm DW) with row of 3 flattened, posteriorly-pointing thorns on nucho-scapular region (Fig. 5). In all specimens, tubercles, thorns, and denticles absent on tail, pelvic fins, claspers, and ventral surface of disc.

Color of syntype. Dorsal surface of disc and pelvic fin light ocher; ventral surface of disc and pelvic fin white with light ocher outer and posterior margins, and irregular spots; dorsal surface of tail, dorsal tail fold, and ventral tail fold whitish ocher. Overall appearance pale, probably due to long-term preservation in formalin.

Color when fresh (based on non-type specimens). Dorsal surface of disc and pelvic fin grayish-brown; upper side of eyeball and spiracle with light ocher margins; ventral surface of disc and pelvic fin white with grayish-ocher outer and posterior margins and irregular grayish-ocher spots; dorsal tail fold blackish; dorsal surface of tail grayish-brown; ventral tail fold blackish; ventral surface of tail gray-

Table 3. Comparison of original description and syntype and non-type specimens of *Dasyatis laevigata*.

	Original description (Chu 1960)	Syntype 154,103-8 (4)	Non-type specimens (included in the description)
Disc width/Disc length (%)	120–130	123.5	111.5–122.9
Preorbital snout length/Disc length (%)	22.2	20.7	19.6–23.7
Eyeball diameter/Interorbital width (%)	66.7	37.7*	31.4–49.1
Interorbital width/ Preorbital snout length (%)	50.0	72.0*	54.8–72.3
Preoral snout length/Mouth width (%)	240–270	223.2*	223.1–272.6
5th interbranchial width/ 3rd gill opening length (%)	350	386.0*	297.7–465.5
Tail length/Disc length (%)	140–180	174.7	120.2–199.0
Ventral tail fold length/Tail length (%)	40.0	24.9	27.7–58.6
Snout angle	about 60°	115°	108–120°
Oral papillae	3	3	1–4
Upper jaw teeth	about 40	–	34–55
Dark spots on dorsal surface of disc	present	absent	absent
Dorsal tail fold	black	whitish-ocher	blackish
Ventral tail fold	black	whitish-ocher	blackish
Dorsal texture of disc in adult	smooth	smooth	smooth
Midline thorns on dorsal surface of disc	absent	absent	0–3
Tubercles before spine	absent	absent	absent
Posterior tail texture	smooth	smooth	smooth

* Measurements from photo.

ish-ocher; distal one-third of tail blackish.

Color in formalin. Similar to that of fresh specimens, except dorsal surface of disc brown; ventral surface whitish with dark outer and posterior margins.

Distribution and habitat. Known from the Yellow Sea and East China Sea off China (Zhu and Meng 2001), Taiwan (Chen and Joung 1993), and Japan, including the Goto Sea (Goto-Nada), Ariake Sea, and Tachibana Bay in Nagasaki Pref., and the Amakusa Sea (Amakusa-Nada) in Kumamoto Pref. (Yamada and Irie 1989; Furumitsu *et al.* 2006; Furumitsu 2009) (Fig. 6).

Dasyatis laevigata has been recorded inshore and to depths of 60 m on sandy and muddy bottoms. Juveniles commonly occur in estuaries and shallow coastal waters in summer, but inhabit deeper coastal areas during winter. The species is caught as a bycatch in most fisheries operating in shallow waters off western Kyushu, Japan.

Remarks. Chu (1960) originally described *D. laevigata* based on six syntypes but did not state the repository of those specimens. A search lasting more than seven years was successful in locating only one syntype (154, 103-8 (4)), at the East China Sea Fisheries Research Institute of the Chinese Academy of Fishery Sciences, Shanghai. We were able to examine the syntype at the Institute in April 2006. At the time of writing, however, that specimen, too, has also gone missing (Mr. Anglv Shen, pers. comm., 15 December 2009).

Eight proportional measurements, plus snout angle and two counts, were in-

Fig. 6. Collection localities of *Dasyatis laevis*. Open circle, syntype (154,103-8 (4)); solid circles, NSMT-P 91808–91814, 91816–91824, 93294, and 96557.

cluded in the original description. Although some differences between the original description and the present data were found (Table 3), the latter correspond well with the measurements of the syntype (154,103-8 (4)) obtained earlier in this study. The measurement methods employed by Chu (1960) were not described, and it is possible that differences in methodology are responsible for the above differences. Variations in the upper tooth rows and oral papillae have been observed, the numbers of the former being about 40 according to Chu (1960), and 34–49 here. The number of oral papillae was three in each of the six specimens of *D. laevis* described by Chu (1960), compared with the marked variation (1–8, generally 3) observed in this study. Such variation in tooth row number has been reported previously in *Dasyatidae* (e.g., Nishida and Nakaya 1988a, b). On the other hand, oral papilla numbers are often conservative between individuals and can be used as a diagnostic taxonomic character in some species of *Dasyatis*. Still, Nishida and Nakaya (1990) observed considerable variation in oral papillae counts in *D. akajei*. Although the numbers of tooth rows and oral papillae given by Chu (1960) coincided completely with the ranges obtained in the present study, marked variations among individuals in both counts show that neither is suitable as a diagnostic taxonomic character of *D. laevis*. Size at sexual maturity was smaller in *D. laevis* than in any other rhomboid-shaped dasyatid species (Furumitsu 2009). A male specimen of 429 mm total length (converted to 218 mm DW) shown in Chu (1960) had already reached maturity, judging by the appearance of the clasper in his fig.

162, a situation that supports the identification of the present specimens as *D. laevigata*. The ventral and dorsal tail folds were described as black in the original description but were whitish-ocher in the syntype (154, 103-8 (4)) that we examined. Since the syntype had been fixed and preserved in formalin for a long time, some coloration may have been lost. The original description indicated that irregular dark spots occurred on the dorsal surface of the disc, but no such spots were shown in the accompanying sketches (figs 160, 162) in Chu (1960). Neither could they be found during our investigations of the syntype (154, 103-8 (4)) and other specimens. It is possible that the spots described by Chu (1960) were simply short-term manifestations resulting from the poor condition of the specimens. Chu (1960) described the dorsal surface of the disc as smooth in all six syntypes (310–630 mm TL), which included mature specimens. In the non-type specimens examined here, while no thorns were observed in immature specimens ($n=200$, 95–312 mm DW), several (13.8%) sub-adult and mature specimens ($n=282$, 203–389 mm DW) had a row of one to nine midline thorns on the dorsal surface of the disc. No differences were found in the 12S rRNA, COI, or cytochrome *b* regions of mitochondrial DNA between specimens with and without thorns (Yamaguchi and Furumitsu unpublished data); therefore, the occurrence of thorns on the dorsal surface of the disc merely represents intraspecific variation and may have some relationship with growth.

Sexual dimorphism is apparent in the pelvic radial counts (Table 2), possibly resulting from modification of the pelvic cartilage to form clasper elements in males. Sexual dimorphism was also observed in the dentition of males and females. We observed male *D. laevigata* biting at the pectoral fins of females during the mating season, and similar mating behavior is widely known in dasyatids (e.g., Taniuchi and Shimizu 1993; Kajiura *et al.* 2000; Chapman *et al.* 2003). Sexual dimorphism was also apparent in size at maturity, with a size difference of approximately 70 mm in DW between the sexes. A similar trend has been reported in many dasyatids (e.g., Snelson *et al.* 1989; Capapé 1993; Taniuchi and Shimizu 1993; Villavicencio Garayzar *et al.* 1994; Capapé and Zaouali 1995).

Nishida and Nakaya (1990) recognized 17 species of *Dasyatis* from the Northwestern Pacific, including two unnamed species, although three of these have subsequently been placed in *Neotrygon*, *Pastinachus*, and *Pteroplatytrygon* by Last and Stevens (2009). Of the remainder, *D. akajei*, *D. izuensis* Nishida and Nakaya, 1988, *D. navarrae* (Steindachner, 1892), *D. sinensis* (Steindachner, 1892), *D. ushie* Jordan and Hubbs, 1925, and *D. sp. 2*, all having a rhomboid-shaped disc and a dorsal tail fold, and a dorsal disc surface without white spots, are compared with *D. laevigata* in Table 4. The latter clearly differs from these congeners by a unique combination of characters.

Biological data. *Dasyatis laevigata* is a relatively small marine dasyatid, reaching at least 290 mm DW in males and 369 mm DW in females. Clasper outer length ranged from 2.5 to 14.7% of DW in immature and sub-adult males. The claspers elongated rapidly from 210 mm DW, but at a decreasing rate as males attained maturity. All males larger than 240 mm DW were sexually mature (Fig. 7). Uterus weight ranged from 0.01 to 2.60 g in immature and sub-adult females, increasing rapidly from ca. 300 mm DW. All females larger than 310 mm DW were sexually mature (Fig. 8), maturity generally being attained at ca. 300 mm DW. Although ovaries and uteri were found on both sides in all examined specimens, only those on the left side were functional. Fertilized eggs and embryos were observed

Table 4. Comparison of *Dasyatis laevigata* and six allied species in the Northwestern Pacific.

	<i>D. laevigata</i> Syntype, non-types 198♂, 285♀	<i>D. akajei</i> Non-types 410♂, 466♀	<i>D. izuensis</i> Non-types 8♂, 6♀	<i>D. navarrae</i> * Holotype ♂	<i>D. sinensis</i> * Holotype ♂	<i>D. ushiei</i> * Holotype ♂	<i>D. sp. 2*</i> Non-type ♂
Disc width (mm)	95-389	114-877	211-726	316	380	367	437.2
Disc length/Disc width (%)	79.1-92.7	82.4-96.8	82.2-92.6	94.9	95.5	81.6	94.2
Total length/Disc width (%)	148.1-241.7	103.2-249.2	153.5-199.3	-	223.2	267.8	301.2
Intestinal valve turns	15-20	18-23	19-21	-	-	26	19
Prespine separate centra	87-98	104-112	103-108	-	-	124	113
Ventral tail fold color	blackish	blackish	white	dark	dark	dark	blackish
Dorsal texture of disc in adult	smooth	rough	smooth	rough	rough	smooth	rough
Tubercles before spine	absent	0-6	0-5	3 large	many small	absent	present
Posterior tail texture	smooth	rough	smooth	-	-	smooth	rough

* From Nishida and Nakaya (1988b, 1990).

Fig. 7. Relationship between disc width and clasper outer length in 198 males of *Dasyatis laevis*. White circles, immature individuals; gray circles, sub-adult individuals; black circles, mature individuals with calcified claspers.

Fig. 8. Relationship between disc width and uterus weight in 272 females of *Dasyatis laevis*. White circles, immature individuals; gray circles, sub-adult individuals; black circles, mature individuals.

in the uteri of specimens larger than 290 mm DW during the breeding season.

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