Zootaxa 3752 (1): 185–198
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.3752.1.11
http://zoobank.org/urn:lsid:zoobank.org:pub:F51BDBEB-E635-46A8-B103-ED785C986F0B

A new species of wedgefish, *Rhynchobatus immaculatus* (Chondrichthyes, Rhynchobatidae), from Taiwan

PETER R. LAST[1], HSUAN-CHING HO[2,3,*] & ROU-RONG CHEN[3]

[1]*CSIRO Marine & Atmospheric Research, Wealth from Oceans Flagship, GPO Box 1538, Hobart, TAS, 7001, Australia*
[2]*National Museum of Marine Biology & Aquarium, Checheng, Pingtung 944, Taiwan. E-mail: ogcoho@gmail.com*
[3]*Institute of Marine Biodiversity and Evolutionary Biology, National Dong Hwa University.*
**Corresponding author.*

Abstract

A new species of wedgefish, *Rhynchobatus immaculatus* sp. nov., is described from a small collection of specimens obtained from fish markets in northern Taiwan. It is probably a medium-sized species (probably attaining ca. 1.5 m TL) because the largest known specimen, an immature male (ca. 1 m TL), has prolongated dorsal and caudal fins typical of adult wedgefishes. *Rhynchobatus immaculatus* is unique within the family in having a very high vertebral count (within the range of 165–170 total free centra) and in lacking a dark pectoral marking. Other *Rhynchobatus* species occurring in Taiwanese seas appear to attain a larger adult size, possess a dark pectoral marking at least in young, and have lower vertebral counts (fewer than 161 total fee centra). *Rhynchobatus yentinesis*, which was described from a specimen taken nearby at Wenzhou, China, has not yet been attributed to a currently recognised species. However, based on the illustration of the holotype, which reveals a broad-snouted species with a dark pectoral spot, it is closest to either *R. palpebratus* or *R. springeri*.

Key words: Rhynchobatidae, *Rhynchobatus immaculatus*,Taiwanese Wedgefish, new species, western North Pacific

Introduction

The genus *Rhynchobatus* Müller & Henle comprises at least seven species of moderate-sized to very large (0.8–3 m total length as adults) shark-like batoids (Compagno & Last, 2010): *R. australiae* Whitley, 1939 from Australia, Thailand, Philippines, Singapore, Taiwan, and Indonesia; *R. djiddensis* (Forsskål, 1775) from the western Indian Ocean, including southern Africa, Mozambique and the Red Sea; *R. laevis* (Bloch & Schneider, 1801) from Zanzibar, the Arabian Sea, Oman, the Persian Gulf, India, Sri Lanka, and Bangladesh; *R. luebberti* Ehrenbaum, 1914 from tropical West Africa, including Mauritania to Congo and Angola; *R. palpebratus* Compagno & Last, 2008 from the Indo–Malay Archipelago; *R. springeri* Compagno & Last, 2010 from the Indo–Malay Archipelago and possibly further west; and *R.* sp. 1 (Compagno & Last, 1999) only known from Singapore and Java. The placement of the unique holotype of *Rhynchobatus yentinesis* Wang, 1933 from the East China Sea is uncertain.

In March 2012, during a workshop to investigate the shark and ray biodiversity of Taiwan, the authors discovered a small wedgefish in fish markets that was undescribed. This wedgefish is most likely a medium-sized *Rhynchobatus* and differs from its congeners in coloration and having a very high vertebral count.

Materials and Methods

Proportional dimensions, expressed as percentages of total length, are given in Table 1. External measurements of *Rhynchobatus* specimens are based on batoid measurements proposed by Bigelow & Schroeder (1953), Hubbs & Ishiyama (1968), Compagno & Roberts (1982), Compagno & Randall (1987) and Randall & Compagno (1995), and the shark measurements of Compagno (1984, 2001). Terminology for enlarged dermal denticles or spines is

Accepted by M.R. de Carvalho: 16 Dec. 2013; published: 24 Dec. 2013

based on Hubbs & Ishiyama (1968). Vertebral centra, pectoral-fin radials, and crania were examined and meristic details counted from radiographs (see also Compagno & Last, 2008). The vertebral column of *Rhynchobatus* is more differentiated than in sharks and is explained herein (see also Compagno & Last, 2010): a group of vertebrae behind the cranium are fused to form a large cervical synarcual element (Garman, 1913; Compagno, 1973, 1988, 1999, 2003) containing from 25–34 segments; the synarcual element has an anterior centrum-free region of 13–21 segments and a posterior region with 11–16 embedded centra. The number of synarcual segments is determined by counting the synarcual centra and the corresponding spinal nerve foramina and canals in the anterior centrum-free region on properly exposed, high-resolution radiographs; it is often not possible to count the centrum-free region in some specimens, particularly newborn and poorly calcified individuals, although synarcual centra are usually visible. Posterior to the synarcual, the vertebral column can be subdivided into monospondylous precaudal (MP) centra in the trunk, diplospondylous precaudal (DP) centra in the precaudal tail, and diplospondylous caudal (DC) centra in the caudal fin. The MP centra have very long ribs that are reduced posteriorly before the transition to DP centra, in which the centra suddenly become smaller and two per myomere. The DC centra have strongly expanded neural and haemal arches modified as pterygiophores for the caudal fin but, for purposes of consistency, counts are delimited anteriorly at the upper caudal-fin origin as in sharks (Springer & Garrick, 1964). Counts presented here include the numbers of centra in the synarcual element, and the MP centra, DP centra, DC centra, total free centra, and total centra; centrum-free segments and total segments were not included as some of these counts proved difficult to obtain.

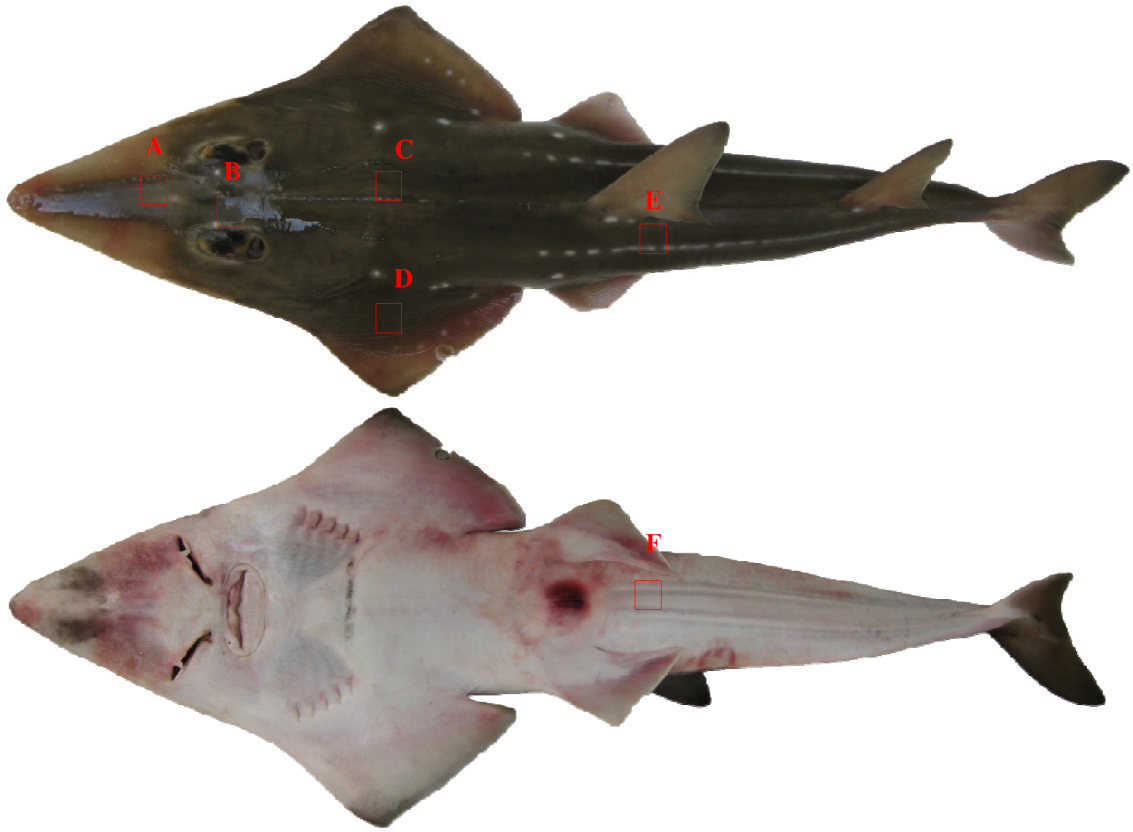

FIGURE 1. Sites for examining denticle morphology using SEM in *Rhynchobatus*. A. dorsal surface of snout; B. supraorbital; C. midscapular; D. pectoral fin; E. flank; and F. ventral anterior tail.

The pectoral fin skeleton was described in Compagno & Last (2010) but is repeated here to avoid ambiguity. In *Rhynchobatus*, as in most modern elasmobranchs or neoselachians (Compagno, 1973, 1977, 1988, 1999, 2003), there are three basal cartilages to the pectoral-fin skeleton: the anterior propterygium, intermediate mesopterygium, and posterior metapterygium, which bears most of the pectoral-fin radials. *Rhynchobatus* (and various other batoids) have a space between the mesopterygium and metapterygium where 'neopterygial' radials articulate directly with the synarcual. The propterygium of *Rhynchobatus* is a single, unsegmented cartilage with its front end terminating behind the nasal capsules; anterior to the propterygium are 1–8 free propterygial radials suggesting that

a segmented propterygial axis, such as that present in other batoids, may have been lost in *Rhynchobatus*. The propterygium itself has 16–26 radials, the mesopterygium about 5–7 radials, the neopterygial space on the scapulocoracoid about 4–6 radials, and the metapterygium 21–29 radials. Counts presented include free, propterygial, mesopterygial, neopterygial, metapterygial, total basal radials (excluding free radials), and total radials. Cranial morphology of the new *Rhynchobatus* species is not considered in detail here but we note that *Rhynchobatus* species differ in the shape of their rostral appendices, and by the position of the anterior ends of the anterior orbital cartilages relative to the anterior ends of the nasal capsules.

The denticle morphology was examined using scanning electron microscopy (SEM). The shapes and sizes of denticles vary at different positions on the body. For the purposes of this study, the regions examined included the snout, supraorbit, beside the midscapular ridge, on the pectoral fin, the flank beneath the first dorsal fin, and on the ventral surface at the anterior tail (Figure 1).

Morphometric and meristic data given in the description includes information on the holotype and three paratypes. Data taken for other material contains some methodological inconsistencies and was excluded. Material discussed in this manuscript is deposited in the ichthyological collections of the Australian National Fish Collection, Hobart (CSIRO) and the National Museum of Marine Biology & Aquarium, Pingtung (NMM-B).

Species Treatment

***Rhynchobatus immaculatus* sp. nov.**
(Figures 2–8, Table 1)

Holotype. NMMB–P16274, immature male 730 mm TL, Keelung fish market, Taiwan, 16 Mar. 2012, purchased from market by P. Last, field no. HO–179.

Paratypes. 3 specimens: CSIRO H 7418–01, immature male 890 mm TL, Wu-chi fish market, Taichung County, Taiwan Strait, western Taiwan, ca. 24°18'N, 120°29'E, 21 May 2010, purchased from market by H. Ho; NMMB–P16135, female 780 mm TL, Keelung fish market, Taiwan, 9 Mar 2012, purchased from market by H. Ho; NMMB–P16275 [HO–180], female 740 mm TL, collected together with holotype.

Non-types. 6 specimens: ASIZP 63513, immature male 408 mm TL, Ao-di, Taipei county, northeastern Taiwan, ca. 25°03'N, 121°56'E,17 Jul. 2001, coll. Z.-H. Wu; ASIZP 66972, female 835 mm TL, Da-xi, northeastern Taiwan, 5 Feb 2007; NMMB–P16225, immature male 744 mm TL, Da-xi, Yilan County, northeastern Taiwan, ca. 24°56'N, 121°54'E,13 Mar 2012, purchased from market by P. Last; NMMB–P16224, immature female 915 mm TL, Wu-chi fish market, Taichung, Taiwan Strait, western Taiwan, ca. 24°18'N, 120°29'E, 10 Apr 2012, purchased from the market by H. Ho; NMMB–P15684, immature male 992 mm TL, collected together with CSIRO H 7418–01; NMMB–P15661, immature male 591 mm TL, Wu-chi fish market, Taichung, Taiwan Strait, western Taiwan, ca. 24°18'N, 120°29'E, 11 Sep 2011, purchased from the market by H. Ho.

Diagnosis. A medium-sized species of the genus *Rhynchobatus* with the following combination of characters: a broad, wedge-shaped snout; preoral snout 19–21% TL; eye small, length 4.1–4.5 in preorbital snout; interorbital space 2.6–2.9 in preorbital snout; tooth rows about 48; spines absent from snout; supraorbital spines small, well differentiated, extending from preorbit to beyond end of spiracle; predorsal spines relatively well developed; two disjunct rows of 6–9 small scapular spines on each side of disc; predorsal space 48–49% of total length; origin of first dorsal fin well behind origin of pelvic-fin bases; dark greenish brown dorsally with a few white spots scattered on pectoral disc; black pectoral marking absent; prominent row of white spots commencing just forward of a single white spot (above pelvic-fin origin) and coalescing posteriorly to form a white mid-lateral line on tail; orbital membrane white with dark bar over eye; no alternating light and dark markings on interorbital space; total pectoral-fin radials 65–68; vertebrae with 28–30 monospondylous precaudal centra, 124–131 precaudal free centra, 38–42 diplospondylous caudal (free) centra, 165–170 total free centra, 179–184 total centra (including synarcual centra).

Description. Body relatively robust; snout in front of eyes bluntly angular to obtusely wedge-shaped, angle about 50° in holotype (52–53° in paratypes). Lateral margin of snout slightly convex beside orbit, otherwise almost straight. Preorbital length 3.3 in holotype (3.3–3.4 in paratypes) times interorbital width. Preoral length 3.4 (3.0–3.3) times mouth width. Disc width across pectoral-fin apices 75% (75–77%) of disc length from snout tip to pectoral-fin free rear tips. Head strongly depressed, trowel-shaped, disc thickness 1.5 (1.6–1.7) times in interorbital

space; ventral head length 3.2 (3.2–3.4) times in total length; surface between eyes and spiracles almost flat. Precloacal length 85% (86–88%) of length of tail from anterior vent to caudal-fin tip. Tail moderately depressed; in cross section, arched dorsally, almost flat ventrally, angular ventrolaterally at lateral keels, tapering evenly from pelvic-fin insertions. Width of tail at first dorsal-fin insertions of holotype 1.8 (1.6–1.9) times interspiracular distance. Lateral keels extended forward as a thickened angular edge along precaudal tail, reaching forward to below posterior half of first-dorsal fin; strongly differentiated on anterior part of caudal fin.

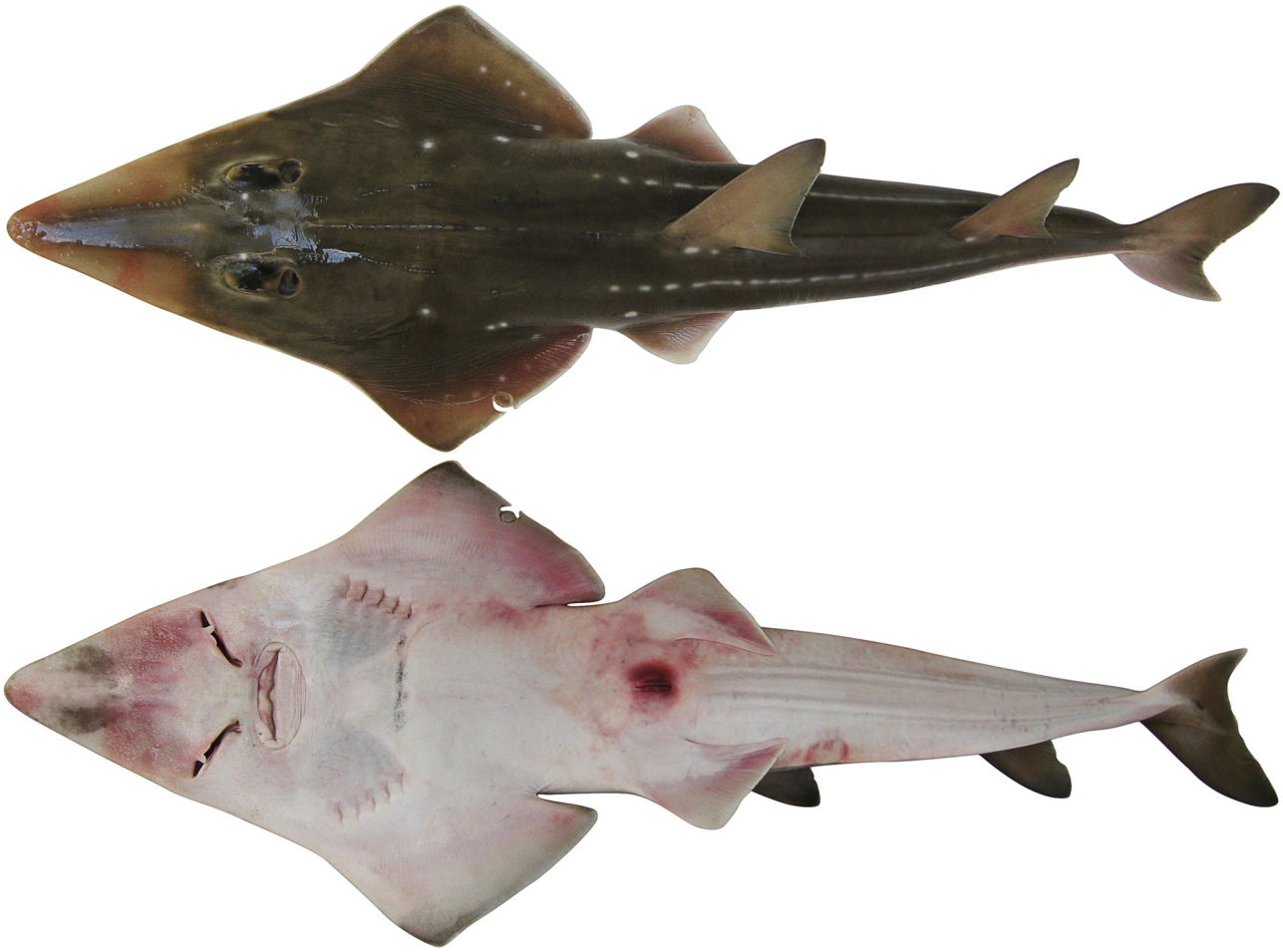

FIGURE 2. *Rhynchobatus immaculatus* sp. nov. immature male holotype (NMMB–P16274, 730 mm TL, recently preserved). A. dorsal view; B. ventral view.

Horizontal eye (eyeball) diameter about 63% (64–67%) of interspiracular width, distance from anterior margin of orbit to posterior margin of spiracle slightly smaller than interspiracular width; greatest dimension of spiracles 58% (47–50%) of horizontal eye diameter; distance between spiracle and eye less than a fifth horizontal eye diameter, membrane of orbit almost continuous with spiracular opening. Spiracle dorsolateral, anterior margin with a partly concealed thickened valve, posterior margin with two short anteriorly directed spiracular folds; outer fold slightly taller and larger than inner fold.

Nostrils diagonal, forming about a 45° angle with body axis, incurrent aperture directed more laterally. Nasal cavity fully exposed, without dividing flaps; aperture straight anterolaterally, recurved posteromedially. Anterior nasal flap narrow, low, anteromedial on nasal aperture, inserted near midlength of nasal aperture; anterior process short, bilobed, its base length about twice as long as its width. Posterolateral nasal flap low, narrow and elongated, weakly lobate; originating just behind anterior lateral edge of incurrent aperture, extending posteriorly to about midlength of nasal aperture. Posterior nasal flap low, short based; joined to undersurface of posterolateral flap near anterior third of its length, junction concealed beneath posterolateral nasal flap; inserted near posterior quarter of nostril. Nostril width 1.3 (1.2) times in internarial width.

Mouth opening somewhat arcuate, weakly undulating to nearly straight laterally; strong medial depression on upper jaw corresponding to a very prominent anterior protrusion at symphysis of lower jaw; much weaker

corresponding depressions and convexities laterally. Labial folds and furrows short, but well developed at corners of mouth; shallow pockets, circumoral grooves, and low folds and depressions, surround jaws laterally to labial folds; grooves most prominent on lower jaw. Teeth in quincunx, about 48 rows in both upper and lower jaws of paratype CSIRO H 7418–01. First four gill openings subequal in length, the fifth slightly shorter. Third gill opening 2.6 (2.3–2.6) in internarial width, 3.3 (2.8–3.1) times in nostril length, 1.2 (1.2–1.7) times length of fifth gill opening.

FIGURE 3. *Rhynchobatus immaculatus* sp. nov. View of central dorsal disc of immature male holotype (NMMB–P16274, 730 mm TL, preserved) showing markings and the spine rows.

Dermal denticles minute, covering all of body surface, varying in shape and size over body (Figure 7). Denticles with slender pedicels and elevated crowns; crowns rhomboidal, subcircular to broadly ovoid, margins irregularly rounded to crenulate anteriorly; crowns weakly unicuspidate, rounded or tricuspidate posteriorly, usually with prominent medial and lateral ridges. On snout, broadly ovoid, textured with 3–5 pronounced longitudinal ridges; median ridge best developed; posterior margin weakly tricuspidate; scales in two main sizes, weakly imbricated with some gaps (Figure 7a). On interorbit, somewhat similar to snout (Figure 7b); those on orbital membrane slightly smaller than those on interorbit; an indistinct patch of slightly enlarged (often more elongate) denticles present in front of eyes. On mid-dorsal surface, more regular in size, dense, often weakly imbricate; narrow patches of skin exposed where scales are missing; posterior margins irregular to rounded (Figure 7c). On outer pectoral fin, much smaller, similar to those of snout (Figure 7d). On flank below first dorsal fin, similar to outer pectoral fin but relatively much broader (Figure 7e). On ventral surface, subrhomboidal, usually acuspid, strongly imbricate; slightly larger than on dorsal flank but mostly smaller than on disc (Figure 7f).

Small, variable-sized spines present on dorsal surface of body and tail; present in series on orbital margin, along dorsal midline of disc and tail, and in scapular region; those of nuchal and mid-scapular regions largest; rostral spines absent. Spines along midline of disc and tail narrow and long based or globular and weakly oblique; distal surfaces of globular spines smooth, with corrugated bases; keel-like spines with corrugated bases and sometimes lateral edges. Orbit of paratype CSIRO H 7418–01 with a single, continuous series of ca. 20, small, variable-sized spines; series extending along inner margin of orbit from anterior mid-eye to beyond posterior margin of spiracle; similar in form to those along midline; row partly interrupted above mid spiracle in some types

(partially subdivided into orbital and spiracular groups of spines). Predorsal series with ca. 27 spines of varying size in CSIRO H 7418–01, well developed, spines partly embedded in a low, cutaneous ridge; extending from anterior nuchal region to over pelvic-fin origin; spine bases often within a shallow groove; closely and more or less evenly spaced anteriorly, more widely spaced posteriorly. Interdorsal series barely emergent; absent and not forming a ridge behind second dorsal fin. Scapular spines of CSIRO H 7418–01in two short, disjunct, linear series of on each side of disc; commencing just behind origin of predorsal series, terminating at level of pectoral-fin apex; anterior series with ca 8–9 spines, its length subequal to eye diameter; posterior series with 6–9 spines, short, slightly longer than anterior series; no obvious lateral patches present.

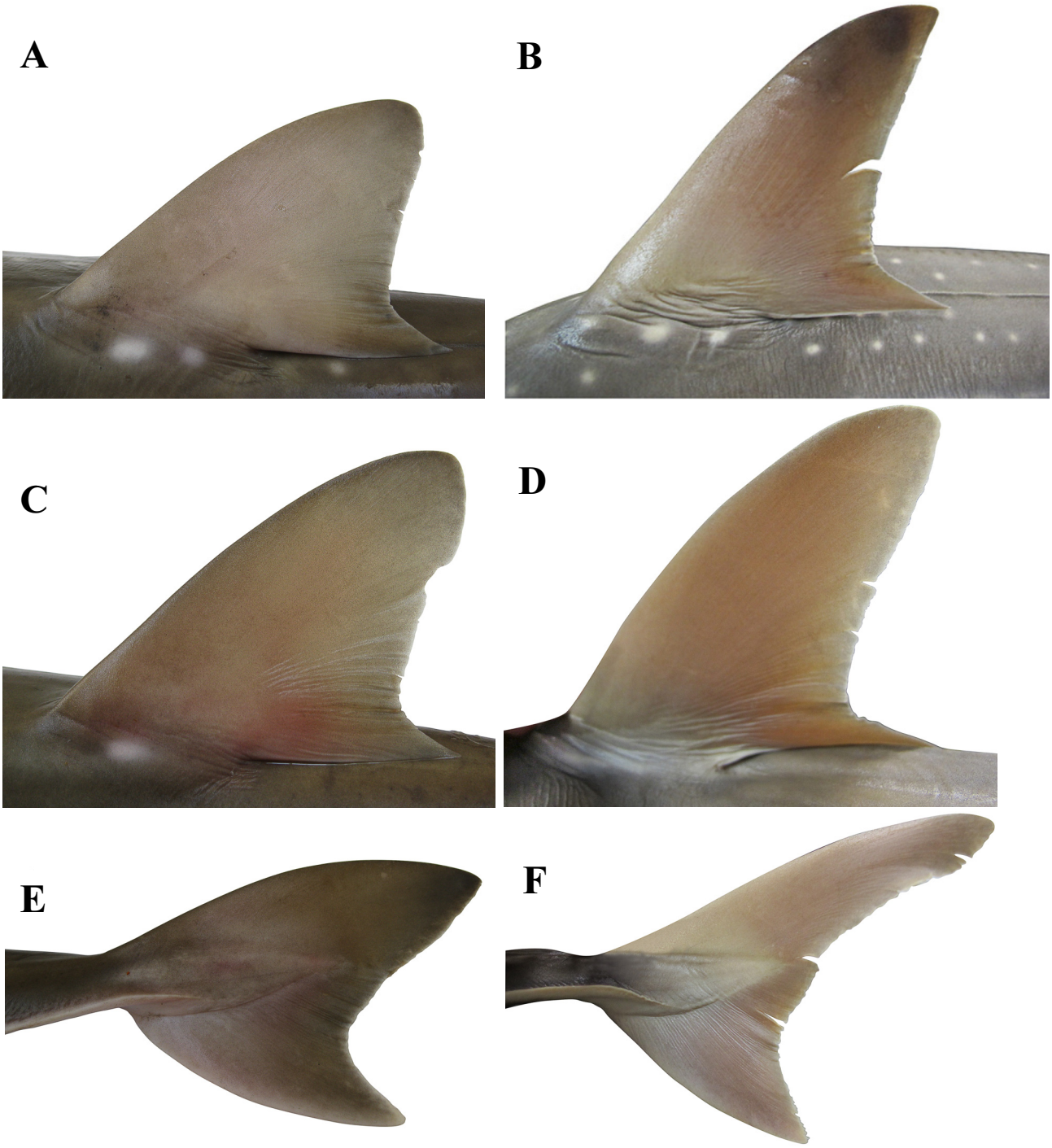

FIGURE 4. *Rhynchobatus immaculatus* sp. nov. fin shape and development. Immature male holotype (NMMB–P16274, 730 mm TL, recently preserved): A. Lateral view of first dorsal fin, C. Lateral view of second dorsal fin, E. Lateral view of caudal fin. Immature male non-type (NMMB–P15684, 992 mm TL, preserved): B. Lateral view of first dorsal fin, D. Lateral view of second dorsal fin, F. Lateral view of caudal fin.

FIGURE 5. *Rhynchobatus immaculatus* sp. nov. Snout and orbito-spiracular region of immature male non-type (NMMB–P15684, 992 mm TL, preserved).

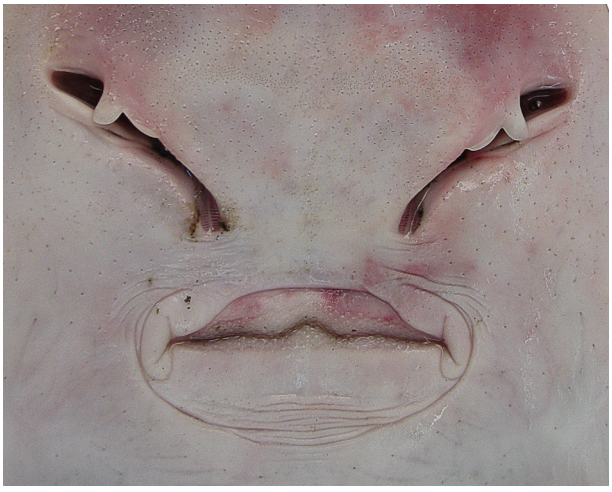

FIGURE 6. *Rhynchobatus immaculatus* sp. nov. View of oronasal region and snout immature male holotype (NMMB–P16274, 730 mm TL, recently preserved).

Dorsal fins similar in shape in young, raked, shark-like, with convex anterior margins (shallowly concave at base), bluntly pointed apices, deeply concave posterior margins, sharply acute free rear tips, and straight inner margins. Inner margin of first dorsal fin about twice (1.9–2.0 times) in its base length. First dorsal fin larger than second; origin just forward of mid-base of pelvic fins; free rear tip slightly behind free rear tips of pelvic fin.

Interdorsal space 2.8 (2.3–2.7) times length of first dorsal base, 3.5 (2.9–3.3) of length of second dorsal-fin base. Caudal fin rather short, strongly forked; dorsal caudal margin 6.5 (5.9–6.5) in total length, subequal to interdorsal space. Dorsal caudal margin strongly convex, weakly concave near its origin; tip bluntly pointed. Preventral caudal margin strongly convex; ventral lobe well developed, tip strongly angular. Lower postventral caudal margin short, weakly concave, 2.9 (2.2–3.2) in length of upper margin. Upper postventral margin weakly concave. Caudal axis elevated slightly, forming a narrow angle to main body axis. Pectoral fin originating at about level of spiracle, with initially concave then convex anterior margins; apices broadly pointed, posterior margins moderately convex; free rear tips narrowly rounded, extending 101% (85–89%) of distance between pectoral and pelvic-fin bases (pectoral–pelvic space); inner margins straight to weakly concave. Pelvic fins small, with weakly convex to straight anterior margins, broadly rounded apices, weakly concave posterior margins, elongate and very narrowly rounded free rear tips, and concave inner margins; inner margin very long, 1.5 (1.3–1.5) times length of pelvic base; fin base 1.0 (0.9) in pectoral–pelvic space; height of pelvic fin about 2.1 (2.0–2.3) in their length. Distance between pelvic-fin insertions much longer than pelvic-fin base length. Vent with well-developed folds laterally; well separated from pelvic-fin inner margins. No data on adult clasper.

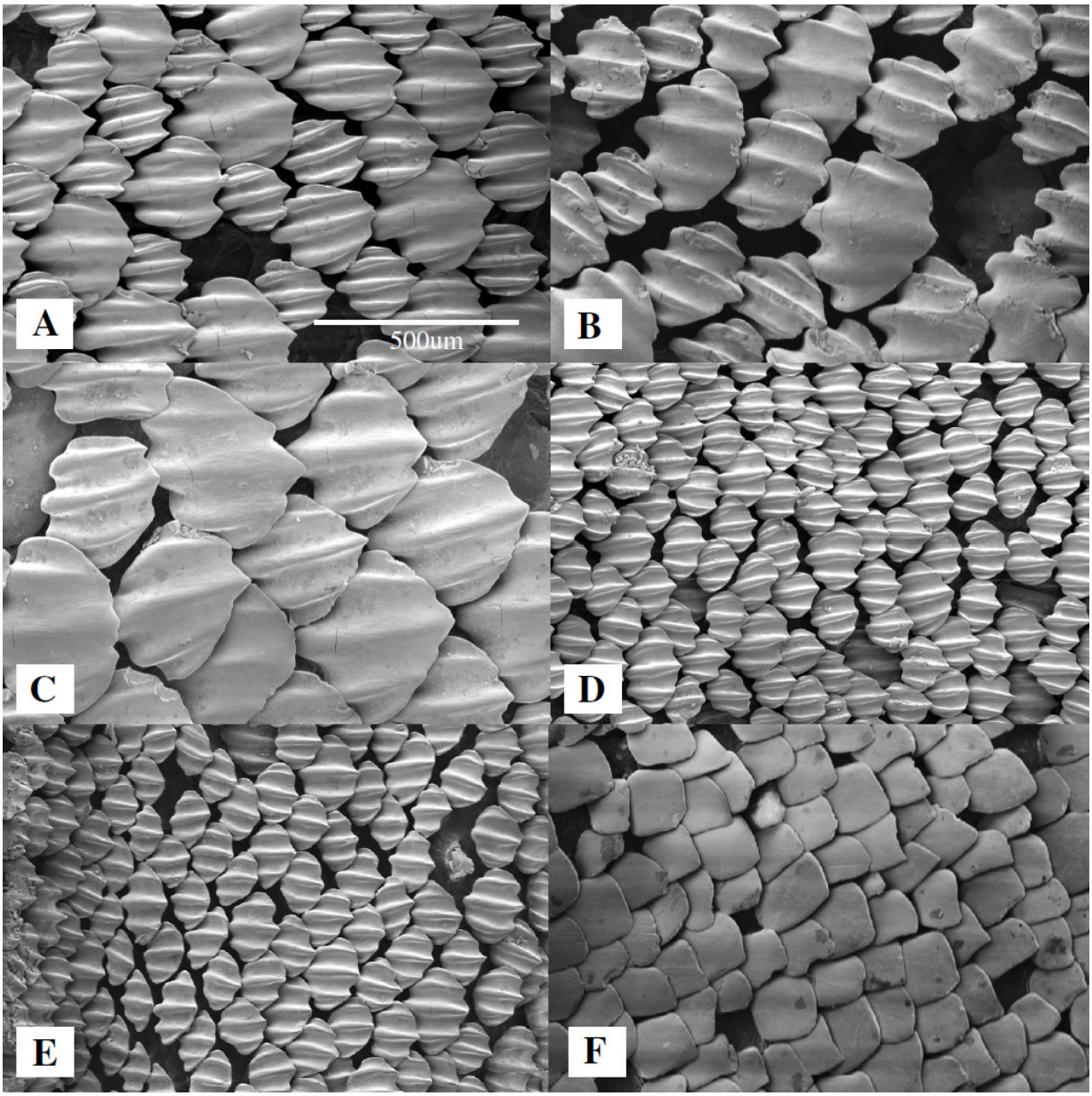

FIGURE 7. *Rhynchobatus immaculatus* sp. nov. SEM images (x100) showing squamation on the left side of a immature male non-type (NMMB–P15684, 992 mm TL, preserved). A. Snout; B. Supraorbit; C. Mid-disc; D. Pectoral fin; E. Flank beneath first dorsal fin; F. Ventral anterior tail. Letters correspond to those in the Figure 1.

TABLE 1. Morphometric data for the immature male holotype (NMMB–P16274) and paratypes (CSIRO H 7418–01, NMMB-P16275 & P16135) of *Rhynchobatus immaculatus* **sp. nov.** Measurements are expressed as percentages of total length. Data for paratypes are expressed as minima, maxima and means.

	Holotype	Paratypes (n=3)		
		Min	Max	Mean
TOT—Total length	730	740	889	
FOR—Fork length	92.7	91.5	92.8	92.2
PCL—Precaudal length	83.7	83.2	84.6	84.0
PD2—Pre-second dorsal length	70.7	69.2	70.4	69.8
PD1—Pre-first dorsal length	48.8	47.8	48.4	48.2
PP2—Prepelvic length	45.8	44.1	45.6	44.7
SVL—Snout–vent length	46.0	44.5	46.8	45.8
PSP—Prespiracular length	21.7	21.1	21.4	21.2
PG1—Prebranchial length	27.5	25.5	27.3	26.5
HDL—Head length	31.4	29.6	31.0	30.5
POB—Preorbital length (direct)	17.7	16.0	17.0	16.7
POR—Preoral length	21.1	19.3	20.5	20.0
PRN—Prenarial length	16.7	15.2	16.3	15.9
IDS—Interdorsal space	16.2	15.5	16.2	15.9
DCS—Dorsal–caudal space	9.2	8.8	9.6	9.2
PPS—Pectoral–pelvic space	4.8	5.2	5.3	5.2
PCS—Pelvic–caudal space	34.7	33.8	34.4	34.1
PDS—Pelvic–dorsal space	2.9	2.4	3.0	2.7
DW—Disc width	33.8	33.1	34.2	33.6
DL—Disc length	45.1	43.4	44.9	44.1
DT—Disc thickness	8.3	8.1	8.3	8.2
Snout—Greatest width	34.7	32.8	33.1	33.0
SWB—Snout width at base	16.3	15.3	16.6	16.0
COL—Corneal/eye length	2.4	1.7	2.5	2.2
COH—Corneal/eye height	1.2	0.9	1.4	1.2
EYL—Eye [eyeball] length	3.9	3.9	4.1	4.0
EYH—Eye (eyeball) height	2.6	2.4	2.6	2.5
INO—Interorbital space	5.4	4.9	5.1	5.0
SPL—Spiracle length	1.5	1.3	2.2	1.6
SPH—Spiracle height	2.2	1.9	2.0	2.0
ESL—Eye–spiracle space	5.6	5.3	5.6	5.4
INS—Interspiracular space	6.1	5.9	6.4	6.1
NOW—Nostril width	5.1	4.8	4.9	4.8
INW—Internarial space	4.0	3.9	4.2	4.0
ANF—Anterior nasal flap length	2.0	1.7	1.8	1.8
NSE—Nostril to snout edge	1.7	1.5	1.6	1.5
MOL—Mouth length	0.5	0.4	0.5	0.4
MOW—Mouth width	6.1	6.2	6.5	6.3
GS1—First gill slit height	1.7	1.4	1.8	1.6
GS2—Second gill slit height	1.7	1.6	1.8	1.7
GS3—Third gill slit height	1.5	1.5	1.7	1.6
GS4—Fourth gill slit height	1.5	1.4	1.7	1.5
GS5—Fifth gill slit height	1.2	1.0	1.3	1.2

..... continued on the next page

TABLE 1. (continued)

	Holotype	Paratypes (n=3)		
		Min	Max	Mean
ING1—Inter 1st gill	14.4	13.7	14.1	13.9
ING5—Inter 5th gill	10.8	10.6	10.7	10.6
HDH—Head height	6.7	6.9	7.5	7.1
TRH—Trunk height	7.7	7.9	8.3	8.1
TRW—Trunk width	13.2	13.3	13.9	13.6
ABH—Abdomen height	5.9	6.2	6.4	6.3
ABW—Abdomen width	11.1	0.0	11.6	7.5
CPH—Caudal peduncle height	1.7	1.6	1.7	1.7
CPW—Caudal peduncle width	3.4	2.9	3.7	3.3
VNL—Vent length	2.7	2.3	2.8	2.6
TFL—Tail fold length	34.0	32.7	35.5	33.9
P1L—Pectoral-fin length	21.2	19.8	21.4	20.8
P1A—Pectoral-fin anterior margin	11.0	10.9	11.9	11.4
P1B—Pectoral-fin base	15.2	15.8	16.4	16.0
P1H—Pectoral-fin height	8.6	8.3	8.8	8.6
P1P—Pectoral-fin posterior margin	14.8	14.0	15.5	14.9
P1I—Pectoral-fin inner margin	4.8	4.4	4.6	4.5
P2L—Pelvic-fin length	12.4	13.3	13.5	13.4
P2A—Pelvic-fin anterior margin	8.0	7.2	7.5	7.4
P2B—Pelvic-fin base	4.9	5.8	5.9	5.9
P2H—Pelvic-fin height	5.9	5.8	6.5	6.1
P2P—Pelvic-fin posterior margin length	8.3	8.8	9.9	9.2
P2I—Pelvic-fin inner margin length	7.4	7.6	8.9	8.2
P2S—Pelvic-fin span	19.4	18.9	20.0	19.4
CLO—Clasper outer length	3.2	0.0	4.0	2.0
CLI—Clasper inner length	7.3	0.0	9.2	4.6
CLB—Clasper base width	0.6	0.0	0.6	0.3
D1L—First dorsal-fin length	11.7	11.3	12.9	12.0
D1A—First dorsal-fin anterior margin	13.6	13.6	15.4	14.3
D1B—First dorsal-fin base	5.9	6.0	6.7	6.3
D1H—First dorsal-fin height	9.5	8.9	9.5	9.2
D1P—First dorsal-fin posterior margin	9.3	9.1	9.7	9.4
D1I—First dorsal-fin inner margin	5.8	5.6	6.4	5.9
D2L—Second dorsal-fin length	9.5	9.3	10.6	9.9
D2A—Second dorsal-fin anterior margin	11.4	11.4	12.4	11.8
D2B—Second dorsal-fin base	4.7	4.9	5.3	5.1
D2H—Second dorsal-fin height	7.8	6.9	7.9	7.3
D2P—Second dorsal-fin posterior margin	7.5	7.0	7.4	7.2
D2I—Second dorsal-fin inner margin	4.9	4.6	5.4	5.0
CDM—Dorsal caudal margin	15.4	15.4	16.9	16.1
CPV—Preventral caudal margin	10.8	9.6	11.1	10.5
CPL—Lower postventral caudal margin	3.3	3.3	4.3	3.7
CPU—Upper postventral caudal margin	9.5	9.4	10.3	9.8

Vertebral column with 184 (179–181) total centra (excluding segments); 14 (14–15) synarcual centra, 28 (29–30) monospondylous centra, 131 (124–127) precaudal free centra, 39 (38–42) diplospondylous caudal (free) centra, 170 (165–166) total free centra. Total synarcual segments 7.6% (7.8–8.3)%, monospondylous 15.2% (16.1–16.8)%, diplospondylous precaudal centra 56.0% (51.9–54.2)%, and precaudal free centra 71.2% (68.5–70.9)% of total centra count. Total pectoral radials 65 (66–68): 4 (5–7) free radials before propterygium, 22 (22) propterygials, 5 (5) mesopterygials, 5 (6) neopterygials, 29 (28) metapterygials, 61 (59–61) total basal radials (excluding free radials).

Colour (when fresh). Based on holotype NMMB–P16274 unless stated otherwise: Dorsal surface of body mostly medium to dark greenish brown (becoming greyish on preservation); paler, yellowish brown laterally beside rostral cartilage on snout and along hind margins of pectoral and pelvic fins; black pectoral marking absent, instead region plain or with 1 (1–3 in paratypes) small, diffuse-edged white spots; a few similar, isolated white spots near insertion of pectoral fins; single white spot above origin of pelvic fin; a few white spots at bases of dorsal fins (sometimes also beneath their inner margins); a well-developed, single row of small white spots on flank originating over origin of pelvic fin, then coalescing beneath first dorsal fin to form a narrow white stripe; stripe extending along dorsolateral surface of each side of tail to anterior part of caudal peduncle; dorsal and caudal fins yellowish brown, paler than body, tips dusky; orbit white with a broad black bar on its upper surface; suborbit pale; interorbit with a white spots on each side near obit and with or without a dark medium blotch. Ventral surface almost uniformly white, strongly contrasted with dorsal surface; anterior half of snout either side of rostral shaft with broad, irregular, semicircular, blackish patch (faint is some preserved material); dark patch also between nostrils in NMMB–P16275; pectoral-fin with narrow dusky tips. In preservative, pale areas on dorsal surface becoming more strongly demarcated from darker areas adjacent.

FIGURE 8. Distribution of *Rhynchobatus immaculatus* sp. nov. Yellow star—holotype; yellow dots—market sites for other material. Map extracted from Google Earth.

Size. Reaches at least 99 cm TL (non-type NMMB–P15684), but this specimen and all five other males examined (41–89 cm TL) were immature. The dorsal and caudal fins were well developed in NMMB–P15684 (see Figure 4), so it is likely to be a medium-size wedgefish with a maximum length less than 150 cm. An investigation of size structure in the Taiwanese population is needed.

Distribution. Known from seas adjacent Taiwan. Possibly more widespread locally in the western North Pacific, but positive confirmation is needed as these fishes are frequently mis-identified.

Etymology. The epithet, immaculate, is a combination of the Latin *im* (not) and *macula* (spot, mark), and is based on the lack of a dark pectoral marking (rather than any white spots) which is otherwise present in small individuals of other nominal species of *Rhynchobatus*. Vernacular: Taiwanese Wedgefish.

Remarks. The Taiwanese Wedgefish, *Rhynchobatus immaculatus*, undergoes ontogenetic changes in fin shape that typify development in many other chondrichthyan fishes. The dorsal fins change shape to become taller and more erect as they develop (see Figure 4). The first dorsal fin becomes more pointed apically (Figures 4a, d), and the caudal-fin lobes become relatively longer and narrower (Figures 4c, f). These changes, which take place within a relatively narrow size range (immature males NMMB–P16274 and NMMB–P15684 are 730 mm and 992 mm TL respectively) in *R. immaculatus*, are likely to be associated with onset of maturity.

Rhynchobatus immaculatus differs from other wedgefishes occurring in the western North Pacific, primarily in vertebral count and coloration. It has a very high vertebral count matched only by *R. djiddensis* from the Indian Ocean; total free centra of *R. immaculatus* 165–170 vs. typically more than 174 in *R. djiddensis*. Another high count species *R. australiae*, has been confirmed from Taiwan (HUMZ–109480, female 790 mm TL; total free centra 161) but, like *R. djiddensis,* has a more complex colour pattern and a black pectoral marking in small individuals. *Rhynchobatus immaculatus* also appears to be a smaller wedgefish than either *R. australiae* or *R. djiddensis*, which both attain about 300 mm TL (Compagno & Last, 1999) and 310 mm TL (Compagno *et al.*, 1989) respectively. An undescribed species from the Indo–Malay Archipelago, *Rhynchobatus* sp. 1 (sensu Compagno & Last, 1999), which also has a dark, white-spotted body and lacks a dark pectoral marking, has a longer snout and much lower vertebral count (113–116) than *R. immaculatus*. All other species occurring in the region have a dark pectoral marking and lower vertebral counts: *R. springeri* has 113–126 free vertebral centra and *R. palpebratus* has 135–139 free vertebral centra (Compagno & Last, 2008). Also, the first dorsal fin is more posteriorly positioned in *R. immaculatus* (predorsal length 48–49% TL vs. 42–45% (mean 43%) TL and 43–48% (mean 46%) TL in *R. springeri* and *R. palpebratus* respectively.

Compagno & Last (1999) considered *Rhynchobatus yentinensis* Wang, described from a specimen taken at nearby Wenzhou, China, to be a possible synonym of *R. springeri* (their former *R.* sp. 2), but later considered it more likely to be synonymous with *R. laevis* (Bloch & Schneider, 1801) (Compagno & Last 2008; Eschmeyer, 2013). Wang's (1933) account of the male holotype (1010 mm TL) gives an upper tooth row count of 27 (much lower the 52 rows in the smaller holotype of *R. springeri* and *R. palpebratus*, or the 48 rows in a smaller type of *R. immaculatus*). The holotype of *R. yentinensis* once existed as a mounted skin but is now missing. According to Prof. Han-Lin Wu (Shanghai Ocean University, pers comm. to Xiaoyu Kong), most type specimens in Chinese collections from the early 1900s were lost during the Second World War. However, based on Wang's description, *R. yentinensis* has a dark spot on the snout (vs. absent in *R. immaculatus*), first dorsal-fin origin above or slightly behind the pelvic-fin origin (vs. first dorsal-fin origin well behind pelvic-fin origin), 2 spines in inner scapular rows on disc (vs. 6–9 spines), 2 series of white spots (vs. none) along the tail of males about 100 cm TL, and possibly a relatively shorter snout (preorbital length 2.4 times space vs. 2.6–2.9 times width of interorbital space). From the illustration and description of the holotype, *R. yentinensis* appears to be a broad-snouted species with a dark pectoral marking and low scapular spine count, suggesting that it is closer to either *R. palpebratus* or *R. springeri*, than to *R. immaculatus*. Its placement will have to be decided using molecular analysis, if the holotype is ever rediscovered and DNA can be extracted from the skin.

Acknowledgements

This research has been supported by the CSIRO, most recently by the Wealth from Oceans Flagship and, in part, with funds from National Science Foundation grants DEB 1132229, DEB 1036500, and DEB 0415486; and by a grant from the National Museum of Marine Biology & Aquarium. We thank William White (CSIRO) preparing the

distribution map. Alastair Graham (CSIRO) assembled data on Australian materials, and also S.-I Wang (NMMB) for his curatorial assistance; John Pogonoski (CSIRO) obtained meristic data and provided editorial comments. Carlie Devine (CSIRO) photographed and etched some of the images.

References

Bigelow, H.B. & Schroeder, W.C. (1953) Fishes of the western North Atlantic. Part two. Sawfishes, guitarfishes, skates and rays. *Memoirs of the Sears Foundation of Marine Research*, 1, 1–514.
http://dx.doi.org/10.2307/1440496

Bloch, M.E. & Schneider, J.G. (1801) *M. E. Blochii, Systema Ichthyologiae iconibus cx illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum et Bibliopolio Sanderiano Commissum.* Systema Ichthyologie, 584 pp.

Compagno, L.J.V. (1973) Interrelationships of living elasmobranchs. *In*: Greenwood, P.H., Miles, R.S. & Patterson, C. (Eds.), Interrelationships of fishes. *Journal of the Linnean Society (Zoology)*, 53 (Suppl. 1), 1–37.

Compagno, L.J.V. (1977) Phyletic relationships of living sharks and rays. *American Zoologist*, 17, 302–322.
http://dx.doi.org/10.1093/icb/17.2.303

Compagno, L.J.V. (1984) FAO Species Catalogue. Sharks of the World. An annotated and illustrated catalogue of shark species known to date. *FAO Fisheries Synopsis No. 125*, 4, part 1 (Hexanchiformes to Lamniformes), 1–250; part 2 (Carcharhiniformes), 251–655.

Compagno, L.J.V. (1988) *Sharks of the order Carcharhiniformes*. Princeton University Press, Princeton, 486 pp.

Compagno, L.J.V. (1999) Chapter 3. Endoskeleton. *In*: Hamlett, W.C. (Ed.), *Sharks, skates and rays. The biology of elasmobranch fishes*. Johns Hopkins Press, Baltimore, pp. 69–92.

Compagno, L.J.V. (2001) *Sharks of the World: an annotated and illustrated catalogue of shark species known to date. Vol. 2. Bullhead, mackerel and carpet sharks (Heterdontiformes, Lamniformes and Orectolobiformes).* FAO, Rome, 269 pp.

Compagno, L.J.V. (2003) *Sharks of the order Carcharhiniformes*. Reprint of the 1988 Princeton edition, with new introduction. Blackburn Press, Massachusetts, 572 pp.

Compagno, L.J.V., Ebert, D.A. & Smale, M.J. (1989) *Guide to the sharks and rays of Southern Africa*. Struik Publishers, Cape Town, 160 pp.

Compagno, L.J.V. & Last, P.R. (1999) Rhinidae (=Rhynchobatidae), Wedgefishes. *In*: Carpenter, K.E. & Niem, V.H. (Eds.), *FAO species Identification Guide for Fishery Purposes. The living marine resources of the Western Central Pacific. Vol. 3. Batoid fishes, chimaeras and bony fishes part 1 (Elopidae to Linophrynidae).* FAO, Rome, pp. 1418–1422.

Compagno, L.J.V. & Last, P.R. (2008) A new species of wedgefish, *Rhynchobatus palpebratus* sp. nov. (Rhynchobatoidei: Rhynchobatidae), from the Indo–West Pacific. *In*: Last, P.R., White, W.T. & Pogonoski, J.J. (Eds.), *Descriptions of new Australian chondrichthyans*. CSIRO Marine and Atmospheric Research Paper 022, pp. 227–240.

Compagno, L.J.V. & Last, P.R. (2010) A new species of wedgefish, *Rhynchobatus springeri* (Rhynchobatoidei, Rhynchobatidae), from the western Pacific. *In*: Last, P.R., White, W.T. & Pogonoski J.J. (Eds.), *Descriptions of new sharks and rays from Borneo*. CSIRO Marine and Atmospheric Research Paper 32, pp. 77–88.

Compagno, L.J.V. & Randall, J.E. (1987) *Rhinobatos punctifer*, a new species of guitarfish (Rhinobatiformes: Rhinobatidae) from the Red Sea, with notes on the Red Sea batoid fauna. *Proceedings of the California Academy of Sciences (Series 4)*, 44, 335–342.

Compagno, L.J.V. & Roberts, T.R. (1982) Freshwater stingrays (Dasyatidae) of southeast Asia and New Guinea, with description of a new species of *Himantura* and reports of unidentified species. *Environmental Biology of Fishes*, 7, 321–339.
http://dx.doi.org/10.1007/bf00005567

Ehrenbaum, E. (1914) Ueber Fische von Westafrica, besonders von Kamerun. *Der Fischerbote*, 6 (11–12), 401–409.

Eschmeyer, W.N. (Ed.) (2013) *Catalog of Fishes electronic version.* Available from: http://research.calacademy.org/ichthyology/catalog/fishcatmain.asp (accessed 19 February 2010)

Forsskål, P. (1775) *Descriptiones animalium, avium, amphibiorum, piscium, insectorum, vermium / quae in itinere orientali observavit Petrus Forskål. Post mortem auctoris edidit Carsten Niebuhr. Adjuncta est material medica kahirina atque tabula maris Rubri geographica.* ex officina Mölleri, Hauniæ, 20 + xxxiv + 164 pp.

Garman, S. (1913) The Plagiostomia (sharks, skates, and rays). *Memoirs of the Museum of Comparative Zoology*, 36, i–xii + 1–515.

Hubbs, C.L. & Ishiyama, R. (1968) Methods for the taxonomic studies and description of skates (Rajidae). *Copeia*, 1968 (3), 483–491.
http://dx.doi.org/10.2307/1442016

Müller, J. & Henle, F.G.J. (1837) *Gattungen der Haifische und Rochen nach einer von ihm mit Hrn. Henle unternommenen gemeinschaftlichen Arbeit über die Naturgeschichte der Knorpelfische*. Bericht Akademie der Wissenschaften zu Berlin 1837, 111–118.

Randall, J.E. & Compagno, L.J.V. (1995) A review of the guitarfishes of the genus *Rhinobatos* (Rajiformes: Rhinobatidae)

from Oman, with description of a new species. *The Raffles Bulletin of Zoology*, 43, 289–298.
Springer, V.G. & Garrick, J.A.F. (1964) A survey of vertebral numbers in sharks. *Proceedings of the United States National Museum*, 116, 73–96.
http://dx.doi.org/10.5479/si.00963801.116-3496.73
Wang, K.F. (1933) Preliminary notes on the fishes of Chekiang (Elasmobranches). *Contributions from the Biological Laboratory of the Science Society of China. (Zoological Series)*, 9, 87–117.
Whitley, G.P. (1939) Taxonomic notes on sharks and rays. *Australian Zoologist*, 9, 227–262.