

DESCRIPTIONS *of* NEW
AUSTRALIAN SKATES
(Batoidea: Rajoidei)

EDITORS:

P. R. LAST › W. T. WHITE › J. J. POGONOSKI › D. C. GLEDHILL



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New Australian skates (Batoidea: Rajoidei) – background and methodology

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ABSTRACT.— A rapid taxonomic approach is used in the following series of papers to formally describe 22 new species of rajoid skates from the Australian region. Most of these species were identified more than a decade ago in a guide to the Australian chondrichthyan fauna, *Sharks and Rays of Australia* (Last & Stevens, 1994). Formal names for these species were needed quickly for a variety of fishery and conservation purposes, and for a revision of the guide. Good descriptive treatments of species were obtained but more rapidly than the timeframes required for group revisions, which usually include full skeletal treatments and descriptions of intraspecific variability across the entire type series. Most skates exhibit sexual and ontogenetic variability, particularly in disc shape and squamation, and this must be captured in some way. Hence, this approach focused on providing detailed descriptions of the holotype (an adult male when available), as well as a representative female (adult size when available) and a representative juvenile (a neonate or small juvenile if available) of each new species. The female and juvenile individuals selected are referred to in the following papers as ‘primary paratypes’. Strong diagnoses are complemented by a thorough use of digital images to demonstrate key morphological features of each species. However, this approach does not remove the need for detailed regional revisions of each skate genus. Morphometric and meristic methodologies are often poorly defined in the literature so all of the measurements taken and meristic techniques used in this study are clearly explained and illustrated.

Key words. Rajoidei – background – methodology – new species – Australia

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THE AUSTRALIAN FAUNA

The first Australian skate discovered, the Thornback Skate (as *Raia lemprieri*) was described from Port Arthur, Tasmania, by Richardson in 1845, based on material taken during the famous voyage of the HMS *Erebus* and *Terror*. While Australian skates have been treated in various guides and lists, a full taxonomic review of the fauna has never been attempted. In his checklist of Australian fishes, McCulloch (1929–30) listed 9 nominal species (of which 5 are now recognised as valid Australian species). Whitley (1940) treated 12 species in a regional handbook, of which only 8 species are now recognised as valid Australian species. Last & Stevens (1994) treated 38 species in their guide to the Australian chondrichthyan fauna, of which 28 could not be identified to species. Since then, there have been biogeographic treatments of the group (Last & Séret, 1999; Last & Yearsley, 2002), and some of the un-named species have been described in published taxonomic papers (Yearsley & Last, 1992; McEachran & Last, 1994; Stehmann, 2005; Last & McEachran, 2006; Last & Gledhill, 2007) or in press (Last *et al.*, 2008).

At least two additional species are now known to occur in Australian seas. Valid nominal species based on currently

accepted generic placements include: *Amblyraja hyperborea* (Collett, 1879); *Bathyraja ishiharai* Stehmann, 2005; *Bathyraja richardsoni* (Garrick, 1961); *Dentiraja lemprieri* (Richardson, 1845); *Dipturus australis* (Macleay, 1884); *Dipturus cerva* (Whitley, 1939); *Dipturus gudgeri* (Whitley, 1940); *Dipturus polyommata* (Ogilby, 1910); *Insentiraja laxipella* (Yearsley & Last, 1992); *Insentiraja subtilispinosa* (Stehmann, 1989), *Irolita waitii* (McCulloch, 1911); *Notoraja hirticauda* Last & McEachran, 2006; *Notoraja ochroderma* McEachran & Last, 1994; *Pavoraja alleni* McEachran & Fechhelm, 1982; *Pavoraja nitida* (Günther, 1880); *Spiniraja whitleyi* (Iredale, 1938); and *Zearaja maugeana* Last & Gledhill, 2007. The Australian shark and ray guide (Last & Stevens, 1994) is being fully revised, so scientific names were needed for the 24 remaining undescribed taxa. These taxa are comprised of: 12 species of *Dipturus*, 4 species of *Pavoraja* (treated in a separate publication in press), 2 species of both *Okamejei* and *Notoraja*, and one species each of *Dentiraja*, *Irolita*, *Leucoraja* and *Rajella*.

The main objectives of this special publication on new Australian skates are to describe the remaining un-named species using a rapid but rigorous taxonomic approach and to complete the task within a relatively brief

timeframe. The 9 included papers are not intended to be revisionary in their approach and important characters, such as the morphology of the claspers, scapulocoracoid and chondrocranium, are not presented. These features are the subject of more detailed investigations that will be presented later in other more comprehensive revisions of the Australasian fauna.

THE APPROACH

A similar rapid approach was adopted to describe new Australian dogfishes, genus *Squalus* (Last *et al.* 2007). This approach involved producing good descriptive treatments of each new species and minimising the number of specimens measured and radiographed from the type series. The main aim was to provide names and strong diagnoses for species rather than to publish full revisionary details of taxa. We attempted to provide a solid description of each species to enable it to be distinguished from related taxa without examining every specimen available in Australian collections. For morphometrics, we provided full measurements of the holotype and at least 5 paratypes, and for meristics, the holotype and at least 9 paratypes (where possible). In species descriptions, morphometric and meristic values for the holotype are given first, followed in parentheses by the ranges of the paratypes (unless stated otherwise). We did not attempt to investigate ontogenetic variability and sexual dimorphism. There are some limitations with this approach, but most of the new skate species treated here are unlike one another, unlike the situation in some other elasmobranch groups where species are superficially similar. Although skeletal morphology, particularly the structure of the adult claspers, is extremely useful in skate systematics, illustrations and details of their structure were not incorporated into this study due to time constraints. Manuscripts in preparation, which provide detailed regional revisions of the Australian skate genera, will detail these characters. Generic usage follows recently published schemes (e.g. Compagno, 1999; Last & Yearsley, 2002) except where explanation is given. Australian skates display a high level of regional endemism, so comparisons with species occurring in other ocean basins have been kept to a minimum.

TYPE MATERIAL

When possible, a representative adult male specimen was designated as the holotype of the new species. Not all paratypes contributed to morphometric and meristic data, and descriptions did not incorporate the full extent of sexual and ontogenetic variation in body shape and squamation. Instead, variability was based largely on three specimens: the adult male holotype, and the 'primary female' (usually an adult-sized specimen) and a 'primary juvenile' (neonate or early juvenile) paratypes. The registration numbers of these specimens are specified

in the methods sections and in species descriptions for each paper, along with lists of those paratypes used to obtain morphometric and meristic data. These special paratypes were examined in detail and used for descriptions of female and juvenile conditions for each of the new species. Type specimens are deposited in ichthyological collections mainly in Australia. Acronyms for all repositories follow Leviton *et al.* (1985).

MORPHOMETRICS

Morphometric characters were selected to discriminate new taxa and enable comparisons to be made with published information on related nominal skate species. Elasmobranch researchers have used various measurements that are often taken in different ways, making data comparisons difficult because of their inconsistency. For example, measurements of some characters (i.e. preorbital and preanial length) have been taken both horizontally and directly (point-to-point). Similarly, measurements such as preoral length have been taken from the snout tip to the mouth, as well as to the upper lip. A standard methodology for measuring skates was needed. In 1996, John McEachran, Bernard Séret and one of the authors (PL), simplified a list of measurements used in manuscripts to 46 main characters which we suggest should be taken for all skate species descriptions. Additional measurements can be taken at the discretion of the author(s). These main measurements are explained in detail in Table 1 and illustrated in Figs 1–2.

Several contributors provided input into the acquisition of morphometric data in these series of manuscripts. However, most of these data were extracted from initial morphometric files on skates prepared by one of us (DG) in 1998. Characters subject to differing interpretation were rechecked during preparation of these documents.

MERISTICS

The methodology described below applies to the taxa treated in the following papers and applies to vertebral counts, pectoral and pelvic-fin ray counts and tooth row counts.

Vertebral counts

Regardless of the methods outlined below and the care taken, there is often a small margin of error in counting vertebral centra, tooth rows and radials from radiographs. Such errors can often be attributed to radiograph quality (e.g. underexposed or faint radiographs are difficult to count) or meristic features being obscured (e.g. pelvic-fins radials can be obscured by claspers; tail centra can be obscured by tail thorns). Radiographs and associated meristic data for all material discussed in the following manuscripts were originally obtained by several persons

Table 1. Definition of the main morphometric characters taken for the various skates. All characters, except those with an (*), are illustrated in Figs 1–2.

Morphometric character	Methodology
1 – Total length (mm)	Direct distance from tip of snout to posteriormost point of caudal fin or tail
2 – Disc width	Width of disc at the widest expanse across the pectoral fins
3 – Disc length (direct)	Direct distance from tip of snout to extreme free rear tip of pectoral fin
4 – Snout to maximum width	Distance from tip of snout to the point perpendicular to the greatest width of disc (taken at midline of disc)
5 – Snout length (preorbital direct)	Direct distance from tip of snout to anterior of orbit
6 – Snout to spiracle	Direct distance from tip of snout to posteriormost part of the spiracle aperture
7 – Head (dorsal length)	Direct distance from tip of snout to the end of the cranium (this point is located by articulating the head and using a thumbnail)
8 – Orbit diameter	Greatest diameter of the orbit (not the exposed eye)
9 – Orbit and spiracle length	Distance from anterior margin of orbit to posteriormost part of the spiracle aperture
10 – Spiracle length (main aperture)	Greatest diameter of the spiracle aperture
11 – Distance between orbits	Distance between inner-most soft margins of each orbit
12 – Distance between spiracles	Distance between inner-most margins of each spiracle
13 – Snout to cloaca (1 st hemal spine)	Direct distance from tip of snout to first hemal spine (located just posterior to cloaca), determined by using finger to locate anterior margin of spine
14 – Distance-cloaca to caudal-fin tip	Direct distance from first hemal spine to posteriormost point of caudal fin or tail
15 – Ventral snout length (pre upper jaw)	Direct distance from tip of snout to posterior part of skin overlaying the middle of the upper jaw
16 – Prenasal length	Direct distance from tip of snout to anterior margin of left nostril
17 – Ventral head length (to fifth gill)	Direct distance from tip of snout to anterior inner margin of fifth gill slit
18 – Mouth width	Width of exposed part of mouth
19 – Distance between nostrils	Shortest distance between incurrent nasal openings
20 – Nasal curtain length	Horizontal measurement from anteriormost margin of nostril to posterior margin of nasal curtain
21 – Nasal curtain (total width)	Greatest width of nasal curtain
22 – Nasal curtain (min. width)*	Base width of posterior nasal curtain at inner margins of excurrent nasal openings (located beneath nasal curtain)
23 – Nasal curtain (lobe width)*	Width of posterior lobe from inner margin of excurrent nasal opening to posterolateral tip of nasal curtain
24 – Width of first gill opening	Greatest diameter of first gill opening
25 – Width of fifth gill opening	Greatest diameter of fifth gill opening
26 – Distance between first gill openings	Shortest distance between first gill openings
27 – Distance between fifth gill openings	Shortest distance between fifth gill openings
28 – Clasper (post cloacal length)	Direct distance from hemal spine (see measurement 13) to apex of clasper (in natural state, i.e. glans not dilated)
29 – Length of anterior pelvic lobe	Direct distance from articulation of anterior pelvic fin (using thumbnail to locate cartilaginous point of articulation) to rear tip of anterior lobe of pelvic fin
30 – Length of posterior pelvic lobe	Direct distance from articulation of anterior pelvic fin (using thumbnail to locate cartilaginous point of articulation) to rear tip of posterior lobe of pelvic fin
31 – Pelvic base width	Distance between points of articulation of anterior pelvic fin
32 – Tail at axil of pelvic fins (width)	Width of tail at pelvic-fin insertion (excluding lateral tail folds)
33 – Tail at axil of pelvic fins (height)	Height of tail at pelvic-fin insertion (not including thorns)
34 – Tail at midlength (width)	Width of tail at its midlength (defined as half of the distance from first hemal spine to posteriormost point of caudal fin or tail), excluding lateral tail folds
35 – Tail at midlength (height)	Height of tail at its midlength (defined as half of the distance from first hemal spine to posteriormost point of caudal fin or tail), not including thorns
36 – Tail at D1 origin (width)	Width of tail at first dorsal-fin origin (taken just dorsal of lateral tail fold), excluding lateral tail folds

Table 1. cont'd.

Morphometric character	Methodology
37 – Tail at D1 origin (height)	Height of tail at first dorsal-fin origin (not including thorns)
38 – D1 base length	Distance from first dorsal-fin origin to its insertion
39 – D1 height	Vertical measurement taken from base (using axis through origin and insertion of fin) to highest point of fin
40 – D1 origin to caudal-fin tip	Direct distance from first dorsal-fin origin to posteriormost point of caudal fin or tail
41 – D2 origin to caudal-fin tip	Direct distance from second dorsal-fin origin to posteriormost point of caudal fin or tail
42 – Caudal-fin length	Distance from origin of epichordal lobe of caudal fin to its rear tip
43 – Cloaca to pelvic-clasper insertion	Direct distance from first hemal spine to junction of lateral margin of clasper and pelvic fin

but data for all species were checked and assembled by one of us (JP). Methods are outline below:

Trunk centra — includes all complete vertebral centra of the cranium and monospondylous centra of the trunk. Hence, the last trunk centrum is at the transition point from monospondylous to diplospondylous centra and approximates the position of the hemal spine (Hubbs & Ishiyama, 1968) or slightly forward thereof. This transition point is demarcated by the point at which the centra become abruptly shorter. If there is a gradual decrease in size posteriorly, the changeover is considered to be at a point where the diplospondylous centra become constant in size (i.e. the first of the uniformly small centra is the first diplospondylous centra). Incomplete cranial centra (i.e. anterior triangular shaped centra not demarcated by a complete cross) were not included in monospondylous counts (1 incomplete centra but sometimes 2 are usually present). These centra are difficult to distinguish on underexposed or poor quality radiographs, but complete centra are usually clearer.

Predorsal caudal centra — also known as predorsal tail centra (Vprd) and includes all diplospondylous centra before the origin of the first dorsal fin (it excludes the centra below the dorsal-fin origin). Dorsal-fin origins were demarcated using pins before x-raying specimens. When pins were absent on radiographs, fin origins can usually be seen with careful examination.

Predorsal centra — sum of trunk centra and predorsal diplospondylous centra.

Centra between origins of dorsal fins — number of centra from the first dorsal-fin origin to immediately before the second dorsal-fin origin. Includes the centrum directly below the first dorsal-fin origin, but excludes the centrum directly below the second dorsal fin origin.

Total diplospondylous centra — includes all diplospondylous centra from the posterior extremity of the

trunk to the tail tip. All centra that can be seen (regardless of whether partial or complete at the tail tip) are included. Those at the tail tip are sometimes very difficult to count accurately as they decrease in size and calcification posteriorly and are often poorly exposed on radiographs. Hence, predorsal counts are usually more useful than total diplospondylous or total vertebral counts, which should be treated as approximate rather than exact values.

Total vertebral centra — the sum of trunk and total diplospondylous centra.

Pectoral and pelvic-fin radial counts

Hubbs & Ishiyama (1968) recommended that all radiographs be taken from the ventral surface (dorsal side down). However, positional information has not always been recorded in CSIRO X-ray logbooks, so counts for left and right radials were based on their presentation on radiographs. As left and right counts are pooled for ranges, counting radials on both sides of each specimen helps to confirm the accuracy of counts and caters for the slight variability that sometimes occurs between left and right sides of specimens. Variability in radial counts (expressed as ranges) in holotypes indicates that counts differed between the left and right sides. Counts were contained separately from the three main pterygial elements and from the pelvic girdle.

Propterygial radials — includes all radials arising from the propterygium to the junction of the mesopterygium. The anterior-most segment was excluded from this count.

Mesopterygial radials — includes all radials arising from the mesopterygium. Transitional radials sharing a common base with the propterygium and the metapterygium were examined closely and subjectively assigned to the most appropriate count based on physical overlap with each pterygium (this often accounts for variability in holotypes).

Metapterygial radials — includes all radials arising from

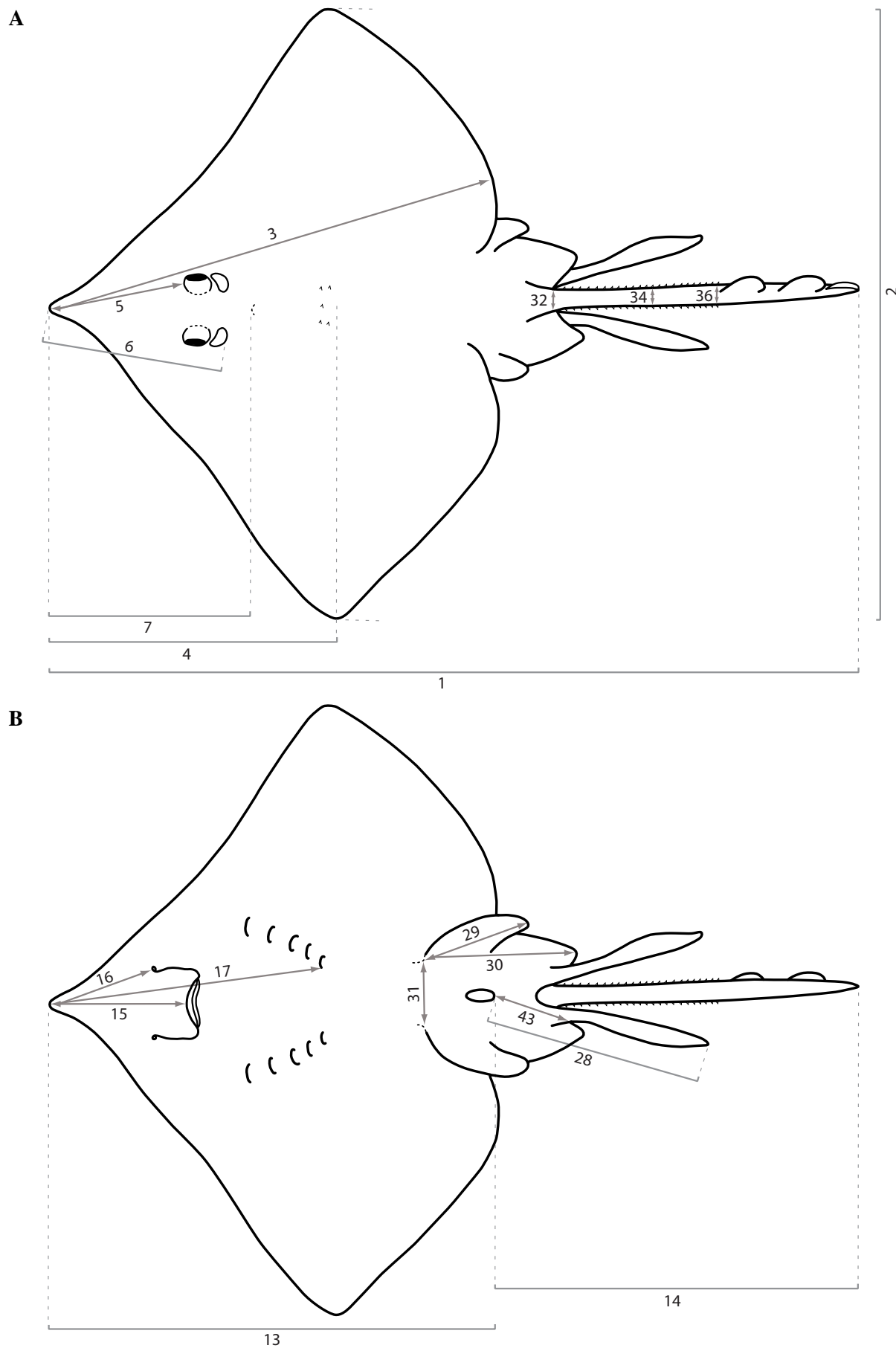


Figure 1. Diagrammatic representation of the morphometric characters used for skates (Rajoidei): A. dorsal view; B. ventral view. Refer to Table 1 for definitions and explanations of each of the measurements.

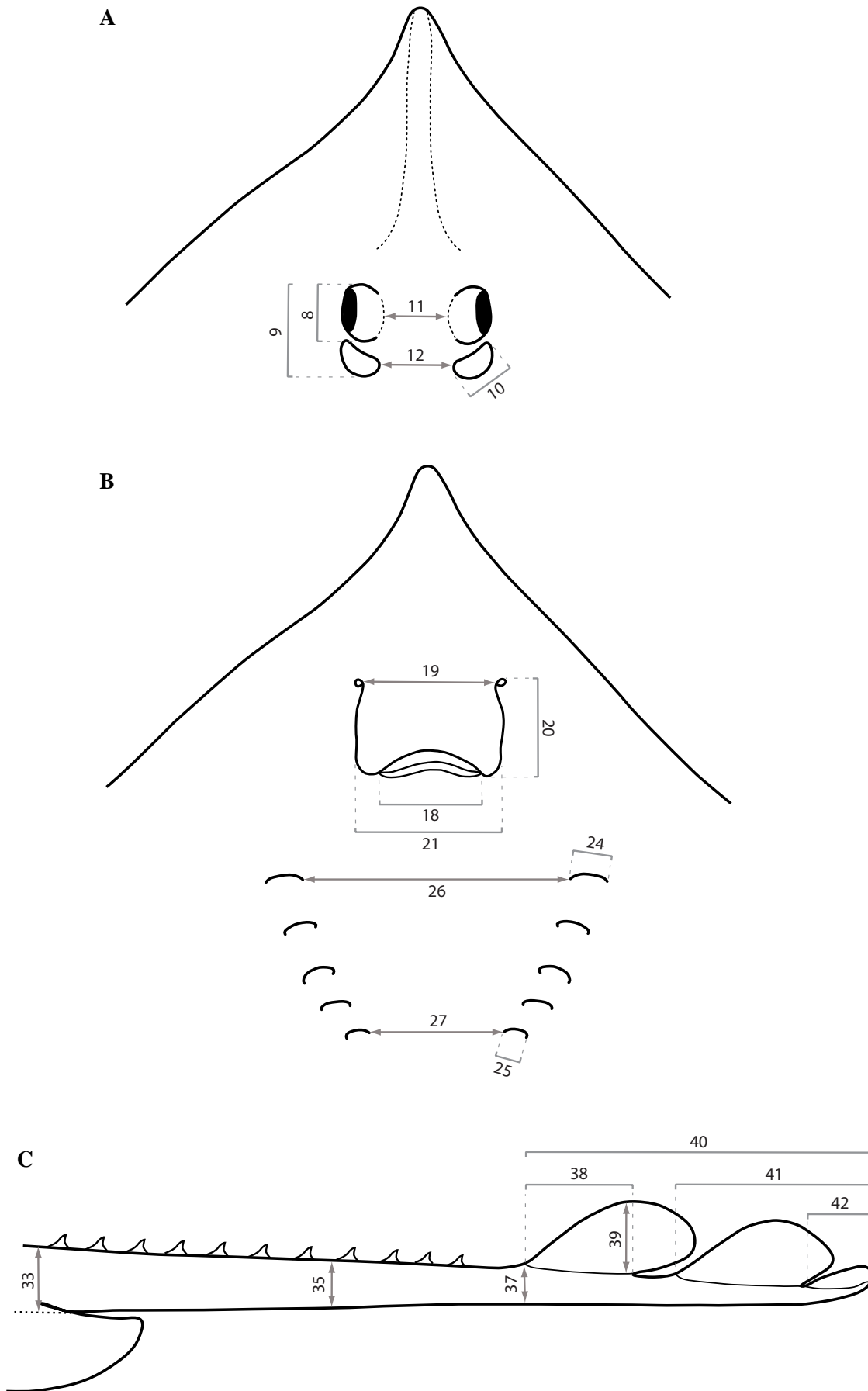


Figure 2. Diagrammatic representation of the morphometric characters used for skates (Rajoidae): A. anterodorsal view; B. anteroventral view; C. lateral tail view. Refer to Table 1 for definitions and explanations of each of the measurements.

the metapterygium. In complex metapterygia, the final posterior metapterygial radial is sometimes difficult to determine. We counted the penultimate complete radial, but exclude the final mesial radial which we considered to be the posterior extension of the metapterygium. Very small radials sometimes appear on the mesial side of the metapterygium facing the tail centra – these radials were excluded from the counts as they are often very difficult to detect in radiographs.

Pelvic-fin radials — These are recorded in the following format: e.g. 1, 17. Where 1 = the main anterior pelvic structure (thicker than all other radials), and 17 = the number of smaller radials arising from the pelvic-fin lobe(s). The first or single thickened element is usually excluded from the summaries comparing species as it is common to all skates treated here. In males, the clasper (the modified posterior radial) is not included in the count (as it is regarded as the posterior most radial of the main structure). In females the final posterior radial is excluded from the count for the same reason. Pelvic-fin counts can be difficult to obtain due to the tail and/or claspers obscuring the posterior radials of the pelvic fin. Anterior radials are sometimes obscured by the posterior radials of the metapterygium.

Tooth row counts

Rows in the upper and lower jaws were recorded as totals (i.e. disregarding left and right counts). Although Hubbs & Ishiyama (1968) recommended taking radiographs of specimens from the ventral surface (dorsal side down), x-raying specimens ventral side down produced a clearer definition of the jaw and made the counting of teeth easier. Hubbs & Ishiyama (1968) noted that occasionally, because of the quincuncial arrangement of the tooth rows in the young skates, the tooth rows of the jaws can be difficult to count.

Thorn counts

Thorns were counted from major regions on the dorsal surface of the disc and tail, and occasionally from the ventral surface. These mainly include the general orbito-spiracular region, snout, nuchal and scapular regions, alar and malar patches, and in rows along the mid-disc and tail. Orbito-spiracular thorns are divided into marginal patches on the preorbit (typically forward of the eye), midorbit (beside the eye) and postorbit (posterior of the eye and include spiracular thorns unless specified). The term ‘rosette’ (symmetrical arrangement of orbiting bodies arranged around a common center of mass, Wikipedia 2007) refers to the continuous distribution of thorns beside the dorsal margin of the orbit (usually from the preorbit to the postorbit). When absent from any part of the margin (usually the midorbit), these thorns are considered to form an ‘incomplete rosette’. Snout thorns are usually, but not exclusively, along the rostral cartilage. Thorns are often present or absent on the nuchal region and may extend posteriorly as a median series; some species have accompanying scapular thorns on the

shoulders. Descriptions of alar and malar patches follow conventional definitions by Hubbs & Ishiyama (1968) and others. Thorns of varying sizes usually extend along the tail in linear to staggered, complete or incomplete, rows. Information on thorn numbers and their shape in median, and when present, lateral and dorsolateral rows, are usually given for the holotype and primary paratypes. The general distributions of smaller denticle patches are also provided. Thorn counts were taken by the authors of the individual papers.

LITERATURE CITATION

Some inconsistencies exist in the way references are reported in the literature so we opted to follow conventions used by Eschmeyer (2008).

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New skates of the genus *Dipturus* (Rajoidei: Rajidae) from Australian Seas

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ABSTRACT.— Five new species of long-snout skates belonging to the genus *Dipturus* are described based on material from Australia. These species, i.e. *Dipturus acrobelus* sp. nov. (southern Australia), *D. healdi* sp. nov. (northwestern Australia), and *D. apricus* sp. nov., *D. melanospilus* sp. nov. and *D. queenslandicus* sp. nov. (eastern Australia), were identified prior to and as part of research to produce a guide to the shark and ray fauna of Australia (Last & Stevens, 1994). Main identifying features of these species were given but they were not formally named in this publication. The new species differ from each other by a combination of body shape, squamation, morphometrics and meristics. Hence, the primary object of this paper is to name and describe these species for inclusion in an update of the original guide.

Key words. Rajidae – skate – *Dipturus acrobelus* – *Dipturus apricus* – *Dipturus healdi* – *Dipturus melanospilus* – *Dipturus queenslandicus* – new species – Australia

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INTRODUCTION

The genus *Dipturus* Rafinesque 1810 (designated type of the genus *Raja batis* Linnaeus, 1758) was once considered a subgenus of *Raja* by most authors (e.g. Stehmann 1973; Ishihara & Ishiyama, 1986; Ishihara, 1987; Séret, 1989; Jacob & McEachran, 1994), but has since been resurrected to generic level by McEachran & Dunn (1998). Ebert & Compagno (2007) recognised 31 nominal species and 15 undescribed species belonging to the genus *Dipturus*. However, two of these nominal species and one of the undescribed species have since been reassigned to the genus *Zearaja* by Last & Gledhill (2007), i.e. *Z. chilensis* (Guichenot, 1848), *Z. maugeana* Last & Gledhill, 2007 and *Z. nasuta* (Müller & Henle, 1841). Of the remaining 29 nominal species listed by Ebert & Compagno (2007): 15 occur in the Atlantic Ocean, i.e. *D. batis* (Linnaeus, 1758), *D. bullisi* (Bigelow & Schroeder, 1962), *D. diehli* Soto & Mincarone, 2001, *D. dourei* (Cadenat, 1960), *D. garricki* (Bigelow & Schroeder, 1958), *D. laevis* (Mitchell, 1818), *D. leptocauda* (Kreffft & Stehmann, 1975), *D. linteus* (Fries, 1838), *D. mennii* Gomes & Paragó, 2001, *D. nidarosiensis* (Storm, 1881), *D. olsenii* (Bigelow & Schroeder, 1958), *D. oregoni* (Bigelow & Schroeder, 1958), *D. oxyrinchus* (Linnaeus, 1758), *D. teevani* (Bigelow & Schroeder, 1951) and *D. trachyderma* (Kreffft & Stehmann, 1975); 14 occur in the Indo-Pacific region, i.e. *D. campbelli* (Wallace, 1967), *D. crosnieri* (Séret, 1989), *D. ecuadoriensis* (Beebe & Tee-Van, 1941), *D. gigas* (Ishiyama, 1958), *D. gudgeri* (Whitley, 1940), *D. innominata* (Garrick & Paul, 1974),

D. johannisdavisi (Alcock, 1899), *D. kwangtungensis* (Chu, 1960), *D. lanceorostrata* (Wallace, 1967), *D. macrocauda* (Ishiyama, 1955), *D. pullopunctata* (Smith, 1964), *D. springeri* (Wallace, 1967), *D. stenorhynchus* (Wallace, 1967) and *D. tengu* (Jordan & Fowler, 1903). All but one of the 15 undescribed species listed by Ebert & Compagno (2007) occur in the Indo-Pacific region. Three additional nominal species of short-snout skates from Australia, i.e. *D. australis* (Macleay, 1884), *D. cerva* (Whitley, 1939) and *D. polyommata* (Ogilby, 1910), which do not conform to existing definitions of *Dipturus* (Last & Yearsley, 2002), are also provisionally placed in the genus *Dipturus*.

Last & Yearsley (2002) discussed the generic placement of Australasian rajin skates. Six long-snout species were considered to conform closely with non-Australian members of the genus *Dipturus*. This group consists of *Dipturus gudgeri*, and five undescribed species, *Dipturus* sp. C, *Dipturus* sp. F, *Dipturus* sp. H, *Dipturus* sp. J and *Dipturus* sp. K (referred to in Last & Stevens, 1994 as *Raja* sp. C, F, H, J and K respectively). *Dipturus* sp. I probably belongs to this group but no adult males were available for clasper analysis. In addition, another undescribed species, *Dipturus* sp. G (referred to in Last & Stevens, 1994 as *Raja* sp. G), was considered close to *Dipturus* morphologically but differed in clasper anatomy. Five of these undescribed, long-snout species (i.e. *Dipturus* sp. F, G, H, J and K) are formally described below. New members of the group of small, short-snout *Dipturus* skates (including *Dipturus* sp. C) are treated in

the following paper of this series. Once again, we stress that the object of this approach is to provide names, good diagnoses and solid descriptions for these species rather than to adopt a full revisionary approach of the genus.

METHODS

The descriptive format is based on McEachran & Fechhelm (1982), and meristic and morphometric methods are outlined in the first paper of this special publication on new Australian skates (Last *et al.*, 2008). Some specimens of the 5 new species treated in this paper (i.e. *Dipturus acrobelus*, *D. apricus*, *D. healdi*, *D. melanospilus* and *D. queenslandicus*), were assigned as primary types, and paratypes from which meristic and/or morphometric information was obtained. Detailed descriptive information is based on an adolescent or adult male (designated as the holotype), a large female (referred to herein as the 'primary female paratype'), and a typical juvenile (referred to herein as the 'primary juvenile paratype'). Morphological variability within other paratypes is discussed where necessary. Note that both meristic and morphometric data was collected from the holotype of each of the new species. Body measurements, expressed as a percentage of total length (TL), are provided in tables; range data for paratypes are provided in parentheses after data for the holotype in Description sections. Radiographs of additional material were used to obtain counts of tooth rows, vertebrae, and pectoral and pelvic-fin radials; data for paratypes is also given in parentheses after the holotype in Description sections. Vertebral counts were made using methods described by Hubbs & Ishiyama (1968); trunk counts include only monospondylous centra and whole synarcual centra (the anteriormost element is often fragmented). Materials examined are deposited in ichthyological collections of the Australian National Fish Collection, Hobart (CSIRO), the Australian Museum, Sydney (AMS), Museum Victoria (NMV), the Western Australian Museum (WAM) and the Queensland Museum (QM).

Dipturus acrobelus: holotype (CSIRO H 226–01), primary female paratype (CSIRO H 879–01), primary juvenile paratype (CSIRO H 789–03); 7 morphometric paratypes (AMS I 27722–007, AMS I 44540–001, CSIRO H 615–01, CSIRO H 871–01, CSIRO H 879–01, CSIRO H 2637–01 and CSIRO H 2644–01); 11 meristic paratypes (AMS I 44540–001, CSIRO CA 2805, CSIRO H 51–01, CSIRO H 52–01, CSIRO H 54–01, CSIRO H 615–02, CSIRO H 789–04, CSIRO H 2637–01, CSIRO H 2644–01, CSIRO H 2654–01 and CSIRO T 456).

Dipturus apricus: holotype (CSIRO H 601–01), primary female paratype (CSIRO H 3643–12), primary juvenile paratype (CSIRO H 617–09); 6 morphometric paratypes (CSIRO H 692–01, CSIRO H 718–25, CSIRO H 947–14, CSIRO H 3643–12, NMV A 29737–001 and NMV A 29737–002); 9 meristic paratypes (CSIRO H 600–03,

CSIRO H 692–02, CSIRO H 692–05, CSIRO H 692–06, CSIRO H 699–02, CSIRO H 715–03, CSIRO H 3643–12, QM I 19317 and QM I 19320).

Dipturus healdi: holotype (CSIRO H 4071–15), primary female paratype (CSIRO H 4071–16), primary juvenile paratype (CSIRO CA 4368); 5 morphometric paratypes (CSIRO CA 2827, CSIRO CA 2828, CSIRO CA 4364, CSIRO CA 4394 and CSIRO H 1650–01); 9 meristic paratypes (CSIRO CA 2827, CSIRO CA 3911, CSIRO CA 4364, CSIRO CA 4383, CSIRO CA 4394, CSIRO H 2273–03, CSIRO H 2897–05, CSIRO H 2897–06 and CSIRO H 4071–14).

Dipturus melanospilus: holotype (CSIRO H 715–05), primary female paratype (CSIRO H 948–03), primary juvenile paratype (CSIRO H 2204–01); 5 morphometric paratypes (CSIRO H 600–02, CSIRO H 948–03, CSIRO H 2199–01, CSIRO H 2203–01 and CSIRO H 6639–01); 8 meristic paratypes (AMS I 20118–009 [2 specimens], CSIRO H 600–02, CSIRO H 948–03, CSIRO H 2203–01, CSIRO H 2204–04, QM I 18608 and QM I 19316).

Dipturus queenslandicus: holotype (CSIRO H 715–07), primary female paratype (CSIRO H 720–34), primary juvenile paratype (QM I 18527); 5 morphometric paratypes (CSIRO H 715–02, CSIRO H 715–04, CSIRO H 715–09, CSIRO H 720–34 and CSIRO H 957–01); 9 meristic paratypes (CSIRO H 715–01, CSIRO H 715–02, CSIRO H 715–04, CSIRO H 715–06, CSIRO H 715–09, CSIRO H 715–10, CSIRO H 947–13, CSIRO H 957–01 and QM I 19985).

Dipturus acrobelus sp. nov.

Figs 1–6; Table 1

Raja sp. J: Last & Stevens, 1994: pp 301, 336–337, fig. 34.25, key fig. 16, pl. 59.

Raja sp. 3: Gomon, Glover & Kuitert, 1994: pp 161, 164, fig. 141.

Holotype. CSIRO H 226–01, adolescent male 840 mm TL, east of St Patricks Head, Tasmania, 41°33' S, 148°42' E, 905–990 m, 04 Sep 1983.

Paratypes. 24 specimens. AMS I 27722–007, female 506 mm TL, east of Newcastle, New South Wales, 32°56' S, 152°39' E, 705–750 m, 05 May 1988; AMS I 44540–001, juvenile male 464 mm TL, Great Australian Bight, Western Australia, 33°40' S, 127°17' E, 876–923 m, 02 Nov 1989; CSIRO CA 2805, adolescent male 799 mm TL, east of Sydney, New South Wales, 33°36' S, 152°00' E, 624–632 m, 24 Jan 1982; CSIRO H 51–01, juvenile male 360 mm TL, off Bicheno, Tasmania, ca. 42° S, 148° E, 840 m, 16 Jun 1982; CSIRO H 52–01, juvenile male 242 mm TL, west of Granville Harbour, Tasmania, 41°44' S, 144°24' E, 936–952 m, 05 Jun 1982; CSIRO H 53–01, female 202 mm TL, CSIRO H 54–01, female

265 mm TL, south of Port MacDonnell, Victoria, 38°30' S, 140°43' E, 502–914 m, 05 Aug 1983; CSIRO H 223–01, adult male >890 mm TL (tail tip damaged), south-west of King Island, Tasmania, 40°42' S, 143°29' E, 942–1058 m, 09 Jan 1982; CSIRO H 558–02, female 1064 mm TL, west of Granville Harbour, Tasmania, 41°48' S, 144°28' E, 770–790 m, 16 May 1986; CSIRO H 614–01, female 1350 mm TL, east of Granville Harbour, Tasmania, 41°48' S, 144°22' E, 1288–1328 m, 25 May 1986; CSIRO H 615–02, juvenile male 449 mm TL, west of Mawson Bay, Tasmania, 40°58' S, 143°45' E, 820–872 m, 15 May 1986; CSIRO H 622–12, adult male >945 mm TL (tail tip damaged), north-west of Kenneth Bay, Tasmania, 41°17' S, 144°02' E, 900–920 m, 14 May 1986; CSIRO H 789–03, female 214 mm TL, CSIRO H 789–04, juvenile male 413 mm TL, west of Mawson Bay, Tasmania, 40°58' S, 143°45' E, 820–872 m, 15 May 1986; CSIRO H 871–01, female 1055 mm TL, east of Jervis Bay, New South Wales, 34°58' S, 151°09' E, 490–576 m, 10 Sep 1986; CSIRO H 879–01, female 1346 mm TL, west of Temma, Tasmania, 41°13' S, 144°00' E, 808–940 m, 09 Jun 1987; CSIRO H 1004–01, adult male >950 mm TL (tail tip damaged), south-east of Gabo Island, Victoria, 37°38' S, 150°22' E, 1035–1062 m, 21 Nov 1984; CSIRO H 2637–01, female 574 mm TL, south-east of Portland, in Bass Strait, Victoria, 39°00' S, 142°19' E, 690–1060 m, 03 Mar 1989; CSIRO H 2644–01, juvenile male 465 mm TL, south-west of Cape Sorell, Tasmania, 42°24' S, 144°45' E, 824–830 m, 19 Mar 1989; CSIRO H 2654–01, female 357 mm TL, south-west of King Island, Tasmania, 40°36' S, 143°26' E, 845–850 m, 08 Mar 1989; CSIRO H 6639–02, juvenile male 213 mm TL, east of Crowdy Head, New South Wales, 31°52' S, 153°16' E, 485–925 m, 09 Dec 1987; CSIRO T 456, adolescent male 810 mm TL, east of Sydney, New South Wales, 33°45' S, 151°51' E, 446–468 m, 20 Dec 1982; NMV A 5938 (2 specimens), female 214 mm TL, juvenile male 219 mm TL, west of Cape Banks, South Australia, 37°47' S, 139°35' E, 800–820 m, 03 Feb 1988.

Other material. 22 specimens. CSIRO H 222–01, female 1011 mm TL, CSIRO H 224–01, female 694 mm TL, south-west of King Island, Tasmania, 40°40' S, 143°28' E, 677–750 m, 22 Feb 1979; CSIRO H 225–01, adolescent male >855 mm TL (tail tip damaged), off Sandy Cape, Tasmania, 41°15' S, 144°03' E, 673 m, Jan 1979; CSIRO H 558–03, female 818 mm TL, CSIRO H 558–04, female 1218 mm TL, CSIRO H 558–05, female 1196 mm TL, west of Granville Harbour, Tasmania, 41°48' S, 144°28' E, 770–790 m, 16 May 1986; CSIRO H 614–02, female 1371 mm TL, west of Granville Harbour, Tasmania, 41°48' S, 144°22' E, 1288–1328 m, 25 May 1986; CSIRO H 615–01, female 1290 mm TL, CSIRO H 615–03, juvenile male 224 mm TL, west of Mawson Bay, Tasmania, 40°58' S, 143°45' E, 820–872 m, 15 May 1986; CSIRO H 622–11, juvenile male 335 mm TL, CSIRO H 622–13, female 1338 mm TL, north-west of Kenneth Bay, Tasmania, 41°17' S, 144°02' E, 900–920 m, 14 May 1986; CSIRO H 789–05, juvenile male 280 mm TL, west

of Mawson Bay, Tasmania, 40°58' S, 143°45' E, 820–872 m, 15 May 1986; CSIRO H 995–03, female >1220 mm TL (tail tip damaged), south-east of Gabo Island, Victoria, 37°41' S, 150°20' E, 981–1026 m, 21 Nov 1984; CSIRO H 1931–01, juvenile male 687 mm TL, west of Mawson Bay, Tasmania, 41°02' S, 143°49' E, 866–930 m, 19 Feb 1989; CSIRO H 2447–01, female 318 mm TL, CSIRO H 2447–02, juvenile male 443 mm TL, CSIRO H 2447–03, juvenile male 447 mm TL, east of Newcastle, New South Wales, 32°56' S, 152°39' E, 705–750 m, 05 May 1988; CSIRO H 2665–01, juvenile male 237 mm TL, west of Trial Harbour, Tasmania, 41°55' S, 144°31' E, 815–840 m, 14 Mar 1989; CSIRO H 2871–01, adolescent male 776 mm TL, Great Australian Bight, South Australia, 33°45' S, 130°58' E, 834–883 m, 07 Mar 1992; CSIRO H 2888–01, female 1229 mm TL, Great Australian Bight, South Australia, 33°37' S, 129°58' E, 920–1188 m, 12 Mar 1992; CSIRO H 2958–01, female 730 mm TL, Great Australian Bight, South Australia, 33°35' S, 129°03' E, 905–916 m, 01 Jun 1992; CSIRO H 2959–01, female 1103 mm TL, Great Australian Bight, South Australia, 33°45' S, 130°41' E, 931–975 m, 22 May 1992.

DIAGNOSIS.— A large species of *Dipturus* (to 137 cm TL) with the following combination of characters: disc relatively broad with angular to narrowly rounded apices, width 66–71% TL, 1.1–1.2 times its length; snout angle 60–74°; tail length 0.7–1.0 in distance from snout tip to rear of cloaca; tail slender, somewhat rounded in cross-section and slightly expanded near its midlength, width 1.6–1.8 times height at its midlength, 1.4–1.8 times at first dorsal-fin origin; pre-upper jaw length 24–27% TL, 3.0–3.4 times internasal width; ventral head length 35–38% TL; snout length 5.4–7.0 times interorbital width; orbit diameter 55–92% interorbital width; first dorsal-fin height 1.2–2.1 in its base length; distance from first dorsal-fin origin to tail tip 3.0–4.2 times first dorsal-fin base length, 2.6–3.5 times caudal-fin length; pelvic fins of medium size; anterior margins of both surfaces of disc of adult males and largest females (>1350 mm TL) with narrow bands of fine denticles; 1–3 nuchal thorns; malar thorn patch very well-developed; tail with 1–3 thorn rows (lateral rows poorly developed) in males, females with additional dorsolateral and occasionally weak ventrolateral thorn rows (up to 7 thorn rows in total); total pectoral radials 83–88; trunk centra 26–31; predorsal centra 78–85; total centra about 130–141; tooth rows in upper jaw 35–41; mainly uniformly pale grey to brownish dorsally; darker brownish or blackish ventrally (often mottled), snout tip darker than rest of snout; upper lip usually blackish bordering tooth band; ventral sensory pores very small, with indistinct dark edges; dorsal and caudal fins, tail tip, margins of pelvic fins, and posterior margins of pectoral fins black in juveniles (to at least 570 mm TL).

DESCRIPTION.— Disc broadly quadrangular, 1.14 times as broad as long in adolescent male holotype (1.07–1.19 times in paratypes); angle in front of spiracles

A

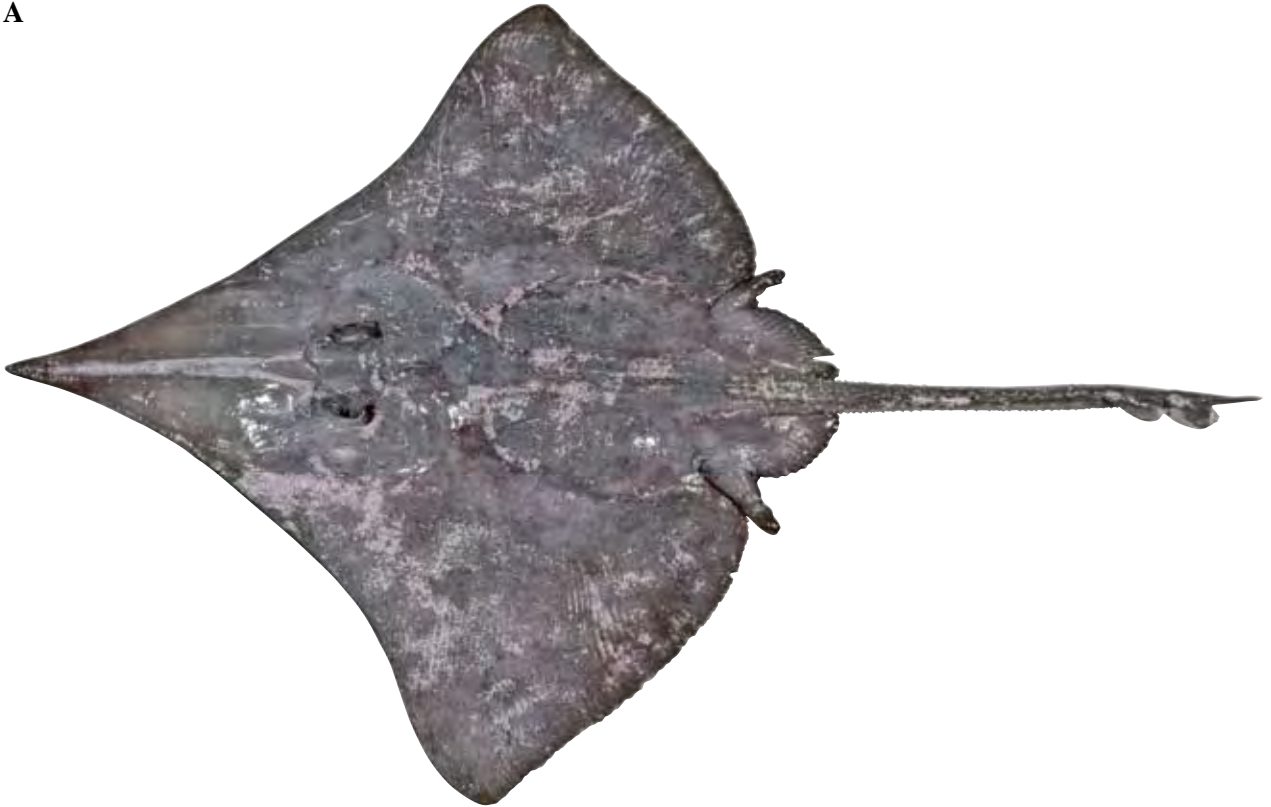


B



Figure 1. *Dipturus acrobelus* sp. nov., adolescent male holotype (CSIRO H 226–01, 840 mm TL, preserved): A, dorsal surface; B, ventral surface.

A



B



Figure 2. Dorsal surface of *Dipturus acrobelus* sp. nov.: A, primary female paratype (CSIRO H 879–01, 1346 mm TL, fresh); B, primary juvenile paratype (CSIRO H 789–03, female 214 mm TL, preserved).



Figure 3. Dorsal head of *Dipturus acrobelus* sp. nov., adult male paratype (CSIRO H 622–12, >945 mm TL), showing snout, orbito–spiracular and nuchal regions.

68° (60–74°); axis of greatest width 65% (63–69%) of disc length; anterior margin extremely concave, weakly double concave in large males and females (also strongly double concave in juveniles), long and evenly concave anteriorly, almost straight to weakly convex beside eyes, very deeply concave just behind level of spiracles; apex angular to narrowly rounded (slightly broader in juveniles); posterior margin weakly concave near apex, convex posteriorly; free rear tip very broadly rounded. Head very long, snout slightly more extended in adult females (length 25.8–26.1%, about 23.0% in large males, 23.3–25.8% TL in juveniles shorter than 600 mm TL); preorbital length 7.47 (7.20–9.74) times orbit length, 5.42 (5.39–6.97) times interorbit; pre-upper jaw length 2.97 (3.01–3.36) times internarial distance. Snout tip very well produced, narrowly pointed; no fleshy process at apex. Orbit small, diameter 0.73 (0.55–0.92) times interorbital width. Spiracle large, length 2.24 (1.80–2.37) in orbit diameter; opening variable, mostly tear-drop shaped. Nostril subrectangular to suboval, usually distorted in types; anterior nasal flap expanded, its lateral margin forming a small semi-circular tube; anterior margin of flap lobe-like, not concealed beneath nasal curtain; posterior inner margin concealed beneath

nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with thick fringe; internarial distance 1.52 (1.47–1.63) in distance between first gill slits, 0.99 (0.94–1.09) in distance between fifth gill slits. Upper jaw arched slightly, weakly indented at symphysis (more so in adult male paratypes); lower jaw moderately convex (only slightly more so in adult males); lateral teeth of upper jaw usually fully concealed by lobe of nasal curtain. Teeth of an adult male paratype CSIRO H 622–12 strongly unicuspid, with slightly elevated subcircular bases; arranged in longitudinal rows rather than in quincunx; cusps near middle of both jaws very long, caniniform, pointed; cusps near angle of upper jaw more broadly triangular, near angle of lower jaw much narrower, shorter; cusps directed posteriorly in middle of upper jaw, slightly oblique (posterolaterally) in mid-lateral and outer part of jaws; teeth of early adolescent male holotype and primary female paratype H 879–01 with elevated, narrowly oval bases, arranged in well-defined rows, cusps relatively broad-based, raised slightly, pointed (less pronounced near jaw angle), without median ridge; teeth of primary juvenile paratype CSIRO H 789–03 broader based and flatter, with short labial cusps.

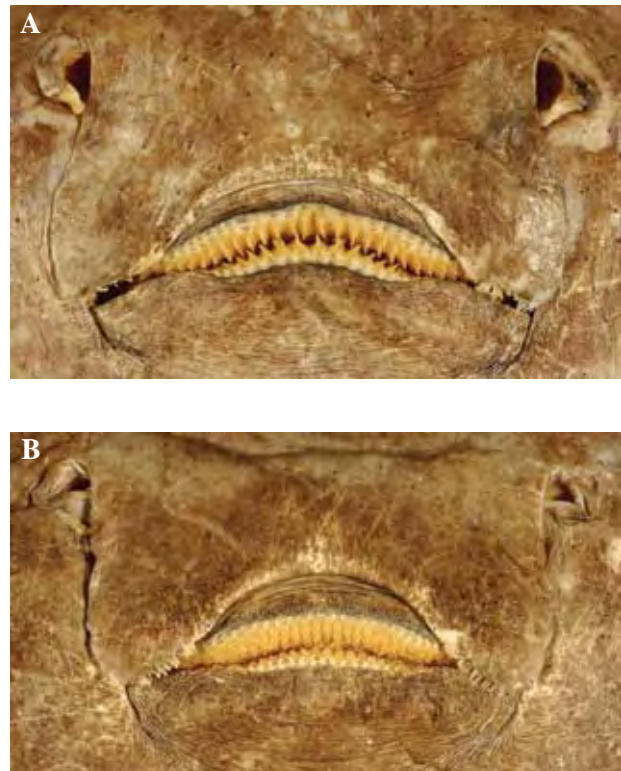


Figure 4. Ventral view of *Dipturus acrobelus* sp. nov. showing oronasal region and tooth band: A, adult male paratype (CSIRO H 622–12, >945 mm TL); B, primary female paratype (CSIRO H 879–01, 1346 mm TL).

Pelvic fins large, very deeply forked; anterior lobe long, narrowly rounded to bluntly pointed distally, lateral margin entire, inner margin deeply incised; posterior lobe moderately elongate in adolescent male, not much longer (length about 13.3% TL) than in females (length 12.2–12.5% TL), lateral margin straight to convex (less so in adult and late adolescent males); free rear tip usually angular to bluntly pointed (more rounded in juveniles); inner margin variable, weakly convex to concave. Clasper elongate, slender, slightly depressed, glans expanded slightly; clasper components include proximal slit and distal cleft, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel and spike; denticles and pseudosiphon absent. Tail deep, rather slender, not strongly depressed (slightly more so in primary female); very narrow at base (narrowest in adult males), not tapering or tapering very gradually distally, often slightly expanded forward of dorsal-fin base; tapering more rapidly to tail tip behind first dorsal-fin; width at insertions of pelvic fins 1.41 (1.29–1.70) times width at midlength of tail and 1.46 (1.36–1.82) times width at first dorsal-fin origin; length from rear of cloaca 0.80 (0.72–0.88) times distance from tip of snout to rear of cloaca; anterior cross-section subcircular to narrowly oval (more depressed in females and juveniles), almost equally convex dorsally and ventrally (more convex dorsally in female), only slightly more strongly convex on dorsal surface than ventral surface posteriorly (flat ventrally in females and juveniles); width 1.39 (1.24–1.59) times height at insertion of pelvic fin, 1.65 (1.55–1.84) times height at midlength, 1.53 (1.36–1.84) times height at first dorsal fin origin; side of tail somewhat angular (more so in large females than males); lateral tail fold narrow, weak anteriorly, broader posteriorly, relatively short-based, better developed in females or juveniles, originating as a fleshy ridge just forward of rear tip of pelvic fin, terminating slightly forward of tail tip, notably broader beneath dorsal fins. Dorsal fins large, of similar shape; first dorsal fin similar in size or slightly larger than second, its height 1.78 (1.23–2.11) in base length; fins strongly raked, relatively tall, with moderately elongate bases; anterior margins of both fins weakly convex, apices broadly rounded, posterior margins short, convex; free rear tip usually angular; inner margins short, usually directed strongly anteroventrally; second dorsal-fin base subequal or slightly longer than first dorsal-fin base; interdorsal space moderate, 3.88 (2.05–7.03) times in first dorsal-fin base length; distance from first dorsal-fin origin to tail tip 3.22 (3.04–4.24) times dorsal-fin base length, 3.36 (2.57–3.46) times caudal-fin length; first dorsal-fin base 1.04 (0.62–1.02) times caudal-fin length. Epichordal caudal-fin lobe very well developed, long-based, relatively tall, height greatly exceeding half tail width at fin origin (less so in juveniles); usually tallest near its midlength or just beyond, its dorsal margin weakly convex, often almost straight; connected sub-basally to second dorsal fin; hypochordal caudal-fin lobe well developed, low, base length subequal to orbit or longer.

Dorsal surface of early adolescent male holotype with moderate orbito-spiracular (forming an incomplete rosette), nuchal and tail thorns (adult male paratype CSIRO H 622–12 with additional well-developed alar and malar patches, and more complete orbital rosette); nuchal thorn(s) usually present (some paratypes with scar indicating it may have been lost); no thorns along mid-disc or in scapular region; primary female paratype with small orbital, nuchal and better developed tail thorns; primary juvenile paratype with well-developed orbital, nuchal and small tail thorns. Main orbital thorns of holotype about 10–11 (5–6 on preorbit, 2 on midorbit, 3 on postorbit), largest preorbital thorn not bifurcate; thorns variable in size, short to moderate in length, usually pungent, narrow based, not notably deciduous, often damaged distally, patch of smaller thornlets laterally usually present on preorbit; primary female paratype with about 22–25 thorns (11 on preorbit, 3 on midorbit, 8–11 on postorbit, medial thorn without greatly enlarged bases), thorns forming a rosette, cluster of smaller thornlets on anterolateral margin of preorbit; early juvenile with 3 large thorns (2 on preorbit, 1 on postorbit), anteriormost thorn directed laterally, additional thorn appearing at about 360 mm TL. Nuchal thorns 2 (1–3, usually 1–2 in large specimens, 1 in juveniles, occasionally absent in adults but scar visible), similar in size, narrow based; juvenile with single tall, pungent, upright thorn. Malar patch in adult male paratypes very well developed, with about 35–39 enlarged thorns; in several irregular rows beside eye near disc margin; thorns large, strongly raked, pungent, largest in inner posterior part of patch, merging in size with large denticles and thornlets associated with marginal denticle band. Alar thorns in adult male paratypes 35–39, in about 3 semi-regular rows; well developed, subequal in length to tail thorns, deeply embedded, tips pungent, directed slightly posteromedially; patch long, almost 3 times longer than orbit diameter. Tail thorns of males slightly variable in size, mostly tall, pungent, upright or slightly tilted, some weakly recurved; in 2 rows (1–3 rows, lateral rows very poorly developed), slightly staggered, semi-continuous, linear, median row, not paired; row commencing above cloaca, extending to dorsal fin, with 40 (about 23 larger primary thorns and about 17 slightly smaller thorns); some main thorns preceded by small interstitial thorns; largest thorns sometimes with dermal flaps on their posterior bases; interdorsal thorns 3 (3–4 in paratypes). Tail of large primary female paratype spiny, with multiple rows of large thorns; with well-developed median, lateral and ventrolateral rows, 2 poorly developed dorsolateral rows (in other female paratypes, median and lateral rows best developed, both dorsolateral rows mostly poorly developed, ventrolateral rows short, present only in largest females, lateral rows appearing at about 210 mm TL); median row commencing just forward of cloaca, extending along length of tail in a double staggered row, with about 73 predorsal thorns (about 52 similar sized primary thorns and 21 smaller thorns); two pairs of dorsolateral rows, poorly developed, discontinuous, upper row with about 14 thorns, lower row



Figure 5. Lateral view of dorsal and caudal fins of *Dipturus acrobelus* sp. nov., adult male paratype (CSIRO H 622–12, >945 mm TL). Note caudal fin damaged.

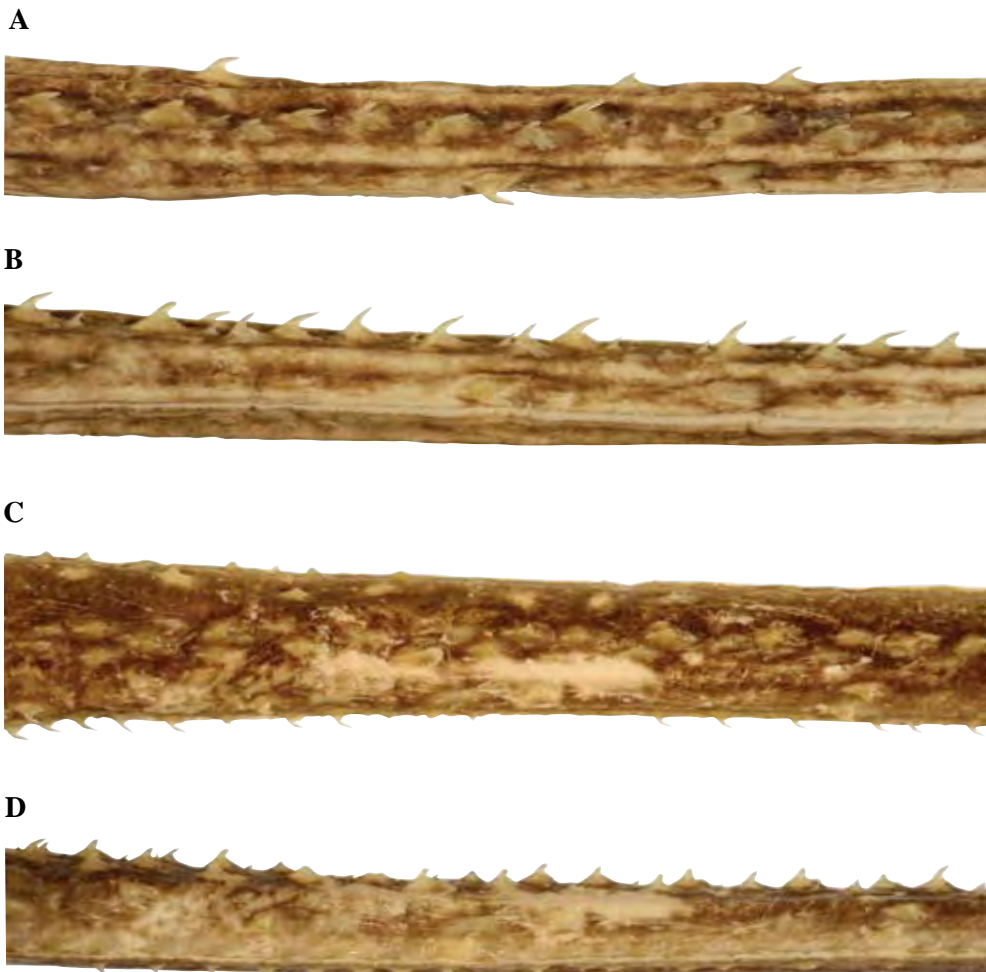


Figure 6. Thorns at tail midlength of *Dipturus acrobelus* sp. nov.: A, dorsal and B, lateral view of adult male paratype (CSIRO H 622–12, >945 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 879–01, 1346 mm TL).

with 1–2 thorns, located close together, near dorsolateral margin of tail, commencing over pelvic-fin inner margin, upper row extending to second dorsal fin, lower row short; lateral rows with about 33–36 thorns, located just above lateral fold, commencing just forward of rear tip of pelvic fin and ending below first dorsal fin; lateral thorns slender, pungent, strongly recurved, directed almost posterolaterally, sometimes weakly barbed, thinner than largest median thorns; moderately elongate ventrolateral

rows on midtail just ventral to skin fold, with 14–15 thorns, other smaller thornlets posteriorly, commencing just behind free rear tip of pelvic fin, extending to about midlength of tail; interdorsal thorns 5 (3–4 in large female paratypes). Primary juvenile paratype with single median thorn row, commencing just forward of level of cloaca; with 16 long, strongly raked predorsal thorns; one small interdorsal thorn present.

Denticles of large males poorly developed, most of disc and tail naked. In holotype, denticles on dorsal surface confined to weak patches on snout and tail tips, and evidence of narrow band forming along anterolateral margin of disc; in adult male paratype denticles extending over most of rostral cartilage, from snout tip along anterior disc margin almost to its apex (patch expanded medially beside orbit, denticles grading in size into thornlets of malar patch, extending almost to orbit), fine granular denticles scattered on posterior disc and over dorsal fins; on ventral surface of holotype, present over anterior three-quarter of rostral cartilage (much larger anteriorly), beside mouth, and extending as a narrow band along anteroventral margin of disc (from snout tip to almost level with mouth); villiform, slightly longer and more widely separated on dorsal head than on ventral head in adult male. Denticles of primary female paratype more widespread than large males; anterodorsal band along disc margin narrow (often naked or denticles sparse, prepropterygial snout naked in all but largest females), disjunct beside orbit; fine granular denticles scattered randomly over body, densest along dorsal midline of posterior disc and tail; interorbit naked; dorsal and caudal fins with granular denticles; on ventral surface, denticles largest on anterior snout, with stellate bases, scattered patchily over ventral disc (densest on preoral head and along anteroventral margin, and around cloaca). Primary juvenile paratype naked, obvious on snout tip and along anteroventral margin of disc by about 210 mm TL.

Meristics (n=12): Tooth rows in upper jaw 36 (35–41); lower jaw 36 (34–41). Pectoral-fin propterygial radials 30 (28–31); mesopterygial radials 16 (16–18); metapterygial radials 39 (37–40); total radials 85 (83–88). Pelvic-fin radials males (n=9) 1 (1) + 20 (18–20); females (n=3) (1) + (18–22). Trunk centra 28 (26–31); predorsal caudal centra 56 (52–56); predorsal centra 84 (78–85); centra between origins of dorsal fins 14 (13–15); diplospondylous centra about 114 (101–110); total centra about 142 (130–141).

COLOUR (in preservative).— Dorsal surface of disc (including orbital membranes), pelvic fins, clasper and tail of holotype mostly uniformly medium brown (pale areas where skin removed, paratypes varying from pale greyish to dark brown); slightly darker brown on tip of posterior lobe of pelvic fin but not significantly paler along posterior disc margin; rostrum not strongly demarcated from adjacent snout. Ventral disc of holotype darker brownish to brownish black, somewhat blotchy; snout tip darker than rest of snout; anteroventral margin of disc not markedly paler than areas adjacent; posterior outer disc dark brown, demarcated slightly from paler areas on head; upper lip bordering tooth band usually blackish, markedly paler anteriorly; tips of anterior lobe and fork of pelvic fin dark brown, margin of posterior lobe pale; tail blotchy, mostly dark brown; dorsal fins dusky, blotchy, margins darkest, caudal fin slightly paler brown. Primary female paratype very similar to holotype

on both surfaces (with large black spot ventrally near snout tip and other smaller spots posteriorly, paratypes often with similar spots in other locations). Specimens from eastern Australia are often darker dorsally than those from southern Australia. Primary juvenile medium brownish above and below, rostral cartilage not sharply demarcated from rest of snout; posterior margins and apex of disc and posterior margins of pelvic fins blackish on both surfaces (retained up to about 600 mm TL), more pronounced and extending further anteriorly on ventral surface (to about level of mouth); dark margin along disc bordered internally by a broad, pale yellowish band; dorsal fins black (retained up to about 650 mm TL, then becoming dusky); caudal fin black with pale margin (otherwise mostly black); sensory pores without dark edges, not demarcated.

SIZE.— Largest specimen a female 1371 mm TL; adolescent males ranged between 776 and ca. 855 mm TL, adult males ca. 890 to ca. 950 mm TL (tail tips damaged); smallest juvenile 202 mm TL.

DISTRIBUTION.— Continental slope off southern Australia from east of Crowdy Head, New South Wales (31°52' S, 153°16' E), to the Great Australian Bight, Western Australia (33°40' S, 127°17' E), including Tasmania, in depths of 446–1328 m (mainly 800–1000 m).

ETYMOLOGY.— Name derived from the Greek *acrobeles* (arrow, or pointed at the end) in allusion to its long, angular snout and somewhat arrow-head shaped body. Vernacular name: Deepwater Skate

REMARKS.— *Dipturus acrobela* belongs to a subgroup of Australian species of *Dipturus* that all have a very long, pointed snout (mean preorbital length exceeding 24% TL in adults). These species, *D. gudgeri* and another new species that is described in this paper (i.e. *D. queenslandicus*), differ markedly in pectoral-fin radial counts. *Dipturus acrobela* has more pectoral-fin radials (83–88 vs. 77–80) and more predorsal diplospondylous centra (52–56 vs. 46–50) than its northern relative *D. queenslandicus*, and is a much larger species (attaining 137 vs. 76 cm TL and males mature by about 89 vs. about 63 cm TL). The species also differ subtly in colour and in morphometrics. The holotype of *D. gudgeri* (AMS E 4284) has more pectoral-fin radials (i.e. 103–104) and more predorsal diplospondylous centra (i.e. 58) than either of these species. Also, *D. gudgeri* is relatively darker dorsally (usually greyish green rather than pale greyish or greyish brown, Fig. 7) and lacks a nuchal thorn (otherwise usually present in the other species). A shallow-water skate, *Zearaja maugeana* Last & Gledhill 2007, also has a long, pointed snout similar to these species but can be distinguished from them by its almost black dorsal surface, broad thorny tail, and spatulate claspers.

A



B

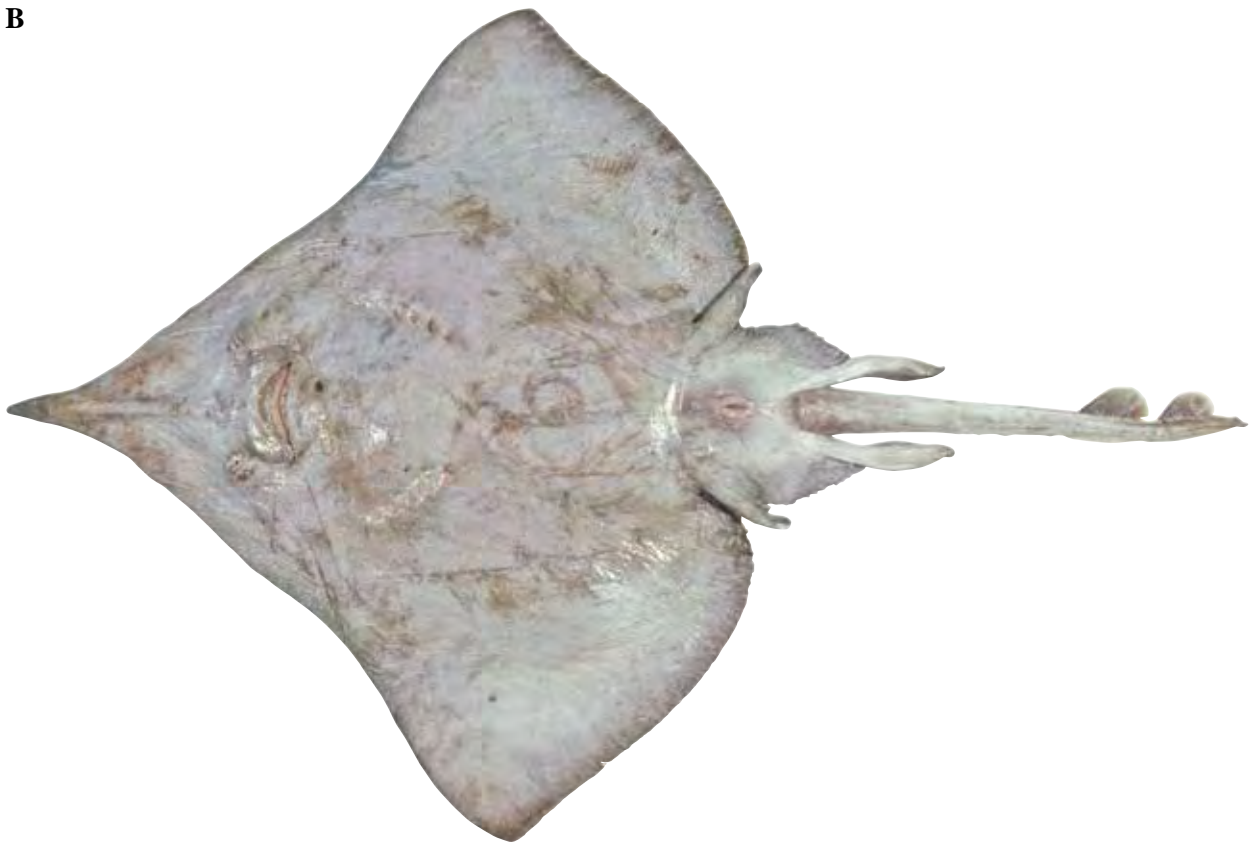


Figure 7. *Dipturus gudgeri*, adolescent male (CSIRO H 599–01, 1282 mm TL, fresh): A, dorsal surface; B, ventral surface.

Dipturus skates are not known to have very widespread distributions across multiple ocean basins so it is unlikely that any of the species from the Australian region occur elsewhere. Australasian species have restricted distributions even within the region. The single New Zealand species, *Dipturus innominata* (Garrick & Paul, 1974), is not conspecific with any Australian species (Last & Yearsley, 2002). *Dipturus doutrei* (Cadenat 1960), another large skate from the eastern Atlantic, is similar in body shape but has fewer tooth rows (29–34 vs. 35–41), lacks a nuchal thorn, and has a darker dorsal surface. Other similar *Dipturus* species exist in other regions but their relationships to *D. acrobelus* and to each other has not been adequately researched. A review of the group is needed.

Morphometric data for adult male *Dipturus acrobelus* are presently unavailable. Mature specimens of *Dipturus acrobelus* had damaged tails and could not be used for morphometrics; hence an early adolescent male was selected as the holotype.

Dipturus apricus sp. nov.

Figs 8–13; Table 1

Raja sp. G: Last & Stevens, 1994: pp 301, 332–333, fig. 34.22, key fig. 12, pl. 57; Daley, Stevens, Last & Yearsley, 2002: pp 40, fig.

Holotype. CSIRO H 601–01, adult male 598 mm TL, south of Saumarez Reef, Queensland, 22°35' S, 153°40' E, 314–319 m, 16 Nov 1985.

Paratypes. 23 specimens. AMS I 25800–047, female 680 mm TL, north-east of Hinchinbrook Island, in Townsville Trough, Queensland, 17°57' S, 146°59' E, 200–222 m, 08 Jan 1986; AMS I 25808–022, female 652 mm TL, north-east of Hinchinbrook Island, Townsville Trough, Queensland, 17°57' S, 147°02' E, 298–306 m, 11 Jan 1986; AMS I 25809–013, female 470 mm TL, north-east of Hinchinbrook Island, Townsville Trough, Queensland, 17°57' S, 147°03' E, 300 m, 11 Jan 1986; CSIRO H 600–03, late adolescent male 644 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°47' S, 154°14' E, 492 m, 17 Nov 1985; CSIRO H 617–09, juvenile male 235 mm TL, CSIRO H 617–10, female 253 mm TL, Saumarez Plateau, Queensland, 22°10' S, 153°29' E, 303–333 m, 19 Nov 1985; CSIRO H 626–04, juvenile male 393 mm TL, Marian Plateau, north of Swain Reefs, Queensland, 20°24' S, 152°54' E, 440–458 m, 22 Nov 1985; CSIRO H 692–01, adult male 659 mm TL, CSIRO H 692–02, juvenile male 399 mm TL, CSIRO H 692–04, female 361 mm TL, CSIRO H 692–05, juvenile male 348 mm TL, CSIRO H 692–06, female 314 mm TL, north-east of Swain Reefs, Marian Plateau, Queensland, 20°38' S, 152°50' E, 398–399 m, 22 Nov 1985; CSIRO H 699–02, female 326 mm TL, south of Saumarez Reef, Queensland,

22°42' S, 154°05' E, 416–419 m, 17 Nov 1985; CSIRO H 715–03, juvenile male 411 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°49' S, 154°10' E, 445–450 m, 17 Nov 1985; CSIRO H 718–25, female 735 mm TL, Capricorn Channel, east of Rockhampton, Queensland, 22°52' S, 152°42' E, 225–282 m, 19 Nov 1985; CSIRO H 947–14, female 449 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°56' S, 154°21' E, 590–606 m, 17 Nov 1985; CSIRO H 1113–09, juvenile male 167 mm TL, south of Saumarez Reef, Queensland, 22°06' S, 153°18' E, 246–254 m, 19 Nov 1985; CSIRO H 1114–02, female 249 mm TL, east of Townsville, Queensland, 19°01' S, 149°28' E, 397–415 m, 26 Nov 1985; CSIRO H 3643–12, female 598 mm TL, north-east of Hinchinbrook Island, Queensland, 17°55' S, 146°56' E, 227–249 m, 30 Nov 1993; NMV A 29737–001, adolescent male 542 mm TL, NMV A 29737–002, female 612 mm TL, north-east of Hinchinbrook Island, Townsville Trough, Queensland, 17°57' S, 147°03' E, 300 m, 10 Jan 1986; QM I 19317, female 690 mm TL, north-east of Capricorn Group, Queensland, 22°54' S, 152°12' E, 348–366 m, 03 Oct 1980; QM I 19320, adolescent male 519 mm TL, mid coast of Queensland, 1980.

Other material. 24 specimens. CSIRO H 450–02, female 540 mm TL, north-east of Hinchinbrook Island, Townsville Trough, Queensland, 17°57' S, 147°03' E, 300 m, 11 Jan 1986; CSIRO H 457–04, female 549 mm TL, north-east of Hinchinbrook Island, Townsville Trough, Queensland, 17°57' S, 147°03' E, 300 m, 10 Jan 1986; CSIRO H 460–03, adult male 549 mm TL, north-east of Hinchinbrook Island, Townsville Trough, Queensland, 17°57' S, 147°02' E, 298–306 m, 11 Jan 1986; CSIRO H 629–02, female >525 mm TL (tail tip damaged), CSIRO H 629–03, female >363 mm TL (tail tip damaged), CSIRO H 629–04, juvenile male >444 mm TL (tail tip damaged), CSIRO H 629–05, female >355 mm TL (tail tip damaged), north-east of Swain Reefs, Marian Plateau, Queensland, 20°44' S, 152°35' E, 350–362 m, 22 Nov 1985; CSIRO H 692–03, female >322 mm TL (tail tip damaged), north-east of Swain Reefs, Marian Plateau, Queensland, 20°38' S, 152°50' E, 398–399 m, 22 Nov 1985; CSIRO H 698–01, female 576 mm TL, CSIRO H 698–02, adolescent male >470 mm TL (tail tip damaged), north-east of Whitsunday Island group, Marian Plateau, Queensland, 19°29' S, 150°17' E, 324–328 m, 15 Nov 1985; CSIRO H 699–01, female >469 mm TL (tail tip damaged), south of Saumarez Reef, Queensland, 22°42' S, 154°05' E, 416–419 m, 17 Nov 1985; CSIRO H 712–02, female 765 mm TL, CSIRO H 712–03, adolescent male >550 mm TL (tail tip damaged), south of Saumarez Reef, Queensland, 22°10' S, 153°29' E, 303–333 m, 19 Nov 1985; CSIRO H 715–08, female 587 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°49' S, 154°10' E, 445–450 m, 17 Nov 1985; CSIRO H 718–26, female 668 mm TL, Capricorn Channel, east of Rockhampton, Queensland, 22°52' S, 152°42' E, 225–282 m, 19 Nov 1985; CSIRO H 720–11, female 155 mm TL, south of Saumarez Reef,

Queensland, 23°12' S, 153°33' E, 399–405 m, 18 Nov 1985; CSIRO H 1119–02, juvenile male 166 mm TL, north-west of Saumarez Reef, Queensland, 21°18' S, 153°29' E, 459–462 m, 21 Nov 1985; CSIRO H 1557–10, adult male 588 mm TL, north-east of Townsville, Townsville Trough, Queensland, 17°53' S, 146°59' E, 300–304 m, 29 Nov 1985; CSIRO H 2469–06, female 522 mm TL, CSIRO H 2469–07, female 628 mm TL, north-east of Hinchinbrook Island, in Townsville Trough, Queensland, 17°58' S, 147°01' E, 260–264 m, 10 Jan 1986; CSIRO H 3402–02, female 150 mm TL, north-east of Hinchinbrook Island, Queensland, 17°53' S, 146°53' E, 196 m, 09 Dec 1985; CSIRO H 6637–01, adolescent male 520 mm TL, north-east of Hinchinbrook Island, in Townsville Trough, Queensland, 17°57' S, 147°01' E, 260–264 m, 10 Jan 1986; QM I 19289, juvenile male 332 mm TL, east of Bunker Group, Queensland, 23°59' S, 152°47' E, 293 m, 15 Sep 1980; QM I 19318, adult male 617 mm TL, east of Bunker Group, Queensland, 23°36' S, 152°43' E, 357–375 m, 30 Sep 1980.

DIAGNOSIS.— A medium-sized species of *Dipturus* (to 76.5 cm TL) with the following combination of characters: disc relatively broad with angular apices, width 67–71% TL, 1.1–1.2 times its length; snout angle 68–77°; tail length 0.7–0.8 in distance from snout tip to rear of cloaca; tail relatively slender, width 1.4–1.7 times height at its midlength, 1.4–1.8 times at first dorsal-fin origin; pre-upper jaw length 18–22% TL, 2.4–2.8 times internasal width; ventral head length 33–36% TL; snout length 4.1–4.8 times interorbital width; orbit diameter 52–72% interorbital width; first dorsal-fin height 1.8–2.4 in its base length; distance from first dorsal-fin origin to tail tip 2.9–3.6 times first dorsal-fin base length, 3.0–3.9 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males 15–17% TL, length of anterior lobe 67–69% of posterior lobe; adult clasper relatively short, 23–27% TL, connected to pelvic-fin inner margin at about 36–41% of its length from cloaca; anterior margins of both surfaces of disc with narrow bands of fine denticles in late adolescent and adult males; no nuchal or malar thorns; tail with a single thorn row in males, 1–2 additional pairs of variably developed lateral rows in largest females; total pectoral radials 86–91; trunk centra 28–31; predorsal centra 75–83; total centra about 128–140; tooth rows in upper jaw 32–40; mainly uniformly greyish brown dorsally; mostly darker greyish brownish (blotchy) ventrally, snout tip usually blackish; ventral sensory pores small, distinct, black-edged, not surrounded by greyish blotches.

DESCRIPTION.— Disc quadrangular, 1.12 times as broad as long in adult male holotype (1.15–1.20 times in paratypes); angle in front of spiracles 68° (71–77°); axis of greatest width 59% (58–63%) of disc length; anterior margin strongly double concave in adult males and large females (slightly less pronounced in juveniles), concave anteriorly, straight to weakly convex beside and just forward of eyes, deeply concave just beside

level of spiracles; apex angular (narrowly rounded in juveniles); posterior margin weakly convex; free rear tip very broadly rounded. Head long, preorbital snout length 6.18 (6.54–7.91) times orbit length, 4.40 (4.14–4.80) times interorbit; pre-upper jaw length 2.42 (2.39–2.75) times internarial distance. Snout tip very well produced, narrowly pointed; no fleshy process at apex. Orbit small, diameter 0.71 (0.52–0.72) times interorbital width. Spiracle large, length 1.67 (1.45–2.07) in orbit diameter; opening mainly tear-drop shaped. Nostril subrectangular, often distorted; anterior nasal flap expanded slightly, its lateral margin forming a short semi-circular tube; anterior margin of flap weakly lobe-like, not or partly concealed beneath nasal curtain; posterior inner margin concealed beneath nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with thick fringe; internarial distance 1.67 (1.67–1.83) in distance between first gill slits, 1.01 (0.99–1.12) in distance between fifth gill slits. Upper jaw strongly arched (less arched in females and juveniles), indented at symphysis (slightly indented in adult male paratype, not indented in other paratypes); lower jaw strongly convex at all sizes; lateral teeth of upper jaw not or partly concealed by lobe of nasal curtain. Teeth of adult male holotype strongly unicuspid, with subcircular bases; arranged in longitudinal rows rather than in quincunx; medial cusps long, conical, bluntly pointed, posteriorly directed in upper jaw; cusps much shorter and slightly oblique laterally; teeth of female paratypes with broadly oval bases and relatively broad-based, blunt subtriangular cusps (more so near jaw symphysis), arranged in defined rows; teeth of primary juvenile paratype (CSIRO H 617–09) with prominent cusps.

Pelvic fins of medium size, deeply forked; anterior lobe short, slender, bluntly pointed distally, lateral margin entire, inner margin deeply incised; posterior lobe moderately elongate, much longer in adult males (length 15.5–16.8% TL) than in females (length 12.3–13.7% TL), lateral margin convex; inner margin almost straight, connected to lateral margin of clasper at 36–41% of its postcloacal length; anterior lobe 0.69 (0.67–0.95) times posterior lobe. Clasper elongate, 23–27% TL, slender, slightly depressed, glans expanded slightly; clasper components include proximal slit and distal cleft, terminal bridge, pseudorhipidion, rhipidion, shield, spike and large sentinel; denticles and pseudosiphon absent. Tail rather slender, weakly depressed (slightly more depressed in primary female paratype CSIRO H 3643–12); narrow at base, initially tapering strongly, then very gradually to first dorsal-fin origin, not expanded at its midlength; tapering evenly and gradually to tail tip behind second dorsal fin; width at insertions of pelvic fins 2.43 (1.85–2.74) times width at midlength of tail and 2.27 (1.73–2.57) times width at first dorsal-fin origin; length from rear of cloaca 0.79 (0.73–0.85) times distance from tip of snout to rear of cloaca; anterior cross-section narrowly oval, equally convex dorsally and ventrally,

Table 1. Morphometrics for the holotype of *Dipturus acrobelus* sp. nov. (CSIRO H 226–01), ranges for measured paratypes (n=7), and means for all morphometric types; and the holotype of *Dipturus apricus* sp. nov. (CSIRO H 601–01), ranges for measured paratypes (n=6), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Dipturus acrobelus</i> sp. nov.				<i>Dipturus apricus</i> sp. nov.			
	Holotype	Paratypes		Mean	Holotype	Paratypes		Mean
		Min.	Max.			Min.	Max.	
Total length (mm)	841	449	1346		598	449	742	
Disc width	68.0	66.5	71.0	68.1	67.2	67.0	70.8	68.8
Disc length (direct)	59.5	58.4	62.3	60.0	59.9	57.0	60.2	59.0
Snout to maximum width	38.8	37.3	42.9	39.4	35.3	32.9	37.5	35.2
Snout length (preorbital direct)	23.0	23.3	26.1	24.6	20.2	19.1	22.5	21.2
Snout to spiracle	27.2	27.4	30.4	28.7	25.2	23.8	27.1	25.9
Head (dorsal length)	28.3	29.1	31.2	30.0	27.2	25.3	28.6	27.5
Orbit diameter	3.1	2.7	3.4	3.1	3.3	2.8	3.4	3.1
Orbit and spiracle length	4.5	3.9	4.5	4.2	4.9	4.4	4.9	4.6
Spiracle length (main aperture)	1.4	1.4	1.6	1.5	2.0	1.6	2.1	1.8
Distance between orbits	4.2	3.6	4.8	4.1	4.6	4.4	5.3	4.7
Distance between spiracles	5.8	5.6	6.4	5.9	6.2	6.0	6.3	6.1
Snout to cloaca (to 1st hemal spine)	55.4	53.3	58.1	55.4	55.9	54.1	57.7	56.2
Cloaca to D1	29.2	25.6	29.3	28.2	26.8	26.4	28.5	27.2
Cloaca to D2	35.2	31.6	35.5	34.3	33.6	31.9	35.7	34.0
Cloaca to caudal origin	39.9	36.3	39.9	38.8	38.7	36.9	41.4	39.0
Distance-cloaca to caudal-fin tip	44.5	41.6	46.1	44.3	43.4	42.0	46.1	43.7
Ventral snout length (pre upper jaw)	23.8	24.4	26.7	25.4	19.5	18.2	22.3	20.6
Prenasal length	21.3	21.6	24.1	22.8	17.0	15.8	19.7	18.1
Ventral head length (to fifth gill)	35.6	34.6	37.8	36.0	34.4	32.7	35.7	34.6
Mouth width	7.1	6.2	7.2	6.7	9.3	8.0	9.0	8.5
Distance between nostrils	8.0	7.6	8.3	8.0	8.0	7.6	8.2	7.9
Nasal curtain length	4.6	3.9	4.5	4.3	5.8	5.0	5.4	5.3
Nasal curtain (total width)	8.1	7.7	8.1	8.0	9.4	8.6	9.3	8.9
Nasal curtain (min. width)	5.7	5.1	5.7	5.5	6.7	6.5	6.8	6.6
Nasal curtain (lobe width)	1.4	1.2	1.3	1.2	1.0	1.0	1.3	1.2
Width of first gill opening	1.2	1.1	1.5	1.3	1.3	1.3	1.7	1.4
Width of fifth gill opening	1.2	0.9	1.3	1.1	1.1	1.0	1.4	1.2
Distance between first gill openings	12.2	11.7	13.1	12.4	13.4	13.1	14.7	13.7
Distance between fifth gill openings	7.9	7.2	8.8	7.9	8.1	7.9	9.0	8.4
Clasper (post cloacal length)	–	–	–	–	26.6	–	23.1	24.9
Length of anterior pelvic lobe	11.2	10.0	13.4	11.8	11.6	10.2	11.7	11.0
Length of posterior pelvic lobe	13.3	12.0	13.2	12.7	16.8	12.3	15.5	14.1
Pelvic base width	7.0	6.3	8.0	7.0	7.5	7.7	8.4	7.9
Tail at axil pelvic fins (width)	2.9	2.5	3.4	2.8	4.0	3.6	4.1	3.8
Tail at axil pelvic fins (height)	2.1	1.8	2.1	2.0	2.4	2.0	2.6	2.2
Tail at midlength (width)	2.0	1.8	2.0	1.9	1.7	1.5	1.9	1.8
Tail at midlength (height)	1.2	1.1	1.3	1.2	1.2	1.0	1.2	1.1
Tail at D1 origin (width)	2.0	1.6	2.0	1.9	1.8	1.6	2.2	1.9
Tail at D1 origin (height)	1.3	1.0	1.2	1.2	1.2	1.0	1.2	1.2
D1 base length	4.7	4.1	5.6	4.7	5.7	4.4	6.0	5.4
D1 height	2.7	2.4	3.4	2.8	3.1	2.1	3.0	2.6
D1 origin to caudal-fin tip	15.3	13.3	17.9	16.1	16.6	15.7	17.8	16.5
D2 origin to caudal-fin tip	9.3	8.2	11.7	10.0	9.9	9.1	10.4	9.7
Caudal-fin length	4.5	4.4	6.8	5.5	4.8	4.1	5.2	4.7

A



B



Figure 8. *Dipturus apricus* sp. nov., adult male holotype (CSIRO H 601–01, 598 mm TL, fresh): A, dorsal surface; B, ventral surface.

A



B



Figure 9. Dorsal surface of *Dipturus apricus* sp. nov.: A, female paratype (CSIRO H 947–14, 449 mm TL, fresh); B, primary juvenile paratype (CSIRO H 617–09, male 235 mm TL, preserved).



Figure 10. Dorsal head of *Dipturus apricus* sp. nov., adult male holotype (CSIRO H 601–01, 598 mm TL), showing snout, orbito-spiracular and nuchal regions.

more strongly convex on dorsal surface than ventral surface posteriorly; ventral surface almost flat ventrally on postdorsal tail; width 1.68 (1.51–1.89) times height at insertion of pelvic fin, 1.37 (1.46–1.73) times height at midlength, 1.46 (1.37–1.78) times height at first dorsal fin origin; lateral tail fold weak, narrow, relatively short-based, slightly less well developed in adult males than females or juveniles, originating as a fleshy ridge near rear tip of pelvic fin, terminating slightly forward of tail tip, marginally broader beneath second dorsal fin. Dorsal fins small, of similar shape, first dorsal fin usually slightly taller and more upright than second; first dorsal-fin height 1.84 (1.87–2.43) in base length; fins strongly raked, low, with moderately elongate bases; anterior margins of both fins weakly convex, apices broadly rounded, posterior margins short, strongly convex; free rear tip broadly rounded (usually blending into posterior margin); inner margins short, either directed anteroventrally or almost upright; second dorsal-fin base not longer than first dorsal-fin base; interdorsal space moderate, 5.37 (3.11–4.17) times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 4.00 (2.93–3.59) times dorsal-fin base length, 2.83 (3.02–3.94) times caudal-fin length; first dorsal-fin base 0.71 (0.84–1.33) times caudal-fin length. Epichordal caudal-fin lobe well developed, long-

based, low, height subequal to half tail width at fin origin (as a low ridge in primary juvenile paratype); usually taller posteriorly than anteriorly; tapering distally, its dorsal margin convex; connected sub-basally to second dorsal fin; hypochordal caudal lobe rudimentary.

Dorsal surface of adult male holotype with weak orbito-spiracular (not forming a rosette) and tail thorns, and well-developed alar thorn patch; no malar or nuchal thorns; no thorns along mid-disc or in scapular region; primary female paratype with small orbital and better developed tail thorns; primary juvenile paratype with weak orbital and small tail thorns. Main orbital thorns of holotype about 4–5 (3–4 on preorbit, absent on midorbit, 1 on postorbit), 5–7 thorns in adult male paratype, not forming a rosette; thorns variable in size, very short, usually blunt, broad based, somewhat deciduous, often damaged distally; anteriormost thorns with connected bases, not flanked by thornlets, posterior thorn beside hind margin of orbit. Primary female paratype with 3 (undamaged state probably 4) orbital thorns (2–3 on preorbit, absent on midorbit, 0–1 on postorbit, a pale scar on side of each orbit indicates that thorns have been removed), 3–5 in other female paratypes, thorns not forming a rosette, similar in shape and position to holotype, anteriormost



Figure 11. Ventral view of *Dipturus apricus* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 601–01, 598 mm TL); B, primary female paratype (CSIRO H 3643–12, 598 mm TL).



Figure 12. Lateral view of dorsal and caudal fins of *Dipturus apricus* sp. nov., adult male holotype (CSIRO H 601–01, 598 mm TL).



Figure 13. Thorns at tail midlength of *Dipturus apricus* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 601–01, 598 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 3643–12, 598 mm TL).

thorns connected basally. Primary juvenile paratype with short bulbous thorns (2 on preorbit, 1 on postorbit), medial thorns directed posteriorly, anterolateral thorn directed laterally. Alar thorns in holotype about 27 (18–19 in adult male paratype), in 2 semi-regular rows; well developed, slightly longer than tail thorns, deeply embedded, tips pungent, directed slightly posteromedially; patch long, more than twice orbit diameter. Tail thorns of adult male holotype short, well developed, pungent, weakly recurved, strongly tilted; in single continuous, linear, median row, not paired; row commencing beside pelvic-fin insertion, extending to dorsal fin, with 13 (7 main thorns and about 6 much shorter interstitial thorns); main thorns not preceded by interstitial thorns, anteriormost thorns short; usually without dermal flaps on their posterior bases; interdorsal thorns 2 (3). Tail of primary female paratype with 3 (5 in largest female paratypes) rows of thorns, lateral rows usually rudimentary; median row moderately elongate, commencing near free rear tips of pelvic fin, extending continuously along length of predorsal tail in a single linear series, with 14 predorsal thorns (6 main thorns and 8 smaller interstitial and low, broad-based thorns), 9–22 in median row of other female paratypes, main thorns not preceded by interstitial thorns; dorsolateral rows reduced to 1–2 (2–4 in other female paratypes) thorns on each side beside anteriormost thorn of median row, thorns short, broad based; lateral rows commencing near posterior thorns of dorsolateral rows, barely extending past midtail; interdorsal thorns 1 (1–3 in other female paratypes). Primary juvenile paratype with single median row, commencing near level of pectoral-fin insertion, with 10 short, strongly raked predorsal thorns; one interdorsal thorn present.

Denticles of adult males poorly developed, most of disc and tail naked. In holotype, denticles on dorsal surface confined to small patch on snout tip and narrow band along anterolateral margin of disc (from anterior tip of propterygium almost to front of alar patch); on ventral surface present over most of preoral snout and extending as narrow band along anteroventral margin of disc (from snout tip almost level of first gill slit); granular, longer and more widely separated on dorsal head than on ventral head. Denticles of primary female paratype confined to snout tip on dorsal surface (absent from disc margin); ventrally, similar to holotype. Primary juvenile paratype with narrow denticle band on ventral head to about level of mouth, otherwise naked.

Meristics (n=10): Tooth rows in upper jaw 40 (32–40); lower jaw 37 (30–36). Pectoral-fin propterygial radials 31 (30–35); mesopterygial radials 17 (16–18); metapterygial radials 40–41 (36–41); total radials 88–89 (86–91). Pelvic-fin radials males (n=6) 1 (1) + 21 (20–22); females (n=4) (1) + (21–23). Trunk centra 28 (28–31); predorsal caudal centra 50 (47–53); predorsal centra 78 (75–83); centra between origins of dorsal fins 15 (13–15); diplospondylous centra about 102 (99–109); total centra about 130 (128–140).

COLOUR (in preservative).— Dorsal surface of disc and pelvic fins mostly uniformly greyish brown (often darkest centrally); slightly paler along narrow anterior margin and broader posterior margins of disc and pelvic fins; tail and claspers slightly darker brown; rostrum dark brown, strongly demarcated from rest of snout, area adjacent whitish, much paler than central disc; thorns and alar patch dusky, not obvious; orbital membrane brownish, semi-translucent. Dorsal fins with dusky bases, paler yellow to translucent distally; epichordal lobe of caudal fin with pale base, dusky distally. Ventral surface of disc mostly dark; dark brownish (blotchy) on most of disc and pelvic fins, only slightly paler along posterior margin of disc; whitish over most of denticle band on ventral head and beside rostrum, on mouth, nostrils and cloaca, and along posterior margins of pelvic fins; membranes of gill slits narrowly pale (not strongly demarcated from darker areas adjacent); snout tip blackish; tail and clasper mostly uniformly white; sensory pores small, distinct, black-edged, not surrounded by indistinct dusky blotches, very obvious on preoral snout, much less obvious posteriorly. Primary female paratype extremely similar to male holotype dorsally, ventrally and on fins; tail with brownish patches. Primary juvenile slightly paler brown dorsally and ventrally than adults; pale areas, and margins of mouth, nasal flap and gill slits, better defined; dorsal fins pale brownish with translucent margins; sensory pores dark edged, strongly demarcated.

SIZE.— Largest specimen a female 765 mm TL; adolescent males ranged between ca. 470 (tail tip damaged) and 644 mm TL, adult males 549–659 mm TL; smallest juvenile 150 mm TL.

DISTRIBUTION.— Upper continental slope off Queensland from north-east of Hinchinbrook Island (17°53' S, 146°53' E) to east of the Bunker Group (23°59' S, 152°47' E) in depths of 196–606 m (mainly in 300–500 m).

ETYMOLOGY.— From the Latin *apricus* (meaning exposed to the sun) in cryptic reference to its common name. Vernacular name: Pale Tropical Skate.

REMARKS.— *Dipturus apricus* is distinguishable from all other Australian skates based on its unique clasper morphology characterised by a greatly enlarged sentinel and reduced shield (Last & Yearsley, 2002). Its range partly overlaps with two other, undescribed northeastern species (treated in this paper as *D. melanospilus* and *D. queenslandicus*) which both have an elongate snout and attain about 70–80 cm TL as adults. These species can be distinguished from *D. apricus* based on colour, pectoral-fin radial count, relative width of the disc and interorbit, and the preorbit to orbit diameter ratios. Of the remaining Australian skates, *Dipturus apricus* is most similar morphologically to a new species from northwestern Australia (i.e. *D. healdi*), but has a longer interdorsal distance (1.1–1.7% vs. 0.2–0.5% TL), broader

disc (width 67–71% vs. 64–68% TL), and shorter distance from snout tip to its axis of maximum width (33–38% vs. 38–40% TL).

***Dipturus healdi* sp. nov.**

Figs 14–19; Table 2

Raja sp. F: Last & Stevens, 1994: pp 301, 330–331, fig. 34.21, key fig. 17, pl. 58.

Holotype. CSIRO H 4071–15, adult male 579 mm TL, south-west of Rowley Shoals, Western Australia, 18°02' S, 118°14' E, 388–392 m, 09 Sep 1995.

Paratypes. 22 specimens. CSIRO CA 2827, adult male 551 mm TL, CSIRO CA 2828, female 505 mm TL, south-west of Imperieuse Reef, Western Australia, 18°08' S, 118°04' E, 404 m, 03 Apr 1982; CSIRO CA 3911, female 402 mm TL, south-west of Rowley Shoals, Western Australia, 17°35' S, 118°37' E, 496–504 m, 05 Feb 1983; CSIRO CA 4364, adult male 557 mm TL, south-west of Rowley Shoals, Western Australia, 17°59' S, 118°20' E, 396–402 m, 27 Jan 1984; CSIRO CA 4368, juvenile male 211 mm TL, east of Rowley Shoals, Western Australia, 17°18' S, 120°09' E, 304–305 m, 04 Feb 1984; CSIRO CA 4381, female >563 mm TL (tail tip damaged), south-west of Rowley Shoals, Western Australia, 18°43' S, 117°03' E, 404 m, 31 Jan 1984; CSIRO CA 4383, female 321 mm TL, south-west of Rowley Shoals, Western Australia, 18°05' S, 118°12' E, 402–408 m, 28 Jan 1984; CSIRO CA 4394, adult male 525 mm TL, south-west of Imperieuse Reef, Western Australia, 18°01' S, 118°14' E, 406–416 m, 28 Jan 1984; CSIRO CA 4406, juvenile male 155 mm TL, south-east of Scott Reef, Western Australia, 14°12' S, 122°32' E, 348–350 m, 14 Feb 1984; CSIRO H 1207–03, female >565 mm TL (tail tip damaged), north-west of Port Hedland, Western Australia, 18°20' S, 117°50' E, 430 m, Oct 1987; CSIRO H 1636–03 (2 specimens), juvenile male 138 mm TL, female 139 mm TL, Rowley Shoals area, Western Australia, 17°49' S, 118°29' E, 410 m, 24 Aug 1988; CSIRO H 1650–01, female 567 mm TL, south-west of Rowley Shoals, Western Australia, 18°36' S, 117°20' E, 425 m, 20 Aug 1988; CSIRO H 1652–04, juvenile male 157 mm TL, north-west of Port Hedland, Western Australia, 18°25' S, 117°48' E, 375 m, 21 Aug 1988; CSIRO H 2273–03, female 402 mm TL, north-east of Mermaid Reef (Rowley Shoals), Western Australia, 17°00' S, 120°22' E, 404 m, 06 Apr 1989; CSIRO H 2897–05, adolescent male 380 mm TL, CSIRO H 2897–06, adolescent male 424 mm TL, south-west of Rowley Shoals, Western Australia, 18°03' S, 118°13' E, 395–407 m, 27 Sep 1991; CSIRO H 4071–14, female 302 mm TL, CSIRO H 4071–16, female >673 mm TL (tail tip damaged), collected with holotype; WAM P 28074–005, female 293 mm TL, south-west of Rowley Shoals, Western Australia, 17°42' S, 118°38' E, 402–404 m, 18 Aug 1983; WAM P 28081–003, adult male 587 mm TL, north-east of Rowley Shoals, Western

Australia, 16°44' S, 120°05' E, 431–433 m, 20 Aug 1983; WAM P 28127–002, juvenile male 356 mm TL, south-west of Rowley Shoals, Western Australia, 18°02' S, 118°16' E, 400 m, 03 Sep 1983.

Other material. 54 specimens. CSIRO CA 2815, female 521 mm TL, CSIRO CA 2816, adult male 542 mm TL, west of Clerke Reef, Western Australia, 17°31' S, 118°39' E, 492–520 m, 10 Apr 1982; CSIRO CA 2830, adolescent male 506 mm TL, CSIRO CA 2831, female >285 mm TL (tail tip damaged), south-west of Imperieuse Reef (Rowley Shoals), Western Australia, 17°50' S, 118°28' E, 404 m, 03 Apr 1982; CSIRO CA 3891, female 414 mm TL, south-west of Rowley Shoals, Western Australia, 17°35' S, 118°37' E, 496–504 m, 05 Feb 1983; CSIRO CA 3906, juvenile male 322 mm TL, CSIRO CA 3907, juvenile male 387 mm TL, CSIRO CA 3908, adult male >552 mm TL (tail tip damaged), south-west of Imperieuse Reef (Rowley Shoals), Western Australia, 18°07' S, 118°09' E, 400–404 m, 05 Feb 1983; CSIRO CA 3909, adolescent male 502 mm TL, CSIRO CA 3910, female 429 mm TL, CSIRO CA 3925, female 476 mm TL, south-west of Rowley Shoals, Western Australia, 17°35' S, 118°37' E, 496–504 m, 05 Feb 1983; CSIRO CA 3930, juvenile male >258 mm TL (tail tip damaged), CSIRO CA 3931, female 293 mm TL, CSIRO CA 3933, female 338 mm TL, CSIRO CA 3935, female >477 mm TL (tail tip damaged), CSIRO CA 3937, female >358 mm TL (tail tip damaged), south of Rowley Shoals, Western Australia, 17°34' S, 119°03' E, 318–360 m, 06 Feb 1983; CSIRO CA 4239, adult male 560 mm TL, CSIRO CA 4240, adult male 500 mm TL, CSIRO CA 4241, female >500 mm TL (tail tip damaged), south-west of Rowley Shoals, Western Australia, 17°35' S, 118°37' E, 496–504 m, 05 Feb 1983; CSIRO CA 4334, adolescent male 413 mm TL, CSIRO CA 4335, female 295 mm TL, CSIRO CA 4336, juvenile male 367 mm TL, CSIRO CA 4337, juvenile male 373 mm TL, CSIRO CA 4338, juvenile male 317 mm TL, south-west of Imperieuse Reef, Western Australia, 17°56' S, 118°21' E, 418–420 m, 05 Feb 1983; CSIRO CA 4340, female 448 mm TL, CSIRO CA 4341, juvenile male 417 mm TL, CSIRO CA 4344, adolescent male 444 mm TL, south-west of Imperieuse Reef, Western Australia, 17°45' S, 118°30' E, 442–460 m, 05 Feb 1983; CSIRO CA 4351, juvenile male 403 mm TL, CSIRO CA 4352, juvenile male 358 mm TL, CSIRO CA 4353, juvenile male >392 mm TL (tail tip damaged), CSIRO CA 4354, female 337 mm TL, CSIRO CA 4355, juvenile male 385 mm TL, south-west of Rowley Shoals, Western Australia, 17°58' S, 118°21' E, 416–420 m, 27 Jan 1984; CSIRO CA 4356, juvenile male 311 mm TL, CSIRO CA 4358, juvenile male >283 mm TL (tail tip damaged); CSIRO CA 4359, juvenile male 335 mm TL, south-west of Rowley Shoals, Western Australia, 18°00' S, 118°18' E, 396–412 m, 28 Jan 1984; CSIRO CA 4363, female 326 mm TL, CSIRO CA 4365, female 357 mm TL, south-west of Rowley Shoals, Western Australia, 17°59' S, 118°20' E, 396–402 m, 27 Jan 1984; CSIRO CA 4380, female 531 mm TL, south-west of Rowley Shoals, Western Australia, 18°43' S,

117°03' E, 404 m, 31 Jan 1984; CSIRO CA 4382, female > 411 mm TL (tail tip damaged), CSIRO CA 4384, juvenile male 377 mm TL, south-west of Rowley Shoals, Western Australia, 18°05' S, 118°12' E, 402–408 m, 28 Jan 1984; CSIRO CA 4386, juvenile male 339 mm TL, CSIRO CA 4387, female >321 mm TL, north-west of Cape Leveque, Western Australia, 15°50' S, 120°39' E, 396–400 m, 10 Feb 1984; CSIRO CA 4388, female >390 mm TL (tail tip damaged), CSIRO CA 4389, female 474 mm TL, south-west of Rowley Shoals, Western Australia, 18°33' S, 117°31' E, 404 m, 01 Feb 1984; CSIRO CA 4393, female 340 mm TL, CSIRO CA 4395, female 328 mm TL, CSIRO CA 4396, juvenile male 288 mm TL, CSIRO CA 4397, female >318 mm TL (tail tip damaged), south-west of Imperieuse Reef, Western Australia, 18°01' S, 118°14' E, 406–416 m, 28 Jan 1984; CSIRO CA 4401, female 286 mm TL, south-east of Scott Reef, Western Australia, 14°12' S, 122°32' E, 348–350 m, 14 Feb 1984; CSIRO CA 4418, adult male >425 mm TL (tail tip damaged), north of Monte Bello Islands, Western Australia, 19°18' S, 115°42' E, 348–352 m, 29 Jan 1984; CSIRO H 1207–10, adult male 587 mm TL, CSIRO H 1207–11, female >723 mm TL (tail tip damaged), north-west of Port Hedland, Western Australia, 18°20' S, 117°50' E, 430 m, Oct 1987; CSIRO H 2273–01, female >311 mm TL (tail tip damaged), CSIRO H 2273–02, juvenile male >273 mm TL (tail tip damaged), north-east of Mermaid Reef (Rowley Shoals), Western Australia, 17°00' S, 120°22' E, 404 m, 06 Apr 1989.

DIAGNOSIS.— A medium-sized species of *Dipturus* (to 72 cm TL) with the following combination of characters: disc relatively broad with narrowly rounded to angular apices, width 64–68% TL, 1.1–1.2 times its length; snout angle 64–74°; tail length 0.8 in distance from snout tip to rear of cloaca; tail slender, somewhat rounded in cross-section, width 1.5–1.8 times height at its midlength, 1.5–1.8 times at first dorsal-fin origin; pre-upper jaw length 19–22% TL, 2.3–2.7 times internasal width; ventral head length 33–35% TL; snout length 3.9–4.6 times interorbital width; orbit diameter 53–85% interorbital width; first dorsal-fin height 1.6–2.4 in its base length; distance from first dorsal-fin origin to tail tip 2.8–3.2 times first dorsal-fin base length, 2.2–3.2 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males 17–18% TL, length of anterior lobe 69–74% of posterior lobe; adult clasper elongate, 27–28% TL, connected to pelvic-fin inner margin at about 32–33% of its length from cloaca; anterior margins of both surfaces of disc of adult males with bands of granular denticles, dorsal bands absent in juveniles and large females; nuchal thorns usually absent (single weak thorn occasionally present); malar thorn patch small; tail usually with a single thorn row in males, 1–2 additional pairs of variably developed lateral rows in females; total pectoral radials 74–79; trunk centra 26–30; predorsal centra 76–84; total centra about 121–128; tooth rows in upper jaw 34–40; uniformly pale yellowish brown dorsally; greyish centrally with a paler outer disc and tail

ventrally; gill membranes whitish, strongly demarcated from adjacent ventral head; ventral sensory pores small, distinct, black-edged, sometimes surrounded by small dusky blotches.

DESCRIPTION.— Disc quadrangular, 1.17 times as broad as long in adult male holotype (1.11–1.17 times in paratypes); angle in front of spiracles 68° (64–74°); axis of greatest width 70% (66–70%) of disc length; anterior margin strongly double concave (less pronounced in females and juveniles), deeply concave anteriorly, strongly convex beside and just forward of eyes, deeply concave beside level of spiracles in holotype (much less convex forward of eye and beside spiracle in females and juveniles); apex narrowly rounded to angular; posterior margin weakly convex; free rear tip very broadly rounded. Head short, preorbital snout length 5.11 (5.47–7.97) times orbit length, 4.33 (3.88–4.63) times interorbit; pre-upper jaw length 2.44 (2.29–2.73) times internarial distance. Snout tip very well produced, narrowly pointed; no fleshy process at apex. Orbit medium-sized, diameter 0.85 (0.53–0.73) times interorbital width. Spiracle large, length 1.88 (1.39–1.94) in orbit diameter; opening mainly tear-drop shaped. Nostril subrectangular, often distorted; anterior nasal flap expanded slightly, its lateral margin forming a short semi-circular tube; anterior margin of flap weakly lobe-like, not concealed beneath nasal curtain; posterior inner margin concealed beneath nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with well-developed fringe; internarial distance 1.83 (1.65–1.84) in distance between first gill slits, 1.11 (1.02–1.18) in distance between fifth gill slits. Upper jaw moderately arched (sometimes strongly arched in adult male paratypes), indented at symphysis in adult males (less indented in adolescent male paratypes, not indented in females and juveniles); lower jaw strongly convex, weakly double concave and slightly expanded across symphysis in large females; lateral teeth of upper jaw partially concealed by lobe of nasal curtain. Teeth of adult male holotype strongly unicuspid, with subcircular bases; arranged in longitudinal rows rather than in quincunx; medial cusps long, conical, bluntly pointed, posteriorly directed in upper jaw; cusps shorter and slightly more oblique laterally; teeth of female paratypes in defined rows, with broadly oval to subrectangular bases, cusps very short, pungent; teeth of primary juvenile paratype (CSIRO CA 4368) with weak cusps.

Pelvic fins of medium size, deeply forked; anterior lobe moderately elongate, slender, narrowly rounded distally, lateral margin entire, inner margin deeply incised; posterior lobe elongate, much longer in adult males (length 17.1–17.5% TL) than in females (length 12.3–13.2% TL), lateral margin convex (more so in females); inner margin weakly concave (almost straight in female paratypes), connected to lateral margin of clasper at 30–34% of its postcloacal length; anterior lobe 0.74 (0.69–0.92) times posterior lobe. Clasper elongate,

A



B

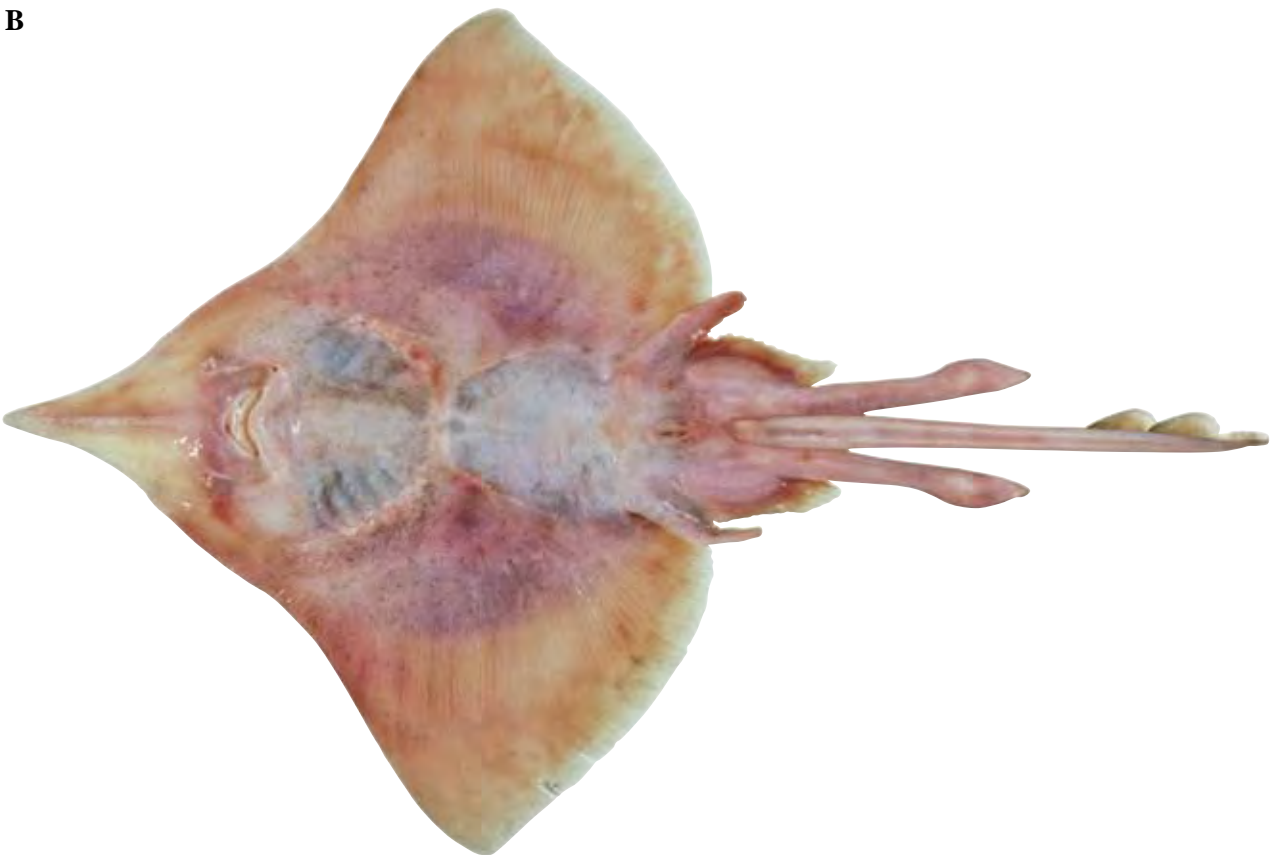


Figure 14. *Dipturus healdi* sp. nov., adult male holotype (CSIRO H 4071–15, 579 mm TL, fresh): A, dorsal surface; B, ventral surface.

A



B



Figure 15. Dorsal surface of *Dipturus healdi* sp. nov.: A, female paratype (CSIRO H 1650–01, 567 mm TL, fresh); B, juvenile paratype (CSIRO H 1652–04, male 157 mm TL, preserved).



Figure 16. Dorsal head of *Dipturus healdi* sp. nov., adult male holotype (CSIRO H 4071–15, 579 mm TL), showing snout, orbito–spiracular and nuchal regions.

27–28% TL, slender, slightly depressed, glans greatly expanded; clasper components include proximal slit and distal cleft, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel and spike; denticles and pseudosiphon absent. Tail rather narrow, weakly depressed (slightly more depressed in female paratype CSIRO H 4071–16); narrow at base, initially tapering slightly, then very gradually to first dorsal-fin origin, not expanded at its midlength; tapering evenly and gradually to tail tip behind first dorsal fin; width at insertions of pelvic fins 2.04 (1.77–2.22) times width at midlength of tail and 2.07 (1.89–2.12) times width at first dorsal-fin origin; length from rear of cloaca 0.85 (0.78–0.82) times distance from tip of snout to rear of cloaca; anterior cross-section oval, equally convex dorsally and ventrally, more strongly convex on dorsal surface than ventral surface posteriorly; ventral surface almost flat on postdorsal tail; width 1.80 (1.57–1.82) times height at insertion of pelvic fin, 1.60 (1.48–1.78) times height at midlength, 1.70 (1.49–1.79) times height at first dorsal fin origin; lateral tail fold weak, narrow, short-based, slightly less well developed in adult males than females or juveniles, usually barely detectable forward of midtail, terminating forward of tail tip, marginally broader beneath second dorsal fin. Dorsal fins

small, of similar shape and height, first dorsal fin usually very slightly more upright than second; first dorsal-fin height 1.59 (1.88–2.45) in base length; fins very strongly raked, low, elongate, with long bases; anterior margins of both fins convex, apices broadly rounded, posterior margins short, convex; free rear tip broadly rounded (usually blending into posterior margin); inner margins long, either directed anteroventrally or almost upright; second dorsal-fin base longer than second dorsal-fin base (variable in paratypes); interdorsal space short (dorsal fins almost connected in CSIRO CA 4394), 24.5 (9.6–17.8) times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 3.14 (2.82–3.21) times dorsal-fin base length, 3.11 (2.24–3.24) times caudal-fin length; first dorsal-fin base 0.99 (0.73–1.15) times caudal-fin length. Epichordal caudal-fin lobe well developed, long-based, low, height exceeding half tail width at fin origin; not much taller posteriorly than anteriorly; subtruncate distally, its dorsal margin weakly convex to almost straight; connected sub-basally to second dorsal fin; hypochordal caudal lobe short, low.

Dorsal surface of adult male holotype with small orbito-spiracular, tail and alar thorns; small malar thorn patch present near disc margin beside eye and spiracle; usually no thorns in nuchal area (single, weak nuchal thorn

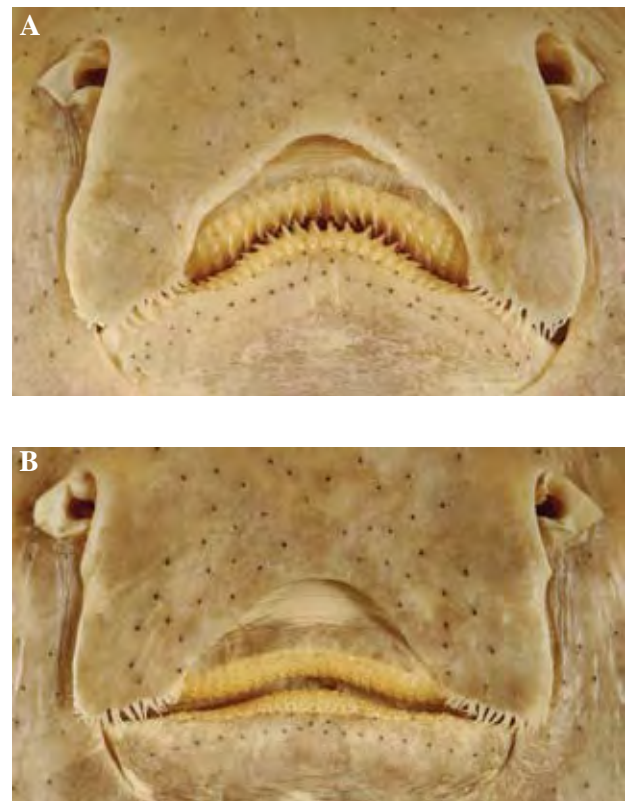


Figure 17. Ventral view of *Dipturus healdi* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 4071–15, 579 mm TL); B, primary female paratype (CSIRO H 4071–16, ca. 673 mm TL).

present in adult male paratype CSIRO CA 2827), along mid-disc or on scapular region; primary female paratype CSIRO H 4071–16 (female >673 mm TL) with small orbital and similar tail thorns (single, weak nuchal thorn present on female paratype CSIRO H 1207–03); primary juvenile paratype with small orbital and tail thorns. Main orbital thorns of holotype about 7–8 (4 on preorbit, 1–2 on midorbit, 2–3 on postorbit; to about 11 orbital thorns in other adult male paratypes), forming an incomplete rosette; thorns variable in size, slender, pungent, raked or upright, little recurved and often damaged distally; not forming a loose cluster on preorbit, anteriormost thorn not bifurcate, not flanked by thornlets. Primary female paratype with orbital thorns in a more complete rosette than holotype, with about 11–12 (5–6 on preorbit, 3 on midorbit, 3 on postorbit) thorns, 7–11 thorns in other female paratypes, main anterior thorn not bifurcate, posteriormost thorn beside rear margin of spiracle. Primary juvenile paratype with short blunt orbital thorns (1 on preorbit, 1 on postorbit, evidence of an emerging thorn on left lateral preorbit; larger juvenile paratypes with increasing number of orbital thorns). Malar patch in holotype with about 9 enlarged thorns beside orbito-spiracular region, merging with denticle band on anterolateral margin of disc; patch extending along disc margin, originating at level of anterior orbit, terminating just posterior to spiracle; largest thorns slender, pungent, mostly similar in shape to each other, strongly raked, directed posterolaterally. Alar thorns in holotype about 29–30, in 3–4 (2–3 in adult male paratypes) semi-regular rows; well developed, slightly longer than tail thorns, deeply embedded, tips pungent, directed slightly posteromedially; length of patch about equal twice orbit diameter. Tail thorns of adult male holotype short, well developed, pungent, recurved, strongly tilted; in single continuous, linear, median row, not paired; row commencing (as a minute interstitial thorn) about an eye diameter forward of pelvic-fin insertion, extending to dorsal fin, with about 28 (11 main thorns and about 17 much smaller interstitial thorns; 7–12 main thorns and 16–18 interstitial thorns in adult male paratypes); main thorns immediately preceded by a minute interstitial thorn; largest thorns with or without small dermal flap on their posterior bases; interdorsal thorns 2 (0–1 in male paratypes). Tail of primary female paratype with 5 rows of thorns, rows not equally well developed; median row long, commencing (as a small thorn) about an eye diameter forward of pelvic-fin insertion, extending along length of predorsal tail in a single linear series to dorsal fin, with about 31 predorsal thorns (13 main thorns and 18 smaller interstitial thorns), most main thorns immediately preceded by an interstitial thorn; dorsolateral rows short, with 6–8 thorns, located near anterior dorsolateral margin of tail, commencing slightly posterior to median row but not extending past rear tip of pelvic fin; lateral rows long, with about 19–22 thorns, located beside lateral fold, commencing near last thorn of dorsolateral row and ending beneath first dorsal fin; lateral thorns slender, strongly recurved, pungent, directed posterolaterally;

interdorsal thorns 1 (0–1 in other female paratypes). Primary juvenile paratype with single median row of tail thorns, commencing just behind level of pectoral-fin insertion, with 17 short, strongly raked predorsal thorns; 1 interdorsal thorn present.

Denticles of adult males poorly developed, most of disc and tail naked. In holotype, denticles on dorsal surface confined to small patch on snout tip and broad band along anterolateral margin of disc (from anterior tip of propterygium to front of alar patch); on ventral surface, present over most of snout, on anterior rostral shaft and extending along anteroventral margin of disc (from snout tip to beside gill slits); villiform, only slightly longer and more widely separated on dorsal head than on ventral head. Denticles of primary female paratype weaker on dorsal surface than in holotype, only a few isolated denticles along disc margin; ventrally similar to holotype. Primary juvenile paratype with narrow denticle band on anterior rostral shaft and along anterolateral margin of ventral disc to about level of mouth, otherwise naked.

Meristics (n=10): Tooth rows in upper jaw 36 (34–40); lower jaw 38 (35–41). Pectoral-fin propterygial radials 29 (27–31); mesopterygial radials 14 (13–16); metapterygial radials 34 (33–35); total radials 77 (74–79). Pelvic-fin radials males (n=6) 1 (1) + 19–20 (18–19); females (n=4) (1) + (18–21). Trunk centra 28 (26–30); predorsal caudal centra 49 (47–55); predorsal centra 77 (76–84); centra between origins of dorsal fins 11 (10–11); diplospondylous centra about 94 (92–99); total centra about 122 (121–128).

COLOUR (in preservative).— Dorsal surface of disc and pelvic fins mostly uniform pale yellowish brown; paler yellowish along narrow anterior margin and broader posterior margins of disc and pelvic fins; tail and claspers darker brown; rostrum demarcated from rest of snout, area adjacent yellowish, much paler than central disc; thorns and alar patch pale; orbital membrane translucent, eye dark. Dorsal fins and epichordal lobe of caudal fin dusky. Ventral surface of disc usually pale; darker grey on central disc (patch expanded laterally beside gill slits), on nasal flap, and through interpelvic space; whitish over gill membranes (strongly demarcated from darker areas adjacent), around mouth, cloaca, claspers, posterior pelvic-fin lobe, and most of ventral tail; sensory pores small, distinct, black-edged, sometimes surrounded by indistinct dusky blotches. Primary female paratype very similar to male holotype dorsally, ventrally and on fins; dark markings on central part of ventral disc usually better defined. Primary juvenile paratype similar dorsally to holotype; pale areas almost white, very strongly contrasted with central disc on snout around border of fin; dorsal fins black; caudal fin dusky anteriorly, white posteriorly; ventral surface uniformly white, pores not dark edged.

SIZE.— Largest specimen a female ca. 723 mm TL (tail



Figure 18. Lateral view of dorsal and caudal fins of *Dipturus healdi* sp. nov., adult male holotype (CSIRO H 4071–15, 579 mm TL).

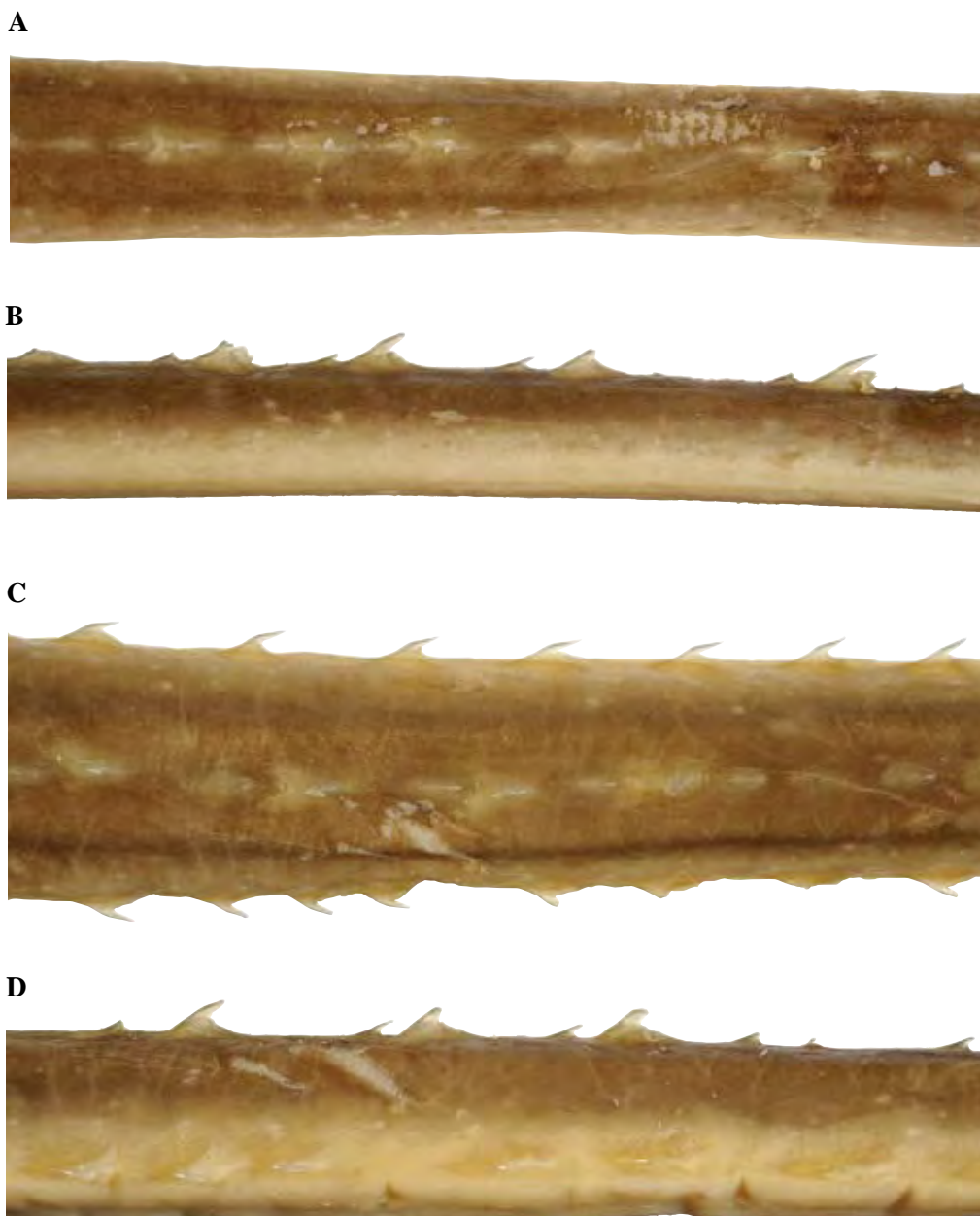


Figure 19. Thorns at tail midlength of *Dipturus healdi* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 4071–15, 579 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 4071–16, ca. 673 mm TL).

tip damaged); adolescent males ranged between 380–506 mm TL, mature males 500–587 mm TL; smallest juvenile 138 mm TL.

DISTRIBUTION.— Upper continental slope off Western Australia from the Monte Bello Islands (19°18' S, 115°42' E) to south of Scott Reef (14°12' S, 122°32' E) in 304–520 m. Once thought to occur south to Bunbury (Last & Stevens, 1994; Williams *et al.*, 1996) but these records may be of another closely related species.

ETYMOLOGY.— Acknowledges the efforts of David Heald (Department of Fisheries Western Australia) who discovered this species off Western Australia in the early 1980's. Vernacular name: Heald's Skate (also referred to as Leyland's Skate; see Last & Stevens, 1994).

REMARKS.— This medium-sized species of *Dipturus* was originally referred to in Last & Stevens (1994) as Leyland's Skate (*Raja* sp. F). Its distribution is described as being from the upper continental slope off Western Australia from Ashmore Reef to Bunbury in 200–440 m depth. Williams *et al.* (1996) reported material from southern Western Australia from off Fremantle (32°02' S, 115°09' E) to off Shark Bay (26°43' S, 112°41' E) in depths of 200–510 m. All except one of the 75 specimens held at the ANFC are from northwestern Australia (i.e. north of 19° S) at similar depths. A single specimen CSIRO H 2570–01 (the voucher for *Raja* sp. F in Williams *et al.*, 1996) was collected just north of Williams *et al.*'s recorded range (and much deeper, in about 1250 m), and well outside the other material of *D. healdi*. Hence, this specimen, which exhibits some morphological differences to typical *D. healdi*, was omitted from the material examined of this species pending further investigation of southern populations.

Dipturus healdi is the only long-snout member of the genus known from the continental slope off northwestern Australia. Of the 'typical' *Dipturus* skates found in Australia seas, it is most similar morphologically to *D. apricus* but has a narrower interdorsal distance (0.2–0.5% vs. 1.1–1.7% TL), slightly narrower disc (width 64–68% vs. 67–71% TL), and longer distance from snout tip to its axis of maximum width (38–40% vs. 33–38% TL). Also, adult males of *D. healdi* have malar thorns (absent in *D. apricus*), and fewer total diplospondylous centra (about 92–99 vs. 99–109) and pectoral-fin radials (74–79 vs. 86–91). It is similar in size and morphologically to *Dipturus lanceorostratus* (Wallace, 1967) from the southwestern Indian Ocean but differs from this species in lacking white spots (vs. present) and usually lacks a nuchal thorn (vs. present).

Dipturus melanospilus sp. nov.

Figs 20–25; Table 2

Raja sp. H: Last & Stevens, 1994: pp 301, 333–334, fig. 34.23, key fig. 11, pl. 56.

Holotype. CSIRO H 715–05, adult male 669 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°49' S, 154°10' E, 445–450 m, 17 Nov 1985.

Paratypes. 21 specimens. AMS I 20118–009 (2 specimens), female 236 mm TL, female 318 mm TL, east of Wooli, New South Wales, 29°52' S, 153°43' E, 502–512 mm TL, 23 Aug 1977; CSIRO H 600–02, adult male 630 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°47' S, 154°14' E, 492 m, 17 Nov 1985; CSIRO H 702–03, female 535 mm TL, north-east of Whitsunday Island group, Marian Plateau, Queensland, 19°01' S, 150°43' E, 642–646 m, 24 Nov 1985; CSIRO H 890–02, adult male 777 mm TL, east of Sydney, New South Wales, 33°40' S, 151°57' E, 468–522 m, 19 Dec 1985; CSIRO H 948–03, female 530 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°58' S, 154°26' E, 678–695 m, 18 Nov 1985; CSIRO H 2199–01, female 495 mm TL, north-west of Frederick Reef, Queensland, 20°24' S, 152°54' E, 440–458 m, 22 Nov 1985; CSIRO H 2201–01, female 235 mm TL, CSIRO H 2201–02, female 297 mm TL, CSIRO H 2201–03, juvenile male 272 mm TL, Swain Reefs, Queensland, 21°31' S, 152°58' E, 239–247 m, 20 Nov 1985; CSIRO H 2202–01, female 284 mm TL, north of Swain Reefs, Marian Plateau, Queensland, 20°23' S, 152°57' E, 508–511 m, 22 Nov 1985; CSIRO H 2203–01, female 439 mm TL, east of Moreton Bay, Queensland, 27°19' S, 153°58' E, 600 m, 10 May 1983; CSIRO H 2204–01, female 204 mm TL, CSIRO H 2204–02, juvenile male 233 mm TL, CSIRO H 2204–03, female 234 mm TL, CSIRO H 2204–04, female 351 mm TL, east of Moreton Bay, Queensland, 27°13' S, 153°52' E, 590 m, 09 May 1983; CSIRO H 2205–01, female 236 mm TL, northern Queensland; CSIRO H 6639–01, female 515 mm TL, east of Crowdy Head, New South Wales, 31°52' S, 153°16' E, 485–925 m, 09 Dec 1987; QM I 18608, juvenile male 343 mm TL, east of Capricorn Group, Queensland, 23°18' S, 154°13' E, 530–585 m, 04 Oct 1980; QM I 19225, juvenile male 334 mm TL, east of Bunker & Capricorn Groups, Queensland, 23°30' S, 153°04' E, 494 m, 20 Sep 1980; QM I 19316, female 607 mm TL, east of Capricorn Group, Queensland, 23°18' S, 154°13' E, 530–585 m, 04 Oct 1980.

Other material. 2 specimens. CSIRO H 890–01, adult male 700 mm TL, east of Sydney, New South Wales, 33°40' S, 151°57' E, 468–522 m, 19 Dec 1985; CSIRO H 965–1, adult male 757 mm TL, east of Broken Bay, New South Wales, 33°43' S, 151°54' E, 495–540 m, 04 Nov 1985.

DIAGNOSIS.— A medium-sized species of *Dipturus* (to 78 cm TL) with the following combination of characters: disc very broad with angular apices, width 71–80% TL,

Table 2. Morphometrics for the holotype of *Dipturus healdi* sp. nov. (CSIRO H 4071–15), ranges for measured paratypes (n=5), and means for all morphometric types; and the holotype of *Dipturus melanospilus* sp. nov. (CSIRO H 715–05), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Dipturus healdi</i> sp. nov.				<i>Dipturus melanospilus</i> sp. nov.			
	Holotype	Paratypes		Mean	Holotype	Paratypes		Mean
		Min.	Max.			Min.	Max.	
Total length (mm)	579	505	672		669	439	630	
Disc width	66.7	63.5	67.8	66.4	71.0	71.7	79.8	76.0
Disc length (direct)	57.0	57.0	58.3	57.5	56.2	56.4	61.0	57.8
Snout to maximum width	40.2	37.8	39.6	38.8	36.1	34.6	38.5	36.9
Snout length (preorbital direct)	19.3	19.1	22.1	20.6	18.5	18.2	22.0	20.1
Snout to spiracle	24.4	23.9	26.6	25.3	23.5	23.0	26.9	24.8
Head (dorsal length)	25.7	25.8	28.4	27.0	24.9	24.6	28.1	26.4
Orbit diameter	3.8	2.8	3.5	3.2	3.1	3.1	3.8	3.4
Orbit and spiracle length	5.1	4.6	5.0	4.8	4.6	4.4	4.8	4.6
Spiracle length (main aperture)	2.0	1.8	2.1	2.0	1.0	1.2	1.8	1.4
Distance between orbits	4.5	4.8	5.2	4.9	4.1	3.9	4.3	4.0
Distance between spiracles	6.7	5.9	6.9	6.4	6.7	6.4	6.9	6.7
Snout to cloaca (to 1st hemal spine)	54.1	54.9	56.1	55.3	54.6	52.8	56.6	54.6
Cloaca to D1	30.5	28.5	30.5	29.6	27.3	26.2	27.9	27.0
Cloaca to D2	35.7	33.8	35.7	34.9	34.5	32.7	34.7	33.7
Cloaca to caudal origin	41.2	37.8	40.4	39.4	40.1	37.9	40.0	39.1
Distance-cloaca to caudal-fin tip	46.2	43.5	45.5	44.6	46.1	42.9	46.4	44.9
Ventral snout length (pre upper jaw)	19.2	18.8	22.2	20.5	18.9	17.5	23.3	20.6
Prenasal length	17.1	16.6	19.5	18.1	16.3	15.9	19.8	17.7
Ventral head length (to fifth gill)	34.1	33.3	34.7	34.1	31.9	31.6	35.5	32.9
Mouth width	8.5	7.7	8.7	8.2	7.9	7.4	8.1	7.7
Distance between nostrils	7.9	8.1	8.6	8.2	7.5	7.6	8.5	7.9
Nasal curtain length	6.0	4.5	5.7	5.3	5.5	4.8	5.6	5.2
Nasal curtain (total width)	9.5	8.6	9.9	9.2	8.4	8.3	9.7	8.7
Nasal curtain (min. width)	6.5	6.1	7.0	6.6	6.3	6.1	7.1	6.4
Nasal curtain (lobe width)	1.7	1.1	1.6	1.4	1.1	1.0	1.5	1.2
Width of first gill opening	1.3	1.4	1.6	1.5	1.2	1.4	1.7	1.5
Width of fifth gill opening	1.0	1.1	1.3	1.1	0.9	1.0	1.2	1.1
Distance between first gill openings	14.4	14.0	15.1	14.5	12.8	12.3	14.4	13.2
Distance between fifth gill openings	8.7	8.6	9.7	9.1	7.7	8.2	9.5	8.5
Clasper (post cloacal length)	28.0	–	27.1	27.5	23.1	–	25.1	24.1
Length of anterior pelvic lobe	12.9	11.0	11.9	11.7	10.8	10.9	12.6	11.6
Length of posterior pelvic lobe	17.5	12.3	17.1	14.9	15.2	11.0	16.2	13.7
Pelvic base width	8.1	7.3	9.2	8.3	7.2	7.0	7.8	7.4
Tail at axil pelvic fins (width)	4.1	3.5	3.9	3.8	3.2	2.9	3.4	3.2
Tail at axil pelvic fins (height)	2.3	2.1	2.4	2.2	1.9	1.9	2.1	2.0
Tail at midlength (width)	2.0	1.7	2.2	1.9	1.8	1.5	2.0	1.8
Tail at midlength (height)	1.3	1.1	1.2	1.2	1.1	1.1	1.2	1.2
Tail at D1 origin (width)	2.0	1.7	2.1	1.9	1.7	1.6	2.1	1.9
Tail at D1 origin (height)	1.2	1.0	1.2	1.1	1.1	1.1	1.3	1.1
D1 base length	5.0	4.7	5.5	4.9	5.1	4.8	5.1	5.0
D1 height	3.1	2.0	2.6	2.4	2.9	2.1	2.8	2.6
D1 origin to caudal-fin tip	15.7	13.9	16.2	15.0	18.8	16.4	18.4	17.9
D2 origin to caudal-fin tip	10.5	8.7	10.2	9.7	11.6	10.3	12.5	11.2
Caudal-fin length	5.0	4.3	6.4	5.2	6.0	4.7	6.8	5.8

A



B

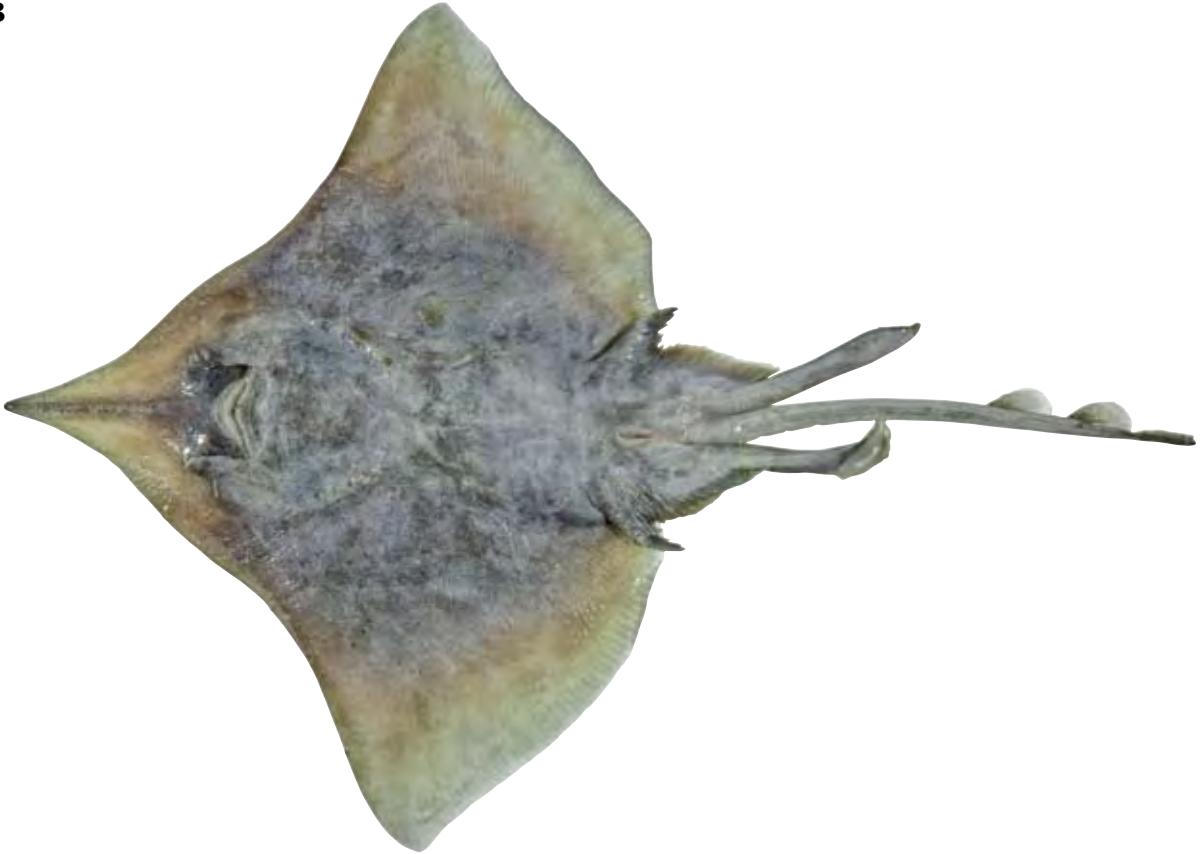


Figure 20. *Dipturus melanospilus* sp. nov., adult male holotype (CSIRO H 715–05, 669 mm TL, fresh): A, dorsal surface; B, ventral surface.

A



B



Figure 21. Dorsal surface of *Dipturus melanospilus* sp. nov.: A, primary female paratype (CSIRO H 948–03, 530 mm TL, fresh); B, primary juvenile paratype (CSIRO H 2204–01, female 204 mm TL, preserved).

1.3–1.4 times its length; snout angle 72–82°; tail length 0.8–0.9 in distance from snout tip to rear of cloaca; tail slender, somewhat rounded in cross section, width 1.3–1.7 times height at its midlength, 1.4–1.9 times at first dorsal-fin origin; pre-upper jaw length 17–23% TL, 2.3–2.8 times internasal width; ventral head length 32–36% TL; snout length 4.2–5.6 times interorbital width; orbit diameter 73–97% interorbital width; first dorsal-fin height 1.7–2.3 in its base length; distance from first dorsal-fin origin to tail tip 3.2–3.8 times first dorsal-fin base length, 2.7–3.5 times caudal-fin length; pelvic fins small, length of posterior lobe of adult males 15–16% TL, length of anterior lobe 67–71% of posterior lobe; adult clasper relatively elongate, 23–25% TL, connected to pelvic-fin inner margin at about 40–44% of its length from cloaca; anterior margins of both surfaces of disc with a narrow band of granular denticles (band absent from dorsal surface of large females and juveniles); no nuchal or malar thorns; tail with a single thorn row in both males and females; total pectoral radials 92–98; trunk centra 29–32; predorsal centra 77–86; total centra 136–140; tooth rows in upper jaw 32–37; mainly uniformly greyish brown dorsally; mostly greyish brown (not blotchy) ventrally, gill membranes not paler than adjacent head; anteroventral margin of disc distinctly whitish (on denticle band), outer half black-edged (areas very strongly contrasted in juveniles); ventral sensory pores black-edged, not surrounded by dusky blotches, prominent on snout; epichordal lobe blackish.

DESCRIPTION.— Disc very broadly quadrangular, 1.26 times as broad as long in adult male holotype (1.27–1.36 times in paratypes); angle in front of spiracles 72° (73–82°); axis of greatest width 64% (61–66%) of disc length; anterior margin strongly double concave in adult males, females and juveniles, strongly concave anteriorly, convex beside and forward of orbit, deeply concave just behind level of spiracle; apex angular (even in juveniles); posterior margin straight to weakly concave anteriorly, then strongly convex posteriorly; free rear tip very broadly rounded. Head moderately elongate, preorbital snout length 6.02 (5.73–6.10) times orbit length, 4.55 (4.22–5.56) times interorbit; pre-upper jaw length 2.52 (2.30–2.76) times internarial distance. Snout tip well produced, very narrowly pointed (less so in juveniles); no fleshy process at apex. Orbit small, diameter 0.76 (0.73–0.97) times interorbital width. Spiracle relatively small, length 3.17 (1.69–2.86) in orbit diameter; main opening mainly suboval to slit-like. Nostril suboval to subrectangular, often distorted; anterior nasal flap expanded slightly, its lateral margin forming a short semi-circular tube; anterior margin of flap weakly lobe-like, not or partly concealed beneath nasal curtain; posterior inner margin concealed beneath nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with thick fringe; internarial distance 1.71 (1.62–1.71) in distance between first gill slits, 1.04 (1.06–1.12) in distance between fifth gill slits. Upper

jaw strongly arched, not indented at symphysis (slightly arched in females and juveniles); lower jaw strongly convex (weakly convex in females and juveniles); lateral teeth of upper jaw not or partly concealed by lobe of nasal curtain. Teeth of adult male holotype strongly unicuspid, with elevated subcircular bases; arranged in longitudinal rows rather than in quincunx; medial cusps long, caniniform, pointed, posteriorly directed in middle of upper jaw; cusps much shorter, subtriangular and slightly oblique laterally; similar in lower jaw but with relatively shorter cusps toward jaw angle; teeth of female paratypes with broadly oval bases and relatively broad-based, blunt subtriangular cusps (cusps slightly more pronounced near jaw symphysis), arranged in defined rows; teeth of primary juvenile paratype (CSIRO H 2204–01, female 204 mm TL) with short cusps.

Pelvic fins small, deeply forked; anterior lobe short, slender, bluntly pointed distally, lateral margin entire, inner margin incised; posterior lobe short to moderately elongate, much longer in adult males (length 15.2–16.2% TL) than in females (length 11.0–13.5% TL), lateral margin convex; inner margin convex to almost straight, connected to lateral margin of clasper at 40–44% of its postcloacal length; anterior lobe 0.71 (0.67–0.99) times posterior lobe. Clasper elongate, 23–25% TL, slender, slightly depressed, glans expanded slightly; clasper components include proximal slit and distal cleft, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel and spike; denticles and pseudosiphon absent. Tail rather slender, weakly depressed (similarly depressed in primary female paratype CSIRO H 948–03, 530 mm TL); narrow at base, initially tapering slightly, then barely tapering to second dorsal-fin, not expanded at its midlength; tapering evenly and gradually to tail tip behind second dorsal fin; width at insertions of pelvic fins 1.80 (1.50–2.16) times width at midlength of tail and 1.85 (1.53–1.81) times width at first dorsal-fin origin; length from rear of cloaca 0.83 (0.77–0.89) times distance from tip of snout to rear of cloaca; anterior cross-section narrowly oval, equally convex dorsally and ventrally, much more strongly convex on dorsal surface than ventral surface posteriorly; ventral surface flat to weakly convex on postdorsal tail; width 1.67 (1.43–1.79) times height at insertion of pelvic fin, 1.62 (1.46–1.65) times height at midlength, 1.60 (1.38–1.86) times height at first dorsal fin origin; lateral tail fold very weak, very narrow, relatively short-based, slightly less well developed in adult males than females or juveniles, originating as a fleshy ridge behind rear tip of pelvic fin, terminating well forward of tail tip, broadest beneath dorsal fins. Dorsal fins small, of similar shape, first dorsal fin usually marginally taller and more upright than second; first dorsal-fin height 1.78 (1.71–2.32) in base length; fins strongly raked, low, with elongate bases; anterior margins of both fins weakly convex, apices broadly rounded, posterior margins short, strongly convex; free rear tip broadly rounded (usually blending into posterior margin); inner margins short, usually directed anteroventrally; second dorsal-fin base



Figure 22. Dorsal head of *Dipturus melanospilus* sp. nov., adult male holotype (CSIRO H 715-05, 669 mm TL), showing snout, orbito-spiracular and nuchal regions.

subequal in length to first dorsal-fin base; interdorsal space moderate, 2.58 (2.12–5.17) times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 3.65 (3.23–3.83) times dorsal-fin base length, 3.13 (2.72–3.46) times caudal-fin length; first dorsal-fin base 0.86 (0.74–1.07) times caudal-fin length. Epichordal caudal-fin lobe well developed, long-based, low, height slightly exceeding half tail width at fin origin (developed, not as a low ridge in primary juvenile paratype); sometimes taller posteriorly than anteriorly; not tapering distally, its dorsal margin weakly convex to straight; connected sub-basally to second dorsal fin; hypochordal caudal lobe obvious, short, low.

Dorsal surface of adult male holotype with weak orbito-spiracular (not forming a rosette) and tail thorns, and well-developed alar thorn patch; no malar or nuchal thorns; no thorns along mid-disc or in scapular region; primary female paratype with small orbital (forming a partial rosette) and slightly better developed tail thorns; primary early juvenile paratype with small orbital and small tail thorns. Main orbital thorns of holotype about 5–7 (2–3 on preorbit, 1 on midorbit, 2–4 on postorbit;

6–7 in adult male paratypes), not forming an obvious rosette; thorns variable in size, mostly very short, pungent or blunt; preorbit of right side of holotype with a large, broad based, scute-like, bifurcated thorn; thorns somewhat deciduous, often damaged distally; anteriormost thorns not flanked by thornlets, posterior thorn beside hind margin of orbit. Primary female paratype with 3–5 (undamaged state probably 5) orbital thorns (2 on preorbit, 0–1 on midorbit, 2 on postorbit, pale scars indicates that thorns have been removed); 6–7 in total in other large female paratypes; thorns forming a partial rosette (most obvious in largest females), similar in shape and position to holotype, anteriormost thorn scute-like, bifurcate; early juvenile with slender, pungent thorns (2 on preorbit, 1 on postorbit), medial thorns directed posteriorly, anterolateral thorn directed posterolaterally. Alar thorns in holotype about 24 (18–20 in adult male paratypes), in 2–3 semi-regular rows; well developed, slightly longer than tail thorns, deeply embedded, tips pungent, directed slightly posteromedially; patch long, slightly more than twice orbit diameter. Tail thorns of adult male holotype short, not well developed, pungent, weakly recurved, strongly tilted; in single broken, linear,



Figure 23. Ventral view of *Dipturus melanospilus* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 715-05, 669 mm TL); B, primary female paratype (CSIRO H 948-03, 530 mm TL).



Figure 24. Lateral view of dorsal and caudal fins of *Dipturus melanospilus* sp. nov., adult male holotype (CSIRO H 715-05, 669 mm TL).

A



B



C



D



Figure 25. Thorns at tail midlength of *Dipturus melanospilus* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 715-05, 669 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 948-03, 530 mm TL).

median row, not paired; row commencing just forward of pelvic-fin insertion, extending to dorsal fin, with 16 (9 main thorns and about 7 shorter interstitial thorns), 22 thorns in another adult male paratype; main thorns not preceded by interstitial thorns, anteriormost thorns short; usually without dermal flaps on their posterior bases; interdorsal thorns 1 (2 in another adult male paratype). Tail of primary female paratype with single row of thorns, no lateral thorn rows; median row moderately elongate, commencing forward of pelvic-fin insertion, extending almost continuously along length of predorsal tail as a single, linear series of thorns to dorsal fin; with about 15 predorsal thorns (4 large intact thorns and 11 slightly smaller damaged thorns, some thorns lost as evidenced by scars), 18–27 in other large female paratypes; main thorns not preceded by interstitial thorns; interdorsal thorns 1 (0–1). Primary juvenile paratype with single median row of tail thorns, commencing slightly forward of pectoral-fin insertion, with 13 (12–15) well developed, strongly raked predorsal thorns; 1 (0–2) interdorsal thorn present.

Denticles of adult males poorly developed, most of disc and tail naked. In holotype, denticles on dorsal surface confined to prominent patch on snout tip and narrow band along anterolateral margin of disc (from anterior tip of propterygium almost to front of alar patch); on ventral surface present over anterior half of preoral snout and extending as narrow band along anteroventral margin of disc (from snout tip to about level of third gill slit); villiform, much shorter, less robust and more widely separated on dorsal margin of head than on ventral head. Denticles of primary female paratype confined to ventral surface, naked dorsally (denticles present on snout tip on some larger female paratypes); ventrally, less denticulate than holotype, present only at snout tip, below anterior quarter of rostral cartilage, and in narrow band along disc margin (from snout tip to about level of first gill slit); primary juvenile paratype with very narrow, indistinct denticle band (denticles sparse) on ventral head from snout tip to just behind level of mouth, otherwise naked.

Meristics (n=9): Tooth rows in upper jaw 32 (33–37); lower jaw 36 (34–37). Pectoral-fin propterygial radials 34–35 (34–37); mesopterygial radials 16–17 (17–20); metapterygial radials 41 (40–42); total radials 92 (92–98). Pelvic-fin radials males (n=3) 1 (1) + 19 (21–22); females (n=6) (1) + (21–24). Trunk centra 30 (29–32); predorsal caudal centra 47 (49–56); predorsal centra 77 (79–86); centra between origins of dorsal fins 14 (13–17); diplospondylous centra 106 (107–111); total centra 136 (137–140).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, clasper and tail mostly uniformly greyish brown (slightly darker centrally on adult males); slightly paler along narrow anterior margin and broader posterior margins of disc and pelvic fins; rostrum similar to central disc, strongly demarcated from rest of snout, area

adjacent whitish; thorns and alar patch dusky, obvious; orbit membrane brownish, semi-translucent, eye dark. Dorsal fins with dark greyish black bases, paler yellow to translucent distally; epichordal lobe blackish. Ventral surface of disc mostly dark; greyish brown (irregular but usually not blotchy) on most of disc and pelvic fins, only slightly paler along posterior margin of disc; distinctly whitish over most of denticle band on ventral head; anterior outer margin of disc black edged, strongly contrasted anteriorly with pale denticle band; whitish beside rostrum, on mouth, nostrils and cloaca; margins of pelvic fins usually dark; membranes of gill slits not strongly demarcated from darker areas adjacent; tail and clasper whitish with some pale brownish patches, blackish distally; sensory pores small, distinct, black-edged, not surrounded by indistinct dusky blotches, very obvious on preoral snout, much less obvious posteriorly. Primary female paratype similar to male holotype dorsally (some other female paratypes darker brownish), ventrally and on fins. Primary juvenile paratype slightly paler brown dorsally, snout beside rostrum and posterior margin of disc semi translucent; ventrally, paler than adults, yellowish (sometimes similar to adult coloration in other juvenile paratypes); distinct black marking along anterior outer margin of ventral surface of disc; tail black tipped; sensory pores dark edged, not strongly demarcated; dorsal and caudal fins black.

SIZE.— Largest specimen an adult male 777 mm TL; juvenile males ranged between 233–343 mm TL, adult males 630–777 mm TL; smallest juvenile 204 mm TL.

DISTRIBUTION.— Upper continental slope off eastern Australia from the Marion Plateau, Queensland (19°02' S, 150°43' E) to east of Broken Bay, New South Wales (33°43' S, 151°54' E) in depths of 239–695 m.

ETYMOLOGY.— Derived from the Greek *melanos* (black) and *spilos* (stained, spot) in allusion to the distinctive black margin on the outer half of the anterior ventral disc in juveniles (less distinct in adults). Vernacular name: Blacktip Skate.

REMARKS.— *Dipturus melanospilus* can be distinguished from all other Australian species of *Dipturus* in having a short and broad disc with very angular apices, and the outer anteroventral margin of the disc is blackish (more accentuated in juveniles than adults) and is strongly contrasted with the inner anteroventral margin. It has a higher pectoral-fin radial count than all other new species described here (92–98 vs. 74–91); the *D. gudgeri* holotype has 103–104 radials. Its range partly overlaps with another new northeastern species *D. apricus*, which also has a moderately elongate snout and lacks nuchal and malar thorns. These species differ in colour, pectoral-fin radial count (92–98 vs. 86–91 in *D. apricus*), and in the relative width of the disc (71–80% vs. 67–71% TL), interorbital width (3.9–4.3% vs. 4.4–5.3% TL), and preorbital length (5.7–6.1 vs. 6.2–

7.9 times orbit diameter).

A specimen (CSIRO H 2200–01), which was collected from west of Lihou Reef, Queensland (17°03' S, 150°52' E) well outside the range of *D. melanospilus*, was initially included in the type series of this species based on its strongly contrasted black and white anteroventral disc margin. However, closer inspection of this individual indicates that it is another undescribed species. It differs from *D. melanospilus* in having a smaller orbit, less well-developed orbital thorns, a shorter snout, narrower interdorsal, shorter caudal fin, more strongly contrasted gill membranes, poorer coverage of dark sensory pores on the snout, and in some meristic details. A fuller investigation of this form will be made in the future.

Dipturus queenslandicus sp. nov.

Figs 26–31; Table 3

Raja sp. K: Last & Stevens, 1994, pp 301, 338–339, fig. 34.26, key fig. 15, pl. 59.

Holotype. CSIRO H 715–07, adult male 634 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°49' S, 154°10' E, 445–450 m, 17 Nov 1985.

Paratypes. 11 specimens. CSIRO H 715–01, female 390 mm TL, CSIRO H 715–02, female 761 mm TL, CSIRO H 715–04, female 583 mm TL, CSIRO H 715–06, juvenile male 354 mm TL, CSIRO H 715–09, female 540 mm TL, CSIRO H 715–10, juvenile male 355 mm TL, collected with holotype; CSIRO H 720–34, female 753 mm TL, south of Saumarez Reef, Queensland, 23°12' S, 153°33' E, 399–405 m, 18 Nov 1985; CSIRO H 947–13, female 479 mm TL, CSIRO H 957–01, adult male 659 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°56' S, 154°21' E, 590–606 m, 17 Nov 1985; QM I 18527, juvenile male 292 mm TL, QM I 19985, female 428 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°36' S, 154°14' E, 476–585 m, 04 Oct 1980.

Other material. 1 specimen. QM I 19949, female >476 mm TL (damaged tail tip) mid coast of Queensland, 1980.

DIAGNOSIS.— A medium-sized species of *Dipturus* (to 76 cm TL) with the following combination of characters: disc relatively broad with angular to narrowly rounded apices, width 62–66% TL, 1.0–1.1 times its length; snout angle 62–67°; tail length 0.6–0.8 in distance from snout tip to rear of cloaca; tail relatively slender, width 1.3–1.9 times height at its midlength, 1.0–1.9 times at first dorsal-fin origin; pre-upper jaw length 20–26% TL, 2.6–3.4 times internasal width; ventral head length 34–39% TL; snout length 4.9–6.1 times interorbital width; orbit diameter 66–76% interorbital width; first dorsal-fin height 1.5–2.0 in its base length; distance from first dorsal-fin origin to tail tip 3.2–3.6 times first dorsal-fin

base length, 2.7–3.4 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males 16% TL, length of anterior lobe 67–70% of posterior lobe; adult clasper moderately elongate, 24% TL, connected to pelvic-fin inner margin at about 30–43% of its length from cloaca; anterior margins of both surfaces of disc of adult males with bands of granular denticles; usually 1–2 nuchal thorns; malar thorn patch well-developed, alar patch short; tail with a single thorn row in males, usually with 1–2 additional pairs of lateral rows in large females; total pectoral radials 77–80; trunk centra 26–29; predorsal centra 74–79; total centra 127–136; tooth rows in upper jaw 34–39; mainly uniformly greyish brown dorsally; ventrally mostly greyish or brownish (somewhat blotchy), snout tip mostly pale; ventral sensory pores small, black-edged, obvious, not surrounded by indistinct dusky blotches; dorsal fins blackish, caudal fin mostly whitish.

DESCRIPTION.— Disc quadrangular, 1.13 times as broad as long in adult male holotype (1.04–1.15 times in paratypes); angle in front of spiracles 64° (62–67°); axis of greatest width 63% (61–66%) of disc length; anterior margin strongly double concave in adult males (less undulate in females and juveniles), evenly concave anteriorly, moderately to weakly convex just forward of eyes, very deeply concave just beside level of spiracles; apex angular to narrowly rounded (broadest in juveniles); posterior margin straight anteriorly, more convex posteriorly; free rear tip very broadly rounded. Head very long, snout more greatly extended in adult females, length 24.5–25.9% in large females, 20.4–21.4% in adult males, 20.6% TL in primary juvenile paratype (QM I 18527, male 292 mm TL); preorbital length 6.82 (7.22–9.06) times orbit length, 5.21 (4.91–6.10) times interorbit; pre-upper jaw length 2.59 (2.61–3.42) times internarial distance. Snout tip very well produced, narrowly pointed; no fleshy process at apex. Orbit small, diameter 0.76 (0.66–0.74) times interorbital width. Spiracle large, length 2.09 (1.52–1.96) in orbit diameter; opening variable, rectangular to tear-drop shaped. Nostril subrectangular, often distorted; anterior nasal flap expanded, its lateral margin forming a prominent, semi-circular tube; anterior margin of flap lobe-like, not concealed beneath nasal curtain; posterior inner margin concealed beneath nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with thick fringe; internarial distance 1.67 (1.56–1.73) in distance between first gill slits, 0.95 (0.94–1.17) in distance between fifth gill slits. Upper jaw arched strongly (barely arched in juvenile paratypes, variable), not indented at symphysis; lower jaw strongly convex, less so in juveniles; lateral teeth of upper jaw partly concealed by lobe of nasal curtain. Teeth of adult male holotype strongly unicuspid, with elevated subcircular bases; arranged in longitudinal rows rather than in quincunx; cusps near middle of both jaws long, caniniform, pointed; cusps near angle of upper jaw broadly triangular, near angle of lower jaw much

Table 3. Morphometrics for the holotype of *Dipturus queenslandicus* sp. nov. (CSIRO H 715–07), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Dipturus queenslandicus</i> sp. nov.			
	Holotype	Paratypes		Mean
		Min.	Max.	
Total length (mm)	634	540	761	
Disc width	63.7	62.3	65.9	64.3
Disc length (direct)	56.6	56.1	62.0	59.0
Snout to maximum width	35.7	34.4	40.0	37.6
Snout length (preorbital direct)	21.4	20.4	25.9	23.8
Snout to spiracle	25.6	24.8	30.2	28.0
Head (dorsal length)	26.6	26.3	31.5	29.5
Orbit diameter	3.1	2.7	3.3	3.0
Orbit and spiracle length	4.7	4.2	4.4	4.4
Spiracle length (main aperture)	1.5	1.4	2.0	1.7
Distance between orbits	4.1	4.1	4.5	4.3
Distance between spiracles	6.4	5.8	6.6	6.3
Snout to cloaca (to 1st hemal spine)	54.7	54.5	60.6	57.5
Cloaca to D1	28.0	24.8	27.7	26.1
Cloaca to D2	34.4	30.2	35.0	32.1
Cloaca to caudal origin	39.3	34.4	40.2	36.8
Distance-cloaca to caudal-fin tip	45.0	39.6	45.4	42.3
Ventral snout length (pre upper jaw)	20.2	20.4	26.2	23.6
Prenasal length	18.5	18.1	23.7	21.4
Ventral head length (to fifth gill)	34.0	33.6	38.9	36.3
Mouth width	8.4	7.1	8.1	7.6
Distance between nostrils	7.8	7.4	8.1	7.8
Nasal curtain length	4.2	3.7	4.4	4.1
Nasal curtain (total width)	9.2	8.4	9.0	8.7
Nasal curtain (min. width)	6.0	5.5	6.1	5.9
Nasal curtain (lobe width)	1.4	1.2	1.5	1.4
Width of first gill opening	1.2	1.3	1.4	1.3
Width of fifth gill opening	0.9	0.9	1.1	1.0
Distance between first gill openings	13.0	12.3	13.0	12.7
Distance between fifth gill openings	7.4	7.4	8.7	8.0
Clasper (post cloacal length)	24.2	–	–	–
Length of anterior pelvic lobe	11.4	10.0	10.8	10.6
Length of posterior pelvic lobe	16.3	13.2	15.8	14.6
Pelvic base width	7.5	6.8	8.7	7.8
Tail at axil pelvic fins (width)	3.7	2.9	4.0	3.4
Tail at axil pelvic fins (height)	2.2	2.0	2.5	2.2
Tail at midlength (width)	2.0	1.5	2.2	1.9
Tail at midlength (height)	1.2	1.1	1.2	1.1
Tail at D1 origin (width)	2.1	1.6	2.2	2.0
Tail at D1 origin (height)	1.4	0.9	1.3	1.2
D1 base length	5.0	4.4	5.3	4.7
D1 height	2.8	2.3	3.1	2.8
D1 origin to caudal-fin tip	17.0	14.6	17.7	16.2
D2 origin to caudal-fin tip	10.6	9.3	10.6	10.2
Caudal-fin length	5.6	5.2	6.1	5.5

A



B



Figure 26. *Dipturus queenslandicus* sp. nov., adult male holotype (CSIRO H 715–07, 634 mm TL, preserved): A, dorsal surface; B, ventral surface. NB. right clasper removed.

A



B



Figure 27. Dorsal surface of *Dipturus queenslandicus* sp. nov.: A, primary female paratype (CSIRO H 720–34, 753 mm TL, preserved); B, primary juvenile paratype (QM I 18527, male 292 mm TL, preserved).



Figure 28. Dorsal head of *Dipturus queenlandicus* sp. nov., adult male holotype (CSIRO H 715–07, 634 mm TL), showing snout, orbito–spiracular and nuchal regions.

narrower, shorter; cusps directed posteriorly in middle of upper jaw, strongly oblique (posterolaterally) in middle and outer jaw; teeth of primary female paratype (CSIRO H 720–34, 753 mm TL) with elevated, broadly oval to quadrangular bases and relatively broad-based, blunt, raised, subtriangular cusps (more pronounced near jaw symphysis), arranged in defined rows, central cusps with broad median ridge; teeth of primary juvenile paratype with weak cusps.

Pelvic fins of medium size, deeply forked; anterior lobe short, bluntly rounded distally, lateral margin entire, inner margin deeply incised; posterior lobe moderately elongate, much longer in adult males (length 15.8–16.3% TL) than in females (length 13.2–14.9% TL), lateral margin convex (more so in juveniles); free rear tip usually angular; inner margin weakly convex to almost straight, connected to lateral margin of clasper at 40–42% of its postcloacal length; anterior lobe 0.70 (0.67–0.80) times posterior lobe. Clasper elongate, 24% TL, slender, slightly depressed, glans expanded slightly; clasper components include proximal slit and distal cleft, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel and spike; denticles and pseudosiphon absent. Tail rather slender, weakly depressed (slightly more depressed in primary

females); narrow at base (broader in primary female paratype), initially tapering strongly, then very gradually to first dorsal-fin origin, not obviously expanded at its midlength; tapering evenly and gradually to tail tip behind first dorsal fin; width at insertions of pelvic fins 1.85 (1.57–2.05) times width at midlength of tail and 1.74 (1.49–1.94) times width at first dorsal-fin origin; length from rear of cloaca 0.83 (0.65–0.84) times distance from tip of snout to rear of cloaca; anterior cross-section oval, almost equally convex dorsally and ventrally, much more strongly convex on dorsal surface than ventral surface posteriorly; ventral surface flat on postdorsal tail; width 1.73 (1.24–1.87) times height at insertion of pelvic fin, 1.73 (1.32–1.91) times height at midlength, 1.52 (1.37–1.87) times height at first dorsal fin origin; lateral tail fold weak, narrow, relatively short-based, better developed in adult males than females or juveniles, originating as a fleshy ridge near rear tip of pelvic fin, terminating slightly forward of tail tip, marginally broader beneath dorsal fins. Dorsal fins small, of similar shape; first dorsal fin usually slightly larger than second, its height 1.76 (1.46–2.02) in base length; fins strongly raked, low, with elongate bases; anterior margins of both fins convex, apices broadly rounded, posterior margins short, strongly convex; free rear tip broadly rounded (usually blending into posterior margin); inner margins short,

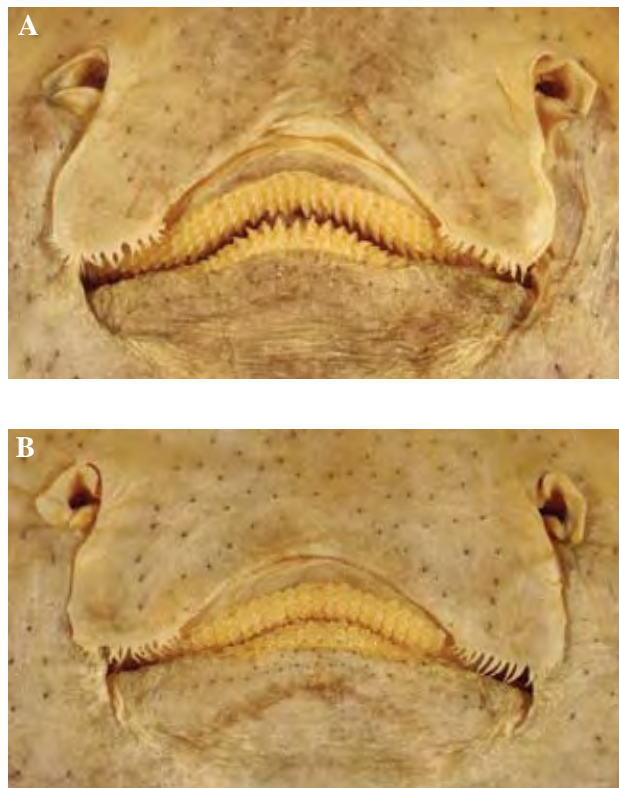


Figure 29. Ventral view of *Dipturus queenlandicus* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 715–07, 634 mm TL); B, primary female paratype (CSIRO H 720–34, 753 mm TL).



Figure 30. Lateral view of dorsal and caudal fins of *Dipturus queenslandicus* sp. nov., adult male holotype (CSIRO H 715–07, 634 mm TL).



Figure 31. Thorns at tail midlength of *Dipturus queenslandicus* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 715–07, 634 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 720–34, 753 mm TL).

usually directed anteroventrally; second dorsal-fin base slightly longer than first dorsal-fin base; interdorsal space moderate (variable, but never connected in paratypes), 3.39 (2.66–6.24) times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 3.42 (3.16–3.64) times dorsal-fin base length, 3.01 (2.70–3.43) times caudal-fin length; first dorsal-fin base 0.88 (0.76–1.03) times caudal-fin length. Epichordal caudal-fin lobe very well developed, long-based, low, height slightly exceeding half tail width at fin origin; usually tallest near its midlength, its dorsal margin convex; connected sub-basally to second dorsal fin; hypochordal caudal-fin lobe short, low.

Dorsal surface of adult male holotype with moderate orbito-spiracular (forming an incomplete rosette) and tail thorns, a small alar thorn patch and a well-developed malar patch; nuchal thorn absent (usually present in paratypes and nuchal scar indicates it may have been lost); no thorns along mid-disc or in scapular region; primary female paratype with small orbital, nuchal and better developed tail thorns; primary juvenile paratype with orbital, nuchal and small tail thorns. Main orbital thorns of holotype about 8 (5 on preorbit, 1 on midorbit, 2 on postorbit, scars on orbital rim indicate that some may have been lost), largest preorbital thorn robust, bifurcate; thorns variable in size, short, usually pungent, broad based, somewhat deciduous, often damaged distally, patch of 2–3 smaller thornlets laterally. Primary female paratype with 11–12 orbital thorns (6 on preorbit, 2 on midorbit, 3–4 on postorbit, medial thorn on preorbit with greatly enlarged base), 7–14 thorns in other female paratypes, thorns forming a rosette. Primary juvenile paratype with 2–3 thorns (1–2 on preorbit, 1 on postorbit), other juvenile paratypes of ~350 mm TL with 7–8 thorns, anteriormost thorn broad based, bifurcated. Nuchal thorns in primary female paratype 2 (0–2 in other female paratypes), posterior thorn larger, broad based; primary juvenile paratype with single, very broad-based, upright thorn. Malar patch in holotype prominent, in several irregular rows beside eye; thorns largest in inner posterior part of patch, merging in size with large denticles and thornlets associated with marginal denticle band, extending from just anterior to level of eye to level of spiracle. Alar thorns in holotype about 16–21, in 2–3 semi-regular rows; well developed, subequal in length to tail thorns, deeply embedded, tips pungent, directed slightly posteromedially; patch short, subequal to interspiracular space. Tail thorns of adult male holotype variable in size, mostly short, pungent, upright or strongly tilted and weakly recurved; in single intermittent, linear, median row, not paired; row commencing beside pectoral-fin insertion, extending to dorsal fin, with 24 (10 main and about 14 smaller interstitial) thorns, adult male paratype with 12 main thorns and 19 smaller interstitial thorns; main thorns not preceded by interstitial thorns, anteriormost thorns short; sometimes with dermal flaps on their posterior bases; interdorsal thorns absent (2 in adult male paratype). Tail of primary female paratype with 5

(4–5 in other large female paratypes) rows of thorns, rows not equally well developed; median row commencing just behind pectoral-fin insertion, extending along length of predorsal tail in a single, linear series, with about 33 (about 18 main predorsal thorns and 15 only slightly smaller interstitial thorns) thorns; other large female paratypes with 37–40 variably-sized thorns; dorsolateral rows very short, with 2–3 (2–4) thorns, located near dorsolateral margin of tail, commencing near pelvic-fin insertion and not extending far past pelvic-fin rear tip; lateral rows with about 17 (7–16) thorns, located beside lateral fold, commencing near rear tip of pelvic fin and terminating at about first dorsal-fin origin; lateral thorns slender, pungent, strongly recurved, directed almost posterolaterally; interdorsal thorns absent (1–2 in other large female paratypes). Primary juvenile paratype with single median row, commencing near level of pectoral-fin insertion; with 23 short, strongly raked predorsal thorns; 1 small interdorsal thorn.

Denticles of adult males poorly developed, most of disc and tail naked. In holotype, denticles on dorsal surface confined to weak patch on snout tip and narrow band along anterolateral margin of disc (from anterior tip of propterygium to just short of alar patch, partly merging with malar patch); on ventral surface present over anterior half of rostral cartilage, and as a narrow band extending along anteroventral margin of disc (from snout tip to almost level of mouth); villiform, longer and more widely separated on dorsal head than on ventral head. Denticles of primary female paratype confined to snout tip on dorsal surface (absent from disc margin); ventrally, similar to holotype. Primary juvenile paratype with narrow denticle band on ventral head to about level of nasal flap, otherwise naked.

Meristics (n=10): Tooth rows in upper jaw 37 (34–39); lower jaw 38 (32–39). Pectoral-fin propterygial radials 28 (28–30); mesopterygial radials 15 (14–17); metapterygial radials 37 (33–36); total radials 80 (77–79). Pelvic-fin radials males (n=4) 1 (1) + 20 (19–20); females (n=6) (1) + (19–23). Trunk centra 28 (26–29); predorsal caudal centra 49 (46–50); predorsal centra 77 (74–79); centra between origins of dorsal fins 15 (12–16); diplospondylous centra about 106 (100–109); total centra about 134 (127–136).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, clasper and tail mostly uniformly greyish brown (often darker centrally and not distinctly paler along propterygium), slightly paler along posterior margins of disc and pelvic fins; rostrum greyish brown, usually strongly demarcated from rest of snout, area adjacent yellowish, much paler than central disc; thorns and alar patch pale, demarcated from skin adjacent; orbital membrane translucent, eye dark. Dorsal fins uniformly greyish or blackish, posterior margins dusky to translucent; epichordal lobe of caudal fin usually pale or translucent, occasionally pale greyish. Ventral surface of

disc moderately dark; dark brownish (somewhat blotchy) on most of disc and pelvic fins, only slightly paler along posterior margin of disc and pelvic fins; whitish over most of denticle band on ventral head and over snout, mouth, and cloaca; membranes of gill slits narrowly pale (not well demarcated from darker areas adjacent; more strongly demarcated in adult male paratype); snout tip mostly pale; median tail brownish, margins white; pelvic fins and claspers blotched, brownish and white; sensory pores small, distinct, black-edged, not surrounded by indistinct dusky blotches, very obvious on preoral snout, less obvious posteriorly. Primary female paratype extremely similar to male holotype dorsally, ventrally and on fins (some other female paratypes more blotchy on posterior part of disc); brown and white blotches on pelvic fins; brown central stripe along tail obvious. Primary juvenile only slightly paler dorsally and ventrally than adults; whitish areas on snout and around mouth better defined than in adults; tail pale brown ventrally, dorsal fins black, caudal fin brownish; sensory pores with fine dark edges, not strongly demarcated.

SIZE.— Largest specimen a female 761 mm TL; no adolescent males but juvenile males ranged between 292–355 mm TL, adult males 634–659 mm TL; smallest juvenile 292 mm TL.

DISTRIBUTION.— Known only from the Saumarez Plateau off Queensland (22°36' S, 154°14' E to 23°12' S, 153°33' E) in depths of 399–606 m. Once thought to occur slightly further north (19°02' S, 150°43' E), but these records appear to be of another closely related undescribed species.

ETYMOLOGY.— Named after the regional geographical range of this species, Queensland. Vernacular name: Queensland Deepwater Skate.

REMARKS.— *Dipturus queenslandicus* has a very long, pointed snout (mean preorbital length 24% TL in adults, n=6) that is shared by two other, much larger Australian species, *D. gudgeri* and *D. acrobelus* (mean preorbital length 24–25% TL, n=14; other *Dipturus* skates treated in this paper have mean preorbital lengths of 20–21% TL, n=20). *Dipturus queenslandicus* differs from these long-snouted relatives in having a relatively shorter anterior pelvic-fin lobe (length 67–80% vs. 81–106% of length of posterior lobe in *D. gudgeri* and *D. acrobelus*) and the midlength of the tail is not so obviously expanded (width at pelvic-fin insertion 1.6–2.1 vs. 1.2–1.7 times its width at midlength). *Dipturus gudgeri* also lacks nuchal thorns (usually present in the other species). *Dipturus queenslandicus* has fewer pectoral-fin radials (77–80 vs. 83–88) and predorsal diplospondylous centra (46–50 vs. 52–56), and is a much smaller species (attaining about 76 vs. 137 cm TL) than its northern relative *D. acrobelus*.

Comparative material.

Dipturus gudgeri: 6 specimens: AMS E 4284 (holotype), juvenile male 699 mm TL; CSIRO C 4782, juvenile male 499 mm TL; CSIRO C 4901, juvenile male 528 mm TL; CSIRO H 63–1, female 541 mm TL; CSIRO H 237–01, female 685 mm TL; CSIRO H 599–01, adolescent male 1282 mm TL.

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New short-snout members of the skate genus *Dipturus* (Rajoidei: Rajidae) from Australian seas

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ABSTRACT.— Six new species of small skates, tentatively assigned to the genus *Dipturus*, are described based on material from Australia. Some of these skates, which have been incorrectly linked to the genus *Okamejei* because of their relatively short snout and small size compared to other *Dipturus* skates, are referred to herein as the ‘short-snout’ *Dipturus* group. Five of these species, *Dipturus canutus* sp. nov. (southeastern and southern Australia), *D. confusus* sp. nov. (southeastern Australia), *D. falloargus* sp. nov. (northwestern Australia), *D. grahami* sp. nov. (eastern Australia) and *D. oculus* sp. nov. (southwestern Australia), were identified and treated a decade ago in a comprehensive guide to the shark and ray fauna of Australia. *Dipturus endeavouri* sp. nov. (eastern Australia) has until recently been confused with *D. polyommata* Ogilby, a similar species that occurs slightly further north off central Queensland. Ogilby’s type series probably contained representatives of both species. Two of these small skates have a plain dorsal coloration whereas the others have complex patterns of spots, blotches, reticulations or pectoral ocelli. They also differ from each other by a combination of body shape, squamation, morphometrics and meristics.

Key words. Rajidae – skates – *Dipturus* – new species – Australia

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INTRODUCTION

The Australian hardnose skate (family Rajidae) fauna consists of 25 species of which 16 are presently undescribed (Last & Stevens, 1994). Last & Yearsley (2002) list 29 species (as members of the subfamily Rajinae) with the inclusion of the Anacanthobatidae (3 species) and another recently discovered hardnose skate from Indo–Australian region. The bulk of these skates (22 species) are members of the genus *Dipturus* Rafinesque (designated type of the genus *Raja batis* Linnaeus, 1758). *Dipturus* was relegated by most authors to subgeneric status (e.g. Stehmann, 1973; Ishihara & Ishiyama, 1986; Ishihara, 1987; Séret, 1989; Jacob & McEachran, 1994) until being resurrected by McEachran & Dunn (1998). This group was distinguished from *Okamejei* Ishiyama by Ishihara (1987) on the basis of: long rostral cartilage (more than 60% dorsal head length); tail sometimes expanded at its midlength and with a single row of thorns in males and 3 or 5 rows in females; ventral surface dark and with denticles not confined to the snout; 30–35 trunk vertebrae; anterior fontanelle of the neurocranium without a distinct anterior margin; no funnel in the clasper of adult males; egg cases exceeding 65 mm in length without horns; and adults usually more than 55 mm TL.

Last & Yearsley (2002) identified a group of small, short-snout Australian *Dipturus*-like skates that did not

conform to Ishihara’s definition of the genus. This group, which consists of three described species, *Dipturus australis* (Macleay, 1884), *D. cerva* (Whitley, 1939), *D. polyommata* (Ogilby, 1910), and four undescribed species, referred to by Last & Stevens (1994) as *Raja* sp. A, B, D and E, were subsequently provisionally assigned by Last & Yearsley (2002) to a new subgroup of *Dipturus* (known as “subgenus A”). These undescribed species and two other small, short-snout *Dipturus* (i.e. *Raja* sp. C *sensu* Last & Stevens, 1994 and a newly identified species) are formally described below.

METHODS

The descriptive format is based on McEachran & Fehhelm (1982). Methods follow those outlined in the first paper of this special publication (Last *et al.*, 2008) and generally follow standards used for skates. Materials of the 6 new species (i.e. *Dipturus canutus*, *D. confusus*, *D. endeavouri*, *D. falloargus*, *D. grahami* and *D. oculus*) are listed below. They include the holotype and primary descriptive types (female and juvenile), as well as specimens from which meristic and/or morphometric information was obtained. Collection acronyms follow Leviton *et al.* (1985).

Dipturus canutus: holotype (CSIRO H 153–01), primary

female paratype (CSIRO H 155–01), primary juvenile paratype (CSIRO H 868–01); 6 morphometric paratypes (CSIRO H 150–01, CSIRO H 227–01, CSIRO H 229–01, CSIRO H 296–01, CSIRO H 302–01 and CSIRO H 606–01); 10 meristic paratypes (CSIRO H 57–01, CSIRO H 150–01, CSIRO H 205–01, CSIRO H 206–01, CSIRO H 227–01, CSIRO H 229–01, CSIRO H 302–01, CSIRO H 606–01, CSIRO H 1010–01 and NMV A 3358).

Dipturus confusus: holotype (CSIRO H 4255–01), primary female paratype (CSIRO CA 4453), primary juvenile paratype (CSIRO H 196–01); 5 morphometric paratypes (CSIRO CA 44, CSIRO CA 47, CSIRO CA 516, CSIRO H 218–01 and CSIRO H 293–01); 10 meristic paratypes (CSIRO CA 44, CSIRO CA 47, CSIRO CA 516, CSIRO H 1264–10, CSIRO H 1264–11, CSIRO H 211–01, CSIRO H 212–01, CSIRO H 218–01, CSIRO H 300–01 and CSIRO T 453–03).

Dipturus endeavouri: holotype (CSIRO H 6630–01), primary female paratype (CSIRO H 2687–01), primary juvenile paratype (CSIRO H 6630–05); 5 morphometric paratypes (CSIRO H 2687–01, CSIRO H 2687–02, CSIRO H 6630–02, CSIRO H 6630–03 and CSIRO H 6630–04); 9 meristic paratypes (CSIRO H 2687–01, CSIRO H 2687–02, CSIRO H 2692–10, CSIRO H 6630–02, CSIRO H 6630–03, CSIRO H 6630–04, CSIRO H 6630–05, QM I 19257 and QM I 19970).

Dipturus falloargus: holotype (CSIRO H 5192–01), primary female paratype (CSIRO H 1035–04), primary juvenile paratype (CSIRO H 1036–23); 5 morphometric paratypes (CSIRO CA 2858, CSIRO CA 4275, CSIRO H 1035–04, CSIRO H 1047–01 and CSIRO H 4074–13); 10 meristic paratypes (CSIRO CA 2857, CSIRO CA 2858, CSIRO CA 2859, CSIRO CA 4273, CSIRO CA 4275, CSIRO CA 4279, CSIRO H 1035–05, CSIRO H 1047–01, CSIRO H 4074–13 and CSIRO H 4074–14).

Dipturus grahami: holotype (CSIRO H 950–01), primary female paratype (CSIRO H 950–02); primary juvenile paratype (AMS I 21777–003); 5 morphometric paratypes (CSIRO H 290–01, CSIRO H 294–01, CSIRO H 950–02, CSIRO H 953–02 and CSIRO H 953–04); 9 meristic paratypes (CSIRO CA 2807, CSIRO H 55–01, CSIRO H 56–01, CSIRO H 58–01, CSIRO H 59–01, CSIRO H 60–01, CSIRO H 61–01, CSIRO H 1199–01 and CSIRO H 1199–02).

Dipturus oculus: holotype (CSIRO H 2619–01), primary female paratype (CSIRO H 2619–02); 5 morphometric paratypes (CSIRO H 3072–01, CSIRO H 3073–01, CSIRO H 3074–02, CSIRO H 3074–04 and CSIRO H 3075–01); 9 meristic paratypes (CSIRO H 203–01, CSIRO H 2613–02, CSIRO H 2619–02, CSIRO H 3072–01, CSIRO H 3074–02, CSIRO H 3074–03, CSIRO H 3075–01, CSIRO H 3076–01 and NMV A 1811–01).

Dipturus canutus sp. nov.

Figs 1–6; Table 1

Raja sp. B: Last & Stevens, 1994: pp 302, 325, fig. 34.17, key fig. 23, pl. 60.

Raja sp. 2: Last, in Gomon *et al.*, 1994: pp 163, fig. 140.

Holotype. CSIRO H 153–01, adult male 775 mm TL, east of Maria Island, Tasmania, 42°40' S, 148°25' E, 448–460 m, 11 Feb 1985.

Paratypes. 21 specimens. CSIRO H 57–01, female 287 mm TL (tail tip damaged), off Norah Head, New South Wales, 33°30' S, 152°05' E, ca. 500 m; CSIRO H 148–01, adult male 795 mm TL, east of Maria Island, Tasmania, 42°40' S, 148°25' E, 428–452 m, 09 Dec 1984; CSIRO H 150–01, juvenile male 499 mm TL, east of Maria Island, Tasmania, 42°39' S, 148°25' E, 422–440 m, 15 Aug 1984; CSIRO H 155–01, female ~820 mm TL, east of Maria Island, Tasmania, 42°40' S, 148°25' E, 460–468 m, 11 Feb 1985; CSIRO H 205–01, juvenile male 316 mm TL, west of Strahan, Tasmania, 42°07' S, 144°41' E, 455 m, 02 Feb 1979; CSIRO H 206–01, juvenile male 479 mm TL, west coast of Tasmania, 546 m, Feb 1979; CSIRO H 227–01, adult male 639 mm TL (tail tip damaged), Great Australian Bight, South Australia, 34°29' S, 132°15' E, 900–952 m, 08 May 1983; CSIRO H 228–01, female 584 mm TL, south of Eucla, South Australia, 33°27' S, 129°11' E, 440–460 m, 04 Jun 1983; CSIRO H 229–01, adult male 697 mm TL, Great Australian Bight, South Australia, 33°21' S, 129°18' E, 155–164 m, 04 Jun 1983; CSIRO H 296–01, female 669 mm TL, off St Helens, Tasmania, ca. 41° S, 148° E, 546 m, Oct 1981; CSIRO H 302–01, adolescent male 652 mm TL, south of King Island and west of Cape Grim, Tasmania, 40°47' S, 143°32' E, 920–927 m, 16 Dec 1981; CSIRO H 606–01, female 636 mm TL, east of Maria Island, Tasmania, 42°41' S, 148°25' E, 475–500 m, 28 May 1985; CSIRO H 868–01, juvenile male 174 mm TL, east of Jervis Bay, New South Wales, 34°58' S, 151°09' E, 490–576 m, 10 Sep 1986; CSIRO H 953–05, juvenile male 202 mm TL, east of Sydney, New South Wales, 33°43' S, 151°54' E, 486–509 m, 18 Dec 1985; CSIRO H 965–02, juvenile male 134 mm TL, east of Broken Bay, New South Wales, 33°43' S, 151°54' E, 495–540 m, 04 Nov 1985; CSIRO H 978–01, female 904 mm TL, east of St Helens, Tasmania, 41°21' S, 148°41' E, 623 m, 12 Sep 1985; CSIRO H 1010–01, juvenile male 367 mm TL, east of Gerringong, New South Wales, 34°43' S, 151°14' E, 450–475 m, 13 Dec 1984; CSIRO H 5308–05, adolescent male 649 mm TL, south of Cape Everard, Victoria, 38°12' S, 149°33' E, 397–428 m, 21 Apr 2000; NMV A 3358, juvenile male 463 mm TL, east of Sydney, New South Wales, 33°44' S, 151°50' E, 440–475 m, 09 Sep 1981; NMV A 3977, juvenile male 240 mm TL, south-west of King Island, Tasmania, 40°23' S, 143°23' E, 560–578 m, 28 Jan 1985; SAMA F 5362, juvenile male 312 mm TL, south of Gabo Island, Victoria, 38°01' S, 150°04' E, 452–460 m, 14 Oct 1984.

Other material. 22 specimens. CSIRO H 149–01, female 724 mm TL, south-east of Gabo Island, Victoria, 37°42' S, 150°15' E, 426–430 m, 28 Nov 1984; CSIRO H 230–01, female 695 mm TL, west of Granville Harbour, Tasmania, 41°45' S, 144°24' E, 900–940 m, 24 Jun 1983; CSIRO H 297–01, female 712 mm TL, CSIRO H 303–01, female >679 mm TL (tail tip damaged), CSIRO H 309–01, female >545 mm TL (tail tip damaged), Great Australian Bight, Western Australia, 33°20' S, 128°15' E, 360–372 m, 02 Aug 1981; CSIRO H 317–01, adult male 650 mm TL, Great Australian Bight, Western Australia, 33°23' S, 128°55' E, 319–336 m, 19 Mar 1980; CSIRO H 318–01, adult male 744 mm TL, off Strahan, Tasmania, 42°20' S, 144°47' E, 549 m, 19 Jan 1979; CSIRO H 320–01, adult male 676 mm TL, off Strahan, Tasmania, ca. 42° S, 145° E, 546 m, Jan 1979; CSIRO H 321–01, adult male 740 mm TL, off St Helens, Tasmania, ca. 41° S, 148° E, 546 m, Oct 1981; CSIRO H 606–02, female 815 mm TL, east of Maria Island, Tasmania, 42°41' S, 148°25' E, 475–500 m, 28 May 1985; CSIRO H 611–01, female 842 mm TL, east of Maria Island, Tasmania, 42°39' S, 148°26' E, 440–456 m, 24 Mar 1985; CSIRO H 965–03, juvenile male 145 mm TL, east of Broken Bay, New South Wales, 33°43' S, 151°54' E, 495–540 m, 04 Nov 1985; CSIRO H 966–03, female >505 mm TL (tail tip damaged), New South Wales; CSIRO H 1010–02 (2 specimens) juvenile male 145 mm TL, juvenile male 156 mm TL, east of Gerringong, New South Wales, 34°43' S, 151°14' E, 450 m, 13 Dec 1984; CSIRO H 2206–01, adolescent male 721 mm TL, south-west of King Island, Tasmania, 40°34' S, 143°29' E, 480–510 m, 12 Oct 1983; CSIRO H 3569–01, adult male 688 mm TL, east of Bermagui, New South Wales, 36°27' S, 150°21' E, 575–602 m, 15 Aug 1993; CSIRO H 5310–06, female 530 mm TL, south of Cape Everard, Victoria, 38°15' S, 149°37' E, 533–617 m, 22 Apr 2000; CSIRO T 356–01, female 795 mm TL, Great Australian Bight, South Australia, 33°43' S, 130°33' E, 997–1050 m, 20 May 1983; CSIRO T 452–01, adult male >537 mm TL (tail tip damaged), Great Australian Bight, South Australia, 33°24' S, 129°32' E, 340–400 m, 03 Aug 1981; CSIRO T 636–01, female 153 mm TL, off St Helens, Tasmania, ca. 41° S, 148° E, 750 m, 28 Mar 1984; CSIRO T 1399–01, adult male 748 mm TL, south-west of King Island, Tasmania, 40°30' S, 143°25' E, 570–580 m, 12 Oct 1983.

DIAGNOSIS.— A medium-sized species of *Dipturus* (to 90 cm TL) with the following combination of characters: disc narrow with rounded apices, width 67–75% TL, 1.2–1.3 times its length; snout angle 82–96°; tail short, length 0.8–0.9 in distance from snout tip to rear of cloaca; tail not broad, width 1.6–2.0 times height at its midlength, 1.3–1.9 times at first dorsal-fin origin; pre-upper jaw length 16–19% TL, 1.7–2.0 times internasal width; ventral head length 30–33% TL; snout length 3.1–3.8 times interorbital width; orbit diameter 63–94% interorbital width; first dorsal-fin height 1.2–1.6 in its base length; distance from first dorsal-fin origin to tail tip 2.7–3.9 times first dorsal-fin base length, 3.0–3.7 times caudal-

fin length; pelvic fins of medium size, length of posterior lobe of adult males 17–19% TL, length of anterior lobe 67–86% of posterior lobe; adult clasper relatively short, 22–25% TL, connected to pelvic-fin inner margin at about 43–45% of its length from cloaca; anterior margins of both surfaces of disc naked; 1–5 nuchal thorns; malar thorns patch well developed; tail with 3 thorn rows in males, additional pair of well-developed lateral rows in females; total pectoral radials 81–88; trunk centra 27–30; predorsal centra 75–82; total centra about 130–139; tooth rows in upper jaw 33–41; mainly uniform greyish or greyish brown dorsally; ventral surface with strong grey and white pattern, dark markings on snout, over abdomen, around cloaca, and along outer margins of pelvic fins; ventral sensory pores usually indistinct, not surrounded by greyish blotches.

DESCRIPTION.— Disc quadrangular, 1.17 times as broad as long in adult male holotype (1.22–1.25 times in paratypes); angle in front of spiracles 82 (86–96)°; axis of greatest width 58 (54–58)% of disc length; anterior margin double concave (less pronounced in females and juveniles), weakly concave anteriorly, weakly convex beside eyes, deeply concave behind level of spiracles in holotype (almost straight in primary juvenile paratype CSIRO H 868–01, male 174 mm TL); apex narrowly rounded, posterior margin convex; free rear tip very broadly rounded. Head short, preorbital snout length 3.87 (3.79–5.49) times orbit length, 3.13 (3.31–3.79) times interorbit; pre-upper jaw length 1.70 (1.80–2.04) times internarial distance. Snout tip well produced, bluntly pointed; no fleshy process at apex. Orbit large, dorsal, diameter 0.81 (0.63–0.94) times interorbital width; eye dorsolateral. Spiracle large, length 2.68 (1.42–2.40) in orbit diameter; opening variable in shape. Nostril suboval to circular, often distorted; anterior nasal flap expanded, its lateral margin forming a short semi-circular tube; anterior margin of flap also lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed beneath nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with well-developed fringe; internarial distance 1.61 (1.57–1.79) in distance between first gill slits, 0.98 (0.90–1.01) in distance between fifth gill slits. Upper jaw arched slightly, more so in adult males than females and juveniles; not or weakly indented at symphysis; lower jaw weakly convex to double convex in males and juveniles, straight to weakly biconcave in large females; lateral teeth of upper jaw usually concealed by lobe of nasal curtain. Teeth of adult male holotype unicuspid, with subcircular bases; arranged in longitudinal rows rather than quincunx; medial cusps short, conical, bluntly pointed, posteriorly directed near mid-jaw, shorter and more oblique laterally; teeth of females and juvenile paratypes in quincunx, with subrectangular crowns, cusps very short, blunt.

Pelvic fins of medium size, deeply forked; anterior lobe short, stubby, narrowly rounded distally, lateral margin

A



B

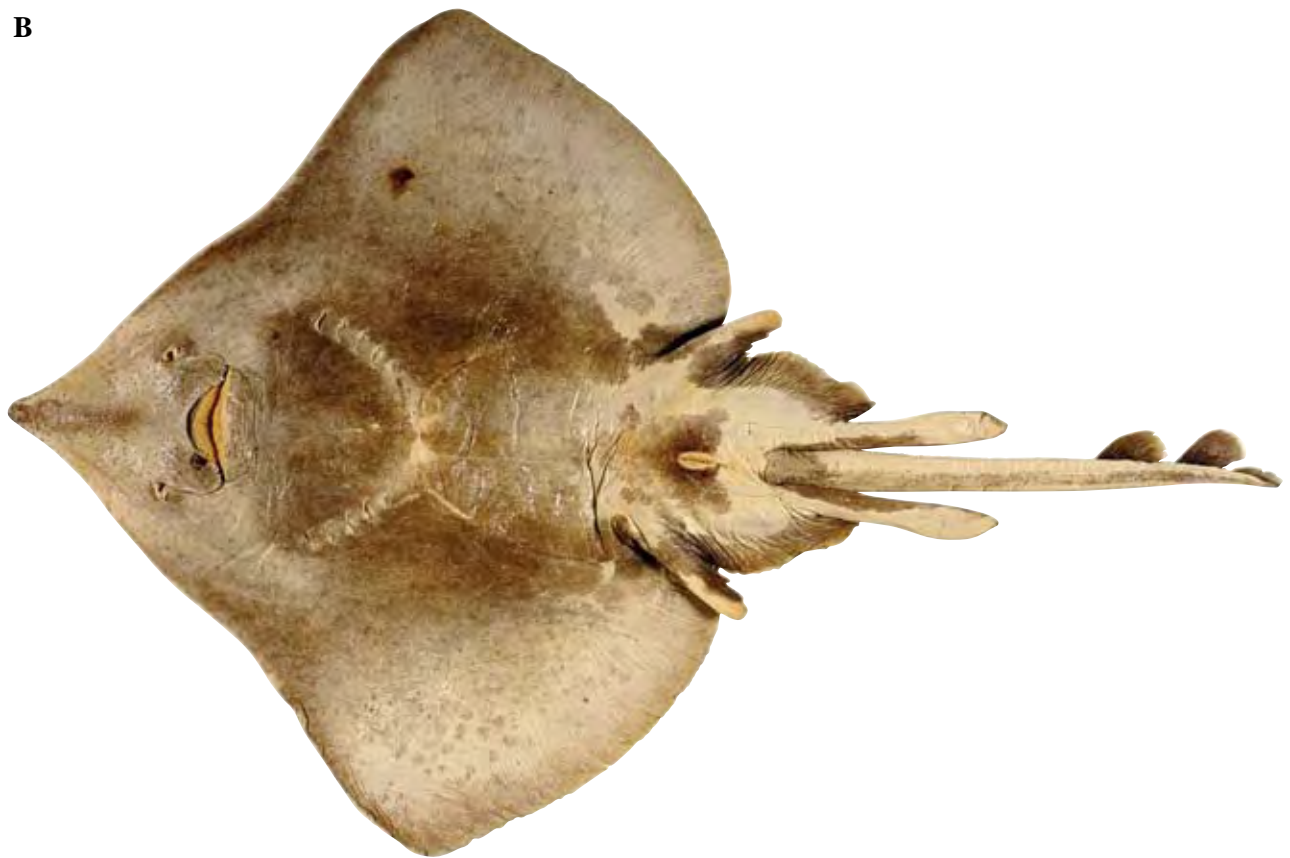


Figure 1. *Dipturus canutus* sp. nov., adult male holotype (CSIRO H 153-01, 775 mm TL, preserved): A, dorsal surface; B, ventral surface.

A



B



Figure 2. Dorsal surface of *Dipturus canutus* sp. nov.: A, female paratype (CSIRO H 978–01, 904 mm TL, fresh); B, juvenile paratype (CSIRO H 965–02, male 134 mm TL, preserved).



Figure 3. Dorsal head of *Dipturus canutus* sp. nov., adult male holotype (CSIRO H 153–01, 775 mm TL), showing snout, orbito–spiracular and nuchal regions.

entire, inner margin well incised; posterior lobe elongate, slightly longer in adult males (length 16.9–19.3% TL) than in females (length 15.0–15.6% TL), lateral margins strongly convex, inner margin convex (almost straight in female paratypes), connected well forward of mid-lateral margin of clasper; anterior lobe 0.67 (0.68–0.86) times posterior lobe. Clasper moderately elongate, 22–25% TL, slender, slightly depressed, glans expanded slightly; clasper components include proximal slit and distal cleft, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel and spike; denticles and pseudosiphon absent. Tail slightly depressed, not broad at base, barely tapering to first dorsal-fin origin, not expanded at its midlength; tapering evenly to tail tip behind first dorsal fin; width at insertions of pelvic fins 1.46 (1.40–1.88) times width at midlength of tail and 1.55 (1.50–2.37) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.82 (0.82–0.95) times distance from tip of snout to rear of cloaca; anterior cross-section equally convex dorsally and ventrally, becoming much more strongly convex on dorsal surface than ventral surface posteriorly, almost flat ventrally near tail apex; width 1.70 (1.66–1.89) times height at insertion of pelvic fin, 1.93 (1.61–1.97) times height at midlength, 1.87 (1.29–1.86) times height at first dorsal-fin origin; lateral tail fold not well developed in

adults or juveniles, in holotype barely detectable forward of midtail, terminating well short of tail tip, broadest beneath second dorsal fin. Dorsal fins of medium size, of similar shape, first dorsal fin usually very slightly more upright than second (slightly damaged in holotype); first dorsal-fin height 1.32 (1.20–1.55) in base length; fins strongly raked, low, elongate, with short bases; anterior margin of first dorsal strongly convex, second almost straight, apices broadly rounded, posterior margins convex, free rear tip broadly; inner margins long, variable in paratypes, directed posterodorsally; first dorsal longer than second; interdorsal distance short, 1.69 (2.59–17.21) times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 3.91 (2.73–3.48) times dorsal-fin base length, 3.20 (3.04–3.68) times caudal-fin length; first dorsal-fin base 0.82 (0.87–1.35) times caudal-fin length. Epichordal caudal-fin lobe well developed, long-based (short in primary female paratype CSIRO H 155–01, ~820 mm TL; very long in primary juvenile paratype CSIRO H 868–01), low, height less than half tail width at fin origin; usually slightly taller posteriorly than anteriorly; truncate or rounded distally, its dorsal margin convex; connected basally or sub-basally to second dorsal



Figure 4. Ventral view of *Dipturus canutus* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 153–01, 775 mm TL); B, female paratype (CSIRO H 978–01, 904 mm TL).

fin; hypochordal caudal lobe vestigial.

Dorsal surface of adult male holotype with well-developed nuchal, orbito-spiracular, tail, malar and alar thorns; no thorns along most of mid-disc or on scapular region; primary female paratype with well-developed nuchal, orbital, tail thorns and enlarged thorn-like denticles at snout tip; primary juvenile paratype with greatly enlarged nuchal and orbital thorns, and prominent tail thorns. Orbital thorns of holotype about 17–19 (highest counts in largest male paratypes), subequal in size, intact (variable in paratypes), low, raked, robust, little recurved; dense, usually forming an almost continuous rosette, with clusters anteriorly and posteriorly separated by single series above eye; female paratype with similar orbital thorns, about 23–26; primary juvenile paratype with 3 well-developed thorns (2 on preorbit, 1 on postorbit, left lateral preorbit damaged), rosette formed in 287 mm TL female (CSIRO H 57–01). Nuchal thorns of holotype 3 (1–3 in other male paratypes), short, broad based, erect to raked, somewhat laterally compressed, not more robust than orbital thorns; female paratype with irregular series of 5 closely spaced thorns (1–3 in other female paratypes); primary juvenile paratype with 1 large, posteriorly directed thorn; single thorn persistent in juveniles to at least 316 mm TL (CSIRO H 205–01). Malar patch in holotype with about 9–13 enlarged thorns beside orbito-spiracular region, these flanked forward and behind by smaller thorns and enlarged denticles; patch extending along disc margin, originating near anterior tip of propterygium (just forward of level of preorbital thorns), terminating as spiniform denticles near level of alar patch, length of main part of malar patch more than 1–2+ times orbit diameter; largest thorns slender, pungent, mostly similar in shape to each other, strongly raked, directed posterolaterally. Alar thorns in holotype about 22–26 (including missing thorns), well developed, subequal in length to tail thorns; deeply embedded, tips pungent, directed slightly posteromedially, in 2 (3–4) main irregular rows; patch distinctly longer than main part of malar patch (about half of dorsal head length). Tail thorns of adult male holotype well developed, pungent, recurved or tilted; predorsal primary thorns with large bases, larger than largest nuchal and orbital thorns; largest thorns with an enlarged dermal flap on their posterior bases; in 3 rows (variably developed in adult male paratypes); median row almost linear, occasionally paired, with about 22 (10–26) main thorns, about 11 (3–16) much smaller interstitial thorns interspersed around main thorns; median row originating over cloaca (rarely near pelvic-fin insertion), terminating at first dorsal-fin origin; lateral rows short, less well developed than median row, with 3–4 (1–8) anteriorly located thorns; interdorsal thorns 4 (0–2), unpaired. Primary female paratype with 5 well-developed rows of thorns; median row best developed, continuous, commencing above cloaca and extending along length of predorsal tail in a single, strongly staggered series (other large female paratypes with multiple paired thorns), with about 37 (26–35) main predorsal thorns, some interstitial

thorns 12 (10–16) present; paired dorsolateral rows closer to lateral fold than to median thorn row; inner lateral rows with about 12–15 (4–8) thorns, elongate, commencing near pelvic-fin insertion, reaching to midlength of tail (usually not far beyond pelvic-fin rear tip); outer lateral rows adjacent to lateral fold, better developed than inner row, with about 22 (12–22) thorns, elongate, commencing slightly forward to slightly beyond tip of pelvic fin, reaching to base of first dorsal fin; interdorsal thorns 2 (1–3), unpaired; some female paratypes with an isolated thorn below dorsal fins. Primary juvenile paratype with single median row, commencing above cloaca, with 12 short, strongly raked predorsal thorns; interdorsal thorn present.

Denticles of adult males not well developed, disc and tail almost entirely naked; patches on head of holotype confined to rostral apex dorsally, and anterior dorsal margin of disc; marginal band merging with thorns and thornlets of malar patch and extending to edge of level of alar patch, denticles slender, widely spaced, upright. Primary female paratype with well developed apical denticles on snout, small granular denticles present above dorsal midregion of pelvic fins, weak patch of widely spaced denticles near dorsal margin of disc beside orbit. Primary juvenile paratype without skin denticles.

Meristics (n=11): Tooth rows in upper jaw 38 (33–41); lower jaw 40 (33–38). Pectoral-fin propterygial radials 30–31 (30–33); mesopterygial radials 15–16 (14–17); metapterygial radials 37 (36–40); total radials 83 (81–88). Pelvic-fin radials males (n=9) 1 (1) + 21–22 (20–23); females (n=2) (1) + (20–22). Trunk centra 28 (27–30); predorsal caudal centra 51 (47–54); predorsal centra 79 (75–82); centra between origins of dorsal fins 14 (12–15); diplospondylous centra 103 (101–109, 94 in CSIRO H 227–01 and CSIRO H 57–01 due to tail damage); total centra about 131 (130–139, 123 in CSIRO H 227–01 and 122 in CSIRO H 57–01 due to tail damage).

COLOUR (in preservative).— Dorsal surface of disc, dorsal and pelvic fins, claspers and tail of holotype almost uniformly dark greyish or greyish brown (flecks where skin has been scratched, (paratypes from Great Australian Bight distinctly paler grey); snout beside rostral cartilage only slightly paler than disc; lateral tail fold and margin of disc and pelvic fins narrowly pale yellowish; eyelid similar to disc, eye blackish; paired nuchal pore patches greyish, darker than adjacent disc. Ventral surface with a characteristic pattern dominated by diffuse greyish and yellowish white areas (almost uniformly pale in paratypes from Great Australian Bight); dark areas variable, usually present on chin, internasal flap, along mid snout (less evident in paratypes), over abdomen to axil of pectoral fins, around cloaca, at axil of pectoral and pelvic fins, on base of anterior lobe of pelvic fin and along distal half of its posterior lobe, at tail base, and along inner margin of claspers; some dark areas along midline of tail; dark-



Figure 5. Lateral view of dorsal and caudal fins of *Dipturus canutus* sp. nov., adult male holotype (CSIRO H 153–01, 775 mm TL). Note second dorsal fin base partially torn.

A



B



C



D



Figure 6. Thorns at tail midlength of *Dipturus canutus* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 153–01, 775 mm TL); C, dorsal and D, lateral view of female paratype (CSIRO H 978–01, 904 mm TL).

edged pores mostly indistinct, obvious on head, not surrounded by dusky blotches; dark areas broken up by white patches, piebald in appearance; paler areas most evident on snout, along anterior disc margin, through gill slits, and around pelvic fins and cloaca. Primary female paratype similar to holotype in dorsal coloration and position of ventral markings. Primary juvenile paratype with dark brown disc, translucent beside rostral cartilage; ventral disc white, with broad black marginal band extending from just behind mouth level on anterior disc to pectoral-fin axil (also evident from dorsal surface); anterior and posterior lobes of pelvic fin with distinctive black margins; posterior tail including dorsal fins black; juveniles at about 320 mm TL (CSIRO H 205–01 and SAM F 5362) still have dark dorsal fins and a white caudal fin. When fresh: Adults and juveniles more greyish dorsally than in preservative; light and dark areas on ventral surface more strongly contrasted, dusky grey and white.

SIZE.— Largest specimen was a female 904 mm TL; adolescent males varied from 649–721 mm TL, and intact adult males from 639–795 mm TL. Smallest juvenile 134 mm TL. Egg cases, which have been described by Treloar *et al.* (2006), are about 93–107 mm long with a maximum width of about 51–57 mm.

DISTRIBUTION.— Southern Australia from south-east of North Head, New South Wales (33°30' S, 152°00' E), and westward to at least Eucla, Western Australia (33°20' S, 128°15' E). Off Tasmania, southward to at least Strahan (42°07' S, 144°41' E) off the west coast and Maria Island (42°41' S, 148°25' E) off the east coast; probably continuous around southern Tasmania; absent from Bass Strait. Occurs mainly on the upper continental slope at depths of 400–600 m, and rarely outside 330–730 m; extralimital records from the Great Australian Bight at depths of 155 m and 1050 m are unusual and may be erroneous.

ETYMOLOGY.— Taken from the Latin *canutus* (grey, ash-coloured) in allusion to its almost uniformly grey dorsal coloration. Vernacular name: Grey Skate.

REMARKS.— *Dipturus canutus* is the largest and most widely distributed of the short-snout *Dipturus* skates. Most members of this subgroup have a strong or obvious colour pattern on the dorsal surface, and only *D. canutus* and another undescribed species described in this paper (i.e. *D. grahami*), are plain-coloured dorsally. These two plain coloured species are sympatric off southeastern Australia. When fresh, *Dipturus canutus* is grey dorsally (rather than chocolate brown in *D. grahami*), is mainly white ventrally with dark markings that are strongly demarcated near the cloaca and along the pelvic-fin margins (rather than having being darker greenish brown to black ventrally), and has more predorsal centra (75–82 vs. 70–75), more total centra (about 130–139 vs. 118–127), a narrower disc (width 67–75% vs. 76–83% TL),

a longer predorsal tail (length from cloaca to first dorsal fin 29–30% vs. 25–28% TL), shorter claspers (post-cloacal clasper length 22–25% vs. 27–28% TL in adult males), smaller dorsal fins (base length of first 4–5% vs. 6–7% TL), is slightly larger (reaching about 90 cm vs. about 64 cm TL), and occurs slightly deeper (recorded to 1050 m and often in 730 m vs. rarely exceeding 500 m depth). Other plain-coloured *Dipturus* skates are either much larger (exceeding 1 m TL) and/or have a much more elongate snout in all but small juveniles (length more than 6 times orbit diameter vs. 3.8–5.5 times in *D. canutus*).

Dipturus confusus sp. nov.

Figs 7–12; Table 1

Raja sp. 1: May & Maxwell, 1986: pp 145, fig.

Raja sp. A: Last & Stevens, 1994: pp 303, 323, fig. 34.16, key fig. 27, pl. 62.

Raja sp. 1: Last, in Gomon *et al.*, 1994: pp 162, fig. 139.

Holotype. CSIRO H 4255–01, adult male 508 mm TL, east of Lakes Entrance, Victoria, 37°52' S, 148°11' E, 27–28 m, 20 Apr 1996.

Paratypes. 17 specimens. AMS I 34086–006, adolescent male 484 mm TL, west of Port Davey, Tasmania, 43°20' S, 145°35' E, 155–157 m, 21 Mar 1989; CSIRO CA 44, female 553 mm TL, Bass Strait, south of Cape Conran, Victoria, 38°15' S, 148°45' E, 118–130 m, 29 Nov 1976; CSIRO CA 47, adolescent male 534 mm TL, south of Tasman Peninsula, Tasmania, 43°45' S, 147°45' E, 160–163 m, 15 Dec 1976; CSIRO CA 59, adolescent male 522 mm TL, south-east of Lakes Entrance, Victoria, 38°27' S, 148°33' E, 250–390 m, 28 Nov 1976; CSIRO CA 516, female 479 mm TL, south-east of Adventure Bay, Tasmania, 43°26' S, 147°33' E, 90–100 m, 09 Nov 1978; CSIRO CA 4453, female 427 mm TL, south-east of Bermagui, New South Wales, 36°32' S, 150°18' E, 200–204 m, 03 Apr 1981; CSIRO H 118–01, juvenile male 292 mm TL, Frederick Henry Bay, Tasmania, 42°57' S, 147°36' E, 20 m, 21 Jul 1983; CSIRO H 196–01, juvenile male 220 mm TL, west of Port Davey, Tasmania, 43°15' S, 145°31' E, 145–161 m, 29 Jan 1979; CSIRO H 211–01, juvenile male 313 mm TL, east of South Bruny Island, Tasmania, 43°24' S, 147°26' E, 100 m, 28 Jan 1980; CSIRO H 212–01, juvenile male 373 mm TL, Adventure, Tasmania, 43°18' S, 147°24' E, 56–60 m, 29 Jan 1980; CSIRO H 218–01, female 599 mm TL, west of Cape Sorell, Tasmania, 42°12' S, 144°50' E, 170–172 m, 22 Oct 1983; CSIRO H 293–01, adolescent male 471 mm TL, Great Oyster Bay, off Refuge Island, Tasmania, 42°11' S, 148°16' E, 18 m, 22 Apr 1980; CSIRO H 300–01, female 587 mm TL, south-east Tasmania, 110 m, May 1978; CSIRO H 1264–10, female 566 mm TL, CSIRO H 1264–11, adult male 551 mm TL, north of Maria Island, Tasmania, 42°33' S, 148°15' E, 81–82 m, 07 Apr 1988; CSIRO H

3716–01, juvenile male 220 mm TL, east of Bega, New South Wales, 36°42' S, 150°08' E, 102–104 m, 23 Mar 1994; CSIRO T 453–03, female 523 mm TL, Adventure Bay, Tasmania, 43°18' S, 147°24' E, 56–60 m, 29 Jan 1980.

Other material. 25 specimens. CSIRO C 4778, female 587 mm TL, east of Batemans Bay, New South Wales, 35°39' S, 150°45' E, 350–380 m, 31 Aug 1976; CSIRO CA 507, juvenile male 374 mm TL, Adventure Bay, Tasmania, 43°15' S, 147°29' E, 50–52 m, 10 Nov 1978; CSIRO CA 515, adult male 606 mm TL, south-east of Adventure Bay, Tasmania, 43°26' S, 147°33' E, 90–100 m, 09 Nov 1978; CSIRO H 119–01, juvenile male 242 mm TL, CSIRO H 198–01, juvenile male 282 mm TL, CSIRO H 299–01, female >597 mm TL (tail tip damaged), south-east Tasmania, 110 m, May 1978; CSIRO H 204–01, juvenile male 313 mm TL, east coast of Tasmania, Oct 1979; CSIRO H 292–01, adolescent male 482 mm TL, CSIRO H 301–01, adult male 649 mm TL, south-east Tasmania, 72 m, Sep 1981; CSIRO H 295–01, adult male 584 mm TL, Storm Bay, west of Wedge Island, Tasmania, 43°08' S, 147°40' E, 49 m, 09 Oct 1979; CSIRO H 316–01, female >644 mm TL (tail tip damaged), off Strahan, Tasmania, 110 m, Jan 1979; CSIRO H 319–01, female 695 mm TL, off Port Davey, Tasmania, ca. 43° S, 145° E, 145 m, 30 Jan 1979; CSIRO H 488–01, female >614 mm TL (tail tip damaged), no data; CSIRO H 933–01, female 320 mm TL, Bass Strait, Tasmania, ca. 39° S, 145° E, 70 m, 24 Jul 1987; CSIRO H 940–03, juvenile male 338 mm TL, south-east of Eddystone Point, Tasmania, 41°04' S, 148°24' E, 80 m, 09 Jul 1986; CSIRO H 3507–09, adult male 500 mm TL, south-east of Lakes Entrance, in Bass Strait, Victoria, 38°56' S, 148°29' E, 151–185 m, 28 Jul 1993; CSIRO H 3568–01, female 565 mm TL, Bass Strait, Victoria, 38°56' S, 148°29' E, 123–125 m, 28 Jul 1993; CSIRO H 3704–05, female 350 mm TL, east of Disaster Bay, New South Wales, 37°19' S, 150°18' E, 139–143 m, 08 Aug 1994; CSIRO H 3848–01, female 328 mm TL, east of Bega, New South Wales, 36°42' S, 150°09' E, 104–106 m, 27 Oct 1994; CSIRO H 4443–01, female 262 mm TL, CSIRO H 4443–02, adolescent male 415 mm TL, Disaster Bay, New South Wales, 37°19' S, 150°00' E, 43–46 m, 29 Nov 1996; CSIRO T 453–01, female 619 mm TL, CSIRO T 453–02, adult male 498 mm TL, CSIRO T 453–04, male 620 mm TL, Adventure Bay, Tasmania, 43°18' S, 147°24' E, 56–60 m, 29 Jan 1980; CSIRO T 454–01, female 607 mm TL, east of Adventure Bay, Tasmania, 43°15' S, 147°28' E, 58–60 m, 29 Jan 1980.

DIAGNOSIS.— A small species of *Dipturus* (to 70 cm TL) with the following combination of characters: disc with narrowly rounded apices, width 70–75% TL, 1.1–1.2 times its length; snout angle 88–96°; tail short, length 0.7–0.8 in distance from snout tip to rear of cloaca; tail rather broad, width 1.8–2.4 times height at its midlength, 2.0–2.1 times at first dorsal-fin origin; pre-upper jaw length 15–19% TL, 1.6–1.9 times internasal width; ventral head length 33–35% TL; snout length

3.1–3.4 times interorbital width; orbit diameter 66–104% interorbital width; first dorsal-fin height 1.3–2.0 in its base length; distance from first dorsal-fin origin to tail tip 2.2–2.6 times first dorsal-fin base length, 4.6–8.7 times caudal-fin length; pelvic fins large, length of posterior lobe of adult males 20–22% TL, length of anterior lobe 57–71% of posterior lobe; adult clasper relatively short, 22–26% TL, connected to pelvic-fin inner margin at about 46–48% of its length from cloaca; long, narrow bands of fine denticles on anterior margins of both surfaces of disc; 0–3 nuchal thorns; malar thorns patch well developed; tail with single median thorn row in males, additional pair of lateral rows in females; total pectoral radials 78–83; trunk centra 28–30; predorsal centra 69–75; total centra about 108–114; tooth rows in upper jaw 33–41; mainly yellowish brown dorsally with distinct pattern of paler and darker spots and reticulations; whitish ventrally with greyish areas over most of head, on belly and near cloaca; ventral sensory pores dark edged anteriorly, usually surrounded by greyish blotches.

DESCRIPTION.— Disc weakly quadrangular, 1.12 times as broad as long in adult male holotype (1.17–1.19 times in paratypes); angle in front of spiracles 88° (89–96°); axis of greatest width 56% (56–58%) of disc length; anterior margin double concave (less pronounced in females and juveniles), deeply concave anteriorly, weakly convex beside eyes, deeply concave behind level of spiracles in holotype (almost straight in primary juvenile paratype CSIRO H 196–01, male 220 mm TL); free rear tip broadly rounded. Head short, preorbital snout length 3.26 (4.03–4.99) times orbit length, 3.38 (3.05–3.39) times interorbit; pre-upper jaw length 1.58 (1.72–1.87) times internarial distance. Snout tip well produced, bluntly pointed; no fleshy process at apex. Orbit large, diameter 1.04 (0.66–0.81) times interorbital width. Spiracle large, length 1.58 (1.45–1.85) in orbit diameter; opening broadly suboval to subrectangular. Nostril suboval to circular, often distorted; anterior nasal flap expanded, its lateral margin forming a short semi-circular tube; anterior margin of flap also lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed by nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with well-developed fringe; internarial distance 1.70 (1.67–1.77) in distance between first gill slits, 0.96 (0.95–1.04) in distance between fifth gill slits. Upper jaw strongly arched in both sexes, not or slightly indented at symphysis; lower jaw uniformly convex, much less so in females and juveniles; lateral teeth fully or partly concealed by lobe of nasal curtain. Teeth of adult male holotype unicuspid with subcircular bases; arranged in distinct longitudinal rows rather than quincunx; medial cusps elongate, conical, bluntly pointed, posteriorly directed; becoming much shorter and more oblique laterally; teeth of female and juvenile paratypes in quincunx, with rectangular crowns, cusps very short, blunt.

A

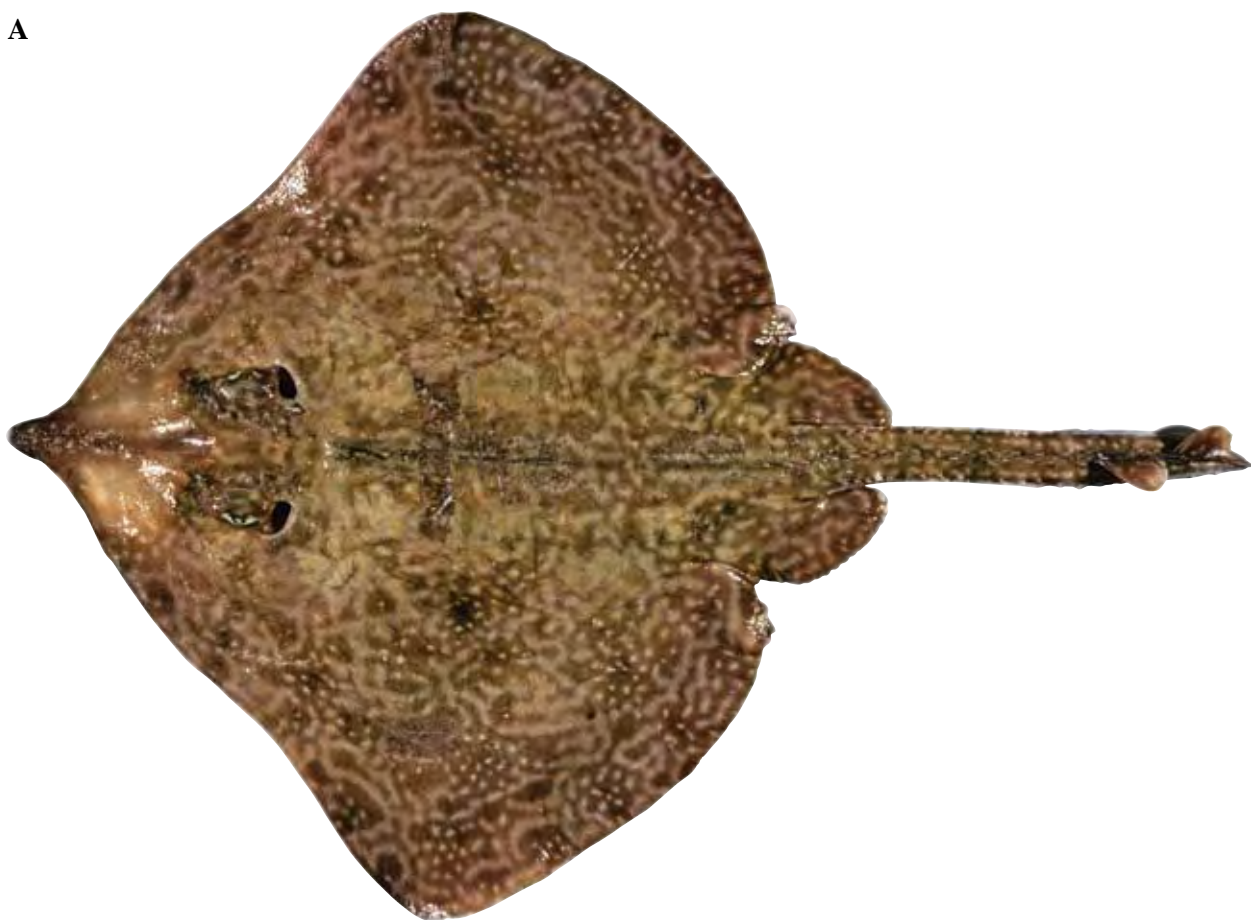


B



Figure 7. *Dipturus confusus* sp. nov., adult male holotype (CSIRO H 4255–01, 508 mm TL, fresh): A, dorsal surface; B, ventral surface.

A



B



Figure 8. Dorsal surface of *Dipturus confusus* sp. nov.: A, female paratype (CSIRO H 1264–10, 566 mm TL); B, juvenile paratype (CSIRO H 3716–01, male 220 mm TL, preserved).



Figure 9. Dorsal head of *Dipturus confusus* sp. nov., adult male holotype (CSIRO H 4255-01, 508 mm TL), showing snout, orbito-spiracular and nuchal regions.

Pelvic fins large, deeply forked; anterior lobe short, slender, narrowly rounded distally, lateral margin entire, inner margin moderately incised; posterior lobe very elongate, slightly longer in males (length 19.7–22.3% TL) than in females (length 17.3–18.7% TL), lateral margins convex, inner margin almost straight, connected to mid-lateral margin of clasper; anterior lobe 0.57 (0.61–0.71) times posterior lobe. Clasper elongate, 22–26% TL, robust, very depressed, glans barely expanded; clasper components include proximal and distal clefts, terminal bridge, pseudorhipidion, rhipidion, shield, dike, sentinel and spike; denticles and pseudosiphon absent. Tail depressed, moderately broad at base, barely tapering to first dorsal-fin origin, not expanded at its midlength; tapering evenly to tail tip behind first dorsal fin; width at insertions of pelvic fins 1.50 (1.37–1.90) times width at midlength of tail and 1.62 (1.60–1.88) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.77 (0.67–0.80) times distance from tip of snout to rear of cloaca; anterior cross-section equally convex dorsally and ventrally, becoming more strongly convex on dorsal surface than ventral surface posteriorly, almost flat ventrally near tail apex; width 1.80 (1.83–2.20) times height at insertion of pelvic fin, 2.10 (1.78–2.40) times height at midlength, 2.07 (2.00–2.14) times height at first dorsal fin origin; lateral tail fold very well developed (even more so in juveniles), originating about

an orbit diameter behind pelvic-fin insertion, extending to or almost to tail tip, broadest distally. Dorsal fins moderately large, of similar shape and size, first dorsal fin usually slightly larger and marginally more upright than second; first dorsal-fin height 1.63 (1.33–1.97) in base length; fins strongly raked, low, elongate, with long bases; anterior margins straight to weakly convex, apices broadly rounded, posterior margins convex, free rear tip narrowly rounded to acute; inner margins of dorsal fins short, first dorsal longer than second; interdorsal distance short or fin almost connected, more than 6 times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 2.39 (2.19–2.61) times dorsal-fin base length, 8.34 (4.59–8.74) times caudal-fin length; first dorsal-fin base 3.48 (1.81–3.88) times caudal-fin length. Epichordal caudal-fin lobe well developed, short-based, low, height about equal to half tail width at fin origin; usually slightly taller posteriorly than anteriorly; usually truncate distally, its dorsal margin straight; connected sub-basally to second dorsal fin; hypochordal caudal lobe vestigial.

Dorsal surface of adult male holotype with well-developed nuchal, orbital, tail, malar and alar thorns; no thorns

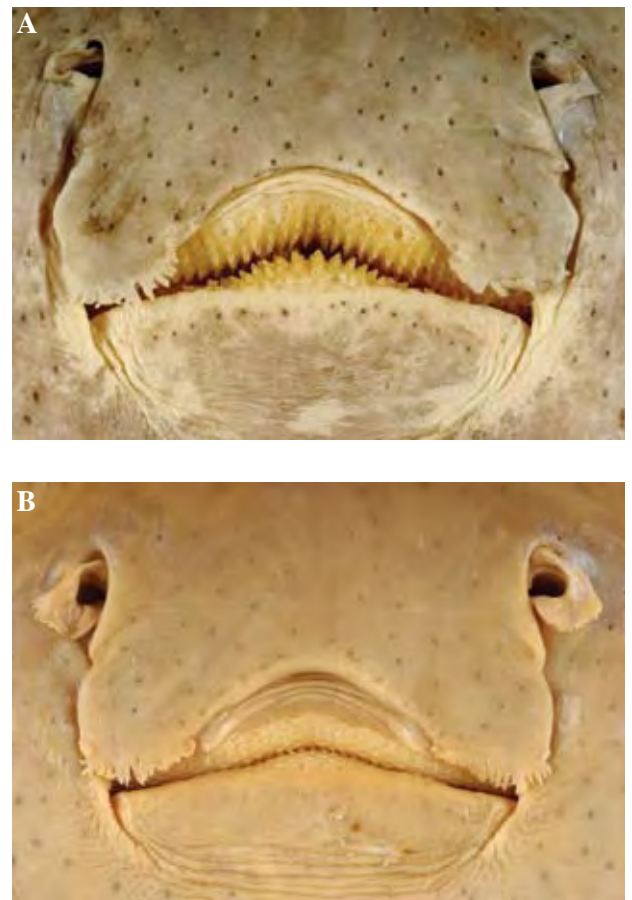


Figure 10. Ventral view of *Dipturus confusus* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 4255-01, 508 mm TL); B, primary female paratype (CSIRO CA 4453, 427 mm TL).

Table 1. Morphometrics for the holotype of *Dipturus canutus* sp. nov. (CSIRO H 153–01), ranges for measured paratypes (n=6), and means for all morphometric types; and the holotype of *Dipturus confusus* sp. nov. (CSIRO H 4255–01), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Dipturus canutus</i> sp. nov.				<i>Dipturus confusus</i> sp. nov.			
	Holotype	Paratypes		Mean	Holotype	Paratypes		Mean
		Min.	Max.			Min.	Max.	
Total length (mm)	775	499	697		508	471	599	
Disc width	67.0	70.4	75.0	71.6	70.1	71.2	75.2	73.0
Disc length (direct)	57.0	56.2	60.5	58.4	62.4	60.2	63.7	62.3
Snout to maximum width	33.5	31.0	34.8	33.0	35.2	32.9	36.7	35.1
Snout length (preorbital direct)	16.0	16.3	18.8	17.3	15.4	16.8	18.5	17.2
Snout to spiracle	20.9	21.2	23.3	22.2	22.0	22.8	24.0	23.1
Head (dorsal length)	22.4	22.6	24.9	23.7	23.5	24.3	25.2	24.7
Orbit diameter	4.1	3.3	4.6	3.8	4.7	3.7	4.2	4.1
Orbit and spiracle length	5.1	4.7	5.7	5.1	6.6	5.5	6.6	6.1
Spiracle length (main pore)	1.5	1.9	2.3	2.0	3.0	2.2	2.8	2.6
Distance between orbits	5.1	4.4	5.4	5.0	4.6	5.1	5.8	5.3
Distance between spiracles	7.6	6.6	7.7	7.3	7.0	7.4	7.8	7.5
Snout to cloaca (to 1st hemal spine)	55.0	51.4	55.1	54.0	56.6	55.7	59.9	57.4
Cloaca to D1	29.3	29.1	30.2	29.8	29.6	26.1	28.7	28.1
Cloaca to D2	35.7	35.1	36.6	36.0	35.7	32.9	35.4	34.4
Cloaca to caudal origin	40.0	40.0	42.2	40.8	41.5	38.4	41.4	40.0
Distance-cloaca to caudal-fin tip	45.0	44.9	47.3	45.8	43.1	40.5	43.7	42.2
Ventral snout length (pre upper jaw)	15.6	16.9	18.6	17.5	14.9	16.1	18.6	16.8
Prenasal length	13.6	14.3	15.8	14.9	12.7	13.9	14.9	14.0
Ventral head length (to fifth gill)	31.8	29.9	32.6	31.6	32.8	32.6	35.1	33.4
Mouth width	8.7	8.2	9.3	8.8	10.0	9.9	10.6	10.2
Distance between nostrils	9.2	8.6	9.7	9.2	9.4	9.3	10.0	9.6
Nasal curtain length	5.4	5.0	5.9	5.5	6.0	5.6	6.2	5.9
Nasal curtain (total width)	10.5	9.1	10.9	10.2	11.5	10.7	11.5	11.2
Nasal curtain (min. width)	7.4	6.4	7.7	7.2	7.4	7.1	8.0	7.4
Nasal curtain (lobe width)	1.7	1.3	1.7	1.5	2.1	1.7	2.0	1.9
Width of first gill opening	1.6	1.5	1.7	1.6	2.0	1.8	2.3	2.1
Width of fifth gill opening	1.0	1.1	1.4	1.2	1.3	1.2	1.7	1.3
Distance between first gill openings	14.8	14.6	16.0	15.3	16.0	15.9	17.6	16.6
Distance between fifth gill openings	9.0	8.4	9.7	8.9	9.0	9.0	10.3	9.4
Clasper (post cloacal length)	22.2	23.4	24.8	23.5	25.9	17.0	22.0	21.6
Length of anterior pelvic lobe	11.7	12.1	13.0	12.6	12.8	12.0	13.7	12.8
Length of posterior pelvic lobe	17.4	15.0	19.3	16.4	22.3	17.3	20.3	19.4
Pelvic base width	8.8	7.9	9.0	8.6	9.2	8.4	9.7	9.2
Tail at axil pelvic fins (width)	4.1	3.7	4.3	4.1	4.8	4.6	5.6	5.2
Tail at axil pelvic fins (height)	2.4	2.0	2.5	2.3	2.7	2.4	2.8	2.6
Tail at midlength (width)	2.8	2.3	2.8	2.6	3.2	2.9	3.5	3.3
Tail at midlength (height)	1.5	1.3	1.6	1.4	1.5	1.4	1.6	1.5
Tail at D1 origin (width)	2.6	1.8	2.7	2.3	3.0	2.9	3.3	3.0
Tail at D1 origin (height)	1.4	1.3	1.6	1.4	1.4	1.4	1.5	1.5
D1 base length	4.1	4.6	5.4	4.9	5.6	5.5	6.6	5.9
D1 height	3.1	3.2	3.8	3.4	3.4	3.1	4.4	3.6
D1 origin to caudal-fin tip	16.0	14.8	17.3	16.1	13.4	12.6	16.6	14.1
D2 origin to caudal-fin tip	9.5	9.1	10.7	9.9	7.4	6.3	9.4	7.8
Caudal-fin length	5.0	4.0	5.4	5.0	1.6	1.5	3.6	2.2

along most of mid-disc or on scapular region; primary female paratype CSIRO CA 4453 (427 mm TL) with well-developed nuchal, orbital, and tail thorns; primary juvenile paratype with prominent nuchal, orbital, and tail thorns. Orbital thorns of holotype forming an irregular rosette, variable in size, damaged; about 7–8 (3 on preorbit, 1–2 on midorbit, 3 on postorbit); low, slender, directed upright or posteriorly, usually recurved; female paratype with similar orbital thorns, also damaged, about 8 (4 on preorbit, 2 on midorbit, 2 on postorbit), up to 16 thorns in paratypes, sometimes with a cluster of smaller thornlets on preorbit; primary juvenile paratype with 3 well-developed thorns (2 on preorbit, 1 on postorbit), midorbit thorn present in CSIRO H 118–01 (juvenile male 292 mm TL). Nuchal thorns of holotype 1 (2–4 in male paratypes), short, broad based, somewhat laterally compressed, more robust than orbital thorns; female paratype with 2 widely spaced thorns (2–6 in other female paratypes); juveniles with 1–2 large posteriorly directed thorn. Malar thorns about 26 in holotype; patch elongate, weakly curved, originating well forward orbit, ending level with spiracle; patch in about 4–5 (3–4) irregular rows posteriorly, converging anteriorly, in 1–2 rows; thorns slender, pungent, mostly similar in shape to each other, largest posteriorly and slightly larger than largest orbital thorn, directed posterolaterally; thorn patch originating just forward of orbit to level of spiracle. Alar thorns in holotype well developed, with about 30–35 (including missing thorns), mostly in 3 irregular rows, subequal in length to tail thorns; embedded, tips pungent, directed posteromedially; patch subequal in length to malar patch. Tail thorns of adult male holotype well developed, in a single row; row linear anteriorly, staggered posteriorly, typically paired near dorsal-fin origin; with 14 (about 18) main thorns, pungent, recurved or upright predorsal thorns with large bases, larger than largest nuchal and orbital thorns; 12 (9–11) much smaller interstitial thorns interspersed and often preceding these larger thorns; interdorsal thorn usually paired (1–3); median row originating near pelvic-fin insertion. Primary female paratype with 3 (usually 5 in other female paratypes) rows of thorns; median row best developed, commencing over cloaca to near pelvic-fin insertion and extending along length of predorsal tail in a single series, staggered posteriorly (largest females with thorns mostly paired, forming a double row); interstitial thorns of median row present, less well developed than in adult males; dorsolateral rows of primary female paratype with 3–4 thorns (up to 11 in other female paratypes), located much closer to lateral tail fold than to thorns of median row, rarely extending to midlength of tail; lateral rows absent (well developed in larger female paratypes, with up to 16 thorns, commencing mostly slightly forward of pelvic-fin rear tip to just forward of dorsal-fin origin or beyond); interdorsal and subdorsal thorns mostly paired (2–4 in other female paratypes). Primary juvenile paratype with single median row, commencing above pelvic-fin insertion, with 13 short, raked thorns; interdorsal thorn absent (usually present).

Denticles of adult males not well developed, disc and tail largely naked; patches on head of holotype confined to rostral cartilage, snout tip and most of ventral head forward of nostrils; dorsal anterior margin of disc granular almost to pectoral-fin apex; tail and posterior half of disc almost entirely naked. Primary female paratype with dorsal surface similar to holotype (slightly less spinulose and with anterior dorsal marginal patch usually interrupted forward of eyes); denticles on ventral head less extensive anteriorly but extending more posteriorly along disc margin to level of mouth. Primary juvenile paratype without skin denticles

Meristics (n=11): Tooth rows in upper jaw 34 (33–41); lower jaw 34 (33–40). Pectoral-fin propterygial radials 29–31 (30–34); mesopterygial radials 12 (13–14); metapterygial radials 35–37 (34–38); total radials 78 (78–83). Pelvic-fin radials males (n=5) 1 (1) + 21 (21–23); females (n=6) (1) + (22–24). Trunk centra 28 (26–30); predorsal caudal centra 44 (40–47); predorsal centra 72 (69–75); centra between origins of dorsal fins 12 (12–14); diplospondylous centra 80 (81–86); total centra about 108 (109–114).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype medium yellowish brown with variable pattern of paler and darker spots and reticulations; snout beside rostral cartilage and extremities of disc and pectoral fins paler yellow, strongly demarcated from adjacent areas; tail similar to disc (some paratypes obviously faded, abraded, colour pattern not obvious), variegated; lateral tail fold and most of dorsal and caudal fins pale yellowish; eyelid similar to disc, eye dark. Ventral surface predominantly white with variably developed greyish areas over most of head, on belly and near cloaca (usually whitish over gill slits and contrasted with darker areas of belly); sensory pores dark-edged, usually surrounded by greyish blotches centrally and posteriorly, somewhat peppered on snout and smaller than those posteriorly; pelvic fin and ventral clasper whitish; tail white with extensive greyish and brownish areas (uniformly white in some paratypes). Primary female paratype (CA 4453) slightly darker dorsally than holotype (other females pale, yellowish brown to dark brown), otherwise similar dorsally and ventrally; pale dorsal blotches better defined (pattern variable), their margins mostly diffuse. Juvenile paratype (CSIRO H 3716–01) brownish with semi-regular spots and blotches dorsally; almost entirely white ventrally, except for dark-edged pores; no greyish blotches around pores. When fresh: Colour pattern often more strongly contrasted.

SIZE.— Largest specimen was a female 695 mm TL; adolescent males varied from 415–534 mm TL, and adult males from 498–649 mm TL (the three smallest mature males were 498–508 mm TL). Smallest juvenile 220 mm TL. Egg cases, which have been described by Treloar *et al.* (2006), are about 56–69 mm long with a maximum



Figure 11. Lateral view of dorsal and caudal fins of *Dipturus confusus* sp. nov., adult male holotype (CSIRO H 4255–01, 508 mm TL).

A



B



C



D



Figure 12. Thorns at tail midlength of *Dipturus confusus* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 4255–01, 508 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO CA 4453, 427 mm TL).

A



B

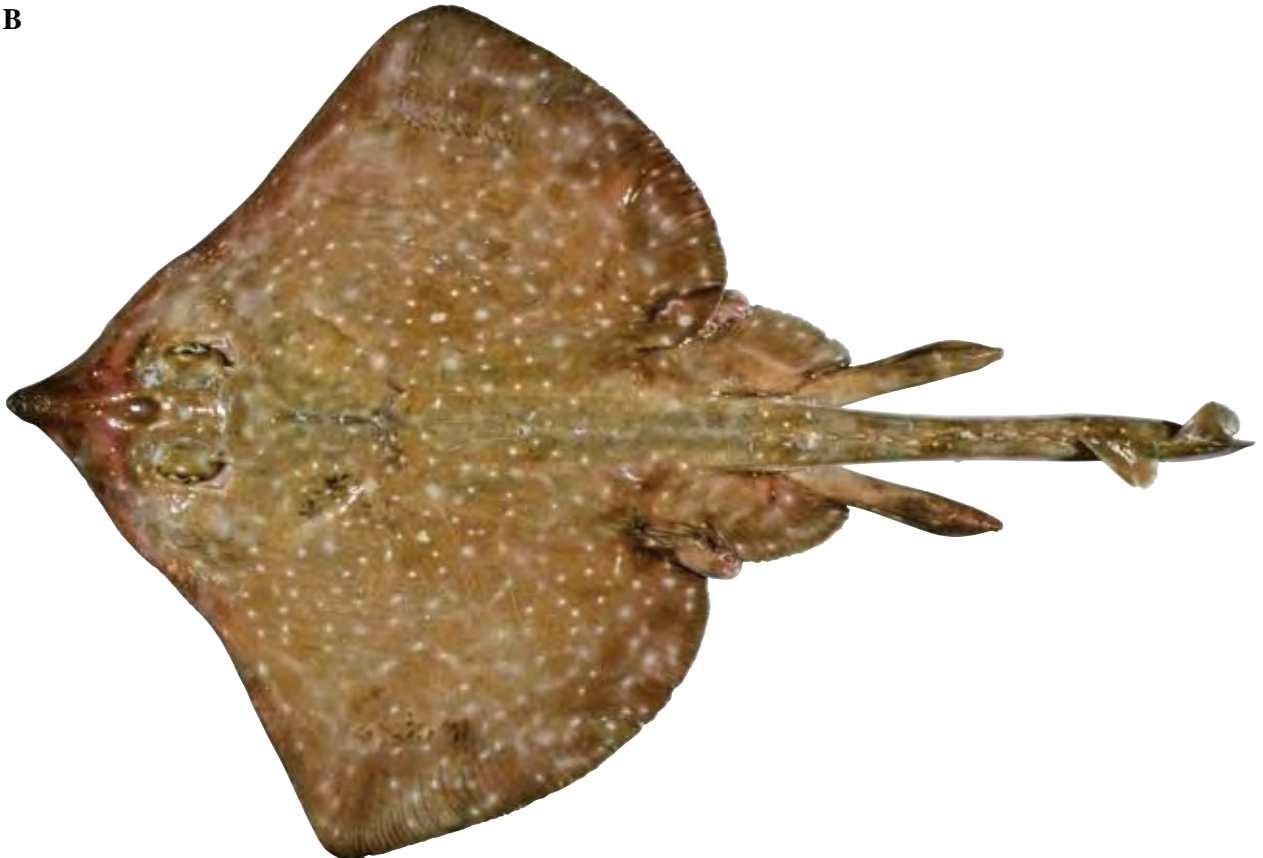


Figure 13. Dorsal view of: A, *Dipturus australis* (CSIRO H 722–01, 485 mm TL, adult male, fresh); B, *Dipturus cerva* (CSIRO H 1264–07, 489 mm TL, adult male, fresh).

width of about 45–53 mm.

DISTRIBUTION.— Southeastern Australia, from east of Batemans Bay, New South Wales (35°39' S, 150°45' E) and possibly north to Sydney (K. Graham, pers. comm.), through Bass Strait and west to Portland, Victoria (ca. 38°30' S, 141°30' E). Off Tasmania, southward to Port Davey (43°20' S, 145°35' E) off the west coast and Tasman Peninsula (43°45' S, 147°45' E) off the east coast. Occurs primarily in inner continental shelf at depths of 18–120 m, but has been taken to about 390 m on the upper continental slope.

ETYMOLOGY.— The epithet is based on the Latin *confusio* in relation to past confusion with other Australasian skates, *Zearaja nasuta* and *Dipturus cerva*. Vernacular name: Longnose Skate.

REMARKS.— This species appears to have been recognised by McCulloch (1911) based on specimens, collected by the F.I.S. *Endeavour* off Flinders Island, Tasmania, that were subsequently discussed and misidentified by Whitley (1940) as *Zearaja nasuta* (Müller & Henle, 1841). McCulloch referred to the rough patch of denticles along the ventral edge of the snout that distinguishes *Dipturus confusus* from its closely related, sympatric congener *D. cerva* (snout edge naked). *Zearaja nasuta* is now known to be a New Zealand endemic (i.e. not conspecific with either *Dipturus confusus* or its Australian sister species *Z. maugeana* Last & Gledhill, 2007 which is known only from Macquarie and Bathurst Harbours, Tasmania). *Dipturus confusus* differs from *D. cerva* in having a larger disc (adult width 70–75% vs. 67–71% TL, length 60–64% vs. 56–60% TL), longer head (ventral length 33–35% vs. 29–32% TL) and broader nasal curtain (width 10.7–11.5% vs. 9.8–10.3% TL), and also has a more complex pattern of spots, blotches and reticulations (rather than a pattern usually dominated by fine white spots, Fig. 13b). *Dipturus australis* also has a similar disc shape and has a light and dark, brownish or yellowish blotched colour pattern (Last & Stevens, 1994; Fig. 13a), but has a shorter precaudal tail (length 34–36% vs. 38–42% TL), narrower nasal curtain (width 9.8–10.9% vs. 10.7–11.5% TL), broader tail (width 3.7–4.5% vs. 2.9–3.5% TL at midlength, length 3.1–3.7% vs. 2.9–3.3% TL at dorsal-fin origin), and in the relative lengths and positions of the posterior tail fins (distance from first dorsal-fin origin to caudal-fin tip 1–3 vs. 5–9 times caudal-fin length, length of first dorsal-fin base about equal to vs. 3–4 times caudal-fin length).

Dipturus endeavouri sp. nov.

Figs 14–19; Table 2

Holotype. CSIRO H 6630–01, adult male 318 mm TL, south-east of North Stradbroke Island, Queensland, 27°46' S, 153°51' E, 205 m, 23 Mar 1983.

Paratypes. 10 specimens. AMS I 39891–017, female 222 mm TL, east of Yamba, New South Wales, 29°19' S, 153°48' E, 175–200 m, 21 Jul 1999; CSIRO H 2687–01, female 367 mm TL, CSIRO H 2687–02, female 292 mm TL, CSIRO H 2692–10, female 258 mm TL, east of Yamba, New South Wales, 29°21' S, 153°47' E, 153–175 m, 22 May 1991; CSIRO H 6630–02, female 353 mm TL, CSIRO H 6630–03, juvenile male 234 mm TL, CSIRO H 6630–04, adult male 321 mm TL, CSIRO H 6630–05, juvenile male 170 mm TL, collected with holotype; QM I 19257, adult male 315 mm TL, east of Noosa, Queensland, 26°20' S, 153°53' E, 182–274 m, 13 Sep 1980; QM I 19970, female 306 mm TL, east of Fraser Island, Queensland, 25°27' S, 153°46' E, 292 m, 14 Sep 1980.

DIAGNOSIS.— A very small species of *Dipturus* (to about 37 cm TL) with the following combination of characters: disc narrow with rounded apices, width 62–69% TL, 1.1–1.2 times its length; snout angle 79–93°; tail moderately elongate, length 0.8–1.0 in distance from snout tip to rear of cloaca; tail relatively broad, width 1.4–2.1 times height at its midlength, 1.6–2.3 times at first dorsal-fin origin; pre-upper jaw length 15–18% TL, 1.9–2.3 times internasal width; ventral head length 30–32% TL; snout length 4.0–4.4 times interorbital width; orbit diameter 98–129% interorbital width; first dorsal-fin height 1.3–1.7 in its base length; distance from first dorsal-fin origin to tail tip 2.8–3.0 times first dorsal-fin base length, 1.2–1.7 times caudal-fin length; pelvic fins large, length of posterior lobe of adult males about 20% TL, length of anterior lobe 56–76% of posterior lobe; clasper of adult male long, about 24–26% TL, connected to pelvic-fin inner margin at about 37–44% of its length from cloaca; anterior margins of dorsal surface with narrow denticle bands, naked ventrally; mainly with a single nuchal thorn; malar thorn patch small; tail with 3 well-developed thorn rows in males, with an additional pair of lateral rows in females; total pectoral radials 76–81; trunk centra 26–29; predorsal centra 69–77; total centra about 112–124; tooth rows in upper jaw 33–44; brownish dorsally with widely spaced clusters of small black and white spots; ventral surface pale, plain coloured; sensory pores on ventral surface black-edged with small dusky surrounding patches.

DESCRIPTION.— Disc subquadrangular, 1.14 times as broad as long in adult male holotype (1.10–1.21 times in paratypes); angle in front of spiracles 83° (79–93)°; axis of greatest width 59% (57–62)% of disc length; anterior margin weakly double concave (similar in other males, females and juveniles but most pronounced in adult males), weakly concave anteriorly, weakly convex beside front of eyes, weakly concave behind level of spiracles (beside eye and spiracles in juveniles); apex broadly rounded; posterior margin strongly convex; free rear tip broadly rounded. Head relatively short, preorbital snout length 3.17 (3.28–4.34) times orbit length, 4.09 (4.00–4.44) times interorbit; pre-upper jaw length 1.91 (2.01–2.29)

A



B



Figure 14. *Dipturus endeavouri* sp. nov., adult male holotype (CSIRO H 6630–01, 318 mm TL, preserved): A, dorsal surface; B, ventral surface.

A



B

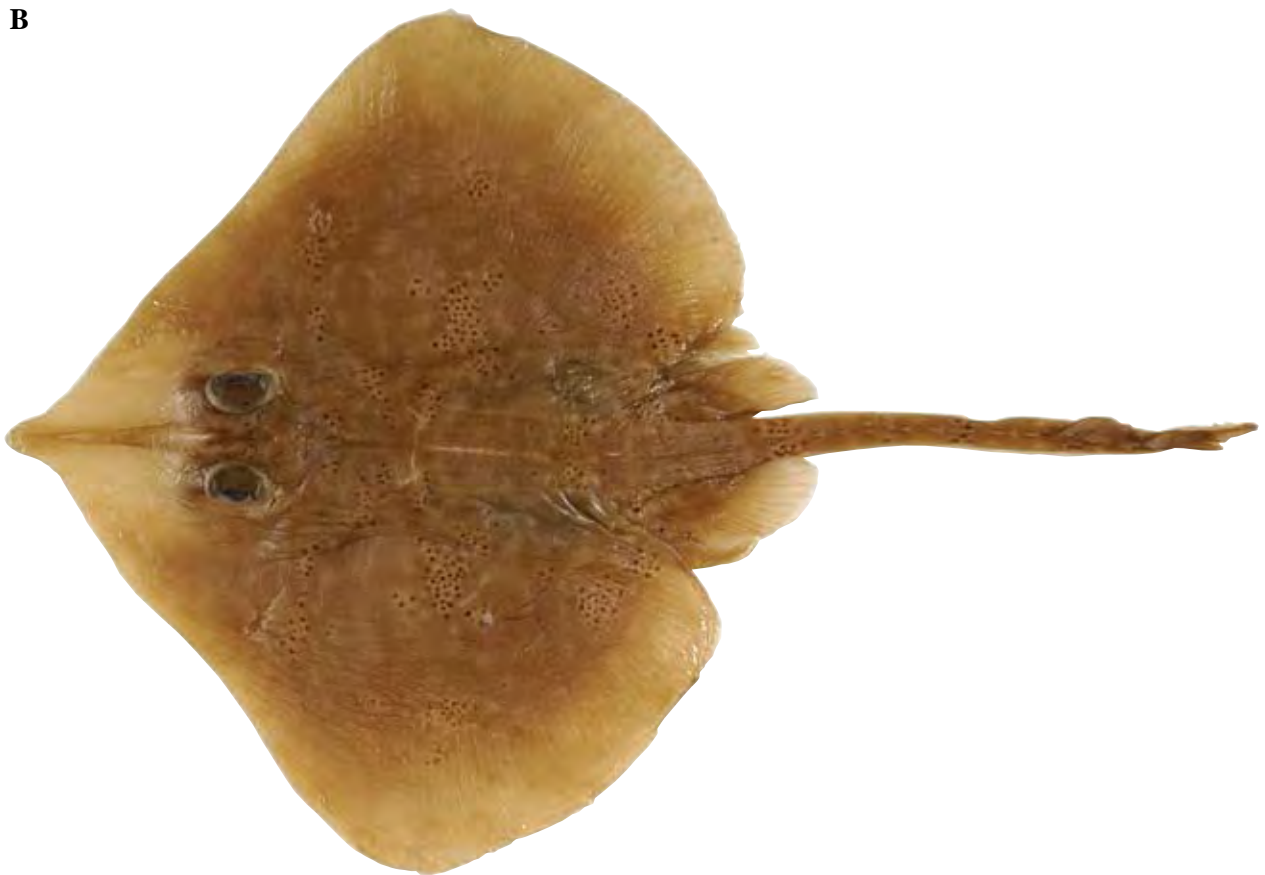


Figure 15. Dorsal surface of *Dipturus endeavouri* sp. nov.: A, primary female paratype (CSIRO H 2687–01, 367 mm TL, fresh); B, primary juvenile paratype (CSIRO H 6630–05, male 170 mm TL, preserved).



Figure 16. Dorsal head of *Dipturus endeavouri* sp. nov., adult male holotype (CSIRO H 6630–01, 318 mm TL), showing snout, orbito-spiracular and nuchal regions.

times internarial distance. Snout tip well produced (more obvious in primary juvenile paratype CSIRO H 6630–05, male 170 mm TL), bluntly pointed; no fleshy process at apex. Orbit dorsal, diameter 1.29 (0.98–1.22) times interorbital width; eye lateral. Spiracle large, length 1.92 (1.55–2.53) in orbit diameter; opening teardrop-shaped to suboval. Nostril usually suboval, often distorted; anterior nasal flap expanded, its lateral margin forming a short open tube; anterior margin of flap strongly lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed by nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with prominent fringe; internarial distance 1.73 (1.81–1.90) in distance between first gill slits, 0.91 (0.80–1.10) in distance between fifth gill slits. Upper jaw strongly arched in both sexes and juveniles (slightly more so in adult male), indented slightly at symphysis in mature males; lower jaw convex, most pronounced near middle of jaw; lateral teeth usually concealed by lobes of nasal curtain. Teeth of adult male holotype strongly unicuspid with narrow, subcircular bases; arranged in obvious longitudinal rows; medial cusps very elongate, subconical, bluntly pointed, posteriorly directed; cusps slightly shorter, more oblique laterally; teeth of female and juvenile paratypes in quincunx, with rectangular to hexagonal crowns, cusps very short, blunt.

Pelvic fins deeply forked; anterior lobe short, slender,

narrowly rounded distally, lateral margin entire, inner margin deeply incised; posterior lobe very elongate, slightly longer in adult males (length 20.0–20.3% TL) than in females (length 16.7–17.6% TL), lateral margins strongly convex, inner margin straight to weakly convex, connected to dorsolateral margin of clasper at about a quarter of its inner margin length; anterior lobe 0.56 (0.63–0.76) times posterior lobe. Clasper moderately elongate, 24–26% TL, slender, moderately depressed, glans expanded slightly; clasper components include proximal and distal clefts, terminal bridge, pseudorhipidion, rhipidion, dike, shield, sentinel and spike; denticles and pseudosiphon absent. Tail rather wide, strongly depressed, relatively broad at base, tapering weakly to first dorsal-fin origin, not expanded at its midlength; behind first dorsal fin tapering rapidly to tail tip; width at insertions of pelvic fins 1.67 (1.74–2.01) times width at midlength of tail and 1.55 (1.55–2.15) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.86 (0.81–0.96) times distance from tip of snout to rear of cloaca; anterior cross-section more convex dorsally than ventrally, much more strongly convex on dorsal

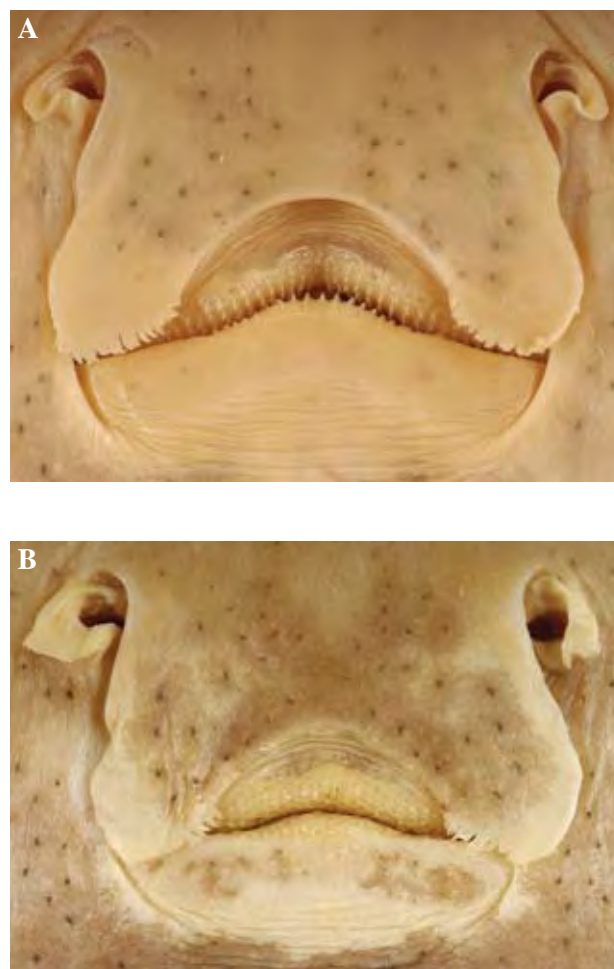


Figure 17. Ventral view of *Dipturus endeavouri* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 6630–01, 318 mm TL); B, primary female paratype (CSIRO H 2687–01, 367 mm TL).



Figure 18. Lateral view of dorsal and caudal fins of *Dipturus endeavouri* sp. nov., adult male holotype (CSIRO H 6630-01, 318 mm TL).

A



B



C



D



Figure 19. Thorns at tail midlength of *Dipturus endeavouri* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 6630-01, 318 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 2687-01, 367 mm TL).

surface than ventral surface posteriorly (almost flat beyond mid-tail); width 1.68 (1.58–2.37) times height at insertion of pelvic fin, 1.74 (1.42–2.12) times height at midlength, 2.08 (1.29–2.26) times height at first dorsal fin origin; lateral tail fold very well developed, origin near middle of pelvic-fin inner margins, extending almost to tail tip, usually broadest near first dorsal-fin origin. Dorsal fins small, of similar shape and size (first dorsal fin not obviously taller and more upright than second); first dorsal-fin height 1.25 (1.32–1.72) in base length; fins very strongly raked, low, elongate, with moderate bases; anterior margins straight to weakly convex, apices broadly rounded, posterior margins short and convex to straight, free rear tip narrowly rounded (often damaged); inner margin of first dorsal variable, usually longer than second; interdorsal distance short to moderate, 3–6 times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 2.91 (2.80–2.96) times dorsal-fin base length, 4.71 (3.60–4.72) times caudal-fin length; first dorsal-fin base 1.62 (1.22–1.69) times caudal-fin length. Epichordal caudal-fin lobe poorly developed, long-based, very low, height much less than half tail width at fin origin, relatively uniform in height; rarely truncate distally, its dorsal margin almost straight; usually connected sub-basally to second dorsal fin; hypochordal caudal lobe vestigial.

Dorsal surface of adult male holotype with small to very small nuchal, orbital, malar and alar thorns; tail thorns distinctly larger than those of disc; no thorns on mid-disc or on scapular region; primary female paratype CSIRO H 2687–01 (367 mm TL) and primary juvenile paratype with very small nuchal and orbital thorns, and much larger tail thorns. Orbital thorns of holotype very small, 4–5 (2 on preorbit, absent from midorbit, 2–3 on postorbit), first thorn slightly lateral of mid-eye, last thorn beside spiracle; variable in size (some indistinct), forming an incomplete rosette in all types; directed upright, slightly posteriorly or laterally; primary female paratype with very small thorns, similar in size and appearance to holotype, 7 (3 on preorbit, 1 on midorbit, 3 on postorbit); primary juvenile paratype with 3 small thorns (2 on preorbit, 1 on postorbit). Nuchal thorns of holotype small, damaged, 2 (only 1 in both other adult male paratypes), short, narrow based, laterally compressed, recurved posteriorly, slightly more robust than orbital thorns; primary female paratype with 1 small thorn (also one in 5 other female paratypes); juveniles with 1 small posteriorly directed thorn. Malar patch of holotype with about 12 main thorns flanked laterally by slightly enlarged denticles; patch small, obvious, elongate, curved, not following convexity of disc (largest thorns subparallel to orbit), originating well forward of orbit as a patch of denticles, ending with short thorns near level of spiracle; main thorns short, slender, pungent, in about 2–3 rows posteriorly, in 1–2 rows anteriorly, mostly similar in shape, slightly larger than largest orbital thorn, directed posterolaterally. Alar thorns in holotype small, deeply embedded, about 13–14 each patch in 1–2 well-defined rows, subequal in length to

tail thorns; tips pungent, directed posteromedially; patch subequal in length to malar patch. Tail thorns of adult male holotype in 3 rows; well developed, pungent, strongly tilted, recurved, with moderate bases, much larger than largest thorns on disc; each thorn with an enlarged skin fold near its posterior margin; median row almost linear, not staggered, predorsal thorns about 19, even mix of large thorns and smaller interstitial thorns (16–19 in adult male paratypes), commencing above clasper origin and extending to first dorsal-fin origin; interdorsal thorns 2 (2 in both paratypes); lateral thorns similar in size and shape to those of median row, 8 on each side, extending from near free rear tip of pelvic fin and extending to just short of first dorsal-fin origin. Primary female paratype with 5 rows of tail thorns; mid and mid-lateral rows equally developed, extending from tail base to first dorsal-fin origin or just beyond, lateral rows only slightly shorter; median row strongly staggered posteriorly, lateral rows in more or less linear series; median row with about 33 thorns (22 enlarged and about 11 smaller interstitial thorns); mid-lateral rows with 17 thorns, located on mid dorsolateral tail, slightly closer to lateral tail fold than to thorns of median row, interstitial thorns absent; lateral rows located adjacent skin fold, with about 10–14 thorns; interdorsal thorns 3, unpaired. Primary juvenile paratype with single median row of tail thorns; with 10 medium-sized, strongly raked thorns, commencing beside pelvic-fin insertions; one interdorsal thorn.

Denticles of adult males poorly developed, disc and tail largely naked; confined dorsally to patches on snout tip, along anterior margin of disc (in a narrow band from just forward of eye to about an orbit diameter short of disc apex) and sparse over posterior tail; ventral surface entirely naked. Primary female paratype almost entirely naked, denticles confined to a very narrow band along ventral margin of prenarial snout (absent in specimens smaller than 300 mm TL), and to snout apex on both surfaces. Primary juvenile paratype without skin denticles.

Meristics (n=10): Tooth rows in upper jaw 44 (33–41); lower jaw 41 (33–40). Pectoral-fin propterygial radials 27–28 (28–31); mesopterygial radials 14–15 (13–16); metapterygial radials 35 (32–38); total radials 77 (76–81). Pelvic-fin radials males (n=5) 1 (1) + 20–21 (20–21); females (n=5) (1) + (21–24). Trunk centra 27 (26–29); predorsal caudal centra 48 (40–49); predorsal centra 75 (69–77); centra between origins of dorsal fins 14 (13–15); total diplospondylous centra 90 (86–96); total centra about 117 (112–124).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype mainly medium brownish, slightly paler on snout beside rostral cartilage and along posterior margins of pectoral and pelvic fins; covered with widely spaced clusters of small black and white spots; clusters most distinctive near disc edge beside nuchal thorn, on inner and outer mid-disc, on

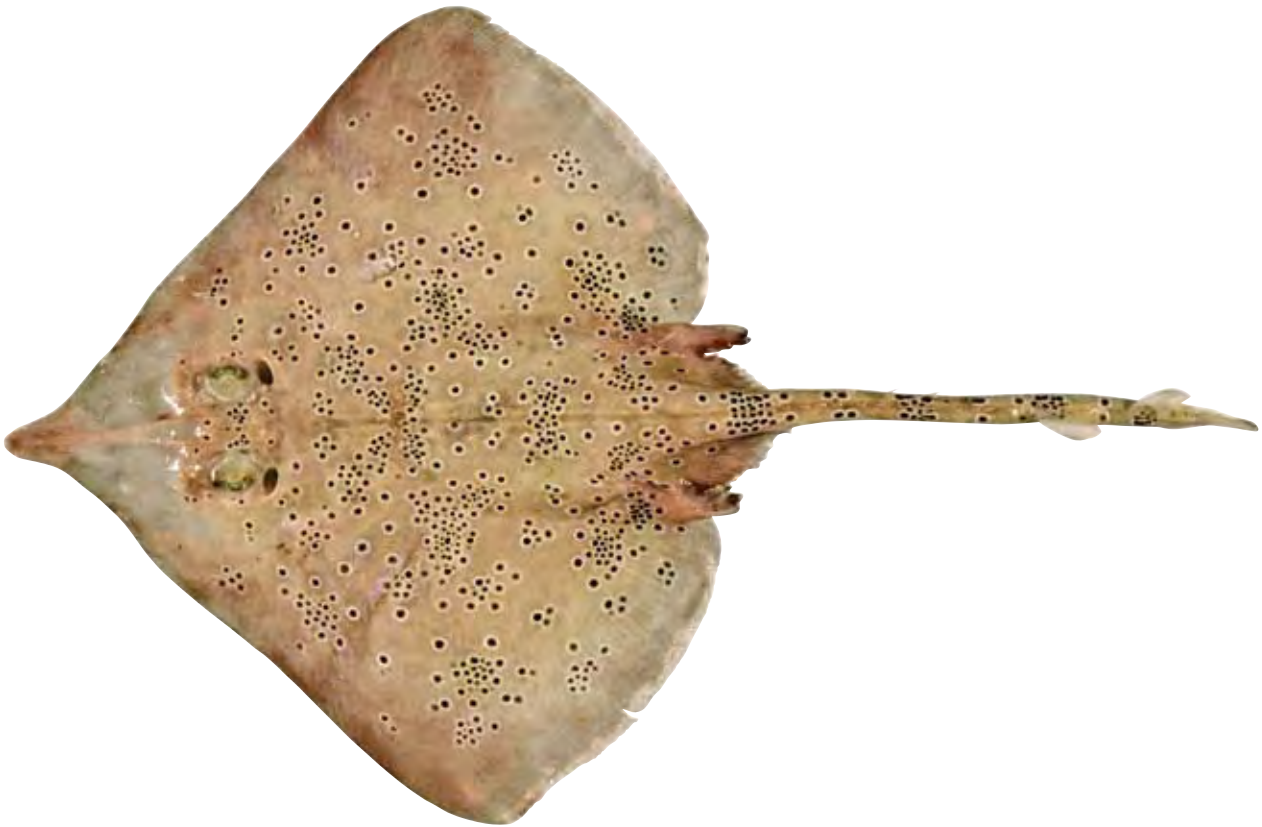


Figure 20. Dorsal view of *Dipturus polyommata* (not retained, Swains Reef, Queensland, female, fresh).

pelvic-fin base, near pectoral-fin insertion, and as bands on tail (near pelvic-fin insertions and on mid-tail); tail at bases of dorsal fins with similar spotting; dorsal fin brownish with paler centres. Ventral surface including mouth and lateral folds yellowish, sensory pores from nostrils to pelvic-fin origin black-edged with small dusky surrounding patches (most evident on internasal flap, chin and above metapterygium). Female paratypes with less or more obvious cluster markings; rostral cartilage much more strongly demarcated from paler lateral snout; usually with more pronounced area surrounding pores and broad dusky areas along outer disc on ventral surface. Primary juvenile paratype with much more obvious cluster markings; markings formed from sharp-edged black spots on larger diffuse-edged white blotches; similar cloudy white blotches between clusters; position of clusters conform closely with holotype; almost uniformly white ventrally, slightly darker near disc apex; sensory pores not defined and dorsal fin not darker than adjacent tail. When fresh: Cluster pattern usually more distinct, with white edges around black spots, and scattered white spots and marks, clearly apparent.

SIZE.— Largest specimen was a female 367 mm TL; no adolescent males but largest juvenile male was 234 mm TL, and adult males from 315–321 mm TL. Smallest juvenile 170 mm TL. Egg cases unknown.

DISTRIBUTION.— Appears to be a narrow-ranging

eastern Australian endemic, occurring from Fraser Island, Queensland (25°27' S, 153°46' E), southward to at least Yamba, New South Wales (29°21' S, 153°47' E); possible records from Coffs Harbour and south to Newcastle (K. Graham, pers. comm.). Occurs primarily on the outer continental shelf and upper slope at 153–292 m depth; recorded to 500 m off New South Wales (K. Graham, unpubl. data).

ETYMOLOGY.— Named after the ill-fated F.I.S. *Endeavour*, the Federal fisheries survey vessel that was responsible for collecting the first specimens of this species and so many of Australia's continental shelf fishes in the early 20th century before it along with all hands was lost at sea in 1914. Vernacular name: Endeavour Skate.

REMARKS.— There has been historical confusion about the identities of two similar eastern Australian species which both have distinctive clusters of dark, white-edged spots on the dorsal surface. These are *D. polyommata* (now known to occur north of 22°56' S, off Rockhampton and the Saumarez Reef) and its southern sister species *Dipturus endeavouri* (Figs 14a and 20). Only *D. polyommata* has been recognised in previous treatments of the Australian fauna (Whitley, 1940; Last & Stevens, 1994). This species (as *Raja polyommata*) was described from 5 specimens by Ogilby (1910) on board the F.I.S. *Endeavour* from a type series

consisting of 10 Queensland specimens, including 3 caught at two stations near North Reef, off Rockhampton (ca. 23° S) and 7 from a single station off Cape Moreton (ca. 27° S). However, given that *D. polyommata* was described at sea, and that these locations are several days of steaming apart, it is most likely that all 5 descriptive types came from the Cape Moreton station. Although it is impossible to be certain, Ogilby's colour description provides some support for this hypothesis: a grey-brown dorsal coloration (rather than yellowish), 4 cross-bands on tail (rather than 6), and the partial disappearance of dark spots and their associated white edges with growth, are more typical of the southern species. Consequently, based on the known ranges of the two species, Ogilby is likely to have collected both species during this survey and material used in the description was likely to be of the southern species. Whitley (1939) designated one of the northern Queensland specimens (AMS I 10904) as a lectotype and this specimen conforms closely to recent material of the northern species. However, Whitley's subsequent designation of the lectotype ensures that the northern species is referable to *D. polyommata*.

Material from the *Endeavour* survey held by the Queensland Museum (QM I 19257 and QM I 19970) may be from Ogilby's original type series, or at least from the type locality. These specimens have been incorporated in the type series of *Dipturus endeavouri*. This species also differs from *D. polyommata* in having a darker brown disc with less well defined clusters of spots, a slightly larger clasper (post-cloacal length 24.4–26.2% vs. 22.4–24.7% TL), a broader posterior tail (width at first dorsal-fin origin 2.3–2.8% vs. 1.1–2.4% TL, width of tail at pelvic-fin insertion 1.6–2.0 vs. 2.1–4.4 times width at first dorsal-fin origin), as well as several other morphometric differences. No other species of *Dipturus* have a similar coloration.

Dipturus falloargus sp. nov.

Figs 21–26; Table 2

Raja sp. D: Last & Stevens, 1994: pp 302, 328, fig. 34.19, key fig. 24, pl. 61.

Raja sp. 1: Sainsbury, Kailola & Leyland, 1985: pp 46, fig.

Holotype. CSIRO H 5192–01, adult male 414 mm TL, north of Exmouth Gulf, Western Australia, 21°29' S, 114°04' E, 242 m, 16 Nov 1998.

Paratypes. 16 specimens. AMS I 21616–001, female 309 mm TL, north-west of Bonaparte Archipelago, Western Australia, 12°57' S, 124°20' E, 188–190 m, 08 Jun 1979; CSIRO CA 2857, juvenile male 302 mm TL, CSIRO CA 2858, female 401 mm TL, CSIRO CA 2859, female 259 mm TL, south-west of Rowley Shoals, Western Australia, 18°22' S, 118°25' E, 201–202 m, 02 Apr 1982; CSIRO CA 4273, adolescent male 325 mm TL, CSIRO CA 4275, female 396 mm TL, north of Dampier

Archipelago, Western Australia, 19°15' S, 116°40' E, 172 m, 25 Jan 1983; CSIRO CA 4279, female 438 mm TL, north-west of Port Hedland, Western Australia, 18°52' S, 118°08' E, 122–126 m, 30 Jan 1983; CSIRO H 1035–04, female 347 mm TL, CSIRO H 1035–05, juvenile male 321 mm TL, north of Dampier Archipelago, Western Australia, 19°08' S, 116°54' E, 196–198 m, 24 Oct 1986; CSIRO H 1036–23, juvenile male 219 mm TL, north of Cape Lambert, Western Australia, 19°06' S, 117°08' E, 178–183 m, 12 Oct 1987; CSIRO H 1047–01, female 491 mm TL, north-west of Port Hedland, Western Australia, 18°45' S, 117°59' E, 145–150 m, 13 Oct 1987; CSIRO H 4074–13, adolescent male 375 mm TL, CSIRO H 4074–14, female 332 mm TL, north of Cape Lambert, Western Australia, 18°53' S, 117°27' E, 206–208 m, 30 Aug 1995; CSIRO H 5188–06, female 335 mm TL, north of Dampier Archipelago, Western Australia, 19°10' S, 116°19' E, 256 m, 27 Oct 1998; NTM S 12926–010, female 305 mm TL, north of Melville Island, Northern Territory, 10°04' S, 130°31' E, 155 m, 15 Nov 1990; WAM P 26193–005, adult male 450 mm TL, north of Dampier Archipelago, Western Australia, 19°17' S, 116°16' E, 170–172 m, 16 May 1978.

DIAGNOSIS.— A very small species of *Dipturus* (to 49 cm TL) with the following combination of characters: disc narrow with angular apices, width 61–64% TL, 1.1–1.2 times its length; snout angle 78–92°; tail moderately elongate, length 0.9–1.0 in distance from snout tip to rear of cloaca; tail slender, width 1.5–1.8 times height at its midlength, 1.6–2.1 times at first dorsal-fin origin; pre-upper jaw length 15–17% TL, 1.8–2.1 times internasal width; ventral head length 29–31% TL; snout length 3.4–4.3 times interorbital width; orbit diameter 75–101% interorbital width; first dorsal-fin height 1.8–2.4 in its base length; distance from first dorsal-fin origin to tail tip 3.2–3.6 times first dorsal-fin base length, 3.8–4.8 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males about 19% TL, length of anterior lobe 67–80% of posterior lobe; adult clasper relatively short, about 26% TL, connected to pelvic-fin inner margin at about 41% of its length from cloaca; narrow bands of fine denticles on anterior margins of both surfaces of disc; a single nuchal thorn; malar thorn patch small; tail with single median thorn row in males, additional dorsolateral rows in females; total pectoral radials 76–81; trunk centra 23–28; predorsal centra 71–80; total centra about 120–133; tooth rows in upper jaw 34–41; brownish to yellowish with paler spots and broken ocellate markings, greyish brown with paler outer margins ventrally; ventral sensory pores dark edged but not surrounded by greyish blotches.

DESCRIPTION.— Disc quadrangular, 1.13 times as broad as long in adult male holotype (1.14–1.17 times in paratypes); angle in front of spiracles 78° (87–92°); axis of greatest width 58% (54–58%) of disc length; anterior margin weakly double concave (similar in other males, females and juveniles), weakly concave anteriorly,

A



B

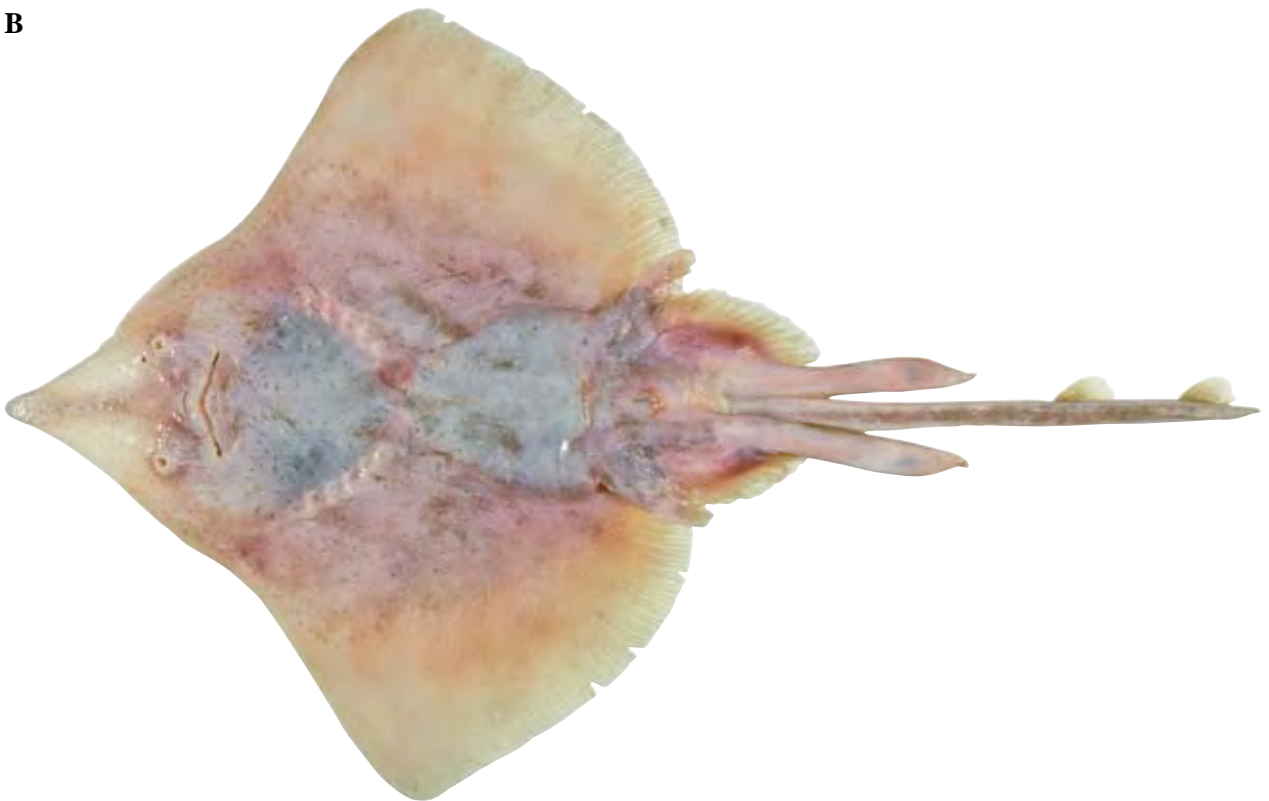


Figure 21. *Dipturus falloargus* sp. nov., adult male holotype (CSIRO H 5192–01, 414 mm TL, fresh): A, dorsal surface; B, ventral surface.

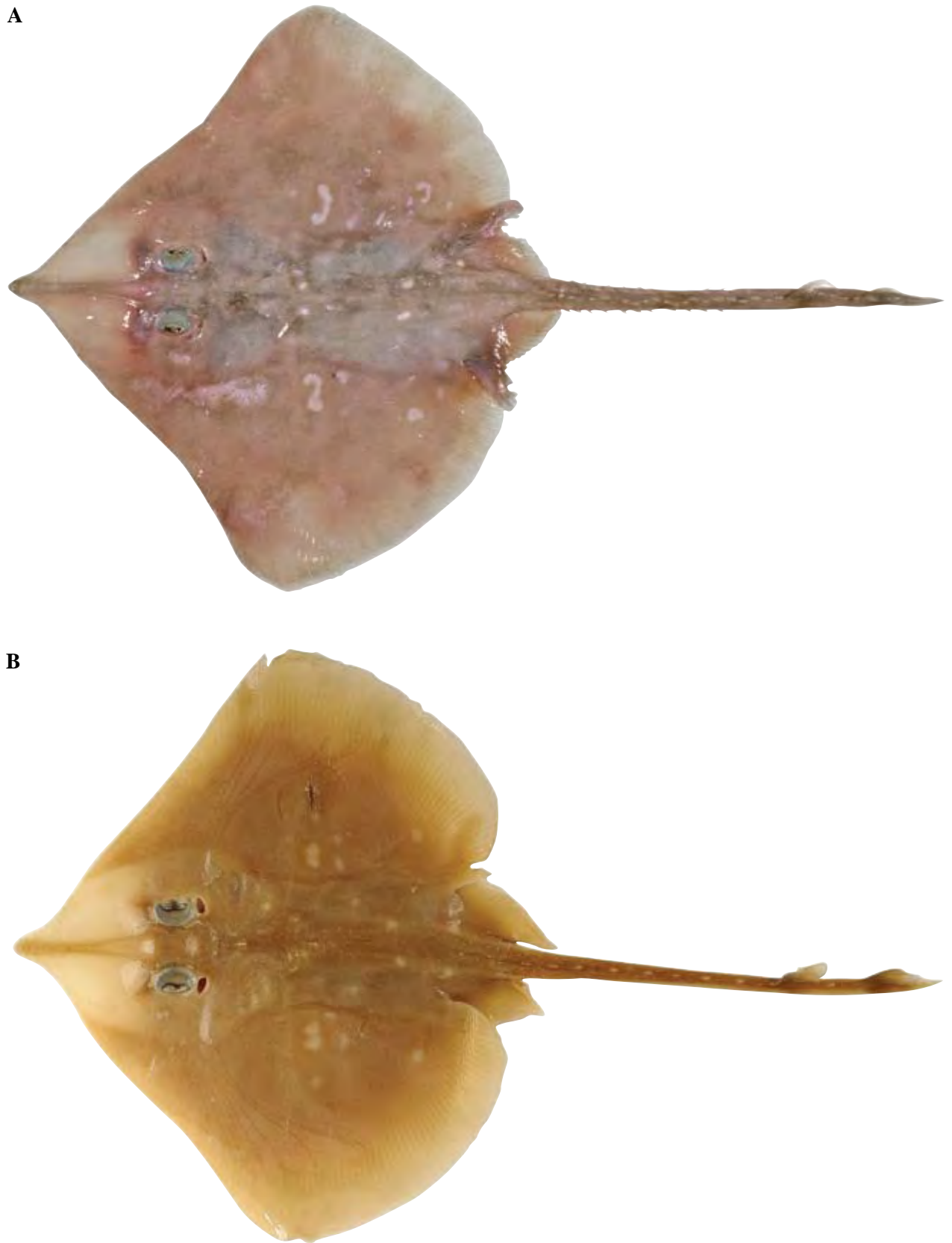


Figure 22. Dorsal surface of *Dipturus falloargus* sp. nov.: A, primary female paratype (CSIRO H 1035-04, 347 mm TL, fresh); B, primary juvenile paratype (CSIRO H 1036-23, male 219 mm TL, preserved).



Figure 23. Dorsal head of *Dipturus falloargus* sp. nov., adult male holotype (CSIRO H 5192–01, 414 mm TL), showing snout, orbito–spiracular and nuchal regions.

weakly convex beside eyes, weakly concave behind level of spiracles; apex narrowly rounded; posterior margin strongly convex; free rear tip broadly rounded. Head short, preorbital snout length 4.34 (4.28–4.86) times orbit length, 4.18 (3.35–4.30) times interorbit; pre-upper jaw length 1.84 (1.91–2.06) times internarial distance. Snout tip well produced (more so in primary juvenile paratype CSIRO H 1036–23, male 219 mm TL), bluntly pointed; no fleshy process at apex. Orbit dorsal, diameter 0.96 (0.75–1.01) times interorbital width; eye lateral. Spiracle large, length 1.60 (1.31–1.93) in orbit diameter; opening teardrop-shaped to subrectangular. Nostril suboval to circular, often distorted; anterior nasal flap expanded, its lateral margin forming a short open tube; anterior margin of flap weakly lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed by nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with well-developed fringe; internarial distance 1.66 (1.66–1.90) in distance between first gill slits, 0.87 (0.98–1.17) in distance between fifth gill slits. Upper jaw strongly arched in both sexes (more so in largest specimens), not indented at symphysis; lower jaw uniformly convex (weakly double convex in females

and juveniles); lateral teeth usually concealed by lobe of nasal curtain. Teeth of adult male holotype unicuspid with subcircular bases; arranged in obvious longitudinal rows; medial cusps elongate, narrowly subconical, bluntly pointed, posteriorly directed; becoming shorter, more oblique laterally; teeth of female and juvenile paratypes in quincunx, with rectangular to hexagonal crowns, cusps very short, blunt (subtriangular in CSIRO H 1047–01).

Pelvic fins deeply forked; anterior lobe short, slender, narrowly rounded distally, lateral margin entire, inner margin deeply incised; posterior lobe very elongate, slightly longer in adult male holotype (length 19.0% TL) than in females (length 14.1–14.6% TL), lateral margins convex, inner margin almost straight, connected to lateral margin of clasper at about a third its length; anterior lobe 0.67 (0.68–0.80) times posterior lobe. Clasper elongate, 26% TL, slender, slightly depressed, glans expanded slightly; clasper components include proximal slit and distal cleft, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel and spike; denticles and pseudosiphon absent. Tail slender, slightly depressed, relatively narrow at base, tapering rapidly to first dorsal-fin origin, not



Figure 24. Ventral view of *Dipturus falloargus* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 5192–01, 414 mm TL); B, primary female paratype (CSIRO H 1035–04, 347 mm TL).

Table 2. Morphometrics for the holotype of *Dipturus endeavouri* sp. nov. (CSIRO H 6630–01), ranges for measured paratypes (n=5), and means for all morphometric types; and the holotype of *Dipturus falloargus* sp. nov. (CSIRO H 5192–01), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Dipturus endeavouri</i> sp. nov.				<i>Dipturus falloargus</i> sp. nov.			
	Holotype	Paratypes		Mean	Holotype	Paratypes		Mean
		Min.	Max.			Min.	Max.	
Total length (mm)	318	234	367		414	349	491	
Disc width	67.9	62.0	69.4	66.6	63.0	60.9	64.4	62.8
Disc length (direct)	59.4	56.4	58.6	57.8	55.8	52.8	55.2	54.4
Snout to maximum width	34.8	32.6	34.8	33.9	32.3	28.7	32.2	30.5
Snout length (preorbital direct)	14.9	14.5	17.4	16.2	16.1	15.5	17.3	16.5
Snout to spiracle	21.0	20.2	22.7	21.9	21.3	20.2	22.0	21.4
Head (dorsal length)	22.2	21.5	24.1	23.2	22.3	21.8	23.7	22.7
Orbit diameter	4.7	4.0	4.4	4.4	3.7	3.3	4.0	3.6
Orbit and spiracle length	6.2	5.3	6.3	5.8	5.6	4.8	5.3	5.2
Spiracle length (main pore)	2.5	1.8	2.9	2.4	2.3	2.1	2.6	2.3
Distance between orbits	3.6	3.6	4.3	3.9	3.9	4.0	4.6	4.2
Distance between spiracles	6.5	6.3	6.9	6.6	6.1	5.8	6.3	6.1
Snout to cloaca (to 1st hemal spine)	53.6	50.9	55.3	53.1	51.7	50.8	52.8	51.6
Cloaca to D1	32.2	30.0	32.8	31.3	30.2	29.2	31.1	30.0
Cloaca to D2	38.5	36.0	39.7	38.0	40.7	37.8	39.8	39.0
Cloaca to caudal origin	43.9	41.4	44.9	43.2	44.3	42.5	45.2	43.8
Distance-cloaca to caudal-fin tip	47.0	44.4	48.9	46.7	48.4	46.6	49.6	48.1
Ventral snout length (pre upper jaw)	15.2	15.1	18.1	16.5	15.6	14.9	17.2	16.2
Prenasal length	12.6	11.9	14.8	13.7	13.4	12.6	14.4	13.6
Ventral head length (to fifth gill)	31.1	30.0	31.8	31.0	30.4	28.8	31.1	29.9
Mouth width	8.8	7.9	8.8	8.5	8.7	7.7	8.8	8.3
Distance between nostrils	8.0	7.5	8.1	7.9	8.5	7.7	8.5	8.3
Nasal curtain length	6.0	5.1	6.1	5.8	5.7	5.0	5.5	5.4
Nasal curtain (total width)	9.9	9.3	10.0	9.7	9.7	8.3	9.4	9.0
Nasal curtain (min. width)	6.9	6.3	6.7	6.6	6.7	5.7	6.5	6.3
Nasal curtain (lobe width)	1.5	1.6	1.9	1.7	1.5	1.4	1.7	1.5
Width of first gill opening	1.7	1.4	1.9	1.7	1.5	1.7	1.9	1.7
Width of fifth gill opening	1.1	1.0	1.6	1.2	1.0	1.1	1.4	1.2
Distance between first gill openings	13.7	13.8	15.0	14.3	14.1	14.0	14.9	14.4
Distance between fifth gill openings	7.3	6.5	8.7	7.4	7.3	8.1	9.0	8.4
Clasper (post cloacal length)	26.2	–	24.4	25.3	25.5	–	–	25.5
Length of anterior pelvic lobe	11.5	11.8	12.7	12.2	12.7	10.4	11.7	11.2
Length of posterior pelvic lobe	20.3	16.2	20.0	18.0	19.0	14.1	15.8	15.4
Pelvic base width	7.9	7.1	9.9	8.4	7.4	8.0	9.3	8.3
Tail at axil pelvic fins (width)	4.3	4.1	5.8	4.6	4.3	3.7	4.3	4.1
Tail at axil pelvic fins (height)	2.5	2.3	2.6	2.5	2.2	2.1	2.6	2.3
Tail at midlength (width)	2.6	2.2	2.9	2.5	1.8	1.9	2.3	2.1
Tail at midlength (height)	1.5	1.4	1.6	1.4	1.2	1.2	1.3	1.2
Tail at D1 origin (width)	2.7	2.3	2.8	2.6	2.1	2.0	2.2	2.1
Tail at D1 origin (height)	1.3	1.2	1.5	1.4	1.2	1.0	1.3	1.2
D1 base length	5.1	4.9	5.9	5.3	5.8	4.8	5.8	5.5
D1 height	4.1	3.3	3.9	3.7	3.0	2.2	2.7	2.6
D1 origin to caudal-fin tip	14.8	14.2	17.3	15.4	18.2	17.2	19.1	18.0
D2 origin to caudal-fin tip	8.5	8.2	9.8	8.7	7.7	8.6	9.8	9.0
Caudal-fin length	3.1	3.1	4.3	3.6	4.1	3.6	4.7	4.2

expanded at its midlength; behind first dorsal fin barely tapering to second dorsal fin then tapering rapidly to tail tip; width at insertions of pelvic fins 2.35 (1.88–2.03) times width at midlength of tail and 2.06 (1.83–2.11) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.93 (0.89–0.97) times distance from tip of snout to rear of cloaca; anterior cross-section almost equally convex dorsally and ventrally, slightly more strongly convex on dorsal surface than ventral surface posteriorly, almost flat ventrally near tail apex; width 2.00 (1.57–1.92) times height at insertion of pelvic fin, 1.49 (1.60–1.80) times height at midlength, 1.69 (1.61–2.13) times height at first dorsal fin origin; lateral tail fold weakly developed, origin obscure, just forward of pelvic-fin rear tips, extending almost to tail tip, broadest distally. Dorsal fins small, of similar shape and size (first dorsal fin marginally taller and more upright than second); first dorsal-fin height 1.93 (1.79–2.38) in base length; fins very strongly raked, low, elongate, with moderate bases; anterior margins weakly convex, apices broadly rounded, posterior margins short and convex, free rear tip narrowly rounded to acute (often damaged); inner margin of dorsal fins variable, usually short; interdorsal distance long, 1.22 (1.24–2.01) in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 3.16 (3.18–3.60) times dorsal-fin base length, 4.45 (3.80–4.79) times caudal-fin length; first dorsal-fin base 1.41 (1.19–1.36) times caudal-fin length. Epichordal caudal-fin lobe poorly developed, long-based, very low, height much less than half tail width at fin origin; usually slightly taller posteriorly than anteriorly; not truncate distally, its dorsal margin almost straight; connected sub-basally to second dorsal fin; hypochordal caudal lobe vestigial.

Dorsal surface of adult male holotype with very small nuchal and orbital thorns (barely larger than thornlets of other species), and small malar, alar and tail thorns; no thorns on mid-disc or on scapular region; primary female paratype CSIRO H 1035–04 (347 mm TL) with well-developed nuchal, orbital, and tail thorns; primary juvenile paratype with relatively small nuchal, orbital, and tail thorns. Orbital thorns of holotype similar in size, not forming a rosette; about 3–4 (2 on preorbit, absent from midorbit, 1–2 on orbit; up to 5 in male paratypes); directed upright or posteriorly; primary female paratype with small thorns, similar in size and shape to holotype, about 4–5 (2 on preorbit, absent from midorbit, 2–3 on postorbit); juvenile with 3 small thorns (2 on preorbit, 1 on postorbit). Nuchal thorns of holotype 1 (also 1 in all paratypes), very short, narrow based, laterally compressed, slightly more robust than orbital thorns; primary juvenile paratype with 1 small posteriorly directed thorn. Malar patch with about 20 thorns in holotype; patch small, elongate, weakly curved, following convexity of disc, originating forward of orbit as a patch of denticles, coalescing with anteromarginal denticles, ending in short thorns at level of spiracle, about a third of dorsal head length; in about 2–3 rows posteriorly, in 1–2 rows anteriorly; thorns short, slender, pungent, mostly similar

in shape to each other, slightly larger than largest orbital thorn, mainly directed posterolaterally. Alar thorns in holotype about 19–24, small, subequal in length to tail thorns; embedded, tips pungent, directed posteromedially, in 2 (3) well-defined rows; patch short, subequal in length to malar patch. Tail thorns of adult male holotype not well developed, in a single row (3 rows in adult male paratype WAM P 26193–005 and in early adolescent male paratype CSIRO CA 4273); row staggered slightly; predorsal thorns 21 (17–22 in male paratypes), pungent, strongly tilted, recurved, with large bases, longer than largest nuchal and orbital thorns; lateral row of WAM P 26193–005 with 4–6 thorns, CSIRO CA 4273 with about 2 thorns and other developing thorns; interdorsal thorns 3 (2–3 in male paratypes). Primary female paratype with 3 main rows of tail thorns, single lateral thorn on right side of tail (larger female paratypes with 5 rows); median and dorsolateral rows equally developed; median row with about 9 thorns and 11 slightly smaller interstitial thorns; thorns commencing just in advance of pelvic-fin free rear tip (variable in other female paratypes) and extending along length of predorsal tail in a single staggered series (strongly staggered and sometimes paired in larger female paratypes); dorsolateral row in a more or less linear series (better developed in largest paratypes, extending from near pelvic-fin insertion almost to first dorsal fin), with 12 (up to 19) thorns, on mid dorsolateral tail, slightly closer to lateral tail fold than to thorns of median row, interstitial thorns absent, length equal to or only slightly shorter than median row, commencing near free rear tip of pelvic fin, extending almost to first dorsal fin; lateral thorn row situated close to dorsolateral row, with up to about 18 sharp, posteriorly directed thorns; interdorsal thorns 2, unpaired (2–5 in other female paratypes). Primary juvenile paratype with single median row of tail thorns; with 8 very short, strongly raked thorns, commencing slightly posterior to pelvic-fin insertion; 1 interdorsal thorn.

Denticles of adult males not well developed, disc and tail largely naked; confined dorsally to patches on snout tip and along anterior margin of disc (not expanded beside malar thorns); ventrally, confined to preoral disc, extending along disc margin to level of mouth; branchial region granular; ventral tail and posterior half of disc entirely naked. Primary female paratype entirely naked dorsally (present on snout tip and a few isolated denticles beside eye in largest female paratypes); on ventral surface with a narrow band of denticles along disc margin to snout tip (in largest females, present on snout tip, along rostral cartilage, anterior disc margin to level of mouth, and over chin and belly). Primary juvenile paratype without skin denticles.

Meristics (n=11): Tooth rows in upper jaw 38 (34–41); lower jaw 35 (32–39). Pectoral-fin propterygial radials 29 (28–32); mesopterygial radials 14 (14–17); metapterygial radials 33–34 (31–34); total radials 76–77 (77–81). Pelvic-fin radials males (n=5) 1 (1) + 2



Figure 25. Lateral view of dorsal and caudal fins of *Dipturus falloargus* sp. nov., adult male holotype (CSIRO H 5192–01, 414 mm TL).



Figure 26. Thorns at tail midlength of *Dipturus falloargus* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 5192–01, 414 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 1035–04, 347 mm TL).

(20–22); females (n=6) (1) + (20–22). Trunk centra 27 (23–28); predorsal caudal centra 42 (44–50); predorsal centra 72 (71–80); centra between origins of dorsal fins 17 (13–17); diplospondylous centra 92 (91–103); total centra about 122 (120–133).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype mainly dark brown (all other types paler greyish yellow to yellowish brown), with paler yellowish areas laterally on disc and pelvic fins, beside rostral cartilage, and above anterior fontanelle of neurocranium; prominent pale yellow,

ocellate marking mid basally on each pectoral fin; each ocellus-like marking with central blotch surrounded by a broken ring of spots and streaks (ocellus often indistinct, usually diffuse or broken in paratypes), its diameter subequal to eye and spiracle distance; sparsely scattered, small, irregular white spots above abdomen and near axils of pectoral fins (more prominent on some paratypes); linear row of very small white spots extending from nuchal region along back and down each side of tail to first dorsal fin (often indistinct in paratypes); interspiracular pores and lateral tail fold white; dorsal fin brownish basally, usually slightly paler

distally. Ventral surface mainly greyish brown centrally on disc and along middle of tail, whitish distally; claspers and gill membranes white, strongly contrasted with adjacent branchial region; pores distinctly black, not surrounded by dark blotches (small blotches present in male paratypes). Primary female paratype pale yellowish brown dorsally, paler than holotype; ocelli poorly defined; ventral surface much paler than holotype, dark central area less extensive (some other female paratypes similar to holotype, others similar to primary female paratype), sensory pores black, well defined, less obvious in some individuals. Primary juvenile paratype similar to female; with white spots dorsally but no clearly defined ocelli; almost white ventrally, pores not well defined; dorsal fin slightly darker than adjacent tail. When fresh: Similar to preserved colour, often paler with white markings.

SIZE.— Largest specimen was a female 491 mm TL; adolescent males varied from 325–375 mm TL, two adult males of 414 and 450 mm TL. Smallest juvenile 219 mm TL. No egg cases available.

DISTRIBUTION.— Northwestern Australia, from Exmouth Gulf, Western Australia (21°29' S, 114°04' E) to north of Melville Island, Northern Territory (10°04' S, 130°31' E). Recorded from the outer continental shelf and near the shelf break at depths of 122–256 m; reported in Last & Stevens from 60 m.

ETYMOLOGY.— The epithet '*falloargus*' is based on a combination of the Latin *fallo* (false, deceive) and *argus* (based on Argus, the mythical hundred-eyed guardian of Io, whose eyes after death were transformed into the feathers of a peacock) in allusion to the vague, eye-like marking on the middle of each pectoral fin. Vernacular name: False Argus Skate.

REMARKS.— One of two short-snout *Dipturus* skates found off western Australia. *Dipturus falloargus* differs from its undescribed, allopatric congener (i.e. *D. oculus* in this paper, as *Raja* sp. E in Last & Stevens, 1994) in having a narrower disc (width 61–64% vs. 71–74% TL), a shorter ventral head (length 29–31% vs. 32–34% TL), a longer (post-cloacal length 47–50% vs. 41–45% TL) and more slender tail (width 1.8–2.3% vs. 2.4–3.2% TL, height 1.2–1.3% vs. 1.4–1.5% TL at midlength), a longer caudal fin (base length 3.6–4.7% vs. 2.2–2.9% TL), and lacking a regular, well-developed, dark ocellus on each pectoral fin (instead, usually with an incomplete, poorly formed or indistinct pale ocellate marking). Its body shape and coloration distinguish it from all other members of this *Dipturus* subgroup.

Dipturus grahami sp. nov.

Figs 27–32; Table 3

Raja sp. C: Last & Stevens, 1994: pp 303, 326, fig. 34.18, key

fig. 25, pl. 60.

Holotype. CSIRO H 950–01, adult male 619 mm TL, east of Terrigal, New South Wales, 33°30' S, 152°04' E, 446–515 m, 11 Feb 1986.

Paratypes. 17 specimens. AMS I 21777–003, female 183 mm TL, off Danger Point, New South Wales, 28°06' S, 153°58' E, 410 m, 01 Jun 1978; CSIRO CA 2807, juvenile male 384 mm TL, east of Sydney, New South Wales, 33°43' S, 151°52' E, 410–420 m, 25 Jan 1982; CSIRO H 55–01, female 529 mm TL, CSIRO H 58–01, female >385 mm TL (tail tip damaged), CSIRO H 59–01, female 361 mm TL, south-east of Norah Head, New South Wales, ca. 33°30' S, 152°00' E, ca. 500 m; CSIRO H 56–01, juvenile male 432 mm TL, CSIRO H 60–01, female 313 mm TL, CSIRO H 61–01, juvenile male 438 mm TL, south-east of Newcastle, New South Wales, ca. 33°02' S, 152° 31' E, 378–432 m, 15 Jul 1981; CSIRO H 290–01, adult male 586 mm TL, CSIRO H 294–01, female 570 mm TL, south-east of Norah Head, New South Wales, ca. 33°29' S, 152° 01' E, 306–318 m, 26 Oct 1982; CSIRO H 889–01, female 641 mm TL, east of Sydney, New South Wales, 33°48' S, 151°46' E, 230–234 m, 18 Dec 1985; CSIRO H 950–02, female 540 mm TL, CSIRO H 950–06, adult male 622 mm TL, CSIRO H 950–08, female 628 mm TL, collected with holotype; CSIRO H 1199–01, juvenile male 468 mm TL, CSIRO H 1199–02, female 448 mm TL, north-east of Wollongong, New South Wales, 34°17' S, 151°26' E, 375–430 m, 28 Jul 1987; QM I 19281, adult male 555 mm TL, north-east of Moreton Bay, Queensland, 26°31' S, 153°48' E, 438–457 m, 13 Sep 1980.

Other material. 6 specimens. CSIRO C 4783, female >626 mm TL (tail tip damaged), east of Batemans Bay, New South Wales, 35°39' S, 150°45' E, 350–380 m, 31 Aug 1976; CSIRO H 307–01, adult male 582 mm TL, east of Wooli, New South Wales, 29°47' S, 153°43' E, 360 m, 18 Jul 1982; CSIRO H 950–03, adult male 605 mm TL, CSIRO H 950–04, adult male 545 mm TL, CSIRO H 950–05, adult male 574 mm TL, CSIRO H 950–07, adult male 577 mm TL, collected with holotype.

DIAGNOSIS.— A small species of *Dipturus* (to 64 cm TL) with the following combination of characters: disc broad with angular apices, width 76–83% TL, 1.3–1.4 times its length; snout angle 84–96°; tail short, length 0.7–0.8 in distance from snout tip to rear of cloaca; tail slender, width 1.7–2.1 times height at its midlength, 1.4–2.0 times at first dorsal-fin origin; pre-upper jaw length 15–18% TL, 1.7–1.9 times internasal width; ventral head length 31–33% TL; snout length 2.9–3.5 times interorbital width; orbit diameter 59–83% interorbital width; first dorsal-fin height 1.5–2.1 in its base length; distance from first dorsal-fin origin to tail tip 2.7–3.0 times first dorsal-fin base length, 3.6–5.4 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males 17–18% TL, length of anterior lobe 66–69% of posterior lobe in adult males, 77–84% in females and juveniles; adult clasper relatively short, 27–

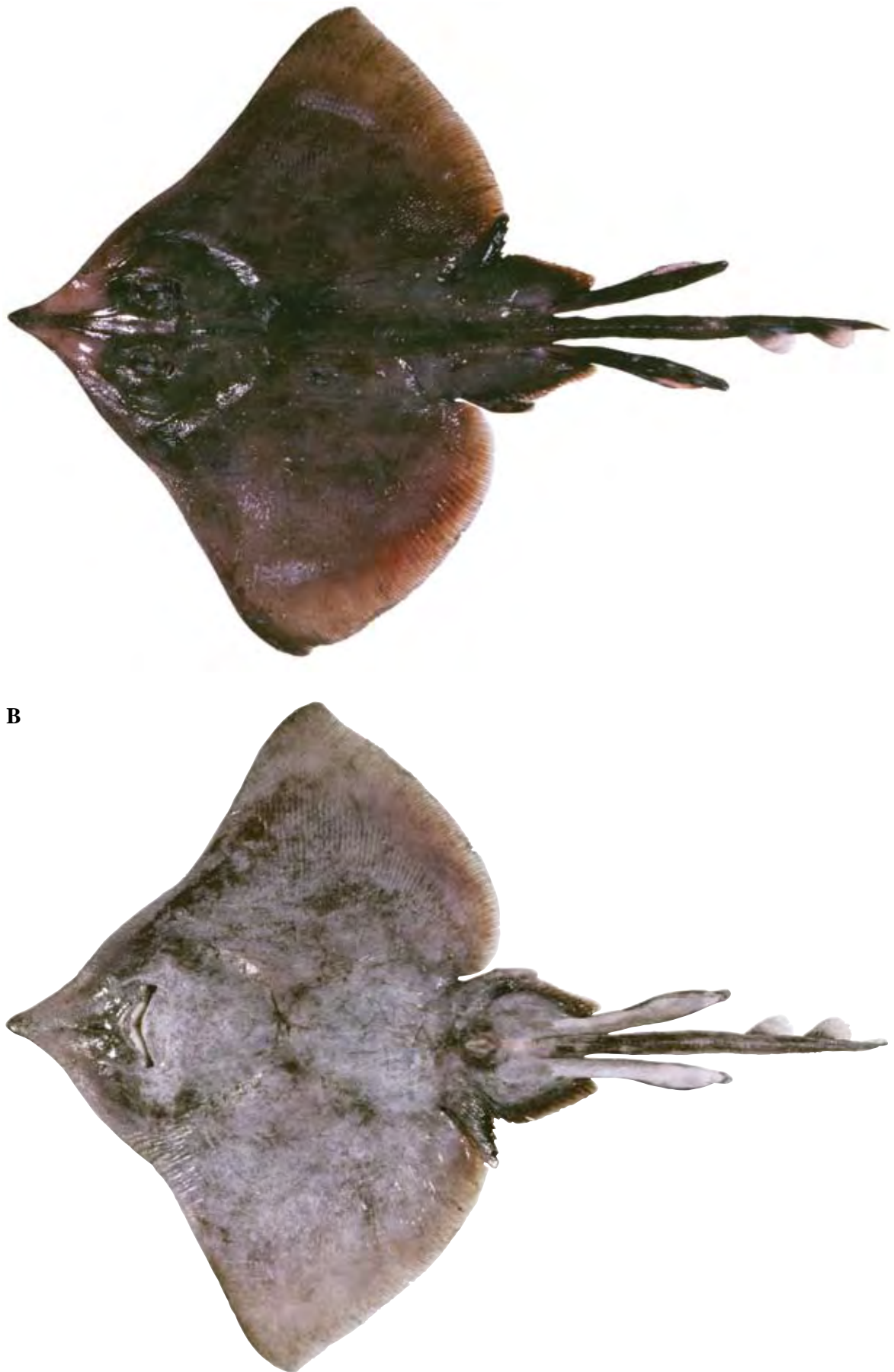


Figure 27. *Dipturus grahami* sp. nov., adult male holotype (CSIRO H 950–01, 619 mm TL, fresh): A, dorsal surface; B, ventral surface.

A



B



Figure 28. Dorsal surface of *Dipturus grahami* sp. nov.: A. primary female paratype (CSIRO H 950–02, 540 mm TL, fresh), B. primary juvenile paratype (AMS I 21777–003, female 183 mm TL, preserved).

28% TL, connected to pelvic-fin inner margin at about 37–39% of its length from cloaca; long, narrow bands of fine denticles on anterior margins of both surfaces of disc; single nuchal thorn; malar thorns absent in adult males; tail with single median thorn row in males, additional short anterior dorsolateral and long lateral rows in large females; total pectoral radials 80–85; trunk centra 27–30; predorsal centra 70–75; total centra about 118–127; tooth rows in upper jaw 34–37; almost uniformly dark brown dorsally, only slightly paler greyish brown ventrally; ventral sensory pores unobvious, dark edged but not surrounded by greyish circles.

DESCRIPTION.— Disc broadly quadrangular, 1.33 times as broad as long in adult male holotype (1.31–1.37 times in paratypes); angle in front of spiracles 86° (84 – 96°); axis of greatest width 58% (54 – 60%) of disc length; anterior margin double concave (less pronounced in females and juveniles), strongly concave anteriorly, moderately convex just forward of eyes, moderately concave behind level of spiracles in holotype (less convex forward of eye in primary female paratype CSIRO H 950–02, 540 mm TL and primary juvenile paratype AMS I 21777–003, 183 mm TL, female); apex narrowly rounded to angular; posterior margin almost straight initially, becoming convex toward free rear tip; free rear tip very broadly rounded. Head short, preorbital snout length 4.31 (3.98 – 4.92) times orbit length, 3.30 (2.91 – 3.54) times interorbit; pre-upper jaw length 1.68 (1.69 – 1.94) times internarial distance. Snout tip well produced, bluntly pointed; no fleshy process at apex. Orbit medium-sized, diameter 0.77 (0.59 – 0.83) times interorbital width. Spiracle medium-sized, length 2.15 (1.68 – 2.21) in orbit diameter; opening variable in shape. Nostril subrectangular, often distorted; anterior nasal flap expanded slightly, its lateral margin forming a short semi-circular tube; anterior margin of flap also lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed beneath nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with well-developed fringe; internarial distance 1.75 (1.63 – 1.74) in distance between first gill slits, 1.01 (0.96 – 1.08) in distance between fifth gill slits. Upper jaw arched slightly, moderately indented at symphysis (more so in adult males than in females and juveniles); lower jaw strongly convex, weakly double concave and slightly expanded across symphysis in large females; lateral teeth of upper jaw usually partly concealed by lobe of nasal curtain. Teeth of adult male holotype strongly unicuspid, with subcircular bases; arranged in longitudinal rows rather than in quincunx; medial cusps long, slender, bluntly pointed (when damaged), posteriorly directed in middle of upper jaw; cusps much shorter, subtriangular and more oblique laterally; teeth of female paratypes in defined rows, with broadly oval to subrectangular bases, cusps short, pungent to blunt apically.

Pelvic fins of medium size, deeply forked; anterior lobe

short, stubby, narrowly rounded distally, lateral margin entire, inner margin well incised; posterior lobe elongate, longer in adult males (length 16.7–18.3% TL) than in females (length 14.6–15.5% TL), lateral margin strongly convex, inner margin convex (almost straight in female paratypes), connected well forward of mid-lateral margin of clasper; anterior lobe 0.64 (0.67 – 0.84) times posterior lobe. Clasper very elongate, 27–28% TL, slender, moderately depressed, glans well expanded; clasper components include proximal and distal clefts, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel and spike; denticles and pseudosiphon absent. Tail rather narrow, weakly depressed (more depressed in primary female paratype); not broad at base, barely tapering to first dorsal-fin origin, sometimes expanded slightly at its midlength; tapering evenly and gradually to tail tip behind first dorsal fin; width at insertions of pelvic fins 1.31 (1.38 – 1.65) times width at midlength of tail and 1.63 (1.45 – 1.82) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.84 (0.75 – 0.80) times distance from tip of snout to rear of cloaca; anterior cross-section equally convex dorsally and ventrally (almost oval to subcircular in cross-section in holotype but more depressed in females), more strongly convex on dorsal surface than ventral surface posteriorly, almost flat ventrally near tail apex; width 1.57 (1.54 – 1.82) times height at insertion of pelvic fin, 1.86 (1.70 – 2.07) times height at midlength, 1.40 (1.41 – 1.96) times height at first dorsal-fin origin; lateral tail fold mostly narrow, not well developed in adults or juveniles, often barely detectable forward of midtail, terminating near tail tip, usually broadest beneath second dorsal fin. Dorsal fins of medium size, of similar shape, first dorsal fin often slightly taller and more upright than second; first dorsal-fin height 1.72 (1.47 – 2.10) in base length; fins strongly raked, low, elongate, with long bases; anterior margins of both fins weakly convex, apices broadly rounded, posterior margins convex; free rear tip broadly rounded, usually blending into posterior margin; inner margins short, first dorsal often longer than second; interdorsal distance short, 7.9 (4.4 – 9.0) times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 2.87 (2.69 – 3.01) times dorsal-fin base length, 3.57 (3.70 – 5.36) times caudal-fin length; first dorsal-fin base 1.24 (1.25 – 1.99) times caudal-fin length. Epichordal caudal-fin lobe well developed, long-based, very low, height much less than half tail width at fin origin; usually slightly taller posteriorly than anteriorly; usually truncate distally, its dorsal margin weakly convex; connected sub-basally to second dorsal fin; hypochordal caudal lobe vestigial.

Dorsal surface of adult male holotype with weak nuchal, orbito-spiracular thorns, tail and alar thorns better developed; malar thorn patch absent; no thorns along mid-disc or on scapular region; primary female paratype with small nuchal and orbital thorns, tail thorns better developed; primary juvenile paratype with enlarged nuchal and orbital thorns, and moderate tail thorns.



Figure 29. Dorsal head of *Dipturus grahami* sp. nov., adult male holotype (CSIRO H 950-01, 619 mm TL), showing snout, orbito-spiracular and nuchal regions.

Main orbital thorns of holotype about 8 (2 on preorbit, 2-3 on midorbit, 3-4 on postorbit; up to about 15 in male paratypes), forming a rosette; thorns variable in size slender, pungent, raked or upright, little recurved and often damaged distally; forming a loose cluster of thorns and thornlets on preorbit; anterior-most thorn on preorbit very broad based (appearing as a small, white tubercle, possibly formed by two coalesced thorns), bifurcate apically. Primary female paratype with similar rosette of orbital thorns, with about 8-9 (2-3 on preorbit, 2 on midorbit, 4 on postorbit; up to about 12 in other female paratypes, some thornlets barely larger than enlarged denticles) thorns, main anterior thorn similar to holotype, broad based, usually bifurcate apically. Early juvenile with 4 well-developed thorns (2 on preorbit, 1 on midorbit, 1 on postorbit; those on midorbit damaged). Nuchal thorn patch of holotype obscure, with 1 (1 in all male paratypes), very short, broad based, erect thorn; primary female paratype with 1 thorn (rarely with none); primary juvenile with 1 large, posteriorly directed thorn. Alar thorns in holotype about 23-29 (including missing thorns), well developed, much longer than tail thorns; deeply embedded, tips pungent, directed slightly posteromedially, in 2-3 (mainly 3 in adult male paratypes) semi-regular rows; patch slightly shorter than

twice orbit diameter. Tail thorns of adult male holotype well developed, pungent, recurved, tilted; predorsal primary thorns with small bases, longer than largest nuchal and orbital thorns; largest thorns with or without small dermal flap on their posterior bases; in single continuous, linear, median row, not paired, with about 14 (8 in male paratype CSIRO H 950-06) main thorns and about 8 (9) much smaller interstitial thorns interspersed between these larger thorns; interdorsal thorns 1 (0-2 in male paratypes). Primary female paratype with 5 rows of tail thorns, rows not equally well developed, median row widely separated from lateral rows; median row commencing near pelvic-fin insertion, extending along length of predorsal tail in a single linear series, thorns not staggered; median row with about 10 (7 in female paratype CSIRO H 889-01) main predorsal thorns and 9 (10) smaller interstitial thorns; dorsolateral rows paired, short, with 4-6 (5-6) thorns, located near lateral margin of tail, commencing near pelvic-fin insertion but barely extending past rear tip of pelvic fin (sometimes evidence of thorns forming posteriorly); lateral rows paired, with about 12-13 (9-11) thorns, located adjacent lateral fold, usually commencing near last thorn of dorsolateral row and terminating slightly forward of first dorsal fin; lateral



Figure 30. Ventral view of *Dipturus grahami* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 950-01, 619 mm TL); B, primary female paratype (CSIRO H 950-02, 540 mm TL).



Figure 31. Lateral view of dorsal and caudal fins of *Dipturus grahami* sp. nov., adult male holotype (CSIRO H 950–01, 619 mm TL).



Figure 32. Thorns at tail midlength of *Dipturus grahami* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 950–01, 619 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 950–02, 540 mm TL).

thorns slender, strongly recurved, pungent; interdorsal thorns 1 (usually 1 in other female paratypes exceeding 500 mm TL, otherwise absent). Early juvenile with 9 relatively short, strongly raked predorsal thorns; in a single median row, commencing near pelvic-fin insertion; interdorsal thorns absent.

Denticles of adult males not well developed, most of disc and tail naked. In holotype, denticles confined to head and anteroventral margin of disc, longer and more widely separated on dorsal head than on ventral head;

dorsally, present on snout tip (absent from most of rostral shaft) and in a narrow band along anterior margin of disc from tip of propterygium to level of alar patch, disc margin between these patches largely naked; denticles granular ventrally, over most of prenarial snout (absent from internasal flap), extending as a narrow band along disc margin to between level of mouth and first gill slit. Denticles of primary female paratype almost identical to adult male holotype ventrally; dorsal surface almost entirely naked, denticles confined to snout apex and in very small patch near disc margin (at about mid-length of

preorbit, present on all large female paratypes); primary juvenile without skin denticles.

Meristics (n=10): Tooth rows in upper jaw 36 (34–37); lower jaw 36 (32–36). Pectoral-fin propterygial radials 30 (29–32); mesopterygial radials 16–17 (15–17); metapterygial radials 36–37 (34–39); total radials 83 (80–85). Pelvic-fin radials males (n=5) 1 (1) + 20 (19–22); females (n=5) (1) + (20–22). Trunk centra 28 (27–30); predorsal caudal centra 45 (42–47); predorsal centra 73 (70–75); centra between origins of dorsal fins 13 (13–17); diplospondylous centra 95 (90–97); total centra about 123 (118–127).

COLOUR (in preservative).— Dorsal surface of disc, dorsal and pelvic fins and tail of holotype almost uniformly dark brown (chocolate, consistent across type series), slightly darker along midline, slightly paler near posterior margin of pectoral fin (sometimes with paler flecks where skin surface has been damaged); snout above anterior fontanelle and beside rostral cartilage much paler than disc, yellowish; anterior margin of disc with a very narrow pale edge; lateral tail fold pale or dusky; alar thorn patch, tail thorns, and tip of anterior pelvic-fin lobe yellowish to whitish. Ventral surface of disc dark greyish brown, only slightly paler than dorsal surface, with irregular brownish patches; tail dark brownish centrally, flanked laterally by paler edges; denticulate portion of disc slightly paler and well demarcated from darker areas on outer pectoral fin; mouth, cloaca and outer anterior margin of anterior pelvic-fin lobe white; gill slits not demarcated from rest of the ventral disc; sensory pores relatively indistinct (most obvious on paler areas of snout), with black edges but not surrounded by dark greyish patches. Clasper brownish dorsally, central ventral portion usually strongly contrasted, white. Dorsal fins dark brown anteriorly, mid-posterior portion of fins much paler, dusky to translucent; caudal fin greyish, translucent. Primary female paratype very similar to male holotype dorsally and ventrally and on fins. Primary juvenile with black posterior and outer ventral margin of disc from just behind level of mouth to pectoral-fin insertion; incised margin of pelvic-fin dark; dorsal and caudal fins black, and associated tail dark. When fresh: Generally similar to preserved colour; sometimes dorsally with dark greenish-brown hue, ventrally greyish black with smudged dusky areas.

SIZE.— Largest specimen was a female 641 mm TL; no adolescent males observed but with undeveloped claspers at 468 mm TL; adult males from 545–622 mm TL. Smallest confirmed juvenile 183 mm TL; no data on egg cases.

DISTRIBUTION.— Eastern Australia, from north-east of Moreton Bay, Queensland (26°31' S, 153°48' E), southward to at least Bermagui, New South Wales (36°15' S, 150°22' E); observed, but not collected from Eden, New South Wales (K. Graham, pers. comm.).

Reported by Last & Stevens (1994) to occur in 70–450 m but unpublished data based of surveys of the RV *Kapala* gives a range of 146–490 m (n=88), and is mainly 250–450 m (K. Graham, pers. comm.). A specimen (CSIRO CA 2807) was originally recorded in the ANFC registers as being collected off northwestern Australia. However, the station given in the register is from a RV *Soela* survey off Sydney, New South Wales. Comments in Last & Stevens (1994), who flagged this isolated record but requested supporting material from the west, were probably based on this specimen. *Dipturus grahami* should be considered as endemic to eastern Australia until reliable material is collected from Western Australia.

ETYMOLOGY.— Named to honour the efforts of two unrelated Australasian ichthyologists, Alastair Graham (Collection Manager, Australian National Fish collection) and Ken Graham (Fisheries Biologist, New South Wales Department of Primary Industries), who have both made very important but very different contributions to the knowledge of Australian sharks and rays. Vernacular name: Graham's Skate.

REMARKS.— *Dipturus grahami* resembles several plain coloured *Dipturus* skates. All other plain-coloured *Dipturus* are larger as adults, with most of these exceeding 1 m TL (rather than attaining only 64 cm TL) and usually have a much more elongate snout in all but small juveniles (length more than 6 times rather than less than 5 times orbit diameter). Only *D. canutus* (which reaches about 90 cm TL) also has a relatively short snout (less than 5.5 times orbit diameter) typical of this subgroup. When fresh, *Dipturus grahami* differs from *D. canutus* in being chocolate brown or greenish brown (rather than mainly greyish) dorsally, greyish or blackish ventrally (rather than mostly pale with dark markings highlighting the cloaca and pelvic-fin margins), and has fewer predorsal centra (70–75 vs. 75–82), fewer total centra (118–127 vs. 130–139), a broader disc (width 76–83% vs. 67–75% TL), a shorter predorsal tail (length from cloaca to first dorsal fin 25–28% vs. 29–30% TL), longer claspers (post-cloacal clasper length 27–28% vs. 22–25% TL in adult males), larger dorsal fins (base length of first 6–7% vs. 4–5% TL), and occurs in slightly shallower depths (less than about 500 m rather than occasionally to 730 m or more).

Dipturus oculus sp. nov.

Figs 33–38; Table 3

Raja sp. E: Last & Stevens, 1994: pp 302, 329, fig. 34.20, key fig. 18, pl. 63.

Holotype. CSIRO H 2619–01, adolescent male 460 mm TL, west of Bunbury, Western Australia, 33°22' S, 114°31' E, 203–204 m, 16 Feb 1991.

Paratypes. 12 specimens. CSIRO H 203–01, female

444 mm TL, north-west of Gantheaume Bay, Western Australia, 27°03' S, 112°49' E, 199–220 m, 27 Jul 1979; CSIRO H 2613–02, juvenile male 332 mm TL, west of Fremantle, Western Australia, 32°08' S, 115°09' E, 225–230 m, 13 Feb 1991; CSIRO H 2619–02, female 557 mm TL, collected with holotype; CSIRO H 3072–01, female 463 mm TL, south-west of Fremantle, Western Australia, 32°21' S, 114°58' E, 362–381 m, 07 Oct 1991; CSIRO H 3073–01, female 519 mm TL, south-west of Fremantle, Western Australia, 32°28' S, 114°52' E, 385–389 m, 07 Oct 1991; CSIRO H 3074–02, female 550 mm TL, CSIRO H 3074–03, female >425 mm TL (tail tip damaged), CSIRO H 3074–04, female 532 mm TL, south-west of Fremantle, Western Australia, 32°21' S, 114°59' E, 342–348 m, 08 Oct 1991; CSIRO H 3075–01, adolescent male 484 mm TL, south-west of Fremantle, Western Australia, 32°27' S, 114°54' E, 343–355 m, 08 Oct 1991; CSIRO H 3076–01, female >517 mm TL (tail tip damaged), south-west of Fremantle, Western Australia, 32°20' S, 114°59' E, 350–360 m, 08 Oct 1991; NMV A 1811 (2 specimens), female 325 mm TL, adolescent male 328 mm TL, south-west of Shark Bay, Western Australia, 27°01' S, 112°48' E, 238–248 m, 03 Mar 1981.

Other material. 1 specimen. CSIRO H 3074–01, female 437 mm TL, south-west of Fremantle, Western Australia, 32°21' S, 114°59' E, 342–348 m, 08 Oct 1991.

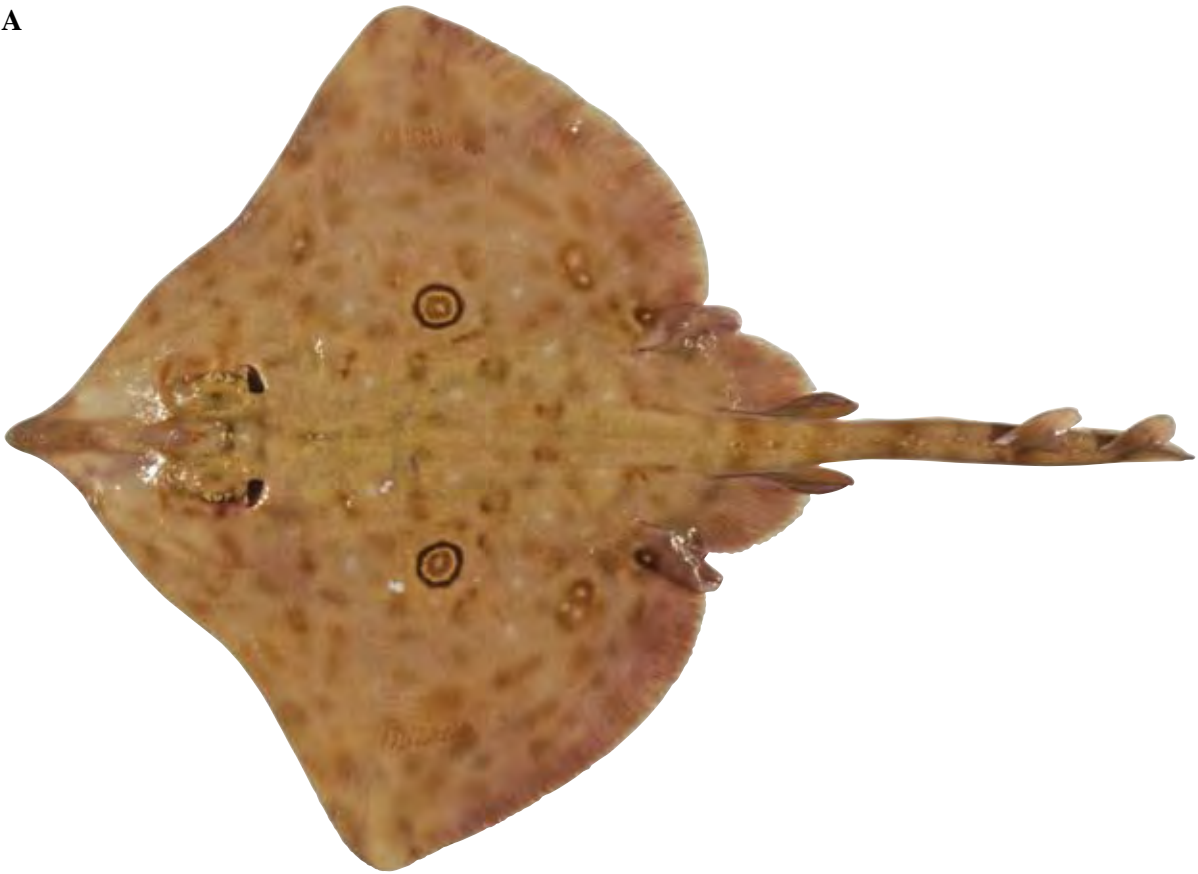
DIAGNOSIS.— A small species of *Dipturus* (to about 56 cm TL) with the following combination of characters: disc narrow with rounded apices, width 71–74% TL, about 1.2 times its length; snout angle 90–96°; tail short, length 0.7–0.8 in distance from snout tip to rear of cloaca; tail relatively broad, width 1.7–2.3 times height at its midlength, 1.9–2.2 times at first dorsal-fin origin; pre-upper jaw length 17–19% TL, 1.7–2.1 times internasal width; ventral head length 32–34% TL; snout length 3.4–3.6 times interorbital width; orbit diameter 68–82% interorbital width; first dorsal-fin height 1.6–1.8 in its base length; distance from first dorsal-fin origin to tail tip 2.4–3.1 times first dorsal-fin base length, 1.8–2.5 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adolescent males about 17% TL, length of anterior lobe 69–75% of posterior lobe; clasper of late adolescent male short, about 15% TL; anterior margins of both surfaces of head with narrow bands of denticles; a single nuchal thorn; malar thorn patch probably present in adult males (early stages of development in mid-adolescent male); tail thorn in single staggered row in males, two additional pairs of lateral rows in females; total pectoral radials 80–89; trunk centra 27–31; predorsal centra 69–85; total centra about 113–127; tooth rows in upper jaw 34–40; brownish or greyish dorsally with a large dark ocellus on each pectoral fin; ventral surface not uniformly coloured, greyish or brown on disc and tail, paler distally; ventral sensory pores greyish or black, without surrounding dusky blotches.

DESCRIPTION.— Disc quadrangular, 1.20 times as broad as long in adult male holotype (1.17–1.20 times

in paratypes); angle in front of spiracles 90° (90–96°); axis of greatest width 55% (57–59%) of disc length; anterior margin double concave (similar in other males and females), weakly concave anteriorly, weakly convex just forward of eyes, weakly concave beside eye and spiracles; apex narrowly rounded; posterior margin strongly convex; free rear tip broadly rounded. Head short, preorbital snout length 4.15 (4.44–5.22) times orbit length, 3.41 (3.37–3.57) times interorbit; pre-upper jaw length 1.75 (1.71–2.06) times internarial distance. Snout tip slightly produced, bluntly pointed; no fleshy process at apex. Orbit dorsal, diameter 0.82 (0.68–0.76) times interorbital width; eye lateral. Spiracle large, length 1.47 (1.42–2.07) in orbit diameter; opening teardrop-shaped to suboval. Nostril suboval to circular, usually distorted; anterior nasal flap expanded slightly, its lateral margin forming a short open tube; anterior margin of flap weakly lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed by nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with well-developed fringe; internarial distance 1.53 (1.65–1.68) in distance between first gill slits, 0.86 (0.95–1.05) in distance between fifth gill slits. Upper jaw strongly arched in both sexes, not indented at symphysis; lower jaw uniformly convex; lateral teeth concealed by lobe of nasal curtain. Teeth of early adolescent male holotype unicuspid with subcircular bases; arranged in vague longitudinal rows; medial cusps short, subtriangular, blunt, posteriorly directed (globular in mid-adolescent paratype CSIRO H 3075–01, 484 mm TL); not shorter but more oblique laterally. Teeth of female paratypes in quincunx, with somewhat hexagonal bases, crowns globular; cusps upright with blunt, transverse apical ridges.

Pelvic fins deeply forked; anterior lobe very short in holotype (relatively longer in primary female paratype CSIRO H 2619–02, 557 mm TL), slender, bluntly pointed distally, lateral margin entire, inner margin deeply incised; posterior lobe very elongate, its length relatively similar in females and adolescent males, lateral margins strongly convex, inner margin almost straight, connected to lateral margin of clasper near its base; anterior lobe 0.75 (0.69–0.74) times posterior lobe. Adult males unknown; clasper of mid-adolescent male in early stages of development, with evidence of a posterior structure off the shield (possibly a funnel). Tail not especially slender, depressed, moderately broad at base, tapering gradually to first dorsal-fin origin, not expanded at its midlength; behind first dorsal fin tapering rapidly to tail tip; width at insertions of pelvic fins 1.67 (1.52–1.67) times width at midlength of tail and 1.55 (1.51–1.79) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.82 (0.70–0.81) times distance from tip of snout to rear of cloaca; anterior cross-section almost equally convex dorsally and ventrally, much more strongly convex on dorsal surface than ventral surface posteriorly, almost flat ventrally near tail apex; width 1.49 (1.55–1.90) times

A



B

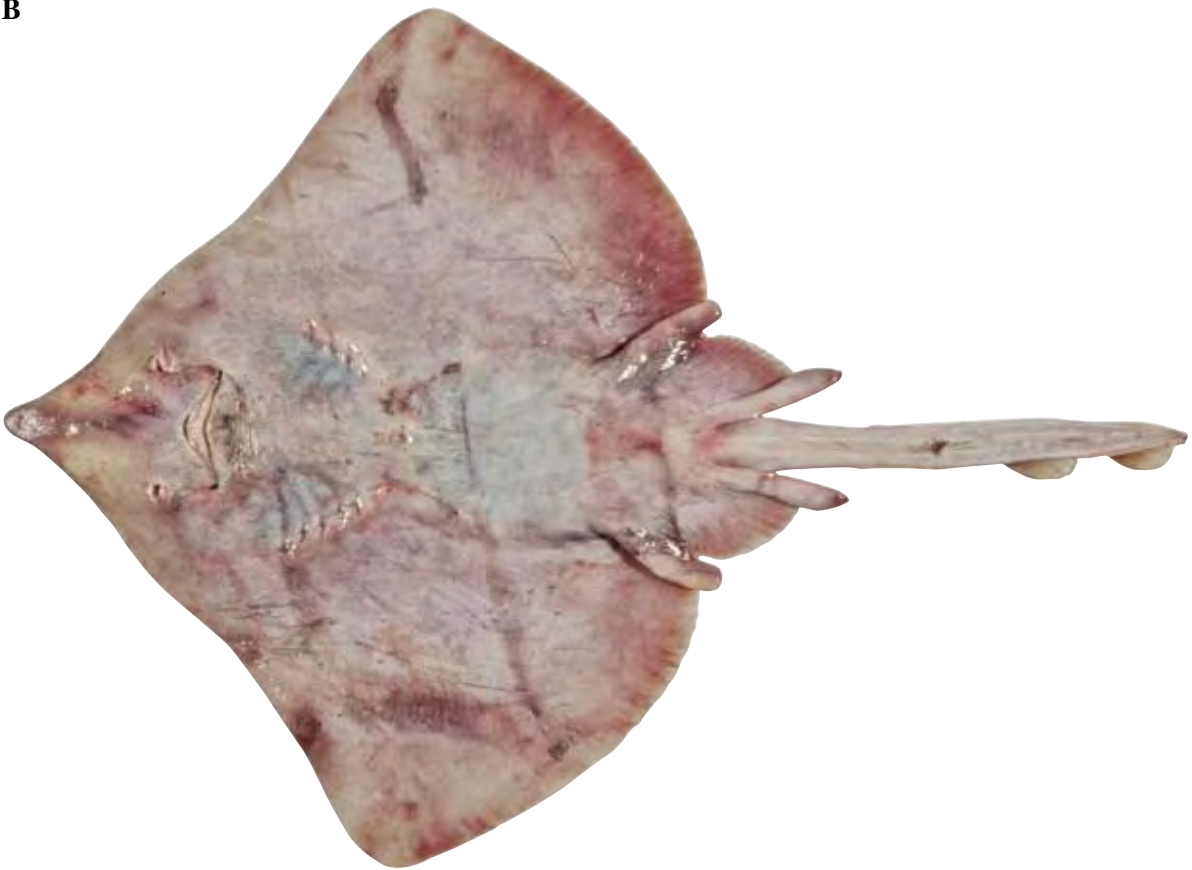


Figure 33. *Dipturus oculus* sp. nov., early adolescent male holotype (CSIRO H 2619–01, 460 mm TL, fresh): A, dorsal surface; B, ventral surface.

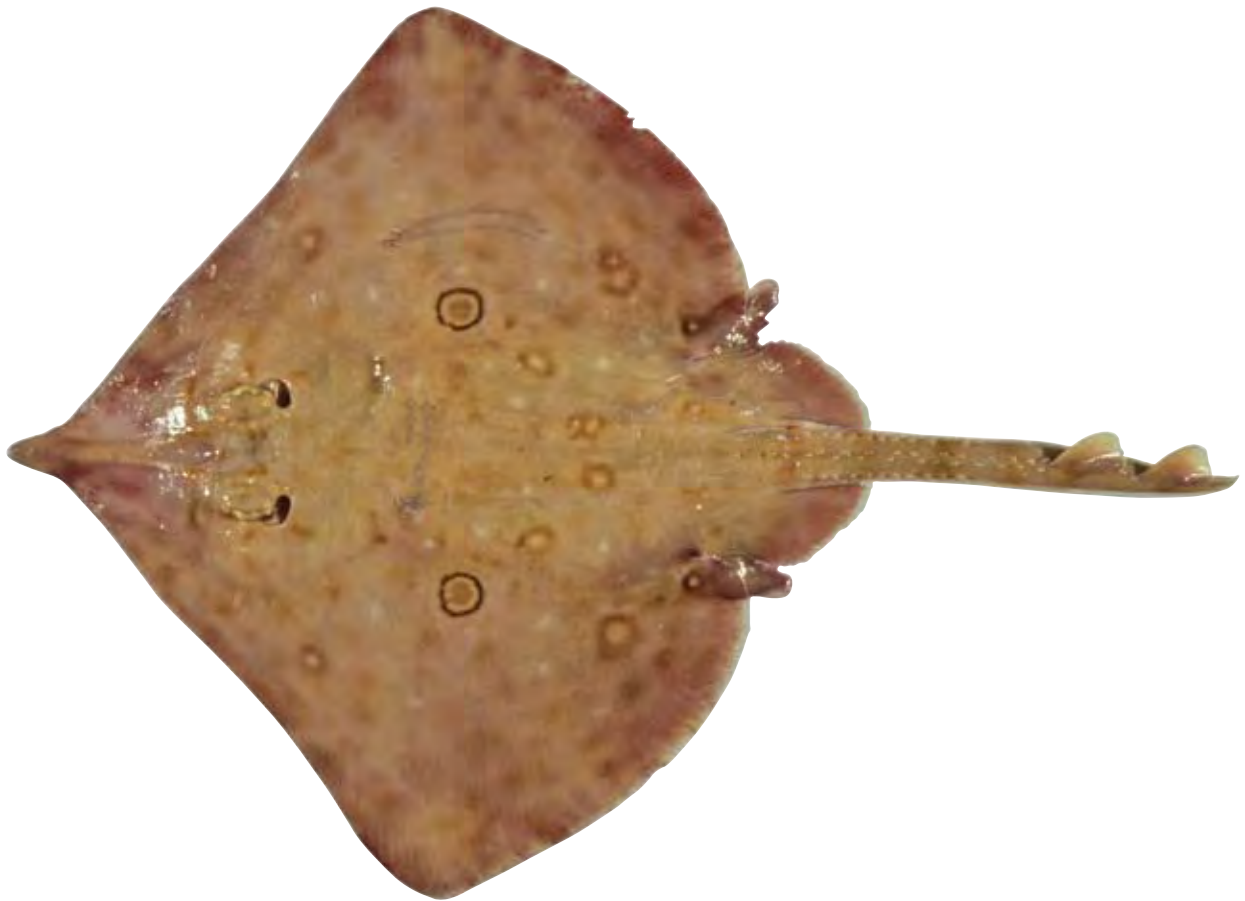


Figure 34. Dorsal surface of *Dipturus oculus* sp. nov., primary female paratype (CSIRO H 2619-02, 557 mm TL, fresh).

height at insertion of pelvic fin, 1.74 (1.94–2.25) times height at midlength, 1.91 (1.91–2.20) times height at first dorsal fin origin; lateral tail fold well developed, origin just forward of pelvic-fin rear tips, extending almost to tail tip, broadest distally. Dorsal fins of moderate size, similar in shape and size (first dorsal fin slightly larger than second in holotype); first dorsal-fin height 1.60 (1.59–1.76) in base length; fins very strongly raked, elongate, with long bases; anterior margins strongly convex, apices broadly rounded, posterior margins short and convex, free rear tip narrowly rounded; inner margin of first dorsal fin variable in length, usually longer than in second dorsal fin; dorsal fins well separated, interdorsal distance moderate, 2.40 (1.99–3.83) in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 2.75 (2.44–3.13) times dorsal-fin base length, 6.18 (5.36–7.23) times caudal-fin length; first dorsal-fin base 2.24 (1.81–2.48) times caudal-fin length. Epichordal caudal-fin lobe well developed, short-based, tall, maximum height exceeding half tail width at fin origin; tallest near its midlength, not truncate distally, its dorsal margin deeply convex; connected sub-basally to second dorsal fin; hypochordal caudal lobe minute.

Dorsal surface of early adolescent male holotype with

small nuchal, orbital, and developing alar thorns (malar patch not evident in holotype but developing in mid-adolescent male paratype); tail thorns slightly larger than those of disc; no other thorns on midline of disc or on scapular region; primary female paratype with relatively small nuchal and orbital thorns, and much larger tail thorns. Orbital thorns of holotype small, variable in shape, usually slender, similar in size, forming an incomplete rosette of 9 (4 on preorbit, 2 on midorbit, 3 on orbit; 5–8 in male paratype CSIRO H 3075-01) thorns. Primary female paratype with weakly protruding orbital thorns, similar in size and shape to holotype, about 8–9 (2 on preorbit, 3–4 on midorbit, 3 on postorbit; up to 10–12 in other female paratypes, mid-orbital thorns often absent). Nuchal thorns of holotype 1 (sometimes lost), short, broad based, slightly compressed laterally, slightly more robust than orbital thorns; primary female paratype with 1 minute thorn (1 thorn present in all other female paratypes). Malar patch developing (2 thorns present beside eye) in mid-adolescent male (CSIRO H 3075-01). Alar thorns in holotype developing, about 10–14 in single row; embedded, tips pungent, directed posteromedially. Tail thorns of early adolescent male holotype moderately well developed, in a single, poorly developed, staggered row; main predorsal thorns 11 (up to 14 in male paratypes)



Figure 35. Dorsal head of *Dipturus oculus* sp. nov., adolescent male holotype (CSIRO H 2619–01, 460 mm TL), showing snout, orbito–spiracular and nuchal regions.

with 9 (9) smaller interstitial thorns; thorns pungent, strongly raked, recurved, compressed, much longer than largest nuchal and orbital thorns; interdorsal thorns 3 (2 in male paratypes), including a single interstitial thorn. Primary female paratype with 5 rows of tail thorns; median and outer lateral rows best developed; median row strongly staggered (almost forming a double row), with about 22 (22 in female paratype CSIRO H 3074–02) main thorns and 8 (4) much smaller interstitial thorns, thorns commencing almost over cloaca and extending along length of predorsal tail; dorsolateral row with 10–11 (6–7) thorns in a short, linear series, near edge of tail, much closer to lateral tail fold than to thorns of median row, commencing near pelvic–fin insertion, usually extending to about midlength of tail; lateral row with 16–17 (11–12) thorns, commencing near free rear tip of pelvic fin, usually extending to beneath first dorsal fin; interdorsal thorns 2 (0–4 in all female paratypes), unpaired, sometimes with an interstitial thorn.

Denticles of early adolescent male holotype poorly developed, disc and tail largely naked; confined dorsally to patches on snout tip and along anterior margin of disc

from beside front of eye almost to pectoral-fin apex; confined to head ventrally, in narrow bands along snout midline and anterior disc margin to level of nostril, and on snout tip; tail and posterior disc entirely naked. Primary female paratype almost entirely naked dorsally, a few isolated denticles along anterior disc margin (female paratype CSIRO H 3074–02 with narrow denticle band extending from beside eye almost to apex of pectoral fin, some granular denticles on tail base beside pelvic fin); denticle distribution similar to holotype on ventral surface.

Meristics (n=10): Tooth rows in upper jaw 39 (34–40); lower jaw 37 (33–39). Pectoral-fin propterygial radials 31 (28–33); mesopterygial radials 15 (15–18); metapterygial radials 37 (35–39); total radials 83 (80–89). Pelvic-fin radials males (n=3) 1 (1) + 21–22 (22); females (n=7) (1) + (21–24). Trunk centra 30 (27–30, 31 in CSIRO H 3076–01); predorsal caudal centra 42 (42–48, 54 in CSIRO H 3076–01); predorsal centra 72 (69–78, 85 in CSIRO H 3076–01); centra between origins of dorsal fins 17 (13–16); diplospondylous centra 90 (86–97); total centra about 120 (113–127).



Figure 36. Ventral view of *Dipturus oculus* sp. nov. showing oronasal region and tooth band: A, adolescent male holotype (CSIRO H 2619–01, 460 mm TL); B, female paratype (CSIRO H 3076–01, >517 mm TL).

Table 3. Morphometrics for the holotype of *Dipturus grahami* sp. nov. (CSIRO H 950–01), ranges for measured paratypes (n=5), and means for all morphometric types; and the holotype of *Dipturus oculus* sp. nov. (CSIRO H 2619–01), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Dipturus grahami</i> sp. nov.				<i>Dipturus oculus</i> sp. nov.			
	Holotype	Paratypes		Mean	Holotype	Paratypes		Mean
		Min.	Max.			Min.	Max.	
Total length (mm)	619	540	628		460	463	550	
Disc width	76.3	76.5	83.0	78.7	73.0	71.1	73.5	72.6
Disc length (direct)	57.4	58.0	60.5	59.1	60.9	59.8	62.4	61.1
Snout to maximum width	33.2	32.5	35.5	33.9	33.7	34.1	37.1	35.3
Snout length (preorbital direct)	15.5	15.9	18.2	16.9	16.9	17.0	19.1	17.9
Snout to spiracle	20.5	21.5	23.3	22.0	22.8	22.6	24.1	23.3
Head (dorsal length)	21.7	22.6	24.6	23.5	24.7	24.4	26.7	25.5
Orbit diameter	3.6	3.6	4.0	3.8	4.1	3.5	4.0	3.8
Orbit and spiracle length	5.2	5.1	5.7	5.3	6.1	5.2	6.1	5.7
Spiracle length (main pore)	1.7	1.7	2.2	1.9	2.8	1.7	2.8	2.3
Distance between orbits	4.7	4.8	6.0	5.3	5.0	4.8	5.5	5.2
Distance between spiracles	7.4	7.6	7.9	7.7	7.1	7.2	7.8	7.4
Snout to cloaca (to 1st hemal spine)	54.4	55.5	57.2	55.9	54.2	54.9	58.7	56.6
Cloaca to D1	27.6	25.3	27.2	26.3	27.4	25.8	28.7	27.5
Cloaca to D2	34.6	32.2	34.2	33.3	36.3	33.5	36.3	35.3
Cloaca to caudal origin	40.4	38.0	39.8	39.3	41.8	39.1	41.9	40.6
Distance-cloaca to caudal-fin tip	45.4	41.8	44.4	43.7	44.6	41.4	44.6	43.2
Ventral snout length (pre upper jaw)	14.7	15.4	18.2	16.5	16.8	17.2	19.2	17.8
Prenasal length	12.3	12.8	15.3	13.8	14.1	13.9	15.3	14.6
Ventral head length (to fifth gill)	30.5	31.2	32.5	31.4	32.3	32.3	33.8	33.0
Mouth width	9.3	9.0	9.5	9.2	9.7	9.0	10.0	9.5
Distance between nostrils	8.7	9.0	9.5	9.2	9.6	9.2	10.1	9.5
Nasal curtain length	5.6	5.6	5.9	5.7	6.0	6.1	6.5	6.3
Nasal curtain (total width)	10.1	9.6	10.4	10.0	9.9	9.9	10.8	10.3
Nasal curtain (min. width)	7.3	7.1	7.8	7.5	7.2	6.8	7.2	7.1
Nasal curtain (lobe width)	1.2	1.2	1.7	1.4	1.3	1.3	1.8	1.5
Width of first gill opening	1.3	1.4	1.7	1.5	1.7	2.0	2.2	2.0
Width of fifth gill opening	1.0	0.9	1.3	1.1	1.3	1.1	1.5	1.3
Distance between first gill openings	15.3	14.6	16.2	15.6	14.7	15.5	16.7	15.8
Distance between fifth gill openings	8.8	8.6	10.0	9.5	8.3	8.8	9.8	9.3
Clasper (post cloacal length)	26.7	27.1	27.6	27.1	15.4	–	–	15.4
Length of anterior pelvic lobe	11.7	11.5	12.3	11.9	13.0	12.0	13.4	12.5
Length of posterior pelvic lobe	17.8	14.6	18.3	16.3	17.3	16.8	18.1	17.5
Pelvic base width	8.2	8.4	9.8	8.9	8.8	8.8	10.4	9.4
Tail at axil pelvic fins (width)	3.5	3.9	4.1	3.9	4.1	4.4	5.1	4.7
Tail at axil pelvic fins (height)	2.2	2.2	2.6	2.3	2.7	2.5	3.3	2.8
Tail at midlength (width)	2.7	2.4	2.8	2.7	2.4	2.8	3.2	2.9
Tail at midlength (height)	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5
Tail at D1 origin (width)	2.1	2.1	2.7	2.4	2.6	2.6	3.2	2.9
Tail at D1 origin (height)	1.5	1.4	1.5	1.5	1.4	1.3	1.5	1.4
D1 base length	6.2	5.7	6.5	6.1	6.2	5.1	5.6	5.5
D1 height	3.6	3.0	3.9	3.4	3.9	2.9	3.4	3.3
D1 origin to caudal-fin tip	17.9	15.8	18.8	17.4	17.2	13.7	15.9	15.7
D2 origin to caudal-fin tip	10.9	9.0	11.0	10.3	8.4	6.6	8.6	7.9
Caudal-fin length	5.0	3.0	4.9	4.4	2.8	2.2	2.9	2.6



Figure 37. Lateral view of dorsal and caudal fins of *Dipturus oculus* sp. nov., adolescent male holotype (CSIRO H 2619-01, 460 mm TL).

A



B



C



D



Figure 38. Thorns at tail midlength of *Dipturus oculus* sp. nov.: A, dorsal and B, lateral view of adolescent male holotype (CSIRO H 2619-01, 460 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 2619-02, 557 mm TL).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype mainly yellowish brown (consistent across type series); pale yellow beside rostral cartilage, on alar patch, and above anterior fontanelle of neurocranium; prominent ocellate marking mid basally on each pectoral fin; each ocellus consisting of a dark ring with a whitish inner border, its diameter subequal to orbit diameter; scattered, ill defined golden blotches over disc; small faint pale centred ocellus near pectoral-fin insertion; eyelid pale yellowish, eye black; dorsal fins pale yellowish basally, translucent distally. Claspers of adolescent males darker dorsally than ventrally. Ventral surface of holotype not pale, coloration strongly contrasted with dorsal surface; disc and tail mostly silvery to greyish brown, paler yellowish grey around disc and pelvic-fin margins; prenarial snout, teeth, cloaca and distal portion of anterior pelvic-fin lobe whitish; gill slits not usually strongly demarcated from adjacent branchial region; sensory pores greyish or black (most distinct on ventral snout), without surrounding dusky blotches. Primary female paratype similar to holotype; slightly darker brown dorsally; large pectoral ocelli very well defined, additional smaller faint ocelli on posterior disc; tail thorns whitish; ventral surface similar to holotype, pores not well defined. When fresh: Similar to preserved colour but dorsal pattern of spots and blotches may be more evident, ventral surface often paler than in preservative.

SIZE.— Largest specimen was a female 557 mm TL; adolescent males varied from 328–484 mm TL (the largest with fully extended claspers) indicating that this is a small skate; no adult males or small juveniles have been collected. Egg cases also unknown.

DISTRIBUTION.— Southwestern Australia from off Bunbury (33°22' S, 114°31' E) to Shark Bay (27°01' S, 112°48' E). Occurs primarily near the shelf break and on the upper continental slope at depths of 200–389 m.

ETYMOLOGY.— Based on the Latin *oculus* in reference to the eye-like marking on each pectoral fin. Vernacular name: Ocellate Skate.

REMARKS.— The only truly ocellated Australian skate and the only small *Dipturus* species with this colour pattern. Among other characters, *D. oculus* differs from its Western Australian congener *D. falloargus*, in having a broader disc (width 71–74% vs. 61–64% TL), a longer ventral head (length 32–34% vs. 29–31% TL), a shorter (post-cloacal length 41–45% vs. 47–50% TL) and more robust tail (width 2.4–3.2% vs. 1.8–2.3% TL, height 1.4–1.5% vs. 1.2–1.3% TL at midlength), and a shorter caudal fin (base length 2.2–2.9% vs. 3.6–4.7% TL). Adult males are not available in collections so, in the absence of details of the fully formed clasper, placement in *Dipturus* is provisional. The largest male, a mid-stage adolescent specimen (CSIRO H 3075–01, 484 mm TL), has partially formed claspers with some of the components evident.

The developing shield is obvious and terminates in an extension that may form a component funnel. If so, this species may belong to the genus *Okamejei*. An adult male specimen is required to resolve this issue.

Comparative material.

Dipturus australis: 10 specimens. CSIRO CA 45, female 492 mm TL; CSIRO H 207–01, female 443 mm TL; CSIRO H 210–01, adolescent male 422 mm TL; CSIRO H 722–01, adult male 485 mm TL; CSIRO H 949–02, adolescent male 429 mm TL; CSIRO H 949–06, adult male 468 mm TL; CSIRO H 980–11, adult male 485 mm TL; CSIRO H 1005–01, adult male 488 mm TL; CSIRO H 4166–01, female 408 mm TL; NMV A 3356, female 439 mm TL.

Dipturus cerva: 10 specimens. AMS E 4970, juvenile male (holotype) 118 mm TL; CSIRO CA 3518, female 439 mm TL; CSIRO H 156–01, female 582 mm TL; CSIRO H 190–01, adolescent male 453 mm TL; CSIRO H 289–01, adult male 596 mm TL; CSIRO H 291–01, female 478 mm TL; CSIRO H 306–01, adult male 454 mm TL; CSIRO H 1264–07, adult male 489 mm TL; CSIRO T 448–01, adult male 585 mm TL; CSIRO H 1265–12, adult male 509 mm TL.

Dipturus polyommata: 9 specimens. AMS I 10904, female 213 mm TL (lectotype); CSIRO H 718–01, adult male 347 mm TL; CSIRO H 718–02, female 369 mm TL; CSIRO H 718–05, female 318 mm TL; CSIRO H 718–07, adult male 326 mm TL; CSIRO H 718–09; adult male 334 mm TL; CSIRO H 718–10, female 369 mm TL; CSIRO H 718–12, adult male 337 mm TL; CSIRO H 718–13, female 356 mm TL.

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This study was initiated in the late 1970's when early exploratory surveys of Australian deepwater fishes resulted in the collation of the first targeted collections of Australian skates since the voyages of the F.I.S. *Endeavour*. Important comparative material made more comprehensive taxonomic investigation possible and this led to the discovery of several new short-snout *Dipturus* skates. I specially acknowledge the efforts of the many field biologists and fishermen who contributed important material to these collections. I thank William White for helping check descriptions, providing editorial comments and helping assemble the final document. Alastair Graham assembled materials and registered material especially for the paper. John Pogonoski provided editorial comments and technical assistance. Louise Conboy etched images of the types. Radiographs and meristic counts were taken by Spikey Riddoch and Tim Fountain, and these were carefully re-examined by John Pogonoski. Dan Gledhill measured most of the type material as part of a larger morphometric database on Australian chondrichthyans. Thanks also to Mark McGrouther and Sally Reader (AMS), Jeff Johnson

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A new Australian skate of the genus *Dipturus* (Rajoidei: Rajidae)

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ABSTRACT.— A new Australian skate of the genus *Dipturus* is described from material collected from off eastern Australia. *Dipturus wengi* sp. nov. is morphologically similar to *D. gigas* from the western North Pacific and *D. gudgeri* from southern Australia. It differs from *D. gigas* primarily in squamation, and from *D. gudgeri* in coloration, morphometrics and meristics. Populations of *D. wengi* from Western Australia and Indonesia, and possibly the Philippines, have higher vertebral counts and may constitute another species. A molecular investigation is needed to resolve remaining forms within the group.

Key words. Rajidae – skate – new species – Australia – *Dipturus wengi*

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INTRODUCTION

Australia's skate fauna consists of 16 species belonging to the hardnose skate genus *Dipturus* (Rajidae). Nine of these belong to a group of small, short-snout species of *Dipturus*, most of which have been discussed in an earlier paper in this volume (Last, 2008): *D. australis* (Macleay, 1884), *D. canutus* Last, 2008, *D. cerva* (Whitley, 1939), *D. confusus* Last, 2008, *D. endeavouri* Last, 2008, *D. falloargus* Last, 2008, *D. grahami* Last, 2008, *D. oculus* Last, 2008 and *D. polyommata* (Ogilby, 1910). The remaining species belong to a group of mostly large, long-snout species of *Dipturus* (Last *et al.*, 2008a): *D. acrobelus* Last, White & Pogonoski, 2008, *D. apricus* Last, White & Pogonoski, 2008, *D. gudgeri* (Whitley, 1940), *D. healdi* Last, White & Pogonoski, 2008, *D. melanospilus* Last, White & Pogonoski, 2008, *D. queenslandicus* Last, White & Pogonoski, 2008, and the undescribed *D. sp. I* (*sensu* Last & Stevens, 1994). Three of these long-snout species, *D. acrobelus*, *D. gudgeri* and *D. sp. I*, are very large skate species attaining lengths of well over 100 cm, with males of the last two species maturing at >120 cm TL. The undescribed species of *Dipturus*, i.e. *D. sp. I*, is described and figured in full below.

METHODS

Methods follow those outlined in the first paper of this special publication (Last *et al.*, 2008b) and generally follow standards used for skates. Materials of the new species described in detail in this paper are listed below.

They include the holotype (CSIRO H 891–01), and primary descriptive types (female paratype CSIRO H 952–01 and juvenile paratype AMS I 20651–008), as well as specimens from which meristic and/or morphometric information was obtained: 13 morphometric paratypes (AMS I 19093–003, AMS I 20118–008, CSIRO H 704–01, CSIRO H 952–01, CSIRO H 1081–01, CSIRO H 2207–01, CSIRO H 2208–01, CSIRO H 2500–04, CSIRO T 1152–02, CSIRO T 1364–02, CSIRO T 2009–01, CSIRO H 6639–03 and CSIRO H 6640–01); and 10 meristic paratypes (AMS I 19093–003, AMS I 20118–008, CSIRO H 704–01, CSIRO H 1081–01, CSIRO H 2207–01, CSIRO H 2208–01, CSIRO H 2500–04, CSIRO T 1364–02, CSIRO H 6639–03 and CSIRO H 6640–01). Collection acronyms follow Leviton *et al.* (1985).

Dipturus wengi sp. nov.

Figs 1–6; Table 1

Raja sp. I: Last & Stevens, 1994: pp 300, 335, figs 34–24 a, b, key fig. 9, pl. 58.

? *Raja* (*Dipturus*) sp. n. 1: Séret, 1994: listed.

? *Dipturus* sp. I: White *et al.*, 2006: pp 212, figs.

Holotype. CSIRO H 891–01, early adolescent male 1050 mm TL, east of Sydney, New South Wales, 33°43' S, 151°54' E, 486–509 m, 18 Dec 1985.

Paratypes. 15 specimens. AMS I 19093–003, female 285 mm TL, east of Wooli, New South Wales, 29°52' S, 153°43' E, 500 m, 10 Oct 1975; AMS I 20118–008,

juvenile male 266 mm TL, east of Wooli, New South Wales, 29°52' S, 153°43' E, 502–521 m, 23 Aug 1977; AMS I 20301–029, juvenile male 268 mm TL, east of Wooli, New South Wales, 29°53' S, 153°42' E, 502 m, 23 Aug 1977; AMS I 20651–008, juvenile male 252 mm TL, east of Southport, Queensland, 27°57' S, 154°03' E, 548 m, 06 Nov 1978; CSIRO H 704–01, juvenile male 749 mm TL, north-east of Whitsunday Island group, Marian Plateau, Queensland, 18°58' S, 150°29' E, 879–886 m, 25 Nov 1985; CSIRO H 952–01, female 1138 mm TL, east of Broken Bay, New South Wales, 33°33' S, 152°11' E, 907–999 m, 12 Feb 1986; CSIRO H 1081–01, juvenile male 281 mm TL, east of Moreton Bay, Queensland, 27°19' S, 153°53' E, 600 m, 10 May 1983; CSIRO H 2207–01, juvenile male 282 mm TL, east of Moreton Bay, Queensland, 27°12' S, 153°52' E, 555 m, 10 May 1983; CSIRO H 2208–01, female 325 mm TL, east of Moreton Bay, Queensland, 27°19' S, 153°53' E, 600 m, 10 May 1983; CSIRO H 2500–04, adolescent male 1081 mm TL, east of Broken Bay, New South Wales, 33°33' S, 152°09' E, 1037–1049 m, 12 Feb 1986; CSIRO H 6639–03, juvenile male 519 mm TL, east of Crowdy Head, New South Wales, 31°52' S, 153°16' E, 485–925 m, 09 Dec 1987; CSIRO H 6640–01, juvenile male 416 mm TL, south-east Queensland (probably east of Moreton Bay), 27° S, 153° E; CSIRO T 1152–02, female 904 mm TL, north-east Tasmania, 28 Jul 1982; CSIRO T 1364–02, female 283 mm TL, east of Moreton Island, Queensland, 27°12' S, 153°52' E, 555 m, 10 May 1983; CSIRO T 2009–01, female 1281 mm TL, off Bicheno, Tasmania, 42° S, 148° E, 840 m, 16 Jun 1982.

Other material. 4 specimens. CSIRO H 609–01, juvenile male 814 mm TL, west of Lihou Reef & Cays, Queensland Plateau, Queensland, 16°54' S, 151°30' E, 880 m, 06 Dec 1985; CSIRO H 965–04, juvenile male 845 mm TL, east of Broken Bay, New South Wales, 33°43' S, 151°54' E, 495–540 m, 04 Nov 1985; CSIRO T 1387–04, female 1049 mm TL, east of Long Point (Seymour), Tasmania, 41°46' S, 148°37' E, 830–850 m, 18 May 1982; CSIRO T 1849–02, adolescent male 1122 mm TL, east of Falmouth, Tasmania, 41°38' S, 148°40' E, 900–1020 m, 22 Apr 1982.

DIAGNOSIS.— A large species of *Dipturus* (to 128 cm TL) with the following combination of characters: disc with angular apices, width 69–81% TL, 1.2–1.3 times its length; snout angle 77–93°; tail length 0.7–1.1 in distance from snout tip to rear of cloaca, expanded at its midlength; tail width 1.3–1.7 times height at its midlength, 1.3–2.8 times at first dorsal-fin origin; pre-upper jaw length 17–23% TL, 1.9–2.6 times internasal width; ventral head length 28–36% TL; snout length 3.5–4.6 times interorbital width; orbit diameter 42–82% interorbital width; first dorsal-fin height 1.7–3.3 in its base length; distance from first dorsal-fin origin to tail tip 2.9–4.3 times first dorsal-fin base length, 0.5–1.2 times caudal-fin length; pelvic-fin anterior lobes relatively elongate 13–17% TL, length of posterior lobe 12–16% TL, length of anterior lobe 86–128% of posterior

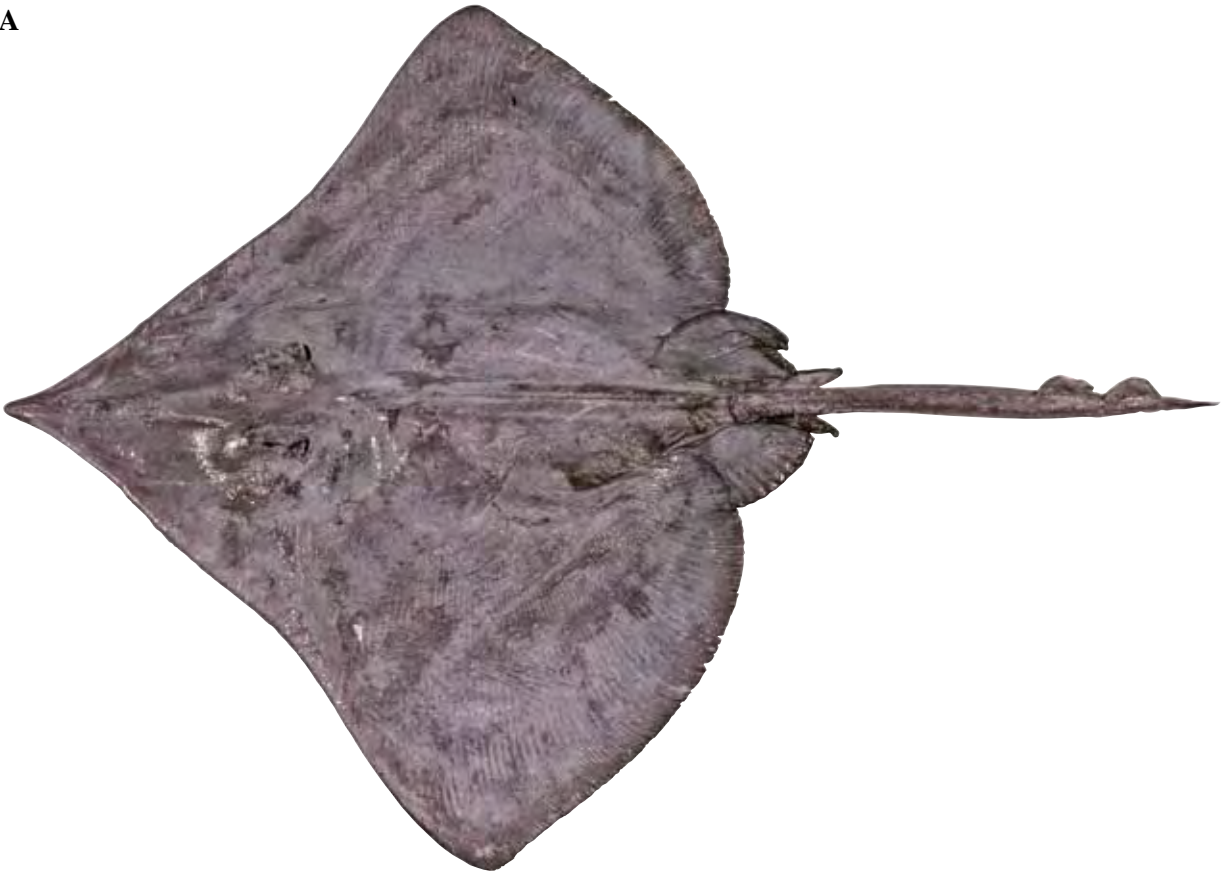
lobe; pelvic-fin base narrow, width 6.3–8.6% TL; disc mostly smooth, denticles confined to ventral snout and anteroventral margin; 0–1 nuchal thorns; tail with single thorn row in both sexes; total pectoral radials 95–99; trunk centra 29–34; predorsal centra 87–90; total centra about 139–148; tooth rows in upper jaw 34–39; dorsal and ventral surfaces dark brown to blackish with black pores on ventral surface of head; pelvic fins sometimes mottled white.

DESCRIPTION.— Disc very broadly quadrangular, broader than long, width 1.23 in holotype (1.01–1.33 in paratypes) times disc length; angle in front of spiracles 80° (90–93° in small paratypes <500 mm TL, 77–80° in large paratypes >500 mm TL), becoming more acute with growth; axis of greatest width 63% (59–65% in small paratypes, 60–66% in large paratypes) of disc length; anterior disc margin moderately undulated (strongly double concave in primary juvenile paratype AMS I 20651–008, 252 mm TL, deeply concave near snout tip), weakly convex slightly forward of orbits, concave at level of spiracles; apex rather angular to narrowly rounded; posterior disc margin weakly concave anteriorly, then convex posteriorly; free rear tip broadly angular; inner margin almost straight. Head moderately elongate, preorbital snout length 8.52 (4.78–6.45 in small paratypes, 7.06–9.12 in large paratypes) times orbit length, 4.18 (3.46–4.60 in small paratypes, 3.79–4.59 in large paratypes) times interorbit; pre-upper jaw length 2.37 (1.93–2.31 in small paratypes, 2.09–2.63 in large paratypes) times internarial distance. Snout tip not well produced, bluntly pointed; no fleshy process at apex. Orbit small, diameter 0.49 (0.63–0.82 in small paratypes, 0.42–0.60 in large paratypes) times interorbital width. Spiracle moderate, 1.59 (1.91–3.69 in small paratypes, 1.34–2.10 in large paratypes) in orbit diameter; opening broadly tear-drop shaped. Nostril opening suboval; anterior nasal flap greatly expanded, its lateral margin forming a tall, semi-circular tube; anterior margin of flap lobe-like, not concealed beneath nasal curtain; posterior inner margin concealed beneath nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded to angular distally, posterior margin with long, fine fringe; internarial distance 1.52 (1.41–1.69 in small paratypes, 1.47–1.63 in large paratypes) in distance between first gill slits, 1.06 (0.97–1.09 in small paratypes, 0.98–1.14 in large paratypes) in distance between fifth gill slits. Upper and lower jaws slightly arched (most pronounced in large specimens), not indented at symphysis; lateral teeth of upper jaw usually fully concealed by lobe of nasal curtain. Teeth of late adolescent male paratype CSIRO H 2500–04 (1081 mm TL) weakly unicuspid, with elevated subcircular bases; arranged in longitudinal rows rather than in quincunx; cusps in both jaws short, bluntly rounded; teeth of juvenile male holotype and primary female paratype H 952–01 similar, cusps slightly shorter, raised slightly (less pronounced near jaw angle), without median ridge; teeth of juvenile paratype CSIRO H 789–03 arranged in

Table 1. Morphometrics for the holotype of *Dipturus wengi* sp. nov. (CSIRO H 891–01), ranges and means for measured large paratypes (>500 mm TL, n=6) and measured small paratypes (<500 mm TL, n=7). Values are expressed as percentages of total length.

	<i>Dipturus wengi</i> sp. nov.						
	Holotype	Large paratypes			Small paratypes		
		Min.	Max.	Mean	Min.	Max.	Mean
Total length (mm)	1050	519	1282		266	416	
Disc width	76.1	73.6	81.2	77.6	69.0	77.6	72.3
Disc length (direct)	61.6	59.2	63.6	61.7	52.4	59.6	55.1
Snout to maximum width	38.9	35.5	41.2	38.3	30.8	36.5	33.6
Snout length (preorbital direct)	21.2	19.4	23.0	21.7	16.0	20.6	18.1
Snout to spiracle	25.6	23.5	27.3	26.0	19.8	24.7	22.1
Head (dorsal length)	27.3	25.8	29.6	28.0	21.7	26.3	24.1
Orbit diameter	2.5	2.3	3.1	2.8	3.0	3.5	3.3
Orbit and spiracle length	4.2	4.0	4.6	4.2	3.9	4.5	4.2
Spiracle length (main aperture)	1.6	1.5	1.9	1.7	0.9	1.7	1.3
Distance between orbits	5.1	5.0	6.0	5.3	4.2	4.9	4.5
Distance between spiracles	6.9	6.8	7.4	7.1	5.9	6.2	6.1
Snout to cloaca (to 1st hemal spine)	56.2	53.5	59.7	56.8	46.8	51.7	49.0
Cloaca to D1	28.0	27.6	30.8	28.8	30.1	32.4	31.5
Cloaca to D2	33.6	32.8	36.8	34.2	37.1	38.9	38.0
Cloaca to caudal origin	39.0	37.0	41.8	38.8	42.9	48.4	44.0
Distance-cloaca to caudal-fin tip	43.7	40.4	46.7	43.1	48.6	52.5	50.3
Ventral snout length (pre upper jaw)	21.6	18.9	23.4	21.8	16.9	20.9	18.8
Prenasal length	18.9	16.9	20.5	19.3	14.5	18.2	16.2
Ventral head length (to fifth gill)	34.4	32.7	35.8	34.6	27.5	32.3	30.2
Mouth width	8.5	7.6	8.8	8.1	6.0	7.8	7.3
Distance between nostrils	9.1	8.5	9.6	9.1	8.1	9.1	8.8
Nasal curtain length	5.0	4.7	5.5	5.2	3.7	5.2	4.4
Nasal curtain (total width)	9.6	8.5	9.4	8.9	7.9	9.2	8.4
Nasal curtain (min. width)	6.8	5.5	6.6	6.2	5.1	6.0	5.6
Nasal curtain (lobe width)	1.3	1.1	2.0	1.4	1.6	2.2	1.9
Width of first gill opening	1.5	1.4	1.6	1.5	1.0	1.2	1.1
Width of fifth gill opening	1.1	1.1	1.4	1.2	0.7	1.1	1.0
Distance between first gill openings	13.8	13.3	15.3	14.4	12.6	14.8	13.7
Distance between fifth gill openings	9.7	8.8	10.1	9.5	8.8	9.6	9.2
Clasper (post cloacal length)	–	–	–	–	–	–	–
Length of anterior pelvic lobe	14.4	13.0	15.6	14.6	14.2	17.3	15.9
Length of posterior pelvic lobe	14.7	13.8	16.3	14.7	11.8	15.1	13.2
Pelvic base width	7.1	7.0	8.6	7.6	6.3	7.1	6.7
Tail at axil pelvic fins (width)	2.6	2.5	3.2	3.0	2.9	3.7	3.2
Tail at axil pelvic fins (height)	2.4	2.1	2.5	2.3	2.0	2.5	2.1
Tail at midlength (width)	2.4	2.4	2.7	2.5	1.9	2.3	2.1
Tail at midlength (height)	1.5	1.3	1.8	1.6	1.2	1.5	1.3
Tail at D1 origin (width)	2.3	2.1	2.4	2.2	1.6	2.6	1.9
Tail at D1 origin (height)	1.3	1.1	1.6	1.4	0.9	1.2	1.1
D1 base length	4.7	4.0	5.4	4.5	4.9	5.5	5.1
D1 height	2.5	2.0	2.8	2.4	1.5	2.7	2.3
D1 origin to caudal-fin tip	15.7	12.8	15.9	14.3	16.3	21.1	18.8
D2 origin to caudal-fin tip	10.2	7.6	10.4	8.9	10.6	13.9	12.3
Caudal-fin length	4.7	3.4	5.4	4.3	5.5	9.1	7.3

A

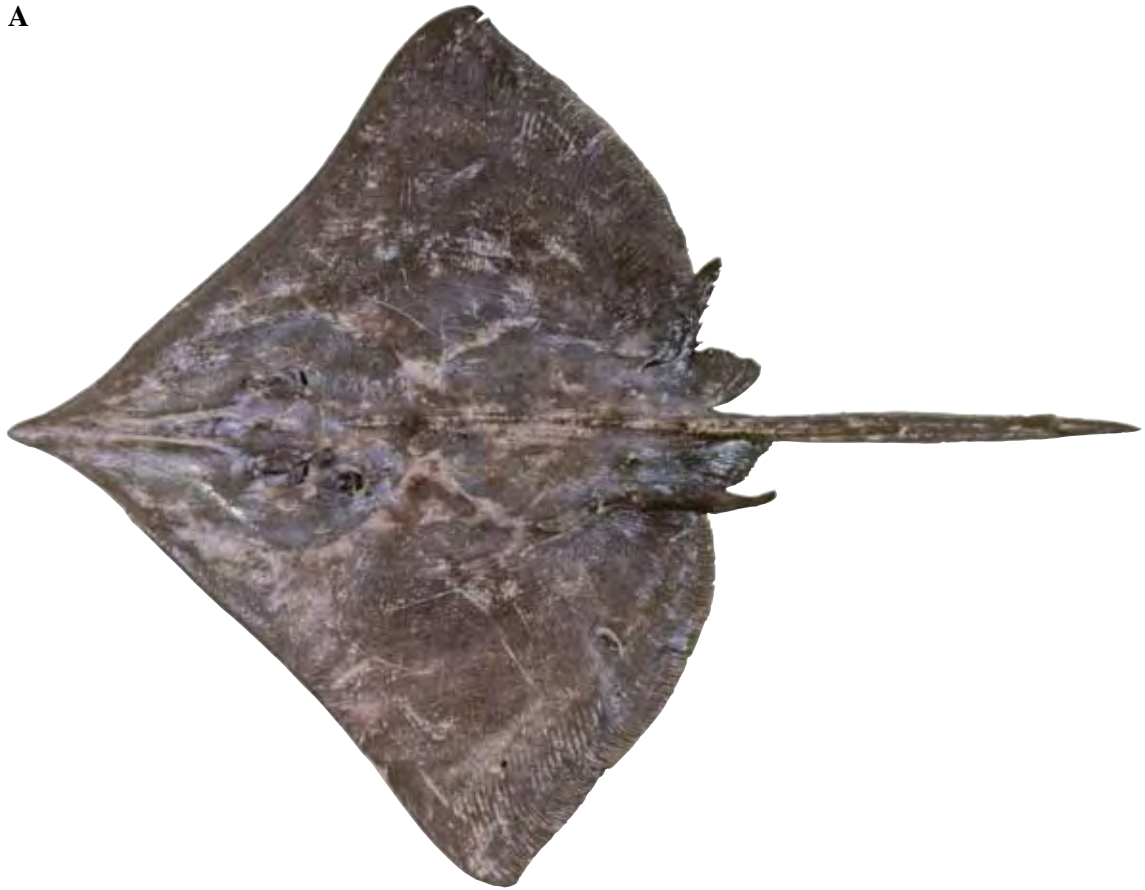


B



Figure 1. *Dipturus wengi* sp. nov., early adolescent male holotype (CSIRO H 891–01, 1050 mm TL, fresh): A, dorsal surface; B, ventral surface.

A



B



Figure 2. Dorsal surface of *Dipturus wengi* sp. nov.: A, primary female paratype (CSIRO H 952–01, 1138 mm TL, fresh); B, primary juvenile paratype (AMS I 20651–008, male 252 mm TL, preserved).



Figure 3. Dorsal head of *Dipturus wengi* sp. nov., early adolescent male holotype (CSIRO H 891-01, 1050 mm TL), showing snout, orbito-spiracular and nuchal regions.

quincunx, broader based with less elevated crowns.

Pelvic fins large, very deeply incised, with distinct lobes; anterior lobe very elongate, equal or somewhat longer than the posterior lobe, 0.98 (1.14–1.28 in small paratypes, 0.86–1.04 in large paratypes) times posterior lobe; anterior lobe long, narrowly rounded to bluntly pointed distally, anterior margin entire, posterior margin deeply incised; posterior lobe moderately short in largest adolescent male, longer (length 16.3% TL) than in large females (length 14.1–14.9% TL); outer margin strongly convex (less so in adult male); free rear tip narrowly rounded (slightly more rounded in females and juveniles); inner margin weakly convex to concave. Clasper of adolescent male moderately slender, glans expanded with external components shield, rhipidion, dike, sentinel, spike, anterior and posterior slit. On radiograph, only the proximal part of the axial cartilage is calcified in the claspers of the largest male (CSIRO H 2500-04), the other internal cartilages are not apparent.

Tail deep, rather slender, not strongly depressed (similar in females and males, more depressed in juveniles); tapering slightly anteriorly then greatly expanded from midlength to dorsal-fin base (not expanded in juvenile); tapering more rapidly to tail tip behind first dorsal fin; width at

axils of pelvic fins 1.09 (1.30–1.80 in small paratypes, 0.91–1.33 in large paratypes) times width at midlength of tail and 1.17 (1.17–2.14 in small paratypes, 1.18–1.40 in large paratypes) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.78 (0.94–1.12 in small paratypes, 0.68–0.83 in large paratypes) times distance from tip of snout to rear of cloaca; anterior cross-section subcircular (narrowly oval in juveniles), almost equally convex dorsally and ventrally, more strongly convex on dorsal surface than ventral surface posteriorly (almost flat); width 1.10 (1.37–1.69 in small paratypes, 1.00–1.36 in large paratypes) times height at axil of pelvic fin, 1.61 (1.39–1.71 in small paratypes, 1.35–1.72 in large paratypes) times height at midlength, 1.69 (1.44–2.77 in small paratypes, 1.33–1.97 in large paratypes) times height at first dorsal-fin origin; side of tail somewhat angular (more so in large females than males); lateral tail folds as very low ridges anteriorly, origin behind clasper insertion, fold distinct from about midlength of tail and more developed below dorsal fins (slightly narrower than height of epichordal lobe at its widest), terminating well forward of tail tip. Dorsal fins rounded, raked backward, subequal in size, first dorsal-fin height about 1.86 (1.82–3.30 small paratypes, 1.73–2.28 in large paratypes) in base length; relatively tall, with moderately elongate to short bases; anterior margins of both fins evenly convex,

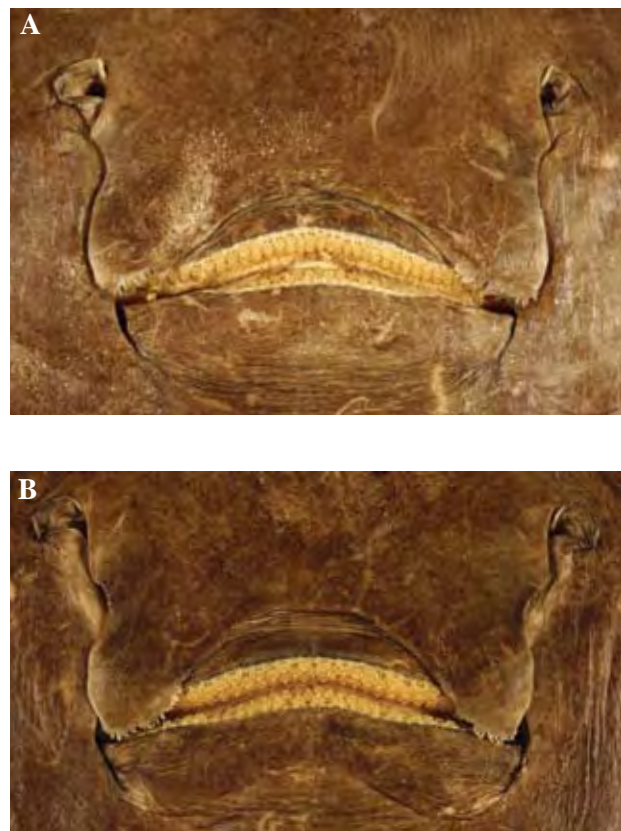


Figure 4. Ventral view of *Dipturus wengi* sp. nov. showing oronasal region and tooth band: A, adolescent male holotype (CSIRO H 891-01, 1050 mm TL); B, primary female paratype (CSIRO H 952-01, 1138 mm TL).



Figure 5. Lateral view of dorsal and caudal fins of *Dipturus wengi* sp. nov., early adolescent male holotype (CSIRO H 891-01, 1050 mm TL).

A



B



C



D



Figure 6. Thorns at tail midlength of *Dipturus wengi* sp. nov.: A, dorsal and B, lateral view of early adolescent male holotype (CSIRO H 891-01, 1050 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 952-01, 1138 mm TL).

apices broadly rounded, posterior margins short, convex; free rear tip usually angular; inner margins short, usually directed strongly anteroventrally; second dorsal-fin base subequal or slightly longer than first dorsal-fin base; interdorsal space variable but mainly short, 5.10 (2.16–12.22 in small paratypes, 3.40–13.37 in large paratypes) times in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 3.37 (3.24–4.25 in small paratypes, 2.88–3.41 in large paratypes) times dorsal-fin base length, 2.35 (2.32–2.96 in small paratypes, 2.93–3.77 in large paratypes) times caudal-fin length; first dorsal-fin base 0.70 (0.54–0.90 in small paratypes, 0.86–1.19 in large paratypes) times caudal-fin length. Epichordal caudal-fin lobe low, connected to second dorsal-fin insertion; hypochordal caudal lobe developed, long and very low, originating at level of midlength of epichordal lobe and confluent with it distally.

Early adolescent male holotype with very short, orbital, nuchal and tail thorns (larger males with alar thorns but no malar thorns); primary female paratype CSIRO H 952–01 also with very short, orbital, nuchal and tail thorns; juveniles with very long orbital, nuchal and tail thorns. Orbital thorns poorly developed in large specimens; holotype with 5–6 thorns (2 on preorbit, 1 on midorbit, 2–3 on postorbit), in an incomplete rosette; paratypes with up to 6 reduced orbital thorns, usually 2 on preorbital, 1–2 on midorbit, 2–3 on postorbit and supraspiracular region. Single nuchal thorn present or absent. Adolescent male holotype with 1–2 rows of 5–10 retractable alar thorns (patches developing), largest male (CSIRO H 2500–04, 1081 mm TL) with 2 rows of about 12 alar thorns; no malar thorns. Tail with single, linear, median row of 20 (18–22) widely spaced thorns, originating over cloaca and extending to first dorsal fin; thorns reduced in size (height 2 mm or less in largest specimens), almost upright, subtriangular to raked slightly in lateral view, regularly spaced, deciduous; 1 (0–1) small interdorsal thorns. Primary juvenile a paratype with 2 preorbital thorns, 1 postorbital thorn, 1 nuchal thorn (rarely absent); median row of tail with 18 (up to 22) closely spaced thorns, and 0–1 small interdorsal thorns close to second dorsal-fin insertion.

Dorsal surface of disc and tail smooth, devoid of denticles, large specimens with a few enlarged denticles on tip of snout; largest male (CSIRO H 2500–04) with a few coarse denticles on anterior disc margins at level of branchial area. Dorsal fin mostly smooth, but edge of anterior margin with denticles in largest specimens. Ventral surface of disc and tail mostly smooth, except over rostral cartilage and in a prominent band (about 10–20 mm wide) along anterior disc margin (continuous from snout tip to just forward of first gill slits); denticles with short (about 0.8 mm long), erect, slightly curved cusps on stellate bases; denticles on tip of snout widely spaced. Primary female paratype similar to male holotype but with less coverage over rostrum and with additional granular denticles over scapular region and abdomen.

Primary juvenile naked dorsally and ventrally; denticle band develops with growth, in new born, denticles are still included in the skin, but appear as a series of pale spots along anterior margins of disc from tip of snout to level of nasal valves; in juveniles the band extends and enlarges gradually.

Meristics (n=11): Tooth rows in upper jaw 39 (34–39); lower jaw 37 (33–40). Pectoral-fin propterygial radials 33 (34–37); mesopterygial radials 20 (17–22); metapterygial radials 43 (42–45); total radials 96 (95–99). Pelvic-fin radials males (n=8) 1 (1) + 20 (20–22); females (n=3) (1) + (21–23). Trunk centra 30 (29–34); predorsal caudal centra 57 (57–60); predorsal centra 87 (87–90); centra between origins of dorsal fins 15 (13–15); diplospondylous centra 115 (107–115); total centra about 145 (139–148); pseudobranchial lamellae 12 (9–15).

COLOUR (in preservative).— Dorsal surface more or less uniformly greyish brown to dark brown (some pale areas but skin not greatly deciduous, alar patch not obvious), sides of snout not paler than rostrum; some specimens with black blotches on head and disc; ventral surface very dark, brown to brownish black with very small black (indistinct) pores on head; denticle band along anterior margin of disc white to creamy white, strongly contrasted from rest of head between base of rostral cartilage and first gill slit; gill slits often pale edged; pelvic fins sometimes mottled white (often darker than disc), some specimens with white blotches at base of anterior pelvic-fin lobes and on base of tail between posterior pelvic-fin lobes; cloaca white; tail mottled brownish to blackish, tail fold pale; dorsal and caudal fins pale brownish (similar to tail), more or less narrowly dark edged. Primary juvenile paler brown than adults dorsally; rostral cartilage not strongly demarcated from adjacent snout; posterior margin of disc very narrowly black edged; tail pale brownish, more dusky behind first dorsal-fin origin, dorsal fins blackish; mainly brownish ventrally (no broad black band around disc apex), with paler areas around mouth and cloaca, blotched on pelvic fins; posterior ventral margin of anterior lobe and tip of posterior lobe blackish. When fresh: Similar to preserved colour.

SIZE.— Reaches at least 1280 mm TL (female); adolescent males 1081–1122 mm TL, no adult males recorded; smallest juvenile 252 mm TL.

DISTRIBUTION.— Found on the continental slope off tropical and temperate eastern Australia from west of Lihou Reef & Cays, Queensland (16°54' S, 151°30' E) southward to Bicheno, Tasmania (ca. 42° S, 148° E) in depths of 486–1049 m. Not recorded in the Great Australian Bight. Western Australian populations of *Raja* (*Dipturus*) sp. I in Last & Stevens (1994) are closely related to *D. wengi* but may be a distinct species.

ETYMOLOGY.— Named after Mr Herman Weng,

a Queensland fisheries biologist, who showed an enthusiastic interest in skates and collected the first validated Australian specimens of the new species in 1983 during an exploratory survey of the continental slope off southern Queensland. Vernacular name: Weng's Skate.

REMARKS.— *Dipturus wengi* differs from other Australian skates in colour, morphometrics and meristics. However, it can be confused with *D. gudgeri*, as these are the only giant skates (exceeding well over 1 m TL) with darkish dorsal and ventral surfaces. *Dipturus wengi* has a broader (snout angle 77–93° vs. 71–76° in *D. gudgeri*) and shorter snout (16.0–23.0% vs. 22.8–24.5% TL), longer anterior pelvic-fin lobes (13.0–17.3% vs. 10.6–11.5% TL), a narrower pelvic base (6.3–8.6% vs. 8.2–10.4% TL), and lower first dorsal fin (1.5–2.7% vs. 2.7–3.7% TL). It is similar to the western North Pacific skate, *Dipturus gigas* (Ishiyama, 1958), another large species that occurs off Japan (Ishiyama, 1967). Both *D. gigas* and *D. wengi* are broad skates with a uniform dark coloration on both surfaces of the disc, a moderately elongate and sharply pointed snout, an expanded central tail region, a relatively long anterior pelvic-fin lobe (extending past the posterior lobe when adpressed), and a high vertebral count (more than 29 trunk and 87 predorsal centra). *Dipturus wengi* differs from *D. gigas* in lacking a denticle band along the anterior dorsal margin of the disc (present on both dorsal and ventral margins in *D. gigas*). Also, juvenile specimens of *D. gigas* (up to 500 mm TL) have the entire dorsal surface of the disc covered with minute denticles which disappear as the skate develops (dorsal surface of the disc is mostly smooth at all stages in *D. wengi*).

We initially thought that the presence/absence of a nuchal thorn identified the existence of two similar species in the eastern Indian Ocean and western Pacific, but have since concluded that this character is intraspecifically variable in *D. wengi*. However, *Dipturus wengi* is very close, if not identical to a possible undescribed species from Western Australia, and a skate from Indonesia only known from 7 juvenile specimens (286–602 mm TL) collected during the KARUBAR exploratory voyage to the Arafura Sea off Tanimbar Island in 393–557 m depth range (Séret, 1994). These populations differ in vertebral counts; Queensland and New South Wales specimens have significantly lower predorsal (87–90 centra, mean 89.2, $n = 11$) and diplospondylous counts (107–115 centra, mean 111.2, $n = 11$) than those of Western Australia and Indonesia (91–98 centra, mean 94.1, and 113–124 centra, mean 116.8, $n = 17$ respectively). A large female specimen from the Philippines (CSIRO H 4126–01) is very closely related, if not conspecific, to western forms of *D. wengi*. It has 115 predorsal centra which falls within the range of the Western Australia–Indonesian populations. However, it shows slight differences in the denticle pattern of the ventral surface of the disc: denticles at the snout tip and along the anterior margins are denser

and disperse gradually over the disc where they become more widely spaced (in Australian populations, denticles of the snout and disc margin form a well-defined band that does not spread across the disc; only one very large female has scattered denticles on the belly, otherwise the disc is smooth). Genetic studies are needed to test the conspecificity of *D. gigas* subgroup forms across the Indo–West Pacific.

Comparative material.

Dipturus cf. *wengi*: 34 specimens. Western Australia: CSIRO CA 2819, juvenile male 663 mm TL; CSIRO CA 4343, female 294 mm TL; CSIRO CA 4347, female 342 mm TL; CSIRO CA 4349, female 290 mm TL; CSIRO CA 4372, female 296 mm TL; CSIRO CA 4373, juvenile male 268 mm TL; CSIRO CA 4375, juvenile male 287 mm TL; CSIRO CA 4385, female 336 mm TL; CSIRO H 822–24, female 343 mm TL; CSIRO H 1207–01, female 295 mm TL; CSIRO H 1207–02, juvenile male 308 mm TL; CSIRO H 1207–05, female 287 mm TL; CSIRO H 1514–24, juvenile male 266 mm TL; CSIRO H 1622–01, juvenile male 233 mm TL; CSIRO H 1630–01, juvenile male 271 mm TL; CSIRO H 1647–01, juvenile male 375 mm TL; CSIRO H 1647–02 (3 specimens), female 248 mm TL, juvenile male 214 mm TL, female 193 mm TL; CSIRO H 1650–02, juvenile male 264 mm TL; CSIRO H 1825–01, female 627 mm TL; CSIRO H 2262–01, female 768 mm TL; CSIRO H 2917–03, female 873 mm TL; CSIRO H 3144–02, juvenile male 288 mm TL; CSIRO H 3144–04, juvenile male 434 mm TL; CSIRO H 3159–01, female 291 mm TL; CSIRO H 3159–02, juvenile male 384 mm TL; CSIRO H 3159–03, female 483 mm TL; CSIRO H 3159–04, juvenile male 285 mm TL; CSIRO H 3159–05, juvenile male 519 mm TL; CSIRO H 3191–01, juvenile male 258 mm TL. Philippines: CSIRO H 4126–01, female 950 mm TL. 2 (of 7) specimens. Indonesia: MNHN 1998-1032; female 548 mm TL; MNHN 1998-1034, female 602 mm TL.

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A new skate of the genus *Dentiraja* (Rajoidei: Rajidae) from southern Australia

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ABSTRACT.— A new species of skate, *Dentiraja flindersi* sp. nov., is described from material collected on the inner continental shelf off southern Australia. Members of the genus *Dentiraja* are small skates with a subcircular disc, very short snout with a black spot on its ventral tip, large pelvic fins, and large claspers with a long glans with most of the major components located near to clasper apex. It differs from its closest relative, *D. lemprieri*, in its smaller adult size, having fewer vertebrae and fewer pectoral-fin radials, and in several morphometric characters. Both species are distributed in temperate Australian seas with *D. flindersi* occurring off South Australia and *D. lemprieri* off Victoria and Tasmania.

Key words. Rajidae – skate – new species – Australia – *Dentiraja*

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INTRODUCTION

The Thornback Skate, *Dentiraja lemprieri* (as *Raja lemprieri*) was described by Richardson (1845) based on material collected near Port Arthur, Tasmania. This species has subsequently been referred to as *Raja lemprieri* (Paxton *et al.*, 1989; Gomon *et al.*, 1994) and as *Raja (Dipturus) lemprieri* by Last & Stevens (1994). *Dipturus* was later elevated to generic level (McEachran & Dunn, 1998) and this species has been subsequently referred to as *Dipturus lemprieri* (Last & Yearsley, 2002; Hoese *et al.*, 2006; Jeong *et al.*, 2007; Eschmeyer, 2008), and also as *Okamejei lemprieri* (McEachran & Dunn, 1998; Compagno, 1999; Ebert & Compagno, 2007). Problems with existing definitions of *Dipturus* and *Okamejei* have been discussed by Last & Yearsley (2002) and most Australian *Dipturus/Okamejei*-like skates do not conform to Ishihara's (1987) definition of either of these genera, or of any other rajid genus.

In 1940, Whitley erected *Dentiraja*, a new subgenus of *Raja*, with *Raja dentata* Klunzinger, 1872 as its type. Klunzinger's two supposed syntypes (probably lost according to Fricke, 1995) were collected at Port Phillip Bay, Victoria, and his species has been listed as a synonym of Richardson's *D. lemprieri* (Paxton *et al.*, 1989; Gomon *et al.*, 1994; Last & Stevens, 1994; Eschmeyer, 2008; Hoese *et al.*, 2006). Fricke (1995) claimed to have rediscovered material that he believed were the lost Klunzinger types. However, only one of these, the holotype SMNS 1658, is a valid type. Fricke suggested that the second specimen (SMNS 1816) was unavailable

when Klunzinger made his description. The female holotype is about 500 mm TL which is consistent with the size of adult female *D. lemprieri*. While researching the book, *Sharks and Rays of Australia*, one of us (Last) discovered a smaller undescribed relative of *D. lemprieri* in the South Australian Museum fish collection, which Last & Stevens (1994) included in the above reference as *Raja* sp. M. This species is described and figured below.

Last & Yearsley (2002) resurrected the subgenus *Dentiraja* and placed it in *Dipturus*. More recent examination of the clasper, supported by other work in progress, has indicated that *Dentiraja* is a monophyletic group endemic to southern Australia. Also, while preparing this manuscript, a third species was discovered from Western Australia. Hence, we have chosen herein to elevate the group to generic level status. A more thorough definition of *Dentiraja* and a review of its species, including a full description of their unique claspers, will accompany a description of this other new species at a later date.

METHODS

Methods follow those outlined in the first paper of this special publication (Last *et al.*, 2008) and generally follow standards used for skates. Materials of the new species described in detail in this paper are listed below. They include the holotype (SAMA F 11849, adult male 293 mm TL), and primary descriptive female paratype (SAMA F 11850, female 315 mm TL), as well as

specimens from which meristic and/or morphometric information was obtained: 7 morphometric paratypes (CSIRO H 6642–01, SAMA F 11844, SAMA F 11845, SAMA F 11846, SAMA F 11848, SAMA F 11850 and SAMA F 11851); 9 meristic paratypes (CSIRO H 6642–01, SAMA F 11844, SAMA F 11845, SAMA F 11846, SAMA F 11848, SAMA F 11850 and SAMA F 11851, SAMA F 11852 and SAMA F 11853). Collection acronyms follow Leviton *et al.* (1985).

Dentiraja flindersi sp. nov.

Figs 1–6; Table 1

Raja sp. M: Last & Stevens, 1994: pp 302, 341–342, fig. 34.28, key fig. 21, pl. 54.

Holotype. SAMA F 11849, adult male 293 mm TL, between Cape St Albans and Penneshaw (Kangaroo Island), South Australia, ca. 35°44' S, 138°04' E, 32 m, Apr 1981.

Paratypes. 10 specimens. CSIRO H 6642–01, adult male 289 mm TL, SAMA F 11844, juvenile male 242 mm TL, SAMA F 11845, female 326 mm TL, Nepean Bay (Kangaroo Island), South Australia, 35°38' S, 137°46' E, 33 m, 28 Apr 1981; SAMA F 11846, female 269 mm TL, SAMA F 11847, adult male >290 mm TL (tail tip damaged), off Emu Bay, Kangaroo Island, South Australia, 35°35' S, 137°31' E, 27 m, 27 Jan 1982; SAMA F 11848, adolescent male 251 mm TL, between North Cape & Penneshaw (Kangaroo Island), South Australia, ca. 35°40' S, 137°45' E, 54 m, 15 Jan 1982; SAMA F 11850, female 315 mm TL, collected with holotype; SAMA F 11851, female 315 mm TL, SAMA F 11852, adult male 316 mm TL, SAMA F 11853, juvenile male 174 mm TL, off Emu Bay, Kangaroo Island, South Australia, 35°35' S, 137°31' E, 30 m, 15 Jan 1982.

DIAGNOSIS.— A very small *Dipturus*-like skate (to about 33 cm TL) with the following combination of characters: disc subcircular, width 64–71% TL, 1.1–1.2 times its length; snout angle 100–114°; tail short, length 0.8–0.9 in distance from snout tip to rear of cloaca; tail broad, width 2.0–2.8 times height at its midlength, 2.0–2.6 times at first dorsal-fin origin; pre-upper jaw length 11–13% TL, 1.2–1.3 times internasal width; ventral head length 27–31% TL; snout length 2.1–2.6 times interorbital width; orbit diameter 54–77% interorbital width; first dorsal-fin height 1.8–2.4 in its base length; distance from first dorsal-fin origin to tail tip 2.1–2.6 times first dorsal-fin base length, more than 8 times caudal-fin length (base of epichordal lobe of caudal fin very short); pelvic fins large, length of posterior lobe of adult males 25% TL, length of anterior lobe 60–69% of posterior lobe; adult clasper relatively large, about 26% TL, connected to pelvic-fin inner margin at about 41–47% of its length from cloaca; anterior margin of disc with denticle band on dorsal surface, naked ventrally;

0–5 nuchal thorns, mostly present; malar thorn patch present, usually small; tail usually with 3 thorn rows; total pectoral radials mainly 70–74; trunk centra mainly 26–29; predorsal centra mainly 62–67; total centra about 94–109; tooth rows in upper jaw mostly 34–41; uniform yellowish brown dorsally or spotted; ventral surface uniformly pale yellow or white with a blackish snout tip; ventral sensory pores not black edged or surrounded by dusky blotches.

DESCRIPTION.— Disc subcircular, 1.12 times as broad as long in adult male holotype (1.09–1.22 times in paratypes); angle in front of spiracles 102° (100° in an adult male paratype, 105–114° in female paratypes); axis of greatest width 52% (50–53%) of disc length; anterior margin strongly double concave (more so in adult males), short and weak concavity near snout tip (sometimes notched at tip of propterygium), strongly convex forward of eyes, deeply concave at and behind level of spiracles (more anterior, beside eye and spiracles in juveniles); apex very broadly rounded; posterior margin strongly convex; free rear tip broadly rounded. Head very short, preorbital snout length 2.97 (3.48–4.04) times orbit length, 2.29 (2.14–2.62) times interorbit; pre-upper jaw length 1.15 (1.15–1.30) times internarial distance. Snout tip extended only slightly, broadly rounded; no fleshy process at apex. Orbit diameter 0.77 (0.54–0.75) times interorbital width. Spiracle small, length 1.81 (1.38–1.74) in orbit diameter; opening usually teardrop-shaped. Nostril suboval to subrectangular, often distorted; anterior nasal flap expanded, its lateral margin forming a pronounced open tube; anterior margin of flap strongly lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed by nasal curtain; posterior lobes very well developed, forming nasal curtain, produced posterolaterally, narrowly rounded distally, posterior margin with prominent fringe; internarial distance 1.55 (1.62–1.78) in distance between first gill slits, 0.94 (0.89–1.06) in distance between fifth gill slits. Upper jaw broad, strongly arched in adult males (weakly arched in females and juveniles), deeply indented at symphysis in mature males; lower jaw strongly convex, most pronounced near middle of jaw; lateral teeth concealed by lobes of nasal curtain. Teeth of adult male holotype strongly unicuspid with narrow, subcircular bases; arranged in obvious longitudinal rows; medial cusps very elongate, subconical, bluntly pointed; directed posteromedially near symphysis of upper jaw, directed more posteriorly toward angle of jaw; cusps slightly shorter laterally; teeth of female and juvenile paratypes in strong quincunx, with broadly rectangular to subhexagonal crowns, cusps mostly short, usually blunt.

Pelvic fins large, deeply forked; anterior lobe short, narrowly rounded distally, lateral margin entire, inner margin deeply incised; posterior lobe very elongate, slightly longer in males (length 24.9–25.3% TL) than in females (length 21.5–23.3% TL), lateral margins convex, inner margin straight to weakly convex, connected to

Table 1. Morphometrics for the holotype of *Dentiraja flindersi* sp. nov. (SAMA F 11849), ranges for measured paratypes (n=7) and means for all morphometric types, and ranges and means for two juveniles and 6 adults of *Dentiraja lemprieri*. Values expressed as a percentage of total length.

	<i>Dentiraja flindersi</i> sp. nov.				<i>Dentiraja lemprieri</i>					
	Holotype	Paratypes		Mean	Juveniles			Adults		
		Min.	Max.		Min.	Max.	Mean	Min.	Max.	Mean
Total length (mm)	293	242	326		268	324		463	527	
Disc width	65.9	63.5	71.4	67.0	68.2	70.5	69.4	62.9	72.4	67.2
Disc length (direct)	59.0	55.5	60.2	58.7	59.0	59.3	59.1	56.6	62.2	58.9
Snout to maximum width	30.9	27.8	31.8	30.6	30.0	30.5	30.3	29.4	32.6	31.1
Snout length (preorbital direct)	12.7	13.0	13.8	13.5	14.2	14.5	14.3	12.7	14.8	14.0
Snout to spiracle	18.2	17.3	19.3	18.4	19.9	20.0	20.0	17.9	19.8	19.1
Head (dorsal length)	20.0	19.6	21.1	20.3	21.3	21.7	21.5	19.8	21.7	21.0
Orbit diameter	4.3	3.2	4.0	3.8	3.8	4.3	4.1	3.7	4.1	3.9
Orbit and spiracle length	5.8	4.5	5.8	5.2	5.7	5.9	5.8	5.2	5.8	5.5
Spiracle length (main aperture)	2.4	2.2	2.5	2.3	2.4	3.0	2.7	2.0	2.6	2.3
Distance between orbits	5.6	5.3	6.4	5.8	5.1	5.4	5.2	5.5	6.6	6.0
Distance between spiracles	8.4	7.9	8.9	8.5	7.9	8.2	8.0	7.6	8.4	8.0
Snout to cloaca (to 1 st hemal spine)	53.9	52.0	56.0	54.1	52.7	54.4	53.6	52.8	59.0	56.0
Cloaca to D1	30.1	26.1	29.1	28.1	29.9	30.6	30.2	28.8	33.7	30.1
Cloaca to D2	39.0	34.4	39.5	37.0	37.2	38.5	37.8	35.0	39.9	36.5
Cloaca to caudal origin	45.4	41.1	45.5	43.8	43.4	45.4	44.4	39.4	45.8	42.4
Distance-cloaca to caudal-fin tip	46.0	42.7	47.5	45.4	45.1	47.1	46.1	41.3	47.2	44.0
Ventral snout length (pre upper jaw)	11.2	11.4	13.1	12.1	13.9	14.1	14.0	11.5	13.5	12.6
Prenasal length	9.4	9.4	10.2	9.7	11.5	11.5	11.5	9.5	10.9	10.3
Ventral head length (to fifth gill)	28.9	26.7	31.2	29.2	30.0	30.1	30.1	28.9	31.6	30.0
Mouth width	9.8	9.4	10.8	10.1	8.7	10.0	9.3	9.3	10.3	9.8
Distance between nostrils	9.7	9.2	10.6	10.0	9.3	9.6	9.5	9.2	10.5	9.9
Nasal curtain length	6.6	5.9	6.5	6.3	6.0	6.2	6.1	6.1	6.9	6.3
Nasal curtain (total width)	11.7	10.0	11.7	11.3	10.6	10.7	10.6	10.5	11.6	11.1
Nasal curtain (min. width)	7.9	6.6	8.0	7.6	6.7	6.9	6.8	6.7	7.5	7.1
Nasal curtain (lobe width)	2.4	1.6	2.3	2.0	1.7	1.9	1.8	1.8	2.2	2.0
Width of first gill opening	2.0	1.6	2.3	2.0	1.9	2.0	1.9	1.8	2.0	1.9
Width of fifth gill opening	1.0	1.1	1.6	1.3	1.3	1.5	1.4	1.3	1.7	1.5
Distance between first gill openings	15.1	15.8	18.0	16.7	15.8	16.6	16.2	15.8	18.3	16.5
Distance between fifth gill openings	9.1	9.2	10.8	9.7	9.2	10.5	9.8	8.1	11.0	9.4
Clasper (post cloacal length)	26.0	–	25.8	25.9	–	–	–	22.1	23.7	22.6
Length of anterior pelvic lobe	15.3	13.6	16.1	14.9	14.6	14.9	14.7	12.8	14.5	13.4
Length of posterior pelvic lobe	24.9	21.5	25.3	22.9	19.5	19.9	19.7	19.5	22.6	21.2
Pelvic base width	12.6	10.4	12.3	11.3	8.3	9.1	8.7	8.3	10.7	9.8
Tail at axil pelvic fins (width)	4.7	4.5	5.9	5.2	4.8	4.9	4.8	4.8	5.9	5.3
Tail at axil pelvic fins (height)	2.5	2.1	2.7	2.4	2.6	2.8	2.7	2.6	3.3	2.9
Tail at midlength (width)	3.0	2.8	3.8	3.2	3.3	3.3	3.3	3.0	3.9	3.4
Tail at midlength (height)	1.6	1.3	1.4	1.4	1.5	1.6	1.5	1.5	1.7	1.5
Tail at D1 origin (width)	2.9	2.8	3.5	3.1	3.3	3.3	3.3	2.9	3.8	3.3
Tail at D1 origin (height)	1.4	1.2	1.5	1.3	1.4	1.5	1.4	1.3	1.6	1.4
D1 base length	7.2	7.0	8.2	7.4	6.6	7.4	7.0	6.2	6.5	6.3
D1 height	3.6	3.1	4.1	3.6	4.3	4.6	4.5	3.5	4.2	3.9
D1 origin to caudal-fin tip	15.9	15.7	19.0	17.3	15.3	16.5	15.9	12.4	14.9	13.8
D2 origin to caudal-fin tip	7.0	7.0	9.7	8.4	8.0	8.6	8.3	6.2	8.2	7.5
Caudal-fin length	0.6	1.2	2.3	1.6	1.7	1.7	1.7	1.3	1.8	1.6

A



B



Figure 1. *Dentiraja flindersi* sp. nov., adult male holotype (SAMA F 11849, 293 mm TL, preserved): A, dorsal surface; B, ventral surface.

A



B



Figure 2. Dorsal surface of *Dentiraja flindersi* sp. nov., A, primary female paratype (SAMA F 11850, 315 mm TL, preserved), B, juvenile paratype (SAMA F 11853, male 174 mm TL, preserved).



Figure 3. Dorsal head of *Dentiraja flindersi* sp. nov., adult male holotype (SAMA F 11849, 293 mm TL), showing snout, orbito-spiracular and nuchal regions.

dorsolateral margin of clasper at about 40–50% of its inner margin length from cloaca; anterior lobe 0.62 (0.60–0.69) times posterior lobe; clasper large, robust, postcloacal length about 25% TL in adult males. Tail rather broad, very strongly depressed; relatively broad at base, tapering weakly to first dorsal-fin origin, not expanded at its midlength; behind first dorsal fin tapering gradually to tail tip; width at insertions of pelvic fins 1.54 (1.27–1.88) times width at midlength of tail and 1.59 (1.42–1.83) times width at first dorsal-fin origin respectively; length from rear of cloaca 0.85 (0.76–0.90) times distance from tip of snout to rear of cloaca; anterior cross-section not more convex dorsally than ventrally, slightly more strongly convex on dorsal surface than ventral surface posteriorly (almost flat beyond dorsal fins); width 1.90 (1.67–2.53) times height at insertion of pelvic fin, 1.9 (2.08–2.75) times height at midlength, 2.06 (1.99–2.55) times height at first dorsal fin origin; lateral tail fold extremely well developed, origin near middle of pelvic-fin insertions, extending to tail tip and united distally, broadest below dorsal and caudal fins. Dorsal fins medium-sized, first dorsal-fin height 2.02 (1.77–2.40) in base length; first dorsal fin usually larger and longer than second; fins very strongly raked with long bases; anterior margins convex, apices broadly rounded (second dorsal more angular); posterior margins and inner margins usually united, margin of first dorsal usually directed posterodorsally, margin of second dorsal usually directed anterodorsally; interdorsal distance variable, fins almost confluent to well separated, 4.3 (2.2 or more) times in

length of first dorsal-fin base when separate, adpressed first dorsal fin touching to well short of second dorsal-fin origin. Epichordal caudal-fin lobe usually rudimentary, very short and low; post dorsal tail length less than third base length of second dorsal fin (rear tip of fin often almost adjacent tail apex); usually truncate distally, its dorsal margin variable in shape; usually connected basally to second dorsal fin; hypochordal caudal lobe absent.

Dorsal surface of adult male holotype with small nuchal, orbital, malar, alar thorns and tail thorns (thorns of adult male paratypes variably developed, most weak but with additional posterior median series on disc in SAMA F 11852); no thorns on scapular region; primary female paratype (SAMA F 11850, female 315 mm TL) with additional rows of small thorns and thornlets in a longitudinal median band on disc (female paratype SAMA F 11851 with larger thorns than other paratypes and with prominent median row of thorns on disc). Orbital thorns of holotype small, 5–6 (1–2 on preorbit, 2 on midorbit, 2 on postorbit), first thorn forward of mid-eye, last thorn beside anterior margin of spiracle; subequal in size, forming a rosette, thorns directed posteriorly. Primary female paratype without obvious orbital thorns or a rosette, instead with a patch of enlarged denticles

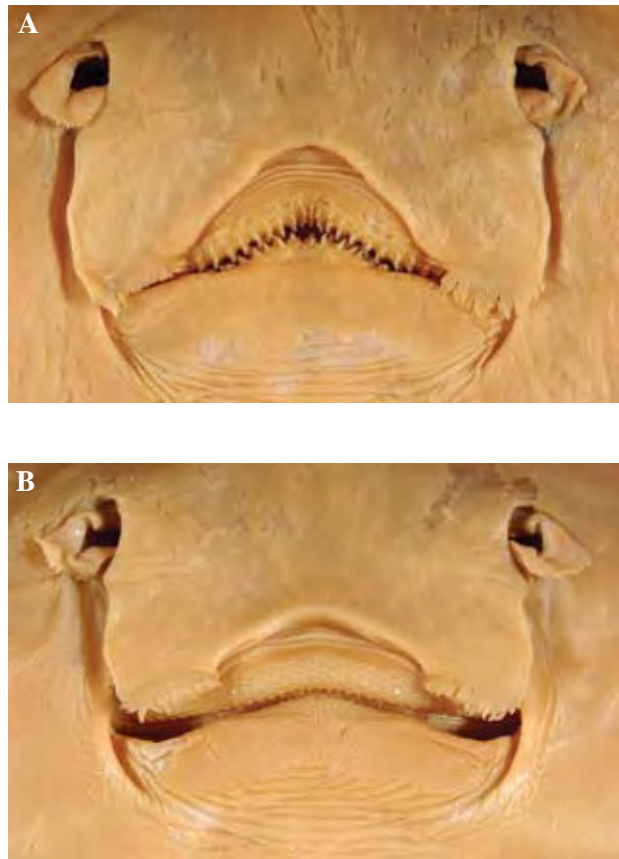


Figure 4. Ventral view of *Dentiraja flindersi* sp. nov. showing oronasal region and tooth band: A, adult male holotype (SAMA F 11849, 293 mm TL); B, primary female paratype (SAMA F 11850, 315 mm TL).



Figure 5. Lateral view of dorsal and caudal fins of *Dentiraja flindersi* sp. nov., adult male holotype (SAMA F 11849, 293 mm TL).

A



B



C



D



Figure 6. Thorns at tail midlength of *Dentiraja flindersi* sp. nov.: A, dorsal and B, lateral view of adult male holotype (SAMA F 11849, 293 mm TL); C, dorsal and D, lateral view of primary female paratype (SAMA F 11850, 315 mm TL).

and thornlets (female paratype SAMA F 11851 with about 7–8 obvious thorns). Nuchal thorns of holotype 4, short, upright with small bases, subequal in size to orbital thorns (0–2 minute thorns in other adult male paratypes); primary female paratype with about 5 thorns (1–4 in other female paratypes). Malar patch variable, holotype with about 3–7 main thorns in a very small patch, loosely clustered near disc edge at orbit level, not in obvious rows following convexity of disc; main thorns short, slender, pungent, recurved posterolaterally, slightly smaller than largest orbital thorn (better developed in paratypes, up to about 12–13 large thorns in 3–4 rows in SAMA F 11852, often grading into large denticles laterally on disc). Alar thorn patch very well developed, elongate, slightly longer than snout length, well separated from disc margin; in holotype, thorns deeply embedded, about 27 in mainly 2 well-defined rows, much longer than tail thorns, tips pungent, directed almost medially. Tail thorns of adult male holotype in 3 rows; thorns small, pungent, upright, similar in size to orbital thorns; thorns sometimes with small skin fold near their posterior margin; median row linear, not staggered, predorsal thorns about 19, even mix of large thorns and smaller interstitial thorns, commencing near pelvic-fin insertion and extending to first dorsal-fin origin (up to 29 thorns in adult male paratypes, extending to forward of cloaca in SAMA F 11852); interdorsal thorns 2 (up to 5 in male paratypes); lateral thorn rows short, best developed anteriorly, originating near pelvic-fin insertion, grading into thornlets posteriorly; additional small, widely spaced denticles usually present on tail. Primary female paratype with 3 main rows of tail thorns, configured similar to holotype (variably developed in other female paratypes, median row often staggered); with about 4 additional rows of enlarged denticles extending anteriorly onto mid-disc.

Denticles of adult male variably developed, not in dense patches, minute to small and widely spaced on disc; most prominent on snout tip and interorbit, and along greatest concavity of dorsal anterior margin of disc; some partly embedded denticles on pectoral fin; ventral surface largely naked, no obvious denticle band along anterior margin of disc. Female paratypes with better developed squamation than males; primary female paratype with a broad, mid-dorsal band of widely spaced denticles that extends through interorbit and over margins of rostral cartilage; denticles often large, prominent on tail, more widely spaced over pectoral fin; ventral surface largely naked. Dorsal fins usually with some fine denticles.

Meristics: Tooth rows in upper jaw 37 (34–41, n=9); lower jaw 35 (32–38). Pectoral-fin propterygial radials 29 (27–29); mesopterygial radials 12 (11–14); metapterygial radials 31–32 (30–34); total radials 72–73 (70–74). Pelvic-fin radials males 1, 21–22 (1, 20–21, n=5), females (1, 21–22, n=4). Trunk centra 29 (26–29); predorsal diplospondylous centra 38 (36–40); total predorsal centra 67 (62–67); centra between origins of dorsal fins 14 (12–15), diplospondylous centra 72 (67–80), total centra

about 101 (94–109). A male paratype (SAMA F 11846) was well outside the ranges for some of these counts: pectoral-fin propterygial radials 22, metapterygial radials 26–28, total radials 62–63, pelvic-fin radials 1, 15–17, trunk centra 23, total predorsal centra 59, post dorsal tail damaged.

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype mainly uniform yellowish brown; marginally paler on snout beside rostral cartilage and along posterior margins of pectoral and pelvic fins; slightly darker brown on snout tip and in nuchal area; blackish beneath skin on nasal capsules; dorsal fins with a brown base, paler central portion and a slightly darker outer portion; middle of tail slightly darker than its edges; ventral surface uniform yellowish to white with a blackish snout tip (weak on the holotype but pronounced on most paratypes), ventral sensory pores not black edged or surrounded by dusky blotches. Some paratypes with dense dorsal coverage of fine white spots (CSIRO H 6642–01, SAMA F 11844, SAMA F 11845 and SAMA F 11853), or evidence of fine dark spots on head (SAMA F 11851, large female).

SIZE.— Largest female 326 mm TL; males adolescent at 251 mm TL, mature at 289–316 mm TL; smallest juvenile 174 mm TL; no information on neonatal juveniles or egg cases.

DISTRIBUTION.— Known only from the Investigator Strait and Backstairs Passage, off Kangaroo Island, South Australia (35°35' S, 137°31' E to 35°44' S, 138°04' E) in 27–54 m depth.

ETYMOLOGY.— The epithet '*flindersi*' is used with reference to this skate's distribution in the western warm temperate biogeographic region of Australia, otherwise known as the Flindersian Province (Whitley, 1932). Vernacular name: Pygmy Thornback Skate.

REMARKS.— *Dentiraja flindersi* differs markedly from its larger relative *D. lemprieri* (Fig. 7) in meristics and morphometrics. Tooth row counts are similar but main skeletal counts are lower in *D. flindersi* (predorsal centra 62–67, n=10 vs. 69–75, n=5, pectoral radials 70–74 vs. 76–81). Several morphometric characters vary between these species and these are usually most evident when comparing specimens of similar size (i.e. adults and large juveniles of *D. flindersi*, which are all smaller than 326 mm TL, with juveniles of *D. lemprieri* smaller than 325 mm TL) rather than adult-sized specimens of each (i.e. *D. lemprieri* specimens that are larger than 450 mm TL). *Dentiraja flindersi* differs in having a relatively shorter snout (preorbital length 12.7–13.8, mean 13.5% TL vs. 14.2–14.5, mean 14.3% TL in juvenile specimens, and 12.7–14.8, mean 14.0% TL in adult-size *D. lemprieri*), prespiracular distance (17.3–19.3, mean 18.4% TL vs. 19.9–20.0, mean 20.0% TL in juveniles, 17.9–19.8, mean 19.1% TL in adults), dorsal head



Figure 7. Dorsal surface of *Dentiraja lemprieri*, juvenile male (CSIRO H 621–02, 378 mm TL, fresh).

(19.6–21.1, mean 20.3% TL vs. 21.3–21.7, mean 21.5% TL in juveniles, 19.8–21.7, mean 21.0% TL in adults), distance from cloaca to first dorsal fin (26.1–30.1, mean 28.1% TL vs. 29.9–30.6, mean 30.2% TL in juveniles, 28.8–33.7, mean 30.1% TL in adults), prenarial length (9.4–10.2, mean 9.7% TL vs. 11.5–11.5, mean 11.5% TL in juveniles, 9.5–10.9, mean 10.3% TL in adults), thinner tail at its midlength (height 1.3–1.6, mean 1.4% TL vs. 1.5–1.6, mean 1.5% TL in juveniles, 1.5–1.7, mean 1.5% TL in adults), lower first dorsal-fin (height 3.1–4.1, mean 3.6% TL vs. 4.3–4.6, mean 4.5% TL in juveniles, 3.5–4.2, mean 3.9% TL in adults), longer first dorsal-fin origin to caudal-fin tip (length 15.7–19.0, mean 17.3% TL vs. 15.3–16.5, mean 15.9% TL in juveniles, 12.4–14.9, mean 13.8% TL in adults), longer posterior pelvic-fin lobe (length 21.5–25.3, mean 22.9% TL vs. 19.5–19.9, mean 19.7% TL in juveniles, 19.5–22.6, mean 21.2% TL in adults), and a wider pelvic fin base (width 10.4–12.6, mean 11.3% TL vs. 8.3–9.1, mean 8.7% TL in juveniles, 8.3–10.7, mean 9.8% TL in adults). Vertebral counts are unavailable for Klunzinger's holotype of *Raja dentata* but, based on its large relative size and type locality (Port Phillip, Victoria), it is not likely to be conspecific with *D. flindersi* (only known from vicinity of Kangaroo Island, South Australia).

Comparative material.

Dentiraja lemprieri: 16 specimens. CSIRO H 82–01, adult male 496 mm TL; CSIRO H 83–01, female 523 mm TL; CSIRO H 84–01, female 467 mm TL; CSIRO H 86–01, adolescent male 444 mm TL; CSIRO H 88–01, adult male 463 mm TL; CSIRO H 96–01, female 268 mm TL; CSIRO H 102–01, juvenile male 324 mm TL; CSIRO H 185–01, female 445 mm TL; CSIRO H 621–02, juvenile male 378 mm TL; CSIRO H 621–04, female 516 mm TL; CSIRO H 1266–02, adult male 507 mm TL; CSIRO H 1266–03, adult male 485 mm TL; CSIRO H 5737–04, female 527 mm TL; CSIRO T 640, juvenile male 127 mm TL; CSIRO T 641 (2 specimens), female 122 mm TL, juvenile male 156 mm TL.

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Two new skates of the genus *Okamejei* (Rajoidei: Rajidae) from the south-east Indian Ocean

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ABSTRACT.— Two new skates of the Indo–Pacific genus *Okamejei*, *O. arafurensis* sp. nov. and *O. leptoura* sp. nov., occur off western and northwestern Australia. The new species are morphologically similar to *O. hollandi* from the western North Pacific. They are closely related to each other and are also superficially similar to some Australian short-snout *Dipturus* species but differ from them in having a component funnel in the clasper (otherwise absent) and have much more widely separated dorsal fins and a longer caudal fin. *Okamejei leptoura* is usually yellowish dorsally (rather than greyish brown as in *O. arafurensis*), the rostral cartilage is less well demarcated from the adjacent snout, and the caudal fin in juveniles is pale (rather than blackish). Also, its orbits are slightly smaller, its precaudal tail longer and broader at the pelvic-fin insertions, and its caudal fin is relatively shorter. *Okamejei leptoura* has a broader distribution than its congener (off most of western Australia’s seaboard) and possibly also occurs off eastern Indonesia. The object of this paper is to formally name and describe these species for inclusion in an update of the original version of a guide to sharks and rays of Australia.

Key words. Rajidae – skate – new species – south-east Indian Ocean – *Okamejei*

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INTRODUCTION

The genus *Okamejei*, formerly as a subgenus of *Raja* by Stehmann (1970), is now given generic status (McEachran & Dunn, 1998). Compagno (2005) listed 14 valid species from the genus *Okamejei*: *O. acutispina* (Ishiyama, 1958); *O. boesemani* (Ishihara, 1987); *O. cerva* (Whitley, 1939); *O. heemstrai* (McEachran & Fechhelm, 1982); *O. hollandi* (Jordan & Richardson, 1909); *O. kenojei* (Müller & Henle, 1841); *O. lemprieri* (Richardson, 1845); *O. meerdervoorti* (Bleeker, 1860); *O. philipi* (Lloyd, 1906); *O. pita* (Fricke & Al-Hassan, 1995); *O. powelli* (Alcock, 1898); *O. schmidti* (Ishiyama, 1958). Most of these species occur in the western North Pacific. As discussed in earlier papers in this volume (Last, 2008; Last & Gledhill, 2008), Australian species, *O. cerva* and *O. lemprieri*, belong to *Dipturus* and *Dentiraja* respectively. Most of the characters used to distinguish *Dipturus* and *Okamejei* are not useful (Last & Yearsley, 2002), but the presence of a component funnel in the clasper is shared by a group of small skates placed in the genus *Okamejei* (Ishihara, 1987). The funnel is absent in *Dipturus* as currently defined. Two new small, plain-coloured skates, both collected off northwestern Australia, have a funnel and have been assigned to *Okamejei*. These species are described below. Once again, we stress that

the object of this approach is to provide names, good diagnoses and solid descriptions for these species rather than to adopt a full revisionary approach for the genus.

METHODS

The descriptive format is based on McEachran & Fechhelm (1982) and methods follow those outlined in the first paper of this special publication (Last *et al.*, 2008) and generally follow standards used for skates. Materials of the 2 new species (i.e. *Okamejei arafurensis* and *O. leptoura*) are listed below. They include the holotype and primary descriptive types (female and juvenile), as well as specimens from which meristic and/or morphometric information was obtained. Note that for both species, morphometrics and meristics were taken from the holotype. Collection acronyms follow Leviton *et al.* (1985).

Okamejei arafurensis: holotype (NTM S 13580–010), primary female paratype (NTM S 12567–008), primary juvenile paratype (NTM S 13579–010, male 245 mm TL); 5 morphometric paratypes (NTM S 12567–008, NTM S 12641–027, NTM S 13147–012 [female 356 mm TL], NTM S 13147–012 [adult male 376 mm TL] and NTM S 13579–010 [juvenile male 245 mm TL]); 8

meristic paratypes (CSIRO H 6638–01, NTM S 12567–008, NTM S 12641–027, NTM S 13147–012 [female 356 mm TL], NTM S 13147–012 [adult male 376 mm TL], NTM S 13579–010 [juvenile male 245 mm TL], NTM S 13579–010 [female 235 mm TL] and NTM S 13580–011).

Okamejei leptoura: holotype (CSIRO H 4031–06), primary female paratype (CSIRO H 4031–07), primary juvenile paratype (CSIRO H 4031–08); 5 morphometric paratypes (CSIRO CA 2810, CSIRO CA 2811, CSIRO CA 3932, CSIRO H 1210–02 and CSIRO H 5188–04); 10 meristic paratypes (CSIRO CA 2811, CSIRO CA 2860, CSIRO H 822–25, CSIRO H 1820–04, CSIRO H 1822–03, CSIRO H 1822–04, CSIRO H 1826–02, CSIRO H 1828–02, CSIRO H 2272–03 and CSIRO H 3107–04).

Okamejei arafurensis sp. nov.

Figs 1–6; Table 1

Holotype. NTM S 13580–010, adult male 407 mm TL, Arafura Sea, off Northern Territory, 09°04' S, 133°04' E, 179–205 m, 20 Oct 1992.

Paratypes. 8 specimens. CSIRO H 6638–01, adolescent male 299 mm TL, NTM S 13147–012 (2 specimens), female 356 mm TL, adult male 376 mm TL, Arafura Sea, off Northern Territory, 09°46' S, 130°25' E, 255 m, 09 Dec 1990; NTM S 12567–008, female 495 mm TL, Arafura Sea, off Northern Territory, 09°19' S, 131°07' E, 292–298 m, 17 Jul 1988; NTM S 12641–027, female 360 mm TL, south-west of Scott Reef, Western Australia, 14°49' S, 121°34' E, 275–280 m, 15 Jul 1989; NTM S 13579–010 (2 specimens) female 235 mm TL, juvenile male 245 mm TL, Arafura Sea, off Northern Territory, 09°00' S, 133°19' E, 193–195 m, 20 Oct 1992; NTM S 13580–011, female 337 mm TL, collected with holotype.

DIAGNOSIS.— A medium-sized species of *Okamejei* (to at least 50 cm TL) with the following combination of characters: disc narrow with angular apices, width 54–61% TL, 1.2–1.3 times its length; snout angle 74–96°; tail long, length 1.1–1.3 in distance from snout tip to rear of cloaca; tail slender, width 1.2–1.5 times height at its midlength, 1.1–1.5 times at first dorsal-fin origin; pre-upper jaw length 12–15% TL, 1.7–2.2 times internasal width; ventral head length 24–27% TL; snout length 3.5–4.0 times interorbital width; orbit diameter 72–98% interorbital width; first dorsal-fin height 2.6–3.5 in its base length; distance from first dorsal-fin origin to tail tip 3.7–4.4 times first dorsal-fin base length, 0.5–0.8 times caudal-fin length; pelvic fins of medium size, length of posterior lobe in late adolescent male 15% TL, length of anterior lobe 70–97% of posterior lobe; adult clasper 22–24% TL, connected to pelvic-fin inner margin at about 31–37% of its length from cloaca; clasper glans bulbous, funnel not claw-like or directed posteriorly; anterior margins of both surfaces of disc of males with denticle bands, dorsal bands absent in females and juveniles;

nuchal thorns absent; malar thorns patch small; tail with variably developed thorn rows, males with a single poorly developed row, large females usually with 5 rows (lateral rows usually better developed than median row); total pectoral radials 71–76; trunk centra 25–27; predorsal centra 68–73; total centra 120–132; tooth rows in upper jaw 34–38; mainly uniform greyish brown dorsally, rostral cartilage strongly demarcated from rest of snout; ventral surface pale, white or translucent; ventral sensory pores not dark edged or surrounded by greyish blotches; juveniles with blackish dorsal and caudal fins.

DESCRIPTION.— Disc quadrangular, 1.16 times as broad as long in adult male holotype (1.15–1.29 times in paratypes); angle in front of spiracles 74° (80–96°); axis of greatest width 60% (57–64%) of disc length; anterior margin strongly double concave (much less pronounced in females and juveniles), strongly concave anteriorly toward snout apex, moderately convex beside and slightly forward of eyes, very strongly concave beside spiracles; apex narrowly rounded to somewhat angular (broadly rounded in juveniles); posterior margin moderately convex; free rear tip broadly rounded. Head short, preorbital snout length 4.00 (4.05–4.90) times orbit length, 3.91 (3.52–4.00) times interorbit; pre-upper jaw length 1.73 (1.95–2.18) times internarial distance. Snout tip greatly produced, prominent, narrowly pointed (more so in adult males); no fleshy process at apex. Orbit diameter 0.98 (0.72–0.91) times interorbital width. Spiracle small, length 1.54 (1.44–1.60) in orbit diameter; opening teardrop-shaped to subrectangular. Nostril suboval to circular, often distorted; anterior nasal flap expanded slightly, its lateral margin forming a short open tube; anterior margin of flap weakly lobelike, fully or partly concealed beneath nasal curtain; posterior inner margin partly concealed by nasal curtain; posterior lobes well developed, forming nasal curtain, produced posterolaterally, narrowly rounded distally, posterior margin with long fringe; internarial distance 1.53 (1.70–2.01) in distance between first gill slits, 0.86 (0.92–1.15) in distance between fifth gill slits. Upper jaw strongly arched in both sexes (much more so in adult male holotype), not indented at symphysis; lower jaw angular (weakly double convex in females and juveniles); jaws protrusible in adult male holotype; lateral teeth usually concealed by lobe of nasal curtain. Teeth of adult male holotype strongly unicuspid with raised subcircular bases in middle of jaws; arranged in obvious longitudinal rows; main cusps elongate, slender, pointed, posteriorly directed in upper jaw, becoming shorter, more oblique laterally; teeth of female and juveniles in quincunx, with broad oval crowns, cusps short, blunt (cusps relatively well developed in juveniles).

Pelvic fins deeply forked; anterior lobe short, slender to broad, narrowly rounded distally, lateral margin entire, inner margin deeply incised; posterior lobe elongate in adult and late adolescent males (length 15.2–15.3% TL), relatively much shorter in females and juveniles

A



B



Figure 1. *Okamejei arafurensis* sp. nov., adult male holotype (NTM S 13580–010, 407 mm TL, preserved): A, dorsal surface; B, ventral surface.

(length 11.9–12.8% TL), lateral margins weakly convex (much more convex in females and juveniles), free rear tip narrowly rounded (usually angular in females and juveniles); inner margin almost straight to convex, connected to anterior lateral margin of clasper at about 31–37% of post cloacal length; anterior lobe 0.70 (0.73–0.97) times posterior lobe. Clasper moderately elongate, 22–24% TL, robust, depressed, glans not expanded; clasper components include proximal and distal clefts,

terminal bridge, pseudorhipidion, rhipidion, shield, sentinel, spike and funnel; denticles and pseudosiphon absent. Tail very slender, slightly depressed; relatively narrow at base, tapering gradually to second dorsal fin, not tapering rapidly to tail tip beyond second dorsal fin; broadly filamentous distally, not expanded at its midlength; width at insertions of pelvic fins 3.38 (2.29–3.49) times width at midlength of tail and 3.45 (2.49–3.91) times width at first dorsal-fin origin respectively;

A



B

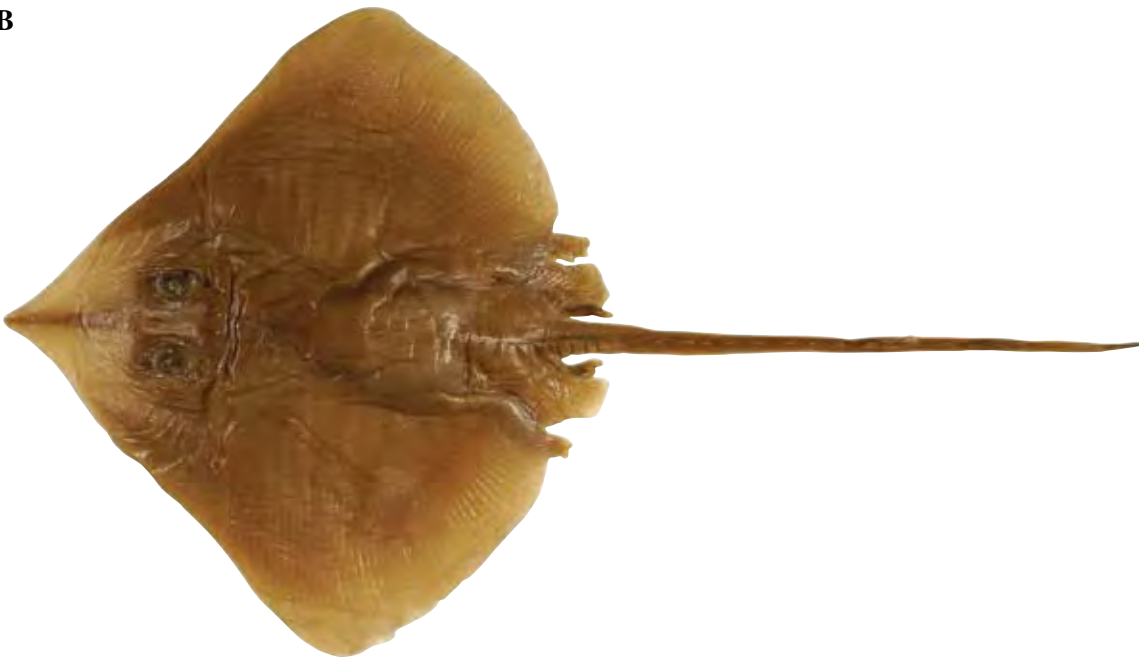


Figure 2. Dorsal surface of *Okamejei arafurensis* sp. nov.: A, primary female paratype (NTM S 12567-008, 495 mm TL, preserved); B, primary juvenile paratype (NTM S 13579-010, 245 mm TL, male, preserved).

length from rear of cloaca 1.27 (1.14–1.27) times distance from tip of snout to rear of cloaca; anterior cross-section hexagonal to oval, not more convex on dorsal surface than ventral surface posteriorly, almost flat ventrally near tail apex; width 2.15 (1.54–1.81) times height at insertion of pelvic fin, 1.19 (1.19–1.46) times height at midlength, 1.13 (1.07–1.50) times height at first dorsal fin origin; lateral tail fold very poorly developed, very narrow and not obvious for most of its length, its origin obscure

(usually beneath first dorsal fin); fold obscure at tail tip. Dorsal fins small, of similar shape and size (first dorsal fin not taller and more upright than second); first dorsal-fin height 2.56 (2.78–3.52) in base length; fins subtriangular, very strongly raked, low, elongate, with very short bases; anterior margins weakly convex, apices broadly rounded, posterior margins convex, usually fused to tail at free rear tip; interdorsal distance very long, 1.42 (1.86–2.68) in length of first dorsal-fin base; distance from first dorsal-



Figure 3. Dorsal head of *Okamejei arafurensis* sp. nov., adult male holotype (NTM S 13580–010, 407 mm TL), showing snout, orbito-spiracular and nuchal regions.

fin origin to tail tip 4.18 (3.67–4.37) times dorsal-fin base length, 2.82 (2.33–2.94) times caudal-fin length; first dorsal-fin base 0.67 (0.53–0.76) times caudal-fin length. Epichordal caudal-fin lobe well developed, very long-based, low, its height slightly less than half tail width at its origin; taller posteriorly than anteriorly; pointed or truncate distally, its posterodorsal margin straight to slightly convex, often irregular; usually connected to second dorsal fin by low ridge; hypochordal caudal lobe vestigial.

Dorsal surface of adult male holotype with relatively small orbital and tail thorns, alar and malar thorns larger; no thorns on mid-disc, nuchal or scapular regions; primary female paratype NTM S 12567–008 (495 mm TL) with small orbital and much larger tail thorns; primary late-juvenile paratype NTM S 13579–010 (245 mm TL, male) with small orbital and tail thorns. Orbital thorns of holotype very small, some indistinct (damaged slightly), forming an incomplete rosette; 5–6 (3 on preorbit, absent from midorbit, 2–3 on orbit); upright or directed posteriorly. Primary female paratype with similar orbital thorns, 5–6 (3 on preorbit, rarely present on midorbit, 2–3 on postorbit); juvenile with 2 small thorns (1 on preorbit, 1 on postorbit). Nuchal thorns absent. Malar patch with about 13–14, enlarged, strongly recurved thorns in about 2–3 poorly defined rows; main patch small,

not elongate, curved slightly, located near disc margin beside eye and spiracle, not following convexity of disc; thorns merging with a patch of smaller thornlets laterally (thorns and thornlets graduated in size near lateral edge of patch). Alar thorns in holotype about 28–30, larger than largest tail thorns; embedded, tips pungent, directed posteromedially, in about 4–5 rows; patch broad, about twice length of malar patch. Tail thorns of adult male holotype very poorly developed, in a single incomplete row; row not staggered; about 9 (2 main and 7 very small thornlets) predorsal thorns, in adult male paratype 13 (4 main and 9 thornlets), pungent, strongly tilted, weakly recurved, with very small bases, subequal in size to largest orbital thorns; interdorsal thorns 1 (absent in adult male paratype). Primary female paratype with 5 rows of tail thorns; rows not developed equally, lateral rows better developed than median row; thorns in median row weak, about 14 (5 main and 9 very small thornlets) thorns, in NTM S 13147–012 (356 mm TL) 16 (9 main and 7 thornlets), commencing near pelvic-fin rear tip as a thornlet and extending along length of predorsal tail in a single linear series, anterior midline largely naked; dorsolateral and lateral rows variably developed, better developed in largest individuals, evidence of emergent thorns in NTM S 13147–012 (356 mm TL); dorsolateral

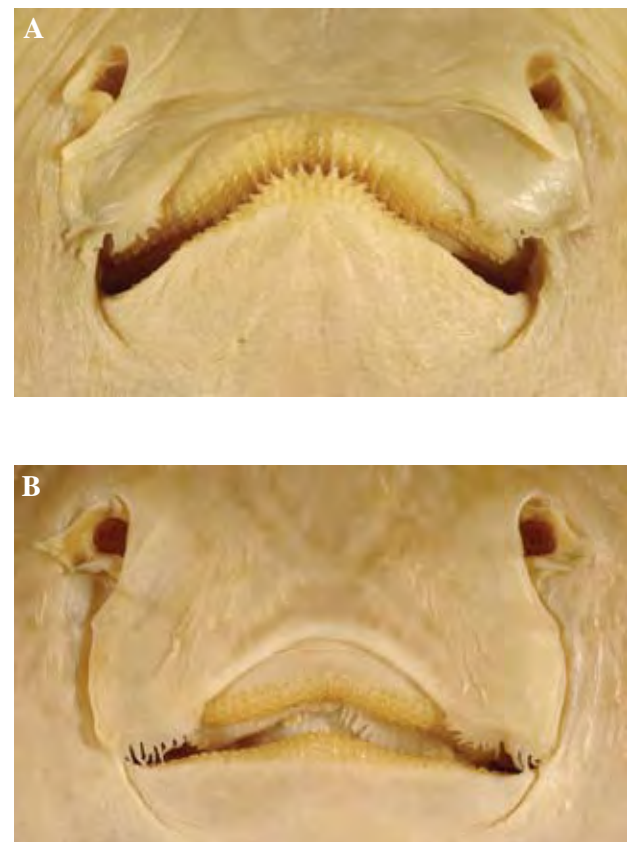


Figure 4. Ventral view of *Okamejei arafurensis* sp. nov. showing oronasal region and tooth band: A, adult male holotype (NTM S 13580–010, 407 mm TL); B, primary female paratype (NTM S 12567–008, 495 mm TL).



Figure 5. Lateral view of dorsal and caudal fins of *Okamejei arafurensis* sp. nov., adult male holotype (NTM S 13580–010, 407 mm TL).



Figure 6. Thorns at tail midlength of *Okamejei arafurensis* sp. nov.: A, dorsal and B, lateral view of adult male holotype (NTM S 13580–010, 407 mm TL); C, dorsal and D, lateral view of primary female paratype (NTM S 12567–008, 495 mm TL).

row with about 14 (2–14 in other female paratypes) similar thorns on each side, almost continuous, extending from pelvic-fin inner margin to about a dorsal-fin length short of its origin (much shorter in one paratype), located on mid-lateral tail, closer to lateral edge of tail than to thorns of median row; lateral rows with 13–14 (2–8) similar thorns, on anterior half of tail, commencing over pelvic fin; interdorsal thornlets minute, 1 (mostly 1). Primary juvenile paratype with single median row of tail thorns; with 10 short, strongly raked thorns, commencing slightly posterior to pelvic-fin rear tips; one interdorsal thorn.

Denticles of adult males not well developed, disc and tail largely naked; confined dorsally to well-developed patch on snout tip, and a band of long, widely spaced,

thorn-like denticles along anterior margin of disc from apex of propterygium to level of alar patch, denticles largest beside malar patch; confined ventrally to small patch at snout tip and a weak, narrow band along anterior margin of disc to about level of mouth; tail and posterior disc entirely naked; denticles short, bristle-like, existing patches not dense (much shorter than those on dorsal margin). Primary female paratype entirely naked dorsally; denticles confined to snout tip and in narrow band along extreme anterior margin of head to just beyond mouth on ventral surface. Primary juvenile paratype naked dorsally, with narrow denticle band along anterior ventral margin of disc.

Meristics (n=9): Tooth rows in upper jaw 34 (34–38); lower jaw 34 (35–38). Pectoral-fin propterygial radials

29–30 (27–30); mesopterygial radials 13–14 (10–13); metapterygial radials 32–33 (30–34); total radials 75–76 (71–75). Pelvic-fin radials males (n=4) 1 (1) + 19 (17–18); females (n=5) (1) + (18–20). Trunk centra 27 (25–27); predorsal caudal centra 42 (42–47); predorsal centra 69 (68–73); centra between origins of dorsal fins 16 (14–16); diplospondylous centra 95 (94–105); total centra about 122 (120–132).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype dark greyish brown, paler around margins of disc and pelvic fins (consistent in all types); rostral cartilage strongly demarcated; whitish beside rostral cartilage and forward of nasal capsules, at snout tip, and above anterior fontanelle of neurocranium; edges of posterior tail whitish; middle of clasper not darker than its edges; dorsal fins dusky to translucent, outer margin slightly darker; caudal fin dusky, apex black; eyelid brownish to translucent, eye dark; thorns pale, contrasted against darker dorsal surface of tail. Ventral surface uniformly whitish, extremities of pectoral fins slightly translucent; sensory pores not dark edged, not surrounded by greyish blotches. Primary female and juvenile paratypes consistent with holotype, dark gills and peritoneum evident beneath pale skin; dorsal and caudal fins of juveniles blackish.

SIZE.— Largest female 495 mm TL; one adolescent male 299 mm TL; males mature at 376–407 mm TL; smallest juvenile 235 mm TL; no information on egg cases.

DISTRIBUTION.— Off northwestern Australia from south-west of Scott Reef, Western Australia (14°49' S, 121°34' E), and north to the Arafura Sea, off the Northern Territory (09°00' S, 133°19' E), in 179–298 m.

ETYMOLOGY.— The epithet *arafurensis* refers to the distribution of this species which occurs in the Arafura Sea. Vernacular name: Arafura Skate.

REMARKS.— *Okamejei arafurensis* belongs to a subgroup of the genus with a long, slender tail, widely spaced dorsal fins, and a long caudal fin and procaudal tail (used by Ishihara, 1987, for the distance from the first dorsal-fin origin to the tail tip). Unlike most of the species which have strong dorsal colour patterns consisting of spots, ocelli or blotches, *O. arafurensis* is plain coloured. The genus is in need of revision but of the non-Australian skates, *O. arafurensis* is probably closest to *O. boesemani* and *O. hollandi* from the western North Pacific. Similar in coloration to *O. arafurensis*, but their dorsal coloration consists of specks and ring-like markings near the pectoral-fin axils (i.e. *O. boesemani*) or small yellowish spots over most of the dorsal surface (i.e. *O. hollandi*). The procaudal tail is longer in *O. arafurensis* than its North Pacific relatives (24.2–26.0% TL vs. 21.1–24.1% TL in *O. boesemani* and 21.1–23.5% TL in *O. hollandi*), and its disc is relatively narrower (54–61% TL vs. 60–71% TL in *O. boesemani* and 62–69% TL in *O. hollandi*).

Of the Australian skates, *O. arafurensis* is most similar to *O. sp. N* (as *Raja sp. N* in Last & Stevens, 1994) which is described in this paper.

Okamejei leptoura sp. nov.

Figs 7–12; Table 1

Raja sp. N: Last & Stevens, 1994: pp 300, 342–343, fig. 34.29, key fig. 6, pl. 56.

Holotype. CSIRO H 4031–06, adult male 437 mm TL, north of Cape Lambert, Western Australia, 18°57' S, 117°14' E, 248–253 m, 30 Aug 1995.

Paratypes. 19 specimens. CSIRO CA 2810, female 449 mm TL, CSIRO CA 2811, adult male 429 mm TL, north of Forestier Island, Western Australia, 18°10' S, 118°20' E, 298–300 m, 10 Apr 1982; CSIRO CA 2860, female 367 mm TL, south-west of Rowley Shoals, Western Australia, 18°22' S, 118°25' E, 201–202 m, 02 Apr 1982; CSIRO CA 3932, female 439 mm TL, south of Rowley Shoals, Western Australia, 17°34' S, 119°03' E, 318–360 m, 06 Feb 1983; CSIRO CA 4411, adult male 420 mm TL, north of Monte Bello Islands, Western Australia, 19°18' S, 115°42' E, 348–352 m, 29 Jan 1984; CSIRO H 822–25, female 412 mm TL, south-west of Shark Bay, Western Australia, 27°03' S, 112°40' E, 402 m, 27 Oct 1986; CSIRO H 1210–02, adult male 434 mm TL, south-west of Ashmore Reef, Western Australia, 14°01' S, 122°08' E, 443 m, Jan 1988; CSIRO H 1820–04, adult male 442 mm TL, west of Shark Bay, Western Australia, 25°36' S, 112°10' E, 435 m, 29 Dec 1989; CSIRO H 1822–03, adult male 476 mm TL, CSIRO H 1822–04, adolescent male 447 mm TL, west of Shark Bay, Western Australia, 26°44' S, 112°19' E, 735 m, 28 Dec 1989; CSIRO H 1826–02, female 457 mm TL, north-west of Cape Naturaliste, Western Australia, 33°20' S, 114°30' E, 435 m, 25 Dec 1989; CSIRO H 1828–02, adolescent male 415 mm TL, west of Geraldton, Western Australia, 28°48' S, 113°37' E, 457 m, 27 Dec 1989; CSIRO H 2272–03, female 496 mm TL, south-west of Geraldton, Western Australia, 29°14' S, 113°52' E, 556 m, 28 Jan 1989; CSIRO H 3107–04, adult male 486 mm TL, west of Gantheaume Bay, Western Australia, 27°46' S, 112°55' E; 536–570 m, 02 Jun 1992; CSIRO H 4031–07, female 376 mm TL, CSIRO H 4031–08, juvenile female 179 mm TL, collected with holotype; CSIRO H 5188–04, adult male 394 mm TL, north of Dampier Archipelago, Western Australia, 19°10' S, 116°19' E, 256 m, 27 Oct 1998; WAM P 26207–006, female 407 mm TL, south-west of Rowley Shoals, Western Australia, 18°42' S, 117°40' E, 260–262 m, 20 May 1978; WAM P 28058–004, female 394 mm TL, south-west of Rowley Shoals, Western Australia, 18°05' S, 118°10' E, 400 m, 17 Aug 1983.

Other material. 43 specimens. CSIRO CA 321, adolescent male 338 mm TL, north-northwest of Port Hedland, Western Australia, 18°21' S, 118°03' E, 258–

270 m, 20 May 1978; CSIRO CA 2853, adult male 398 mm TL, south-west of Rowley Shoals, Western Australia, 18°22' S, 118°25' E, 201–202 m, 02 Apr 1982; CSIRO CA 3936, juvenile male 326 mm TL, north-east of Port Hedland, Western Australia, 17°34' S, 119°03' E, 318–360 m, 06 Feb 1983; CSIRO CA 4377, adolescent male 327 mm TL, north of Legendre Island, Western Australia, 18°47' S, 117°05' E, 350–354 m, 31 Jan 1984; CSIRO CA 4390, adolescent male 351 mm TL, CSIRO CA 4391, adult male 418 mm TL, north-east of Monte Bello Islands, Western Australia, 19°21' S, 115°42' E, 306–308 m, 29 Jan 1984; CSIRO CA 4407, adult male 435 mm TL, south-west of Rowley Shoals, Western Australia, 18°08' S, 118°11' E, 360 m, 27 Jan 1984; CSIRO CA 4408, adult male 413 mm TL, CSIRO CA 4409, adolescent male 350 mm TL, CSIRO CA 4413, female 443 mm TL, CSIRO CA 4414, adolescent male 387 mm TL, CSIRO CA 4416, adult male 462 mm TL, north of Monte Bello Islands, Western Australia, 19°18' S, 115°42' E, 348–352 m, 29 Jan 1984; CSIRO H 201–01, female 482 mm TL, north-west of Cape Naturaliste, Western Australia, 32°58' S, 114°34' E, 400 m, 05 Sep 1979; CSIRO H 822–21, juvenile male 147 mm TL, CSIRO H 822–26, female 310 mm TL, south-west of Shark Bay, Western Australia, 27°03' S, 112°40' E, 402 m, 27 Oct 1986; CSIRO H 1651–01, adult male 440 mm TL, north of Dampier Archipelago, Western Australia, 18°48' S, 116°47' E, 410 m, 11 Sep 1988; CSIRO H 1652–03, female 377 mm TL, north-west of Port Hedland, Western Australia, 18°25' S, 117°48' E, 375 m, 21 Aug 1988; CSIRO H 1819–03, juvenile male 353 mm TL, west of Gantheaume Bay, Western Australia, 27°49' S, 113°01' E, 437 m, 28 Dec 1989; CSIRO H 1821–02, juvenile male 270 mm TL, north-west of Geraldton, Western Australia, 28°13' S, 113°07' E, 616 m, 27 Dec 1989; CSIRO H 1822–02, adolescent male 391 mm TL, west of Shark Bay, Western Australia, 26°44' S, 112°19' E, 735 m, 28 Dec 1989; CSIRO H 1826–01, female 555 mm TL, CSIRO H 1826–03, female 496 mm TL, CSIRO H 1826–04, female 500+ mm TL (tail tip damaged), CSIRO H 1826–05, female 473 mm TL, north-west of Cape Naturaliste, Western Australia, 33°20' S, 114°30' E, 435 m, 25 Dec 1989; CSIRO H 2272–01, adolescent male 463 mm TL, CSIRO H 2272–02, female 315 mm TL, south-west of Geraldton, Western Australia, 29°14' S, 113°52' E, 556 m, 28 Jan 1989; CSIRO H 2565–01, female 429 mm TL, west of Bernier Island, Western Australia, 24°51' S, 112°06' E, 444–468 m, 28 Jan 1991; CSIRO H 2587–13, adolescent male 449 mm TL, south-west of Shark Bay, Western Australia, 27°06' S, 112°44' E, 370–438 m, 02 Feb 1991; CSIRO H 2591–01, female 390 mm TL, west of Leander Point, Western Australia, 29°18' S, 113°56' E, 490–505 m, 06 Feb 1991; CSIRO H 2598–08, adolescent male 423 mm TL, west of Green Head, Western Australia, 29°58' S, 114°27' E, 380 m, 08 Feb 1991; CSIRO H 2611–02, female 499 mm TL, west of Rottneest Island, Western Australia, 32°00' S, 115°09' E, 510 m, 12 Feb 1991; CSIRO H 3015–01, juvenile male 356 mm TL, CSIRO H 3015–03, female 385 mm TL, west

of Mandurah, Western Australia, 32°40' S, 114°46' E, 361 m, 16 Mar 1990; CSIRO H 3053–05, female 322 mm TL, north-west of Perth, Western Australia, 31°29' S, 114°54' E, 390 m, 18 Jan 1990; CSIRO H 4031–09, juvenile male 258 mm TL, CSIRO H 4031–10, female 265 mm TL, CSIRO H 4031–11, female 236 mm TL, CSIRO H 4031–12, female 434 mm TL, CSIRO H 4031–13, female 269 mm TL, CSIRO H 4031–14, juvenile male 252 mm TL, CSIRO H 4031–15, female 214 mm TL, collected with holotype; CSIRO H 5188–05, adult male 418 mm TL, north of Dampier Archipelago, Western Australia, 19°10' S, 116°19' E, 256 m, 27 Oct 1998; MNHN 2007–1934, female 375 mm TL, Arafura Sea, 09°23' S, 131°09' E, 246–275, 04 Nov 1991.

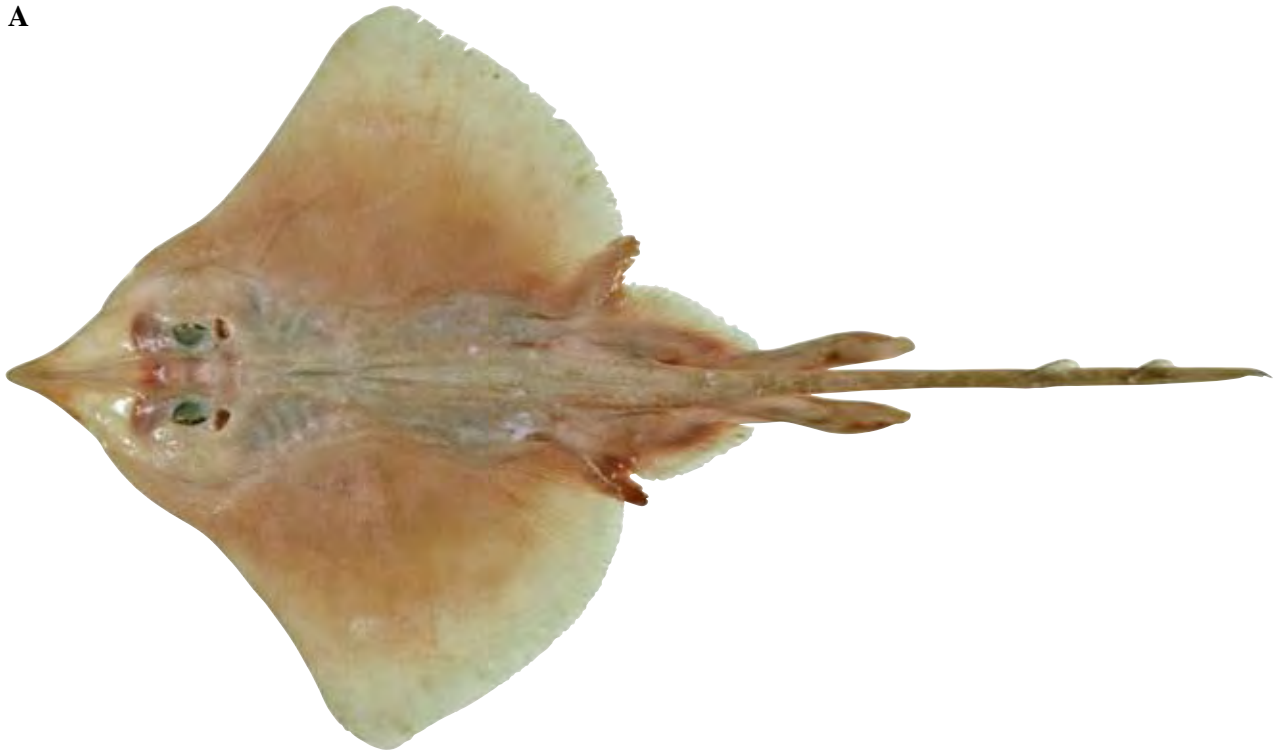
DIAGNOSIS.— A medium-sized species of *Okamejei* (to at least 56 cm TL) with the following combination of characters: disc narrow with angular apices, width 60–64% TL, about 1.2 times its length; snout angle 79–93°; tail long, length 1.1–1.2 in distance from snout tip to rear of cloaca; tail slender, width 1.2–1.6 times height at its midlength, 1.3–1.8 times at first dorsal-fin origin; pre upper jaw length 12–14% TL, 1.6–2.0 times internasal width; ventral head length 26–27% TL; snout length 3.1–3.7 times interorbital width; orbit diameter 63–87% interorbital width; first dorsal-fin height 2.3–3.9 in its base length; distance from first dorsal-fin origin to tail tip 3.4–4.3 times first dorsal-fin base length, 2.7–3.1 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males about 16–18% TL, length of anterior lobe 61–78% of posterior lobe; adult clasper 24–26% TL, connected to pelvic-fin inner margin at about 37–39% of its length from cloaca; clasper glans tapering distally, funnel elongate, claw-like, directed posteriorly; anterior margins of both surfaces of disc of males with denticle bands, dorsal bands absent in females and juveniles; nuchal thorns absent; malar thorn patch small; tail with variably developed thorn rows, males with 1–3 poorly developed rows, large females usually with 5 rows (lateral rows usually short); total pectoral radials 72–76; trunk centra 24–28; predorsal centra 67–77; total centra 122–135; tooth rows in upper jaw 30–39; mainly yellowish dorsally, rostral cartilage not or weakly demarcated from rest of snout; ventral surface pale, white or translucent; ventral sensory pores not dark edged or surrounded by greyish blotches; juveniles with blackish dorsal fins, white caudal fins.

DESCRIPTION.— Disc quadrangular, 1.18 times as broad as long in adult male holotype (1.18–1.23 times in paratypes); angle in front of spiracles 79° (82–93°); axis of greatest width 60% (55–61%) of disc length; anterior margin double concave (less pronounced in females and juveniles), strongly concave anteriorly beside snout apex, moderately convex beside and forward of eyes, strongly concave beside spiracles; apex narrowly rounded to somewhat angular (more broadly rounded in juveniles); posterior margin moderately convex; free rear tip broadly rounded. Head short, preorbital snout length 4.29

Table 1. Morphometrics for the holotypes of *Okamejei arafurensis* sp. nov. (NTM 13580–010) and *Okamejei leptoura* sp. nov. (CSIRO H 4031–06). Ranges for paratypes (n=5), and means for all morphometric types are given separately. Values are expressed as percentages of total length.

	<i>Okamejei arafurensis</i> sp. nov.			<i>Okamejei leptoura</i> sp. nov.				
	Holotype	Paratypes		Mean	Holotype	Paratypes		Mean
		Min.	Max.			Min.	Max.	
Total length (mm)	407	235	495		437	394	449	
Disc width	53.8	54.1	61.3	56.2	58.8	56.8	60.4	58.7
Disc length (direct)	46.2	46.1	49.2	47.1	49.7	47.2	51.0	48.7
Snout to maximum width	27.7	27.1	30.7	28.7	29.7	26.5	31.4	28.9
Snout length (preorbital direct)	13.4	13.6	15.1	14.1	13.6	12.5	14.7	13.7
Snout to spiracle	17.5	18.2	19.2	18.4	18.2	16.9	18.7	18.1
Head (dorsal length)	19.3	19.4	20.8	19.9	19.6	19.0	20.2	19.7
Orbit diameter	3.4	3.1	3.6	3.3	3.2	2.8	3.2	3.0
Orbit and spiracle length	4.4	4.4	4.7	4.5	4.8	4.1	4.7	4.5
Spiracle length (main aperture)	2.2	2.0	2.3	2.1	1.8	1.6	2.1	1.8
Distance between orbits	3.4	3.4	4.3	3.8	3.7	3.8	4.3	4.0
Distance between spiracles	5.3	5.2	6.1	5.6	5.6	5.8	6.3	5.9
Snout to cloaca (to 1st hemal spine)	44.0	44.1	46.7	45.3	45.9	45.4	48.2	46.7
Cloaca to D1	28.4	28.1	30.6	28.9	33.5	27.9	31.4	30.9
Cloaca to D2	39.0	36.8	39.7	38.3	42.0	37.7	40.4	39.9
Cloaca to caudal origin	45.1	42.8	45.7	44.3	46.9	44.3	45.9	45.5
Distance-cloaca to caudal-fin tip	54.3	52.9	55.2	54.1	54.2	51.8	54.4	53.2
Ventral snout length (pre upper jaw)	11.7	13.7	15.0	13.9	12.4	11.8	14.2	13.0
Prenasal length	11.1	11.2	12.6	11.8	10.8	10.1	12.0	11.0
Ventral head length (to fifth gill)	25.4	24.4	27.1	25.9	26.1	25.8	27.4	26.2
Mouth width	7.3	6.9	7.8	7.4	7.6	7.1	8.1	7.7
Distance between nostrils	6.8	6.4	7.5	7.0	6.9	6.9	7.5	7.2
Nasal curtain length	4.0	4.1	5.0	4.4	4.9	4.0	5.0	4.6
Nasal curtain (total width)	8.8	7.9	9.3	8.6	8.6	7.9	9.0	8.5
Nasal curtain (min. width)	5.9	5.4	6.3	5.9	6.1	5.6	6.2	6.0
Nasal curtain (lobe width)	1.7	1.3	1.5	1.5	1.3	1.1	1.5	1.3
Width of first gill opening	1.3	1.2	1.5	1.4	1.4	1.1	1.5	1.4
Width of fifth gill opening	1.0	1.0	1.2	1.1	0.8	0.8	1.2	0.9
Distance between first gill openings	10.3	11.7	14.2	12.5	11.9	11.3	13.2	12.3
Distance between fifth gill openings	5.8	6.3	7.7	6.9	6.5	6.2	8.4	7.1
Clasper (post cloacal length)	21.7	–	23.5	22.6	24.8	23.9	25.9	25.0
Length of anterior pelvic lobe	10.7	10.5	12.3	11.0	10.8	10.5	11.3	10.8
Length of posterior pelvic lobe	15.2	11.9	15.3	13.4	17.7	13.5	18.2	16.2
Pelvic base width	7.4	7.1	8.0	7.6	7.1	6.6	8.2	7.3
Tail at axil pelvic fins (width)	3.7	3.4	3.7	3.5	3.9	3.6	4.1	3.9
Tail at axil pelvic fins (height)	1.7	1.9	2.2	2.0	2.0	1.9	2.1	2.0
Tail at midlength (width)	1.1	1.1	1.5	1.3	1.2	1.1	1.4	1.3
Tail at midlength (height)	0.9	0.9	1.0	0.9	0.9	0.9	1.0	0.9
Tail at D1 origin (width)	1.1	1.0	1.3	1.2	1.5	1.1	1.5	1.4
Tail at D1 origin (height)	0.9	0.9	1.0	0.9	0.9	0.8	1.0	0.9
D1 base length	6.2	5.9	6.6	6.2	5.2	5.0	6.8	5.8
D1 height	2.4	1.9	2.3	2.1	1.9	1.7	2.6	2.0
D1 origin to caudal-fin tip	26.0	24.2	25.7	25.2	20.6	20.4	26.0	22.3
D2 origin to caudal-fin tip	15.4	15.0	16.7	15.8	12.2	12.1	16.2	13.4
Caudal-fin length	9.2	8.5	11.1	9.8	7.3	6.8	9.6	7.8

A



B

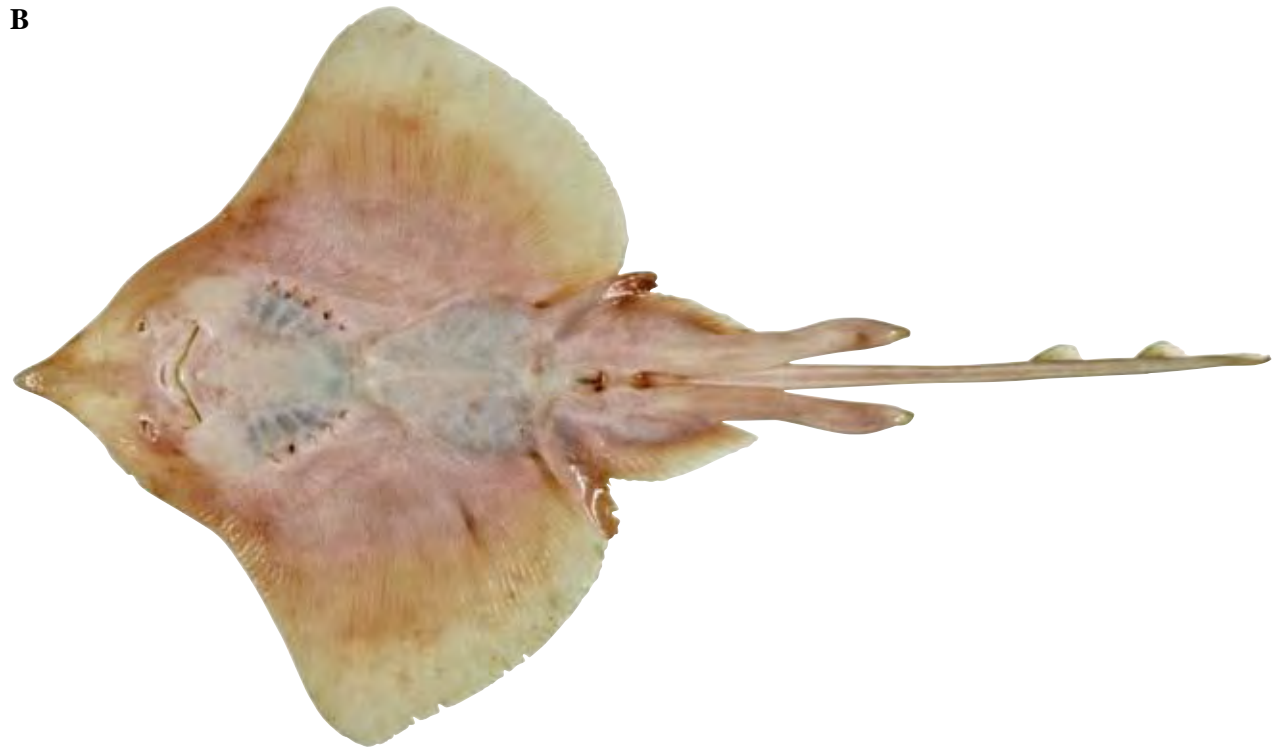


Figure 7. *Okamejei leptoura* sp. nov., adult male holotype (CSIRO H 4031–06, 437 mm TL, fresh): A, dorsal surface; B, ventral surface.

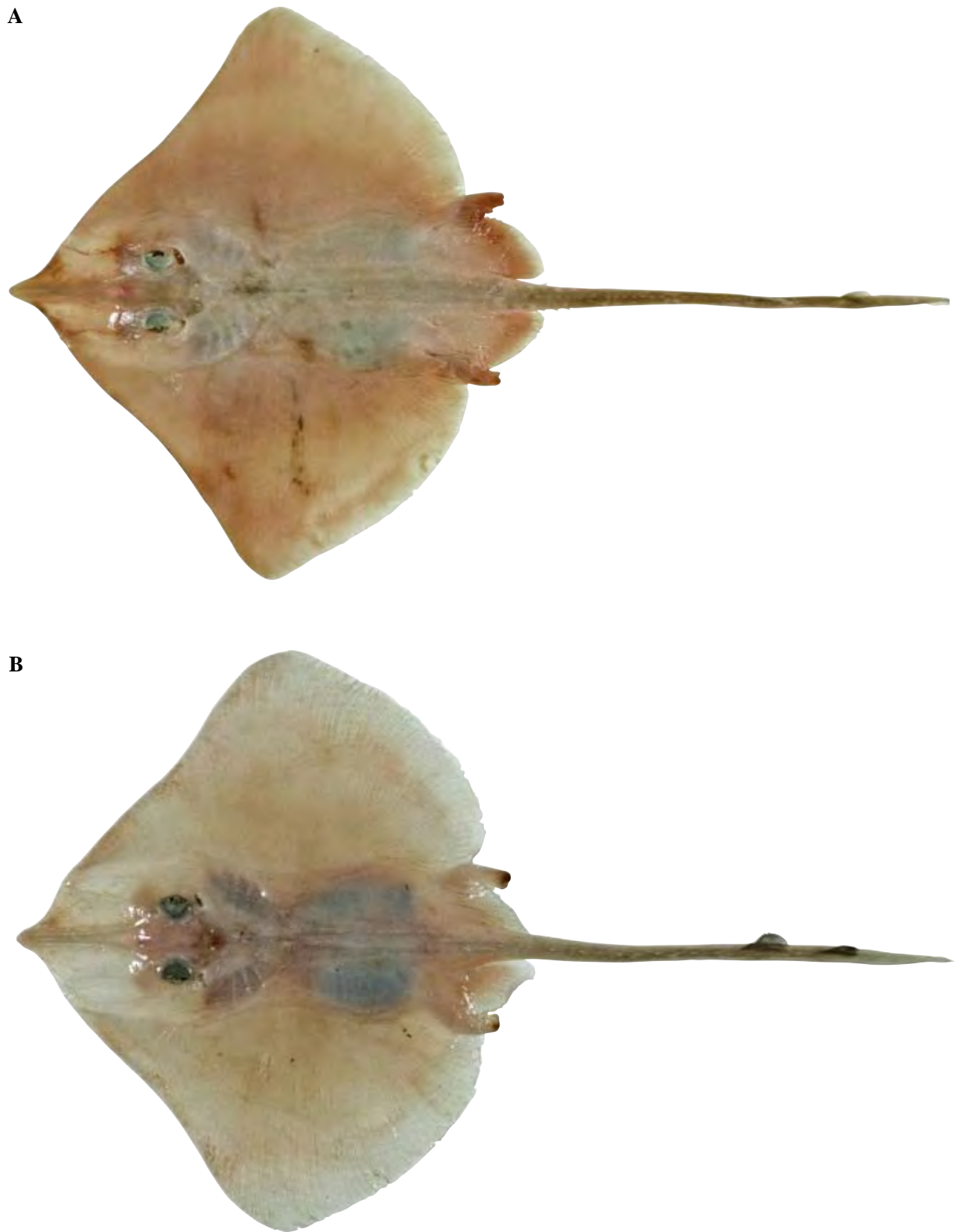


Figure 8. Dorsal surface of *Okamejei leptoura* sp. nov.: A, primary female paratype (CSIRO H 4031–07, 376 mm TL, fresh); B, primary juvenile paratype (CSIRO H 4031–08, 179 mm TL, female, fresh).



Figure 9. Dorsal head of *Okamejei leptoura* sp. nov., adult male holotype (CSIRO H 4031–06, 437 mm TL), showing snout, orbito–spiracular and nuchal regions.

(3.88–5.13) times orbit length, 3.72 (3.15–3.50) times interorbit; pre-upper jaw length 1.80 (1.62–2.04) times internarial distance. Snout tip variably produced, usually prominent (more so in adult males), narrowly pointed; no fleshy process at apex. Orbit diameter 0.87 (0.63–0.81) times interorbital width. Spiracle large, length 1.79 (1.45–1.83) in orbit diameter; opening teardrop-shaped to recurved. Nostril suboval to circular, often distorted; anterior nasal flap expanded slightly, its lateral margin forming a short open tube; anterior margin of flap weakly lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed by nasal curtain; posterior lobes forming nasal curtain, well developed, produced posterolaterally, narrowly rounded distally, posterior margin with well-developed fringe; internarial distance 1.72 (1.55–1.88) in distance between first gill slits, 0.94 (0.83–1.22) in distance between fifth gill slits. Upper jaw strongly arched in both sexes (more so in adult males), usually indented slightly at symphysis; lower jaw strongly convex at symphysis (weakly double convex in juveniles), not sharply angular; lateral teeth usually concealed by lobe of nasal curtain. Teeth of adult male holotype strongly unicuspid with raised subcircular bases; arranged in obvious longitudinal rows; medial cusps elongate, slender, needle-like, bluntly pointed; posteriorly directed in upper jaw, becoming shorter, more oblique laterally; teeth of female and juvenile paratypes in quincunx, with rectangular to hexagonal crowns, cusps short, subtriangular, blunt (relatively shorter in

juveniles).

Pelvic fins deeply forked; anterior lobe short, slender, narrowly rounded distally, lateral margin entire, inner margin deeply incised; posterior lobe elongate in adult males (length 15.9–18.2% TL), relatively much shorter in females (length 13.5–14.5% TL), lateral margins weakly convex (more so in females), free rear tip narrowly pointed to angular; inner margin almost straight, connected to anterior lateral margin of clasper at about 37–39% of post cloacal length; anterior lobe 0.61 (0.62–0.78) times posterior lobe. Clasper moderately elongate, 24–26% TL, slender, depressed, glans expanded slightly; clasper components include proximal and distal clefts, terminal bridge, pseudorhipidion, rhipidion, shield, sentinel, spike, flag and funnel; denticles and pseudosiphon absent. Tail very slender, moderately depressed, relatively narrow at base, tapering gradually to second dorsal fin, not tapering rapidly to tail tip beyond second dorsal fin, almost filamentous, not expanded at its midlength; width at insertions of pelvic fins 3.20 (2.67–3.19) times width at midlength of tail and 2.61 (2.62–3.23) times width at first dorsal-fin origin respectively; length from rear of cloaca 1.18 (1.07–1.20) times distance from tip of snout to rear of cloaca; anterior cross-section almost equally convex dorsally and ventrally, slightly more strongly convex on dorsal surface than ventral surface posteriorly, almost flat

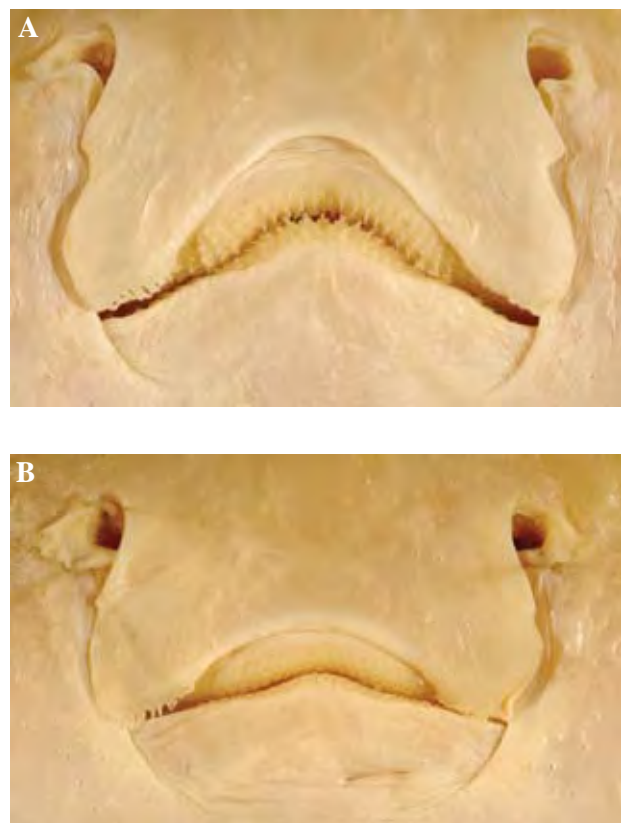


Figure 10. Ventral view of *Okamejei leptoura* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 4031–06, 437 mm TL); B, primary female paratype (CSIRO H 4031–07, 376 mm TL).

ventrally near tail apex; width 1.98 (1.80–2.03) times height at insertion of pelvic fin, 1.35 (1.21–1.62) times height at midlength, 1.76 (1.26–1.66) times height at first dorsal fin origin; lateral tail fold very poorly developed, very narrow and not obvious for most of its length, its origin obscure, usually beneath first dorsal fin, equally obscure at tail tip. Dorsal fins small, of similar shape and size (first dorsal fin not taller and more upright than second); first dorsal-fin height 2.73 (2.34–3.90) in base length; fins very strongly raked, low, elongate, with very short bases; anterior margins convex, apices broadly rounded, posterior margins usually short and convex, free rear tip narrowly rounded to acute (occasional broadly rounded); length of inner margin of first dorsal variable, usually longer than second; interdorsal distance very long, 1.57 (1.22–2.84) in length of first dorsal-fin base; distance from first dorsal-fin origin to tail tip 4.00 (3.44–4.26) times dorsal-fin base length, 2.83 (2.71–3.08) times caudal-fin length; first dorsal-fin base 0.71 (0.64–0.81) times caudal-fin length. Epichordal caudal-fin lobe well developed, very long-based, low, its height subequal to half tail width at its origin; taller posteriorly than anteriorly; pointed or truncate distally, its dorsal margin straight to slightly convex posteriorly, often irregular; often connected to second dorsal fin by low ridge; hypochordal caudal lobe vestigial.

Dorsal surface of adult male holotype with relatively small orbital, malar, alar and tail thorns; no thorns on mid-disc, nuchal or scapular regions; primary female paratype CSIRO H 4031–07 (376 mm TL) with small orbital and slightly larger tail thorns; primary juvenile paratype CSIRO H 4031–08 (179 mm TL, female) with small orbital and tail thorns. Orbital thorns of holotype small, similar in size, forming an incomplete rosette; 7 (4 on preorbit, absent from midorbit, 3 on orbit; up to 8 in adult male paratypes) thorns; directed posteriorly, recurved slightly. Primary female paratype with relatively smaller orbital thorns, similar in shape to holotype, 5–7 (4 on preorbit, absent from midorbit, 1–3 on postorbit; 5–9 in other female paratypes); primary juvenile paratype with 2 small thorns (1 on preorbit, 1 on postorbit). Nuchal thorns absent. Malar patch with about 9, enlarged, strongly recurved thorns in about 3–4 rows in holotype (mostly 2–4 rows in adult male paratypes); main patch small, beside eye and spiracle, not elongate, curved, or following convexity of disc; thorns merging with a patch of large denticles laterally. Alar thorns in holotype about 18–21, subequal in length to largest tail thorns; embedded, tips pungent, directed posteromedially, in 2–3 (2–4 in adult male paratypes) weak rows; patch several times larger than malar patch. Tail thorns of adult male holotype poorly developed, in a single incomplete row (usually in 1 row in adult male paratypes, in 3 rows in CSIRO H 1210–02); row not staggered, commencing near pelvic-fin insertion as a minute thorn and extending along length of predorsal tail almost to first dorsal fin (origin variable in paratypes); predorsal thorns about 18 (7 main and 11 much smaller interstitial thorns; 3–10

main thorns in adult male paratypes), pungent, strongly tilted, weakly recurved, with small bases, subequal in size to largest orbital thorns; interdorsal thorns 2 (1–3 in male paratypes). Primary female paratype with 5 rows of tail thorns (variable in other female paratypes with 1–5 rows); rows not developed equally, lateral rows greatly reduced in length; thorns in median row about 21 (12 main and 9 much smaller interstitial thorns; variable in other female paratypes), usually commencing over pelvic-fin inner margin and extending along length of predorsal tail in a single linear series; dorsolateral rows short, interrupted (with 3 similar thorns on each side anteriorly), located on mid-lateral tail, closer to lateral edge of tail than to thorns of median row; lateral rows also very short, with 1–5 similar thorns, commencing near free rear tip of pelvic fin (dorsolateral and lateral rows not reaching midlength of tail); interdorsal thorns 2, unpaired (0–3 in other female paratypes). Primary juvenile paratype with single median row of tail thorns; with 11 short, strongly raked thorns, commencing slightly posterior to pelvic-fin insertion; one interdorsal thorn.

Denticles of adult males not well developed, disc and tail largely naked; confined dorsally to well-developed patches on snout tip, and along anterior margin of disc from apex of propterygium to level of alar patch; confined ventrally to anterior half of snout and along anterior margin to just beyond mouth; tail and posterior half of disc entirely naked; denticles bristle-like, existing patches dense. Primary female paratype entirely naked dorsally; ventrally, denticles confined to snout tip and along extreme anterior margin of head almost to level of first gill slit. Primary juvenile paratype without denticles.

Meristics (n=11): Tooth rows in upper jaw 39 (30–35); lower jaw 37 (30–35). Pectoral-fin propterygial radials 28 (26–30); mesopterygial radials 14 (12–16); metapterygial radials 32 (31–34); total radials 74 (72–76). Pelvic-fin radials males (n=7) 1 (1) + 19–20 (17–18); females (n=4) (1) + (19–21). Trunk centra 26 (24–28); predorsal caudal centra 48 (42–52); predorsal centra 74 (67–77); centra between origins of dorsal fins 15 (12–17); diplospondylous centra 104 (94–109); total centra about 130 (122–135).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype plain light yellow (often greyish brown on central disc and tail); paler near edge of posterior disc and pelvic fins, beside rostral cartilage, at snout tip, and above anterior fontanelle of neurocranium; edges of tail pale yellow; dorsal fins brownish grey anteriorly and along base, paler centrally and distally (some specimens with almost uniformly dusky fins); middle of clasper darker than its edges; caudal fin pale greyish brown; eyelid semi-translucent, eye dark; thorns pale, often contrasted against darker dorsal surface of tail. Ventral surface uniformly yellowish or white, slightly paler yellowish on snout and



Figure 11. Lateral view of dorsal and caudal fins of *Okamejei leptoura* sp. nov., adult male holotype (CSIRO H 4031–06, 437 mm TL).

A



B



C



D



Figure 12. Thorns at tail midlength of *Okamejei leptoura* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 4031–06, 437 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 4031–07, 376 mm TL).

around disc and pelvic fin; sensory pores not dark edged, not surrounded by grey blotches. Primary female and juvenile paratypes consistent with holotype; dorsal fins of juveniles blackish, caudal fin white.

SIZE.— Largest female 555 mm TL; adolescent males 327–463 mm TL but some individuals with no clasper development at 356 mm TL; males mature at 394–486 mm TL; smallest juvenile 147 mm TL; no information on egg cases.

DISTRIBUTION.— Continental slope off Western Australia from Ashmore Reef (14°01' S, 122°08' E) to Cape Naturaliste (33°20' S, 114°30' E) in 202–735 m; appears to be disjunct between Shark Bay (ca. 25° S) and

the Monte Bello Islands (ca. 19° S). A single specimen (MNHN 2007–1934, female 375 mm TL), from the Arafura Sea near Tanimbar Island (9°23' S, 131°09' E), may be conspecific with this species.

ETYMOLOGY.— Derived from the Greek *leptos* (meaning fine, thin or delicate) and *oura* (tail) with reference to its thin, somewhat filamentous tail. Vernacular name: Thintail Skate.

REMARKS.— *Okamejei leptoura* and its northern relative *O. arafurensis*, are very similar in morphology and belong to a subgroup of *Okamejei* that includes *O. hollandi*. *Okamejei leptoura* is usually yellowish dorsally (greyish brown in *O. arafurensis*), the rostral

cartilage is less well differentiated from the adjacent snout, and the caudal fin in juveniles is pale (rather than blackish). The adult claspers of *O. leptoura*, which differ anatomically (Last, in prep), are slightly longer with a less bulbous glans than *O. arafurensis* (post-cloacal clasper length in adults 23.9–25.9%, mean 24.8% TL vs. 21.7–23.5%, mean 22.6% TL). *Okamejei leptoura* has a slightly smaller spiracle (main aperture length 1.6–2.1%, mean 1.8% TL vs. 2.0–2.3%, mean 2.1% TL), a relatively broader tail at pelvic-fin insertions (width 3.6–4.1%, mean 3.9% TL vs. 3.4–3.7%, mean 3.5% TL), and a relatively shorter caudal fin (length 6.8–9.6%, mean 7.8% TL vs. 8.5–11.1%, mean 9.8% TL). *Okamejei leptoura* has a broader distribution than its congener (off most of Australia's western seaboard) and possibly occurs off eastern Indonesia.

One specimen (CA 4413), which is atypical morphometrically from Australian *Okamejei* species, differs considerably from types measured. It has much larger snout proportions (preorbital length 17.1% vs. 12.5–14.7%, mean 13.7%; pre-upper jaw length 17.0% vs. 11.8–14.2%, mean 13.0%; ventral head length 29.9% vs. 25.8–27.4%, mean 26.2%), slightly larger orbit (diameter 3.4% vs. 2.8–3.2%, mean 3.0%), and longer disc (length 53.7% vs. 47.2–51.0%, mean 48.7%; precloacal length 51.3% vs. 45.4–48.2%, mean 46.7%). A larger number of specimens needs to be examined to gain an understanding of possible interspecific or intraspecific variability within these forms.

ACKNOWLEDGEMENTS

This study follows the discovery of many new sharks and rays as a result of deepwater survey off Australia's north-west. We acknowledge the efforts of field biologists who contributed material to these collections. In particular, we thank William White, Alastair Graham and John Pogonoski for assembling data on Australian materials, and Louise Conboy for photography and etching images of the types and other material. William White and John Pogonoski also provided editorial comments on the manuscript. Radiographs and meristic counts were taken by Spikey Riddoch and Tim Fountain, and these were carefully re-examined by John Pogonoski. Thanks also to Barry Hutchins, Sue Morrison and Glenn Moore (WAM), and Helen Larson and Gavin Dally (NTM) for kindly providing material from their collections.

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Rajella challenger sp. nov., a new deepwater skate from southern Australia

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ABSTRACT.— A new species of skate, *Rajella challenger* sp. nov., is described from material collected on the mid-continental slope off southern Australia. Its description constitutes the first formal record of the genus from the Australian region. Only two other of the 15 known species occur in the Indo–Pacific. *Rajella challenger* is most morphologically similar to a North Atlantic species, *R. bigelowi*, in having pale dorsal and dark ventral surfaces, a thorny tail and similar meristic details, but the two species differ significantly in several body ratios, including the relative eye size, disc width, and tail, snout and head lengths, as well as size of maturity and the squamation of adults and juveniles.

Key words. Rajidae – skate – new species – Australia – *Rajella*

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INTRODUCTION

The genus *Rajella*, formerly as a subgenus of *Raja* by Stehmann (1970), was elevated to generic status (McEachran & Dunn, 1998). Compagno (2005) listed 14 valid species from the genus *Rajella*: *R. annandalei* (Weber, 1913), *R. barnardi* (Norman, 1935), *R. bathyphila* (Holt & Byrne, 1908), *R. bigelowi* (Stehmann, 1978), *R. caudaspinosa* (von Bonde & Swart, 1923), *R. dissimilis* (Hulley, 1970), *R. fuliginea* (Bigelow & Schroeder, 1954), *R. fyllae* (Lütken, 1887), *R. kukujevi* (Dolganov, 1985), *R. leopardus* (von Bonde & Swart, 1923), *R. nigerrima* (de Buen, 1960), *R. purpuriventralis* (Bigelow & Schroeder, 1962), *R. ravidula* (Hulley, 1970) and *R. sadowskii* (Kreffit & Stehmann, 1974). A fifteenth species, *R. eisenhardti* was described by Long & McCosker (1999) from near the Galapagos Island in the central eastern Pacific. *Rajella alia* (Garman, 1899) has been questionably placed in this genus by Compagno (1999). *Rajella annandalei*, assigned to the genus by Stehmann (1976), which has a distinctive round disc and snout, occurs off eastern Indonesia in the Indo–West Pacific. *Rajella eisenhardti* was described from around Galapagos Islands in the central eastern Pacific. All other species occur in the Atlantic and southwestern Indian Ocean. Most species of *Rajella* have a pale ventral surface, including most of those species occurring in the Indian Ocean (i.e. *R. caudaspinosa*, *R. dissimilis*, *R. leopardus* and *R. ravidula*). Only *R. barnardi*, *R. bigelowi* and *R. eisenhardti* have a ventral

surface that has been described as being primarily dark, either greyish or dark brown (Stehmann & Bürkel, 1984; Hulley, 1986; Long & McCosker, 1999). A new species of *Rajella* from deepwater off southern Australia, jointly first studied by the authors in 1989 and identified by Last & Stevens (1994) as *Raja (Rajella)* sp. P, is described below and confirms the distribution of the genus into the Indo–West Pacific.

METHODS

Methods follow those outlined in detail in the first paper of this special publication (Last *et al.*, 2008) and generally follow standards used for skates. Materials of the new species described in detail in this paper are listed below. They include the holotype (CSIRO H 549–01), and primary descriptive types (female paratype CSIRO H 549–02 and juvenile paratype CSIRO H 549–03), as well as specimens from which meristic and/or morphometric information was obtained: 6 morphometric paratypes (CSIRO H 2195–02, CSIRO H 2197–01, CSIRO H 2197–03, CSIRO H 2197–11, CSIRO H 2197–12 and CSIRO T 276); 10 meristic paratypes (CSIRO H 159–01, CSIRO H 160–01, CSIRO H 2195–01, CSIRO H 2195–03, CSIRO H 2197–02, CSIRO H 2197–03, CSIRO H 2197–04, CSIRO H 2197–11, CSIRO H 2197–12 and CSIRO T 276). Collection acronyms follow Leviton *et al.* (1985).

Rajella challengerii sp. nov.

Figs 1–6; Table 1

Raja (Rajella) sp. P: Last & Stevens, 1994: pp 300, 345–346, fig. 34.31, key fig. 4, pl. 52.

Holotype. CSIRO H 549–01, adult male 544 mm TL, west of Trial Harbour, Tasmania, 41°48' S, 144°22' E, 1288–1328 m, 25 May 1986.

Paratypes. 18 specimens. CSIRO H 159–01, juvenile male >440 mm TL (tail tip damaged), south-west King Island, Tasmania, 40°42' S, 143°29' E, 942–1058 m, 09 Jan 1982; CSIRO H 160–01, adult male 521 mm TL, west of Granville Harbour, Tasmania, 41°52' S, 144°28' E, 963–1100 m, 24 Jun 1983; CSIRO H 549–02, female >540 mm TL (tail tip damaged), CSIRO H 549–03, female 178 mm TL, CSIRO H 2195–01, adult male 552 mm TL, CSIRO H 2195–02, female 546 mm TL, CSIRO H 2195–03, adult male 522 mm TL, collected with holotype; CSIRO H 707–11, female 409 mm TL, west of Trial Harbour, Tasmania, 41°47' S, 144°21' E, 1360–1370 m, 20 Jul 1986; CSIRO H 863–06, juvenile male 167 mm TL, west of Trial Harbour, Tasmania, 41°50' S, 144°23' E, 1320–1344 m, 19 Jul 1986; CSIRO H 917–01, juvenile male 316 mm TL, west of Trial Harbour, Tasmania, 41°47' S, 144°22' E, 1230–1280 m, 10 Jun 1987; CSIRO H 2197–01, female 524 mm TL, CSIRO H 2197–02, female 452 mm TL, CSIRO H 2197–03, adult male 535 mm TL, CSIRO H 2197–04, female 412 mm TL, CSIRO H 2197–11, adult male 546 mm TL, CSIRO H 2197–12, adult male 561 mm TL, west of Granville Harbour, Tasmania, 41°47' S, 144°21' E, 1298–1340 m, 25 May 1986; CSIRO H 2198–04, juvenile male 257 mm TL, west of Granville Harbour, Tasmania, 41°47' S, 144°21' E, 1298–1340 m, 24 May 1986; CSIRO T 276–01, female 551 mm TL, west of Cape Banks, South Australia, 37°42' S, 139°18' E, 1000–1010 m, 01 Nov 1984.

Other material. 27 specimens. CSIRO H 549–04, juvenile male 495 mm TL, west of Trial Harbour, Tasmania, 41°48' S, 144°22' E, 1288–1328 m, 25 May 1986; CSIRO H 550–10, female 361 mm TL, west of Cape Sorell, Tasmania, 42°18' S, 144°39' E, 1120–1220 m, 17 May 1986; CSIRO H 707–01, female 329 mm TL, CSIRO H 707–02, female 376 mm TL, CSIRO H 707–03, juvenile male 253 mm TL, CSIRO H 707–04, female 430 mm TL, CSIRO H 707–05, female 449 mm TL, CSIRO H 707–06, female 417 mm TL, CSIRO H 707–07, female 251 mm TL, west of Trial Harbour, Tasmania, 41°47' S, 144°21' E, 1360–1370 m, 20 Jul 1986; CSIRO H 2195–04, juvenile male 389 mm TL, CSIRO H 2195–05, female 531 mm TL, CSIRO H 2195–07 (2 specimens), juvenile male 186 mm TL, juvenile male 212 mm TL, collected with holotype; CSIRO H 2196–01, female 438 mm TL, west of Granville Harbour, Tasmania, 41°45' S, 144°21' E, 1290–1296 m, 10 Aug 1987; CSIRO H 2197–05, female 474 mm TL, CSIRO H 2197–06, female 541 mm TL,

CSIRO H 2197–07, juvenile male 328 mm TL, CSIRO H 2197–08, female 384 mm TL, CSIRO H 2197–09, juvenile male 289 mm TL, CSIRO H 2197–10, female 371 mm TL, west of Granville Harbour, Tasmania, 41°47' S, 144°21' E, 1298–1340 m, 25 May 1986; CSIRO H 2198–01, female 273 mm TL, CSIRO H 2198–02, juvenile male 379 mm TL, CSIRO H 2198–03, female 391 mm TL, CSIRO H 2198–05, female 457 mm TL, west of Granville Harbour, Tasmania, 41°47' S, 144°21' E, 1298–1340 m, 25 May 1986; CSIRO H 2228–01, adult male 545 mm TL, Great Australian Bight, South Australia, 34°03' S, 131°36' E, 1100–1120 m, 05 Nov 1989; CSIRO H 2275–01, adult male >515 mm TL, east of Shoalhaven Heads, New South Wales, 34°52' S, 151°16' E, 1025–1060 m, 10 Aug 1989; CSIRO H 2956–01, female 536 mm TL, Great Australian Bight, South Australia, 33°33' S, 130°05' E, 965–995 m, 07 Jun 1992.

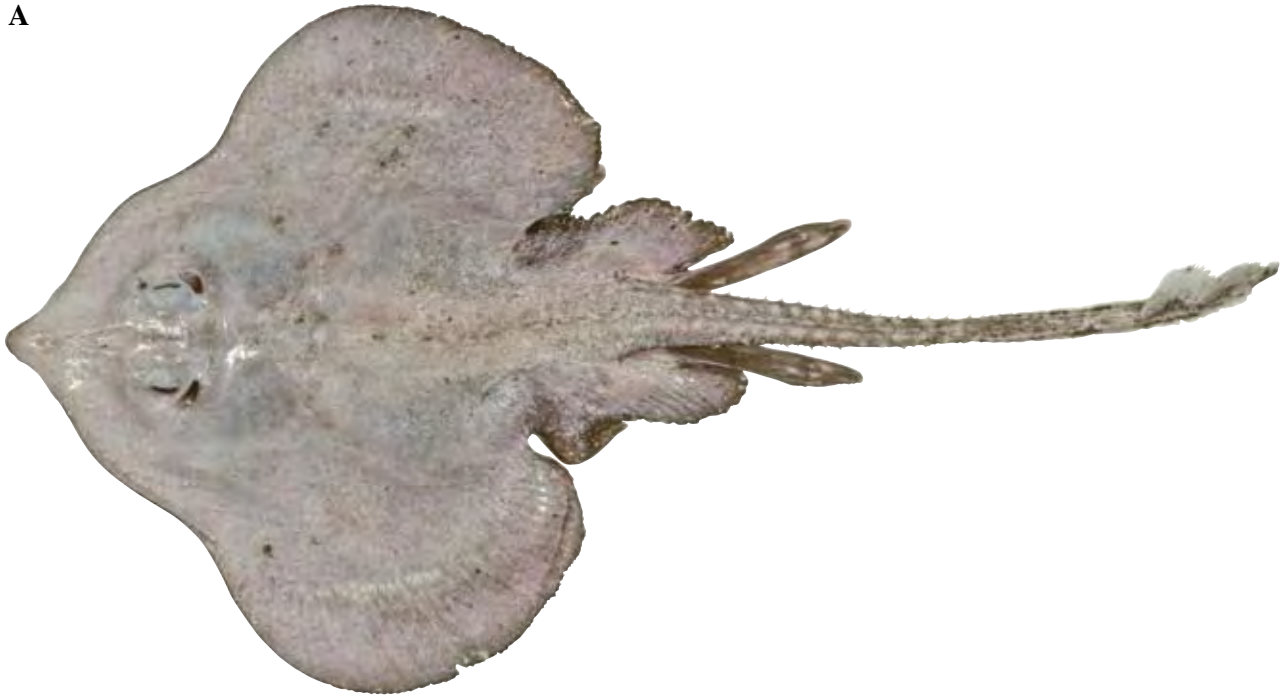
DIAGNOSIS.— A medium-sized species of *Rajella* (to 56 cm TL) with the following combination of characters: disc narrow, heart-shaped to subcircular with rounded apices, width 52–56% TL, about 1.1 times its length; snout angle 89–99°; tail elongate, tapering strongly, length 1.1–1.3 times distance from snout tip to rear of cloaca; tail not broad, width 1.3–1.9 times height at its midlength, 1.5–1.8 times at first dorsal-fin origin; pre-upper jaw length 12–14% TL, 1.8–2.1 times internasal width; ventral head length 24–25% TL; snout length 2.9–3.3 times interorbital width; orbit diameter 77–94% interorbital width; first dorsal fin usually connected to second dorsal fin, its height 1.3–2.1 in its base length; distance from first dorsal-fin origin to tail tip 2.2–2.7 times first dorsal-fin base length, 1.4–3.0 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males 18–19% TL, length of anterior lobe 63–69% of posterior lobe; adult clasper relatively short, 21–22% TL, connected to pelvic-fin inner margin at about 35–44% of its length from cloaca; anterior margins of dorsal surface very spiny; nucho-scapular thorn patch present, 3 thorns in transverse row near scapulocoracoid (one on midline, one on each shoulder); malar thorn patch extensive; tail with 5–7 irregular thorn rows; total pectoral radials 57–61; trunk centra 23–28; predorsal centra 90–98; total centra about 120–130; tooth rows in upper jaw 26–36; mainly almost uniform pale dorsally (anterior pelvic-fin lobe black), much darker brownish black or black ventrally; ventral sensory pores indistinct.

DESCRIPTION.— Disc inverted, heart-shaped (more subcircular in females and juveniles), 1.10 times as broad as long in adult male holotype (1.08–1.11 times in 6 paratypes); angle in front of spiracles 90° (89–99°); axis of greatest width 61% (56–60%) of disc length; anterior margin strongly undulated, double concave (much more so in adult males, uniformly convex to weakly double concave in females and juveniles), margin weakly concave near snout tip, very strongly convex just forward and beside eyes, deeply concave just behind spiracles; apex very broadly rounded; posterior margin

Table 1. Morphometrics for the holotype of *Rajella challengerii* sp. nov. (CSIRO H 549–01), ranges for measured paratypes (n=6), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Rajella challengerii</i> sp. nov.			
	Holotype	Paratypes		Mean
		Min.	Max.	
Total length (mm)	544	524	561	
Disc width	54.8	52.1	55.5	53.7
Disc length (direct)	49.6	47.8	50.8	49.0
Snout to maximum width	30.2	27.4	30.6	28.9
Snout length (preorbital direct)	12.4	11.9	12.8	12.3
Snout to spiracle	16.7	16.0	16.9	16.3
Head (dorsal length)	18.2	18.0	18.7	18.4
Orbit diameter	3.6	3.1	3.5	3.2
Orbit and spiracle length	4.4	3.8	4.3	4.1
Spiracle length (main aperture)	2.1	1.8	2.1	1.9
Distance between orbits	3.9	3.7	4.1	3.9
Distance between spiracles	6.7	6.5	6.7	6.6
Snout to cloaca (to 1st hemal spine)	45.9	44.3	46.7	45.6
Cloaca to D1	41.7	40.6	42.6	41.8
Cloaca to D2	46.5	46.1	47.8	46.9
Cloaca to caudal origin	50.7	50.9	52.8	51.7
Distance-cloaca to caudal-fin tip	54.0	53.0	55.7	54.3
Ventral snout length (pre upper jaw)	12.6	12.3	13.7	12.9
Prenasal length	10.7	10.0	11.5	10.8
Ventral head length (to fifth gill)	25.2	24.2	25.3	24.6
Mouth width	7.6	5.9	6.7	6.2
Distance between nostrils	7.0	6.0	7.0	6.6
Nasal curtain length	4.2	3.6	4.0	3.8
Nasal curtain (total width)	7.4	6.6	7.4	7.1
Nasal curtain (min. width)	5.0	4.5	4.9	4.7
Nasal curtain (lobe width)	1.4	1.1	1.4	1.2
Width of first gill opening	1.4	1.3	1.5	1.4
Width of fifth gill opening	1.1	1.0	1.4	1.2
Distance between first gill openings	13.7	13.3	14.7	14.1
Distance between fifth gill openings	8.2	7.7	9.4	8.7
Clasper (post cloacal length)	20.8	21.5	21.7	21.6
Length of anterior pelvic lobe	12.3	11.6	12.8	12.1
Length of posterior pelvic lobe	19.0	17.5	19.0	18.3
Pelvic base width	8.6	8.0	9.6	8.6
Tail at axil pelvic fins (width)	5.1	4.8	5.2	5.0
Tail at axil pelvic fins (height)	3.2	3.1	3.5	3.3
Tail at midlength (width)	2.0	2.0	2.6	2.2
Tail at midlength (height)	1.4	1.3	1.5	1.4
Tail at D1 origin (width)	1.6	1.3	1.6	1.5
Tail at D1 origin (height)	0.9	0.9	1.0	0.9
D1 base length	4.7	4.2	5.5	5.0
D1 height	3.3	2.5	3.3	2.9
D1 origin to caudal-fin tip	12.2	10.8	14.4	12.5
D2 origin to caudal-fin tip	7.5	6.2	9.0	7.4
Caudal-fin length	3.3	1.6	3.4	2.6

A



B

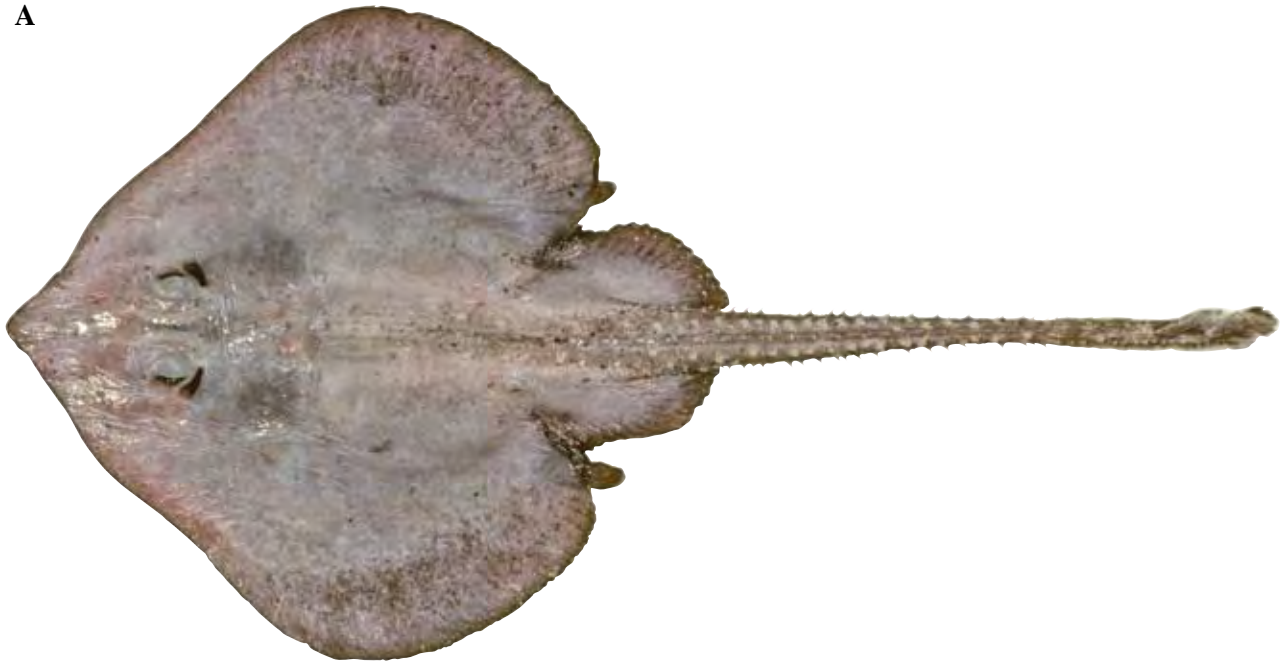


Figure 1. *Rajella challengerii* sp. nov., adult male holotype (CSIRO H 549-01, 544 mm TL, fresh): A, dorsal surface; B, ventral surface.

strongly convex; free rear tip broadly rounded; inner margin strongly convex. Head and snout short, preorbital snout length 3.39 (3.56–4.16) times orbit length, 3.19 (2.94–3.31) times interorbit; pre-upper jaw length 1.81 (1.86–2.12) times internarial distance. Snout tip produced slightly (much shorter in primary female CSIRO H 549-02 and primary juvenile CSIRO H 549-03), narrowly rounded; no fleshy process at apex. Orbit diameter 0.94 (0.77–0.90) times interorbital width. Spiracle medium-

sized, length 1.77 (1.47–1.90) in orbit diameter; opening elongate oval. Nostril suboval, usually distorted; anterior nasal flap enlarged, its lateral margin forming an elongate open tube; anterior margin of flap weakly lobe-like, not concealed beneath nasal curtain; posterior inner margin partly concealed by nasal curtain; posterior lobes well developed, forming nasal curtain, slightly produced posterolaterally, narrowly rounded distally, posterior margin with fine fringe; internarial distance 1.97 (2.00–

A



B

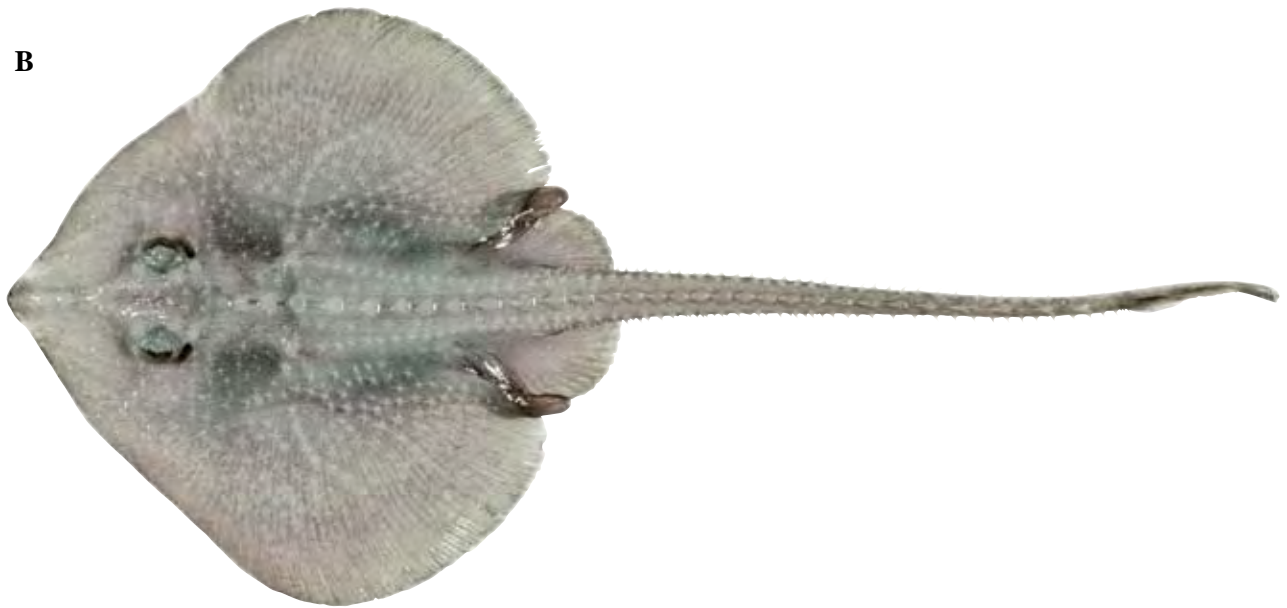


Figure 2. Dorsal surface of *Rajella challengerii* sp. nov.: A, primary female paratype (CSIRO H 549–02, ~540 mm TL, fresh); B, primary juvenile paratype (CSIRO H 549–03, female 178 mm TL, fresh).

2.40) in distance between first gill slits, 1.18 (1.14–1.57) in distance between fifth gill slits. Mouth broad; upper jaw broad, strongly arched in adult male (arched mainly at symphysis in females and juveniles), indented slightly at symphysis in mature males; lower jaw convex, strongly arched near middle of jaw (mirroring profile of upper jaw); lateral teeth usually fully concealed by lobes of nasal curtain. Teeth of adult male holotype small, unicuspid (cusp length variable in paratypes from strongly to weakly cusped in late adolescent) with low, oval bases; arranged in obvious parallel rows;

medial cusps relatively short, narrow, pointed; directed posteriorly (more posterolaterally near jaw angle); cusps much shorter laterally in lower jaw, but not upper jaw; teeth of female and juvenile paratypes in quincunx, with broad rhomboidal crowns, cusps very short.

Pelvic fins bilobed; anterior lobe narrow, short, narrowly rounded distally, lateral margin entire, inner margin weakly incised; posterior lobe moderately elongate, only slightly longer in males (length 18.6–19.0% TL) than in females (length 17.5–18.3% TL), lateral



Figure 3. Dorsal head of *Rajella challengerii* sp. nov., adult male holotype (CSIRO H 549-01, 544 mm TL), showing snout, orbito-spiracular and nuchal regions.

margins strongly convex, inner margin mostly straight, connected to lateral margin of clasper at 35–44% of its postcloacal length; anterior lobe 0.65 (0.63–0.69) times posterior lobe. Clasper moderately short, 21–22% TL, slender, slightly depressed, glans expanded slightly; clasper components include proximal slit and distal cleft, terminal bridge, rhipidion, shield, sentinel, spike, eperon and spur; denticles and pseudosiphon absent. Tail broad based, depressed, tapering strongly and evenly to tail tip, midlength narrow; width at insertions of pelvic fins 2.59 (1.97–2.61) times width at midlength of tail and 3.21 (3.29–3.75) times width at first dorsal-fin origin respectively; length from rear of cloaca 1.18 (1.14–1.26) times distance from tip of snout to rear of cloaca; anterior cross-section not more convex dorsally than ventrally, only slightly more strongly convex on dorsal surface than ventral surface posteriorly (moderately convex beyond dorsal fins); width 1.58 (1.46–1.60) times height at insertion of pelvic fin, 1.45 (1.32–1.85) times height at midlength, 1.78 (1.45–1.63) times height at first dorsal-fin origin; lateral tail fold very short but well-developed, broad posteriorly, originating behind middle of tail, extending almost to tail tip, much broader below dorsal fins, situated slightly on ventrolateral surface of tail (not overhung by its lateral margin). Dorsal fins narrowly suboval to ovoid, small, first dorsal-fin height 1.46 (1.26–2.08) in base length; size and shape variable, usually subequal (posterior longer based and lower in holotype); anterior margins convex, apices broadly rounded;

posterior margins short, rear tip narrowly rounded to angular, inner margins usually directed posterodorsally; fins close together (often confluent), usually connected just above their bases, distance from first dorsal-fin origin to tail tip 2.58 (2.23–2.65) times dorsal-fin base length, 3.71 (4.21–6.72) times caudal-fin length; first dorsal-fin base 1.44 (1.59–3.01) times caudal-fin length; fin spacing similar in primary juvenile paratype. Epichordal caudal-fin lobe short, upright (often missing); usually narrowly to broadly rounded distally, its dorsal margin convex; just separate from or connected to base of second dorsal fin; hypochordal caudal lobe short, as low ridge (when present).

Dorsal surface very rough, with strong, widely spaced thorns, thornlets and enlarged dermal denticles; with relatively large rostral (rarely missing), orbital (sometimes missing), nuchal and scapular (sometimes missing), mid-dorsal (variable), malar and alar thorns on disc of adult males, and multiple, well-developed rows of tail thorns (thorns variably developed in adults, often lost in large adults, well developed in juveniles and subadults). Orbital thorns of holotype forming an incomplete rosette (in a single row, not clustered); with 4 (2 on preorbit, 1 on midorbit, 1 on postorbit; paratypes with always <5) thorns; spiracular thorns rarely present, may have been lost as scar often present; no thorns on interorbit; thorns subequal in size, with very thick bases and slender tip,

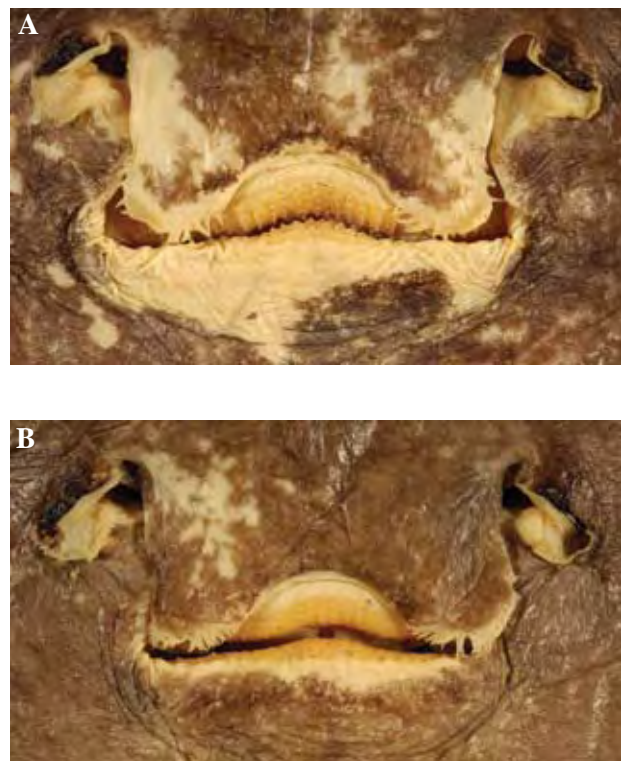


Figure 4. Ventral view of *Rajella challengerii* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 549-01, 544 mm TL); B, primary female paratype (CSIRO H 549-02, ~540 mm TL).

mostly directed posteriorly, recurved. Orbital thorns of primary female paratype not forming a rosette (rarely formed in some other large female paratypes), with 3 (1 on preorbit, 1 on midorbit, 1 on postorbit; up to 6, but rarely >4 in other paratypes) main thorns; single spiracular thorns present in smaller paratypes, usually lost in largest females; primary juvenile with 4 (2 on preorbit, absent on midorbit, 2 on postorbit; 4–5 in other juvenile paratypes) large thorns. Rostral thorns 2 (0–3), situated above rostral appendix (similar in juvenile); female with 2 (0–5) thorns on mid anterior snout. Nucho–scapular thorn patch present, weak, variable; transverse row of 3 thorns (one on midline, one on each shoulder, often all lost) across scapulocoracoids; evidence of mid-scapular thorn in holotype (broken thorn present in primary female paratype); nuchal thorn present or absent (usually lost in largest individuals); patch occasionally with other unpaired thorns; thorns similar in form to those of orbit. Malar patch extensive, with about 18–20 large, widely spaced thorns, extending from tip of propterygium to level of spiracle, in 3–4 (2–4) curved rows posteriorly (large females with irregular patch of thorns in malar region and more posterior). Alar patch extremely elongate, with 20 very long, deeply rooted, mostly medially directed, erectile thorns in 2–3 (1–3, mostly 2) longitudinal rows; length of patch usually exceeding preorbital length. Tail with 5–7 (usually 7) very spiny rows of thorns barely extending onto disc (occasionally to above mid-abdomen); median row continuous and persistent from juveniles to adults, with about 21 thorns, extending from cloaca to just forward of first dorsal fin (or slightly more posterior); median thorns large, usually regularly spaced, narrow based, absent or weak before dorsal fins; dorsolateral row in 2 pairs of irregular, staggered rows; upper-most dorsolateral row with much broader-based thorns, numbering about 13–15, extending from near pectoral-fin insertion (often well anterior of) to just beyond mid-tail (sometimes terminating near midline as a paired thorn); lower dorsolateral row with a few scattered thorns, coalescing posteriorly with upper dorsolateral row just beyond mid-length of tail; lateral rows with about 26–28 smaller thorns, extending along lateral margin from near pelvic-fin rear tip to below second dorsal fin; no interdorsal thorns. Tail rows of primary female paratype with some thorns of dorsolateral rows extending onto disc (frequently also present in other female paratypes); median row shorter than dorsolateral rows (similar to holotype), with about 22 thorns, small or absent posteriorly; median row in some smaller specimens (CSIRO H 707–11, 409 mm TL) extending continuously to nucho–scapular patch, with 30 thorns; dorsolateral thorns in 3 rows anteriorly, 1 row posteriorly; lateral rows terminating under second dorsal fin. Primary juvenile paratype with 30 large, evenly spaced thorns, in a continuous linear, median row; thorns extending from nuchal area to just forward of first dorsal fin; smaller thorns of dorsolateral and lateral rows extending forward to scapular region as rows of denticles; thornlets present on interorbital space.

Denticles of adult male holotype poorly developed, dorsal surface of disc and pelvic fins largely naked, ventral surface naked; denticles present as small sharp thornlets, confined to outer anterior margin and apex of disc (near alar patch), with smaller denticles along anterior lateral margin of tail and on dorsal fins. Primary female paratype similar to adult male, largely naked dorsally; small thornlets confined to anterior dorsolateral margin of disc, smaller denticles on tail; body without granular denticles; naked ventrally. Primary juvenile paratype almost entirely covered dorsally with enlarged, widely spaced denticles and thornlets (mostly absent from posterior disc margin and anterior pelvic-fin lobe); thornlets slender, sharp, mostly posteriorly directed and recurved; naked ventrally.

Meristics (n=11): Tooth rows in upper jaw 33 (26–36); lower jaw 33 (29–36). Pectoral-fin propterygial radials 25–26 (24–25); mesopterygial radials 9–10 (9–10); metapterygial radials 25 (25–27); total radials 60 (57–61). Pelvic-fin radials males (n=8) 1 (1) + 18 (18–19); females (n=2) (1) + (18–19). Trunk centra 27 (23–28); predorsal caudal centra 65 (63–72); predorsal centra 92 (90–98); centra between origins of dorsal fins 8 (8–10); diplospondylous centra 96 (93–104); total centra about 123 (120–130).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype and primary female pale yellowish or whitish; thorns yellowish; tail, outer disc and posterior lobes of pelvic fins usually slightly darker greyish white, fin edges black; anterior lobe of pelvic fin brownish black; spiracles dusky (slightly darker than adjacent disc); eyelid pale yellowish or white; dorsal fins and skin fold mainly pale, mottled with darker markings. Ventral surface of disc mostly dark brownish black (slightly darker, almost blackish around margin of disc and posterior pelvic-fin lobes); mostly white markings around nostrils (lateral margin of anterior nasal flap blackish, strongly contrasted with whitish inner nostril and surrounding area), mouth, cloaca, and at tip of anterior pelvic-fin lobe; sometimes with sparse white blotches on disc and pelvic fins; mouth cavity pale; tail usually paler brownish (often with faint mottling); tail tip often whitish or strongly mottled. Primary juvenile mainly pale, whitish or yellowish with darker greyish blue areas on posterior disc and pelvic fins, and above sides of abdomen and over gill region; eyelid translucent; dorsal fins dusky basally, whitish or translucent distally; epichordal lobe primarily pale; disc dark brown ventrally (slightly paler in specimens <22 cm TL), tail paler brown; white areas around nostrils, mouth, on central disc, cloaca and tail tip.

SIZE.— Largest specimen an adult male 561 mm TL; no adolescent males but still juvenile at 495 mm TL, adult males 521–561 mm TL; smallest juvenile 167 mm TL; no information on egg cases.



Figure 5. Lateral view of dorsal and caudal fins of *Rajella challengerii* sp. nov., adult male holotype (CSIRO H 549–01, 544 mm TL).

A



B



C



D



Figure 6. Thorns at tail midlength of *Rajella challengerii* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 549–01, 544 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 549–02, ~540 mm TL).

DISTRIBUTION.—Based on material examined, occurs on the mid continental slope off southern Australia from east of Shoalhaven Heads, New South Wales (34°52' S, 151°16' E) to the Great Australian Bight, South Australia (33°33' S, 130°05' E), including Tasmania, in depths of 942–1370 m. Last & Stevens (1994) recorded the distribution of this species from off Sydney, New South Wales (ca. 34° S), to off Albany, Western Australia (ca. 118° E) in depths of 860–1500 m.

ETYMOLOGY.— The FRV *Challenger* is the currently commissioned research vessel of the Tasmanian Aquaculture and Fisheries Institute (formerly the Tasmanian Fisheries Development Authority). While this vessel no longer has a trawl capability, in the early 1980's it was used to survey the deepwater demersal fish resources of Tasmania. Most of the continental slope of the region had never been explored previously, so many new records and species were discovered, among them, the Challenger Skate. The epithet of this new species (i.e. *challengeri*) acknowledges the contribution made by this vessel to our knowledge of Australian deepwater demersal fishes. Vernacular name: Challenger Skate.

REMARKS.— Four species of *Rajella* have been described as having a dark ventral surface: *R. barnardi*, *R. bigelowi*, *R. eisenhardti* and the new Australian species, *R. challengeri*. Based on Hulley (1986), *R. barnardi*, from western and southern Africa, differs from *R. challengeri* in being uniformly greyish above and below with darker patches posteriorly (rather than much darker ventrally than dorsally), and has fewer predorsal diplospondylous centra (55–63 vs. 63–72), and more tooth rows in the upper jaw (39–45 vs. 26–36). *Rajella eisenhardti*, from the Galapagos Islands, has a less undulate disc, a denser coverage of denticles, and has more pectoral-fin radials (68–69 vs. 57–61 in *R. challengeri*) and tooth rows (46–48 vs. 26–36 in the upper jaw). *Rajella bigelowi*, which occurs mainly in the eastern and western North Atlantic but spreads southward to the Azores and off NW-Africa to 10° N, and to the Gulf of Mexico, and probably further a field (Stehmann & Bürkel, 1984; Stehmann, 1995), is very similar in body colour and meristics to *R. challengeri*. However, given the generally restricted geographic distributions of most skate species (Last & Yearsley, 2002) and the absence of *R. bigelowi* from the faunas of New Zealand, South Africa and South America, the likelihood of a North Atlantic skate occurring off southern Australia would seem a remote possibility. The Australian species attains a slightly larger size (reaches 56 cm TL and is still juvenile at 50 cm TL, rather than reaching about 50 cm TL and maturity by 43 cm TL), and the dorsal disc and tail of the adults and young are much less spinose than those of *R. bigelowi*. Stehmann's figures (1978, fig. 3) of a juvenile female (GMNH 1977–170–11, 156 mm TL) and a postembryonic female (ZIN 48420, 136 mm TL) *R. bigelowi* (Stehmann, 1995, fig. 22), seem to display smaller and denser disc denticles and the lateral tail thorns are still missing to

near half-grown size (greatly expanded laterally in the primary juvenile paratype CSIRO H 549–03, female 178 mm TL). Similarly, the disc of adults of both sexes of *R. challengeri* is bereft of denticles, whereas in *R. bigelowi* it is 'densely set with spinules' (Stehmann, 1995). Also, based on Stehmann, adolescent *R. challengeri* also have a slightly smaller orbit (diameter 3.1–3.6% vs. 4.5–5.2% TL), smaller orbit and spiracle (length 3.8–4.4% vs. 5.0–5.7% TL), broader disc (width 52.1–55.5% vs. 49.4–51.4 % TL), shorter tail (length 53–56% from end of cloaca vs. 59–62% TL from mid cloaca), and longer preoral snout (pre-upper jaw length 12.3–13.7% vs. 9.3–10.8% TL) and ventral head (length 24.2–25.3% vs. 21.1–22.6% TL). Nevertheless, the two species are otherwise morphologically similar.

ACKNOWLEDGEMENTS

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Leucoraja pristispina sp. nov., a new deepwater skate from Western Australia

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ABSTRACT.— A new skate of the genus *Leucoraja* represents the first record of the group from the eastern Indian Ocean. Unlike most congeners, *Leucoraja pristispina* sp. nov. belongs to one of only a few species that are uniformly coloured dorsally rather than being ornate. It differs from a similar, plain coloured skate, *L. compagnoi* from the southeastern Atlantic Ocean in having a less pointed snout, smaller midline thorns, more teeth rows in the jaws, and a dorsal disc covered with denticles rather than being largely naked. *Leucoraja pristispina* can be distinguished from the remaining species by a combination of disc shape, relative snout length, tail length and thickness, coloration, meristics, and clasper size and shape. It is more thorny dorsally than any other Australian rajid skate.

Key words. Rajidae – skate – new species – Australia – *Leucoraja*

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INTRODUCTION

The genus *Leucoraja* presently contains 12 species: *L. circularis* (Couch, 1838); *L. compagnoi* (Stehmann, 1995); *L. erinacea* (Mitchill, 1825); *L. fullonica* (Linnaeus, 1758); *L. garmani* (Whitley, 1939); *L. lentiginosa* (Bigelow & Schroeder, 1951); *L. leucosticta* (Stehmann, 1971); *L. melitensis* (Clark, 1926); *L. naevus* (Müller & Henle, 1841); *L. ocellata* (Mitchill, 1815); *L. wallacei* (Hulley, 1970); *L. yucatanensis* (Bigelow & Schroeder, 1950). These species occur in the central western Atlantic, eastern Atlantic and south-west Indian Ocean. During an exploratory survey of Australian crustacean resources, a new member of this genus was collected off northwestern Australia. This species is described below. It is assigned to the genus *Leucoraja* on the basis of its disc shape, thorn and denticle patterns on the disc and tail, and external clasper components (McEachran & Dunn, 1998).

METHODS

Methods follow those outlined in the first paper of this special publication (Last *et al.*, 2008) and generally follow standards used for skates. Materials of the new species described in detail in this paper are listed below. They include the holotype (CSIRO CA 3905), and primary descriptive types (female paratype CSIRO H 6420–05

and juvenile paratype CSIRO H 1636–02), as well as specimens from which meristic and/or morphometric information was obtained: 5 morphometric paratypes (CSIRO CA 4339, CSIRO CA 4342, CSIRO CA 4370, CSIRO CA 4403 and CSIRO H 2026–01); 12 meristic paratypes (CSIRO CA 3934, CSIRO CA 4333, CSIRO CA 4370, CSIRO CA 4402, CSIRO CA 4403, CSIRO H 1649–01, CSIRO H 2026–01, CSIRO H 6420–01, CSIRO H 6420–02, CSIRO H 6420–03, CSIRO H 6420–04 and CSIRO H 6420–05). Collection acronyms follow Leviton *et al.* (1985).

Leucoraja pristispina sp. nov.

Figs 1–6; Table 1

Raja (*Leucoraja*) sp. O: Last & Stevens, 1994: pp 300, 344, fig. 34.30, key fig. 5, pl. 52.

Holotype. CSIRO CA 3905, adult male 362 mm TL, south-west of Imperieuse Reef (Rowley Shoals), Western Australia, 18°07' S, 118°09' E, 400–404 m, 05 Feb 1983.

Paratypes. 27 specimens. CSIRO CA 3934, adolescent male 337 mm TL, south of Rowley Shoals, Western Australia, 17°34' S, 119°03' E, 318–360 m, 06 Feb 1983; CSIRO CA 4333, adolescent male 341 mm TL, south-west of Imperieuse Reef, Western Australia, 17°56' S,

118°21' E, 418–420 m, 05 Feb 1983; CSIRO CA 4339, female 360 mm TL, CSIRO CA 4342, female 378 mm TL, south-west of Imperieuse Reef, Western Australia, 17°45' S, 118°30' E, 442–460 m, 05 Feb 1983; CSIRO CA 4370, adult male 374 mm TL, north-east of Rowley Shoals, Western Australia, 15°42' S, 120°34' E, 500–504 m, 10 Feb 1984; CSIRO CA 4402, female 311 mm TL, CSIRO CA 4403, adult male 348 mm TL, south-east of Scott Reef, west of Bonaparte Archipelago, Western Australia, 14°12' S, 122°32' E, 348–350 m, 14 Feb 1984; CSIRO H 1636–02, female 124 mm TL, CSIRO H 1636–04, juvenile male 235 mm TL, Rowley Shoals area, Western Australia, 17°49' S, 118°29' E, 410 m, 24 Aug 1988; CSIRO H 1649–1, adolescent male 332 mm TL, Rowley Shoals area, Western Australia, 17°13' S, 119°00' E, 460 m, 02 Sep 1988; CSIRO H 2025–1, female 195 mm TL, north-east of Mermaid Reef, Rowley Shoals, Western Australia, 17°00' S, 120°22' E, 404 m, 06 Apr 1989; CSIRO H 2026–1, female 372 mm TL, north-east of Mermaid Reef, Rowley Shoals, Western Australia, 16°59' S, 120°13' E, 396 m, 12 Apr 1989; CSIRO H 6420–01, juvenile male 267 mm TL, CSIRO H 6420–02, female 275 mm TL, CSIRO H 6420–03, female 283 mm TL, CSIRO H 6420–04, adolescent male 326 mm TL, CSIRO H 6420–05, female 351 mm TL, CSIRO H 6420–06 (2 specimens) female 184 mm TL, juvenile male 205 mm TL, Ashmore Terrace, Western Australia, 13°32' S, 122°42' E, 416–430 m, 27 May 2006; WAM P 28058–005, juvenile male 234 mm TL, south-west of Rowley Shoals, Western Australia, 18°05' S, 118°10' E, 400 m, 17 Aug 1983; WAM P 28072–010 (4 specimens), juvenile male 195 mm TL, juvenile male >205 mm TL (tail tip damaged), female 183 mm TL, juvenile male 94 mm TL, south-west of Rowley Shoals, Western Australia, 17°51' S, 118°25' E, 449 m, 18 Aug 1983; WAM P 28086–005 (3 specimens), female 337 mm TL, female 333 mm TL, adolescent male 330 mm TL, south-west of Rowley Shoals, Western Australia, 17°49' S, 118°41' E, 308–310 m, 21 Aug 1983.

Other material. 7 specimens. CSIRO CA 2832, female >171 mm TL (tail tip damaged), south-west of Imperieuse Reef (Rowley Shoals), Western Australia, 17°50' S, 118°28' E, 404 m, 03 Apr 1982; CSIRO CA 3904, juvenile male 283 mm TL, south-west of Imperieuse Reef (Rowley Shoals), Western Australia, 18°07' S, 118°09' E, 400–404 m, 05 Feb 1983; CSIRO CA 4405, juvenile male 186 mm TL, south-east of Scott Reef, west of Bonaparte Archipelago, Western Australia, 14°12' S, 122°32' E, 348–350 m, 14 Feb 1984; CSIRO H 1213–01, adult male 401 mm TL, Ashmore Terrace area, Western Australia, 13°25' S, 122°54' E, 420 m, Jan 1988; CSIRO H 1628–01, juvenile male 279 mm TL, north-west of Dampier Archipelago, Western Australia, 18°58' S, 116°01' E, 410 m, 12 Sep 1988; CSIRO H 2025–04, female 303 mm TL, north-east of Mermaid Reef, Rowley Shoals, Western Australia, 17°00' S, 120°22' E, 404 m, 06 Apr 1989; CSIRO T 1362, adolescent male 335 mm TL, west of Shoal Point, Western Australia, 28°06' S,

113°15' E, 202–213 m, 26 Jul 1979.

DIAGNOSIS.— A medium-sized species of *Leucoraja* (to 40 cm TL) with the following combination of characters: disc narrow, inverted heart-shaped to subcircular with broadly rounded apices, width 54–60% TL, 1.1–1.2 times its length; snout angle 90–104°; tail elongate, tapering, length 1.0–1.1 times distance from snout tip to rear of cloaca, relatively slender, width 1.7–1.9 times height at its midlength, 1.7–1.9 times at first dorsal-fin origin; pre-upper jaw length 13–14% TL, 1.7–2.0 times internasal width; ventral head length 25–28% TL; snout length 2.7–3.4 times interorbital width; orbit diameter 88–100% interorbital width; first dorsal fin usually connected to second dorsal fin, its height 1.8–2.6 in its base length; distance from first dorsal-fin origin to tail tip 2.1–2.7 times first dorsal-fin base length, 1.6–4.3 times caudal-fin length; pelvic fins of medium size, length of posterior lobe of adult males 17–20% TL, length of anterior lobe 61–70% of posterior lobe; adult clasper relatively short and stout, 21–24% TL, connected to pelvic-fin inner margin at about 38–46% of its length from cloaca; dorsal disc very spiny, almost wholly covered with fine denticles, thorns and thornlets; nucho–scapular thorn patch dense and triangular; rostral and interorbital thorns present in all but smallest juveniles; malar thorn patch well developed and located at level of orbit and spiracle; alar patch elongate, narrow, only slightly shorter than prespiracular length; tail with multiple irregular thorn rows (thorns of median row usually smaller than those of adjacent lateral rows); total pectoral radials 61–64; trunk centra 26–28; predorsal centra 85–91; total centra about 121–127; tooth rows in upper jaw 47–55; uniform pale greyish or brownish dorsally, uniformly whitish ventrally; ventral sensory pores not black edged; dorsal fins of juveniles pale based with black outer margins (less distinct in adults).

DESCRIPTION.— Disc inverted heart-shaped (more subcircular in females and juveniles), 1.12 times as broad as long in adult male holotype (1.12–1.16 times in paratypes); angle in front of spiracles 90° (91–104°); axis of greatest width 63% (57–61%) of disc length; anterior margin strongly undulate, double concave (much more so in adult males, almost uniformly convex in females and juveniles), margin weakly concave near snout tip, strongly convex beside and forward of eyes, deeply concave beside spiracles; outer corner very broadly rounded; posterior margin strongly and evenly convex; free rear tip broadly rounded; inner margin strongly convex. Head short, preorbital snout length 3.41 (3.36–4.04) times orbit length, 2.89 (2.74–3.42) times interorbit; pre-upper jaw length 1.72 (1.72–1.97) times internarial distance. Snout tip short, extended slightly (much shorter in primary female paratype CSIRO H 6420–05 and primary juvenile paratype CSIRO H 1636–02), broadly rounded; fleshy process absent. Orbit diameter 0.85 (0.82–1.00) times interorbital width. Spiracle medium-sized, length 1.50 (1.39–1.68) in orbit diameter; opening

Table 1. Morphometrics for the holotype of *Leucoraja pristispina* sp. nov. (CSIRO CA 3905), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Leucoraja pristispina</i> sp. nov.			
	Holotype	Paratypes		Mean
		Min.	Max.	
Total length (mm)	362	348	378	
Disc width	56.9	54.0	59.7	56.9
Disc length (direct)	50.8	47.8	51.7	50.2
Snout to maximum width	32.0	27.5	30.9	29.9
Snout length (preorbital direct)	12.9	11.5	13.6	12.9
Snout to spiracle	18.2	16.9	18.7	17.9
Head (dorsal length)	20.2	18.4	20.3	19.7
Orbit diameter	3.8	3.4	3.9	3.6
Orbit and spiracle length	5.6	5.0	5.4	5.3
Spiracle length (main aperture)	2.5	2.2	2.5	2.4
Distance between orbits	4.5	3.9	4.4	4.2
Distance between spiracles	6.8	6.6	7.1	6.9
Snout to cloaca (to 1st hemal spine)	48.5	47.0	51.3	49.5
Cloaca to D1	37.0	34.9	39.0	36.8
Cloaca to D2	42.9	40.5	45.8	42.9
Cloaca to caudal origin	48.2	45.9	51.1	48.3
Distance-cloaca to caudal-fin tip	51.7	47.8	53.4	50.6
Ventral snout length (pre upper jaw)	13.2	13.3	13.9	13.5
Prenasal length	10.1	9.4	11.0	10.2
Ventral head length (to fifth gill)	27.4	25.3	27.9	26.5
Mouth width	8.9	7.8	9.6	8.9
Distance between nostrils	7.7	7.0	7.9	7.6
Nasal curtain length	5.5	4.6	5.7	5.1
Nasal curtain (total width)	8.9	8.1	10.0	8.9
Nasal curtain (min. width)	6.4	6.1	7.0	6.6
Nasal curtain (lobe width)	1.5	1.1	1.6	1.3
Width of first gill opening	1.5	1.2	1.9	1.6
Width of fifth gill opening	1.4	1.3	1.5	1.4
Distance between first gill openings	14.5	14.6	16.2	15.2
Distance between fifth gill openings	7.1	7.5	9.2	7.9
Clasper (post cloacal length)	24.4	21.0	22.1	22.5
Length of anterior pelvic lobe	12.4	12.1	13.3	12.7
Length of posterior pelvic lobe	20.2	17.4	20.1	18.9
Pelvic base width	7.8	8.3	10.9	9.5
Tail at axil pelvic fins (width)	5.6	5.3	6.1	5.6
Tail at axil pelvic fins (height)	3.7	3.4	3.7	3.5
Tail at midlength (width)	2.8	2.3	2.8	2.6
Tail at midlength (height)	1.5	1.4	1.5	1.5
Tail at D1 origin (width)	2.1	1.8	2.0	1.9
Tail at D1 origin (height)	1.1	1.0	1.1	1.1
D1 base length	5.5	5.5	6.3	5.8
D1 height	3.0	2.5	3.3	3.0
D1 origin to caudal-fin tip	14.7	12.3	14.4	13.8
D2 origin to caudal-fin tip	8.9	6.3	8.5	7.8
Caudal-fin length	3.5	1.4	2.7	2.4

A



B

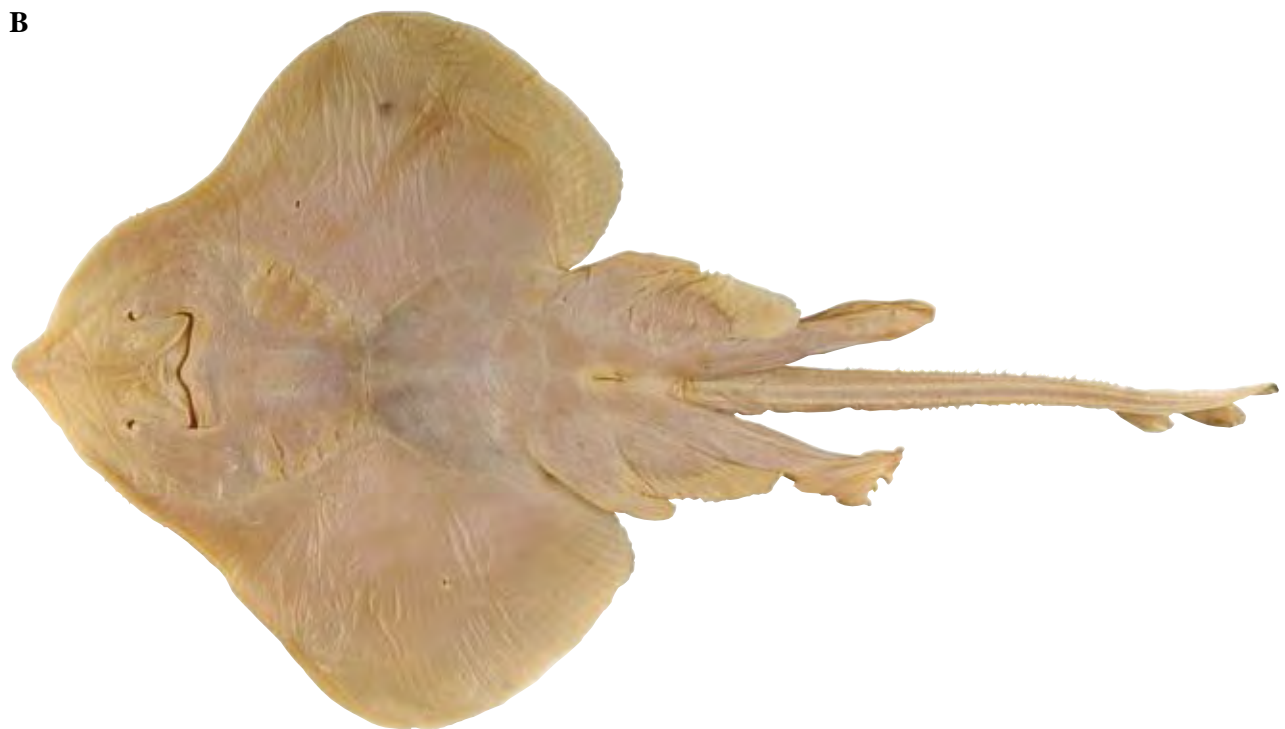


Figure 1. *Leucoraja pristispina* sp. nov., adult male holotype (CSIRO CA 3905, 362 mm TL, preserved): A, dorsal surface; B, ventral surface.

A



B



Figure 2. Dorsal surface of *Leucoraja pristispina* sp. nov.: A, primary female paratype (CSIRO H 6420–05, 351 mm TL, preserved); B, primary juvenile paratype (CSIRO H 1636–02, 124 mm TL, female, preserved).

usually teardrop-shaped or oval. Nostril suboval (usually distorted); anterior nasal flap forming an open tube with outer margin enlarged, pinna-like (relatively longer in primary female); inner margin of flap weakly lobe-like, fully or partly concealed beneath nasal curtain; posterior inner margin concealed by nasal curtain; posterior nasal lobes well developed, forming nasal curtain, produced posterolaterally, narrowly rounded distally, posterior margin with prominent fringe; internarial distance 1.88 (1.93–2.09) in distance between first gill slits, 0.92 (0.94–

1.18) in distance between fifth gill slits. Upper jaw broad, robust, strongly arched in adult males (arched only at symphysis in females and juveniles), deeply indented at symphysis in mature males; lower jaw convex, strongly arched near middle of jaw; lateral teeth not usually fully concealed by lobes of nasal curtain. Teeth of adult male holotype small, moderately unicuspid on subcircular bases; arranged in conspicuous parallel longitudinal rows; cusps of medial teeth moderately elongate, slender, pointed; directed posteromedially to posterolaterally in



Figure 3. Dorsal head of *Leucoraja pristispina* sp. nov., adult male holotype (CSIRO CA 3905, 362 mm TL), showing snout, orbito-spiracular and nuchal regions.

upper jaw, directed more posteriorly toward angle of jaw; cusps of lateral teeth shorter; teeth of female and juvenile paratypes in quincunx, medial teeth with broad rhomboidal crowns, short cusps, and lateral teeth without cusps.

Pelvic fins bilobed; anterior lobe very short, slender, depressed, narrowly rounded distally, anterior margin entire, posterior margin incised; posterior lobe moderately elongate, not longer in males (length 17.4–20.2% TL) than in females (length 17.7–19.8% TL), outer margins convex, inner margin concave to convex, connected to lateral margin of clasper at 38–46% of its postcloacal length; anterior lobe 0.61 (0.66–0.70) times posterior lobe. Clasper moderately elongate, 22–24% TL, robust, depressed, glans only slightly expanded (greatly expanded when clasper everted); components include proximal slit, cleft, promontory, roll, rhipidion, sentinel, spike, shield and eperon; spur, denticles and pseudosiphon absent. Tail relatively broad based, moderately depressed, tapering evenly to tail tip, midlength narrow; width at insertions of pelvic fins 2.01 (2.04–2.30) times width at midlength of tail and 2.71 (2.85–3.28) times width at first dorsal-fin origin respectively; length from rear of cloaca 1.06 (0.95–1.13) times distance from tip of snout to rear of cloaca; anterior cross-section not or only slightly more convex dorsally than ventrally, much more strongly

convex on dorsal surface than ventral surface posteriorly (weakly convex beyond dorsal fins); width 1.52 (1.46–1.78) times height at insertion of pelvic fin, 1.84 (1.69–1.91) times height at midlength, 1.91 (1.73–1.89) times height at first dorsal fin origin; lateral tail fold poorly developed, narrow, short based, originating near middle of tail, extending almost to tail tip, slightly broader below dorsal fins, situated on ventrolateral surface of tail (partly overhung by its lateral margin). Dorsal fins narrowly suboval, small, first dorsal-fin height 1.82 (1.78–2.55) in base length; subequal in size and similar in shape; very strongly raked with short bases; anterior margins long, convex, apices broadly rounded; posterior margins and inner margins usually united (almost membranous), margins usually directed posterodorsally; interdorsal distance very short or fins connected near their bases; distance from first dorsal-fin origin to tail tip 2.67 (2.12–2.56) times dorsal-fin base length, 4.19 (5.15–9.20) times caudal-fin length; first dorsal-fin base 1.57 (2.01–4.33) times caudal-fin length; primary juvenile paratype with fins separated slightly, subequal in size. Epichordal caudal-fin lobe short and low; usually truncate to pointed distally, its dorsal margin straight to convex; connected to base (or slightly above) of second dorsal fin; hypochordal caudal lobe minute, rudimentary.

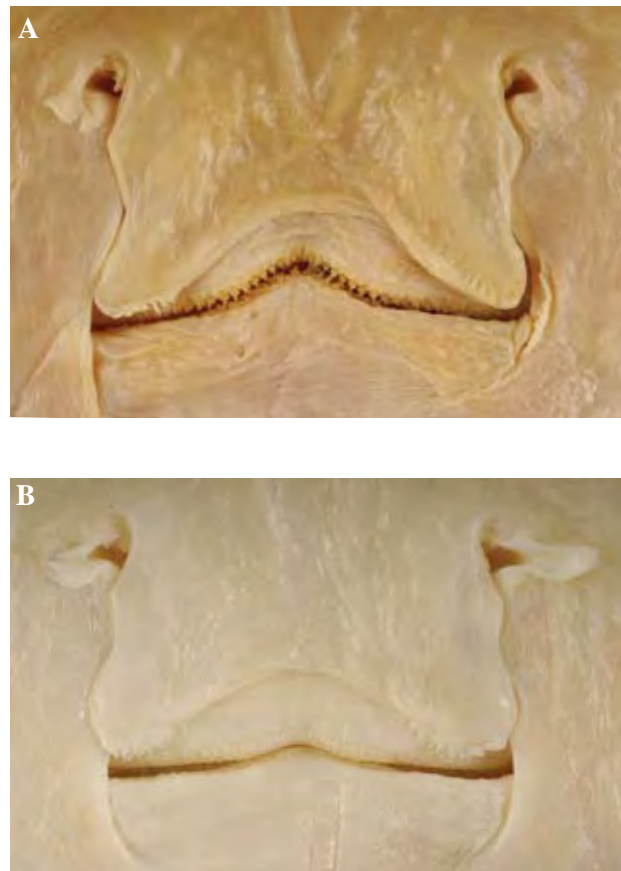


Figure 4. Ventral view of *Leucoraja pristispina* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO CA 3905, 362 mm TL); B, primary female paratype (CSIRO H 6420–05, 351 mm TL).

Dorsal surface of adult male holotype moderately spiny, with small rostral, orbital, interorbital, nuchal, scapular, mid-dorsal, malar, and alar thorns on disc, and multiple rows of tail thorns (thorns variably developed in paratypes, strong ontogenetic relationship, generally more spiny in large individuals). Orbital thorns of holotype and male paratypes forming a dense semicircular rosette, in clusters on preorbit and postorbital region (clusters with both thornlets and larger thorns, best defined in largest individuals); about 12–14 (5–6 on preorbit, 2 on midorbit, 5–6 on postorbit; number variable in paratypes) main thorns; first thorn well forward of eye, last thorn beside posterior margin of spiracle; similar size thorns scattered over interorbit; thorns subequal in size, with thick bases and slender cusps, mostly directed posteriorly, recurved. Orbital thorns of female paratypes also forming a dense rosette, clustered anteriorly and posteriorly; in primary female paratype, with about 17–20 (8–12 on preorbit, 2 on midorbit, 6–7 on postorbit) main thorns (slightly less dense than holotype on interorbit and barely detectable in specimens <270 mm TL); primary juvenile paratype with 5 (2 on preorbit, absent on midorbit, 3 on postorbit) main thorns. Rostral thorns situated along lateral margins and near tip of rostral cartilage, with about 12 main thorns and additional smaller thornlets (about 8 in primary female paratype); thorns undeveloped in juveniles. Nuchal and scapular thorns amalgamated into a dense, triangular patch (width subequal to interspiracular width); thorns similar in form to those of orbit. Malar patch extensive, usually with more than 20 large thorns; extending posteriorly from tip of propterygium to level of spiracle. Alar patch extremely narrow and elongate (length only slightly less than prespiracular length), with about 21–22 erectile thorns in 2 (1–2 in adult male paratypes) longitudinal rows. Some parallel thorn rows on mid-disc in holotype united with dorsolateral rows of tail (usually united in male paratypes). Tail thorns in multiple rows. Median tail row continuous, shorter and less well developed than dorsolateral rows, extending forward to just in advance of pectoral-fin insertion (or more posteriorly); thorns mostly regularly spaced, shorter and with smaller bases than main thorns in dorsolateral rows; row poorly developed before dorsal fins. Dorsolateral tail rows 1–3 on each side, irregular, situated midway between median row and a row of much smaller thornlets along lateral margin of tail; some rows extending forward onto disc and almost reaching nucho-scapular patch; no interdorsal thorns. Female paratypes with multiple rows of tail thorns, usually continuous onto disc, sometimes in linear rows from nuchal region to first dorsal fin (with about 42 thorns in primary female paratype); thorns of median row distinctly smaller than those of adjacent rows; dorsolateral tail thorns posterior to pelvic-fin insertions of similar size (much smaller on posterior disc). Primary juvenile paratype with 4 enlarged thorns along nucho-scapular midline, an additional enlarged thorn on each shoulder; median row of thorns extending from scapular region to first dorsal fin in a single series of 38 thorns; tail thorns of similar shape, raked, pungent, equally spaced;

no dorsolateral or lateral thorns.

Denticles of adult male holotype variably developed and distributed dorsally, from granular to enlarged as thornlets; naked ventrally; granular patches on suborbit, dorsal and caudal fins, and in band along midline of disc and tail; patches of much larger, more widely spaced thornlets on preorbital snout and along outer mid-anterior margins to apex of disc (merging with malar and alar thorns); mid-posterior disc, pelvic fins, and clasper largely naked (or with sparse submerged denticles and thornlets); orbital membranes with granular denticles. Primary female paratype with fine granular denticles uniformly covering disc, also present on basal half of posterior lobe of pelvic fin (but absent from rest of fin); dorsal, lateral and ventrolateral surfaces of tail and all fins granular; thornlets extensive over all of snout, and in a broad band (and more enlarged) along anterior disc margin to disc apex; similar patches of thornlets on posterior disc beside its insertion; ventral surface naked. Primary juvenile paratype almost entirely covered dorsally with fine denticles (absent from anterior pelvic-fin lobe); naked ventrally.

Meristics (n=13): Tooth rows in upper jaw 54 (47–55); lower jaw 52 (43–55). Pectoral-fin propterygial radials 26–27 (26–30); mesopterygial radials 9 (7–11); metapterygial radials 26 (24–27); total radials 61–62 (61–64). Pelvic-fin radials males (n=8) 1 (1) + 18 (18–21); females (n=5) 1 (1) + (20–22). Trunk centra 26 (26–28); predorsal caudal centra 59 (59–64); predorsal centra 85 (87–91); centra between origins of dorsal fins 11 (10–13); diplospondylous centra about 96 (95–100); total centra about 122 (121–127).

COLOUR (in preservative).— Dorsal surface of disc, pelvic fins, claspers and tail of holotype mainly uniform greyish brown (probably becoming brownish from preservation); marginally paler on anterior snout and along posterior margins of pectoral and pelvic fins; thorns pale yellowish white (distinct); dorsal fins dusky basally, margins blackish; epichordal lobe dusky, posterior tip usually black; orbital membrane pale translucent, eye dark; ventral surface of disc uniformly pale yellow to translucent, tail and claspers white; no black-edged pores. Primary female paratype slate grey (with only a short period of preservation) on dorsal disc, paler greyish white on anterior snout and along posterior margins of pectoral and pelvic fins; pelvic fins slightly darker grey basally, whitish along fin margins; dorsal tail mostly greyish, posterior edges and skin fold white; dorsal fins dusky basally, margins blackish; epichordal lobe dusky, posterior tip black; ventral surface of disc, pelvic fins, and tail uniformly whitish. Primary juvenile paratype uniform pale yellowish dorsally, paler semi-translucent around disc margin and beside rostral cartilage; dorsal fins pale basally, black distally; epichordal lobe whitish; ventral surface of disc pale, semi-translucent; tail yellowish white. When fresh: Dorsal surface almost uniformly pale greyish; greyish midsection of tail strongly contrasted



Figure 5. Lateral view of dorsal and caudal fins of *Leucoraja pristispina* sp. nov., adult male holotype (CSIRO CA 3905, 362 mm TL).

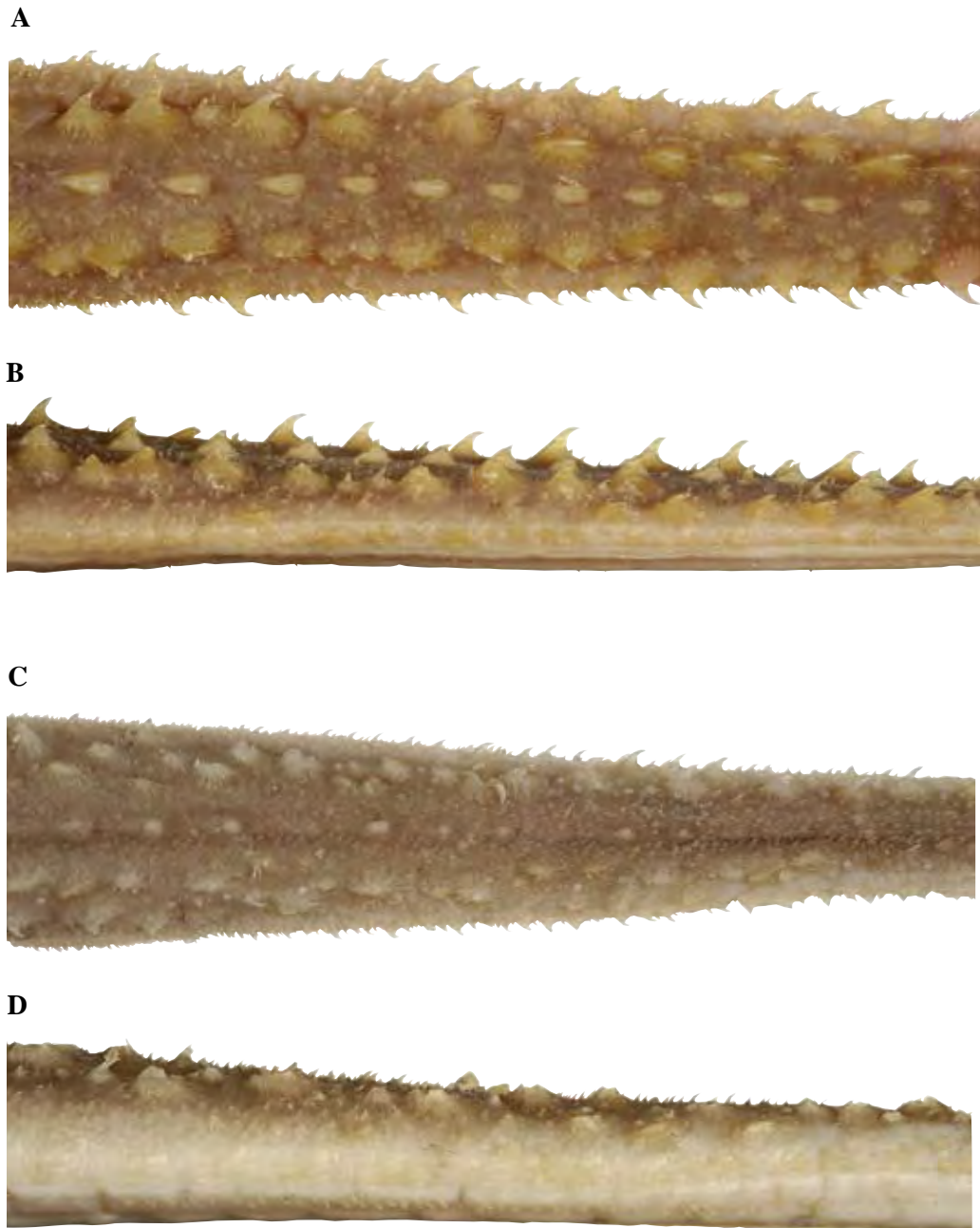


Figure 6. Thorns at tail midlength of *Leucoraja pristispina* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO CA 3905, 362 mm TL); C, dorsal and D, lateral view of primary female paratype (CSIRO H 6420-05, 351 mm TL).

with white lateral margins of tail, slightly paler around disc margin, tips of anterior pelvic-fin lobes and anterior margins of posterior pelvic-fin lobe; dorsal fins dusky basally with blackish outer margins; white to semi-translucent ventrally.

SIZE.— Largest specimen an adult male 401 mm TL, largest female 378 mm TL; adolescent males ranged from 326–341 mm TL, adult males 348–401 mm TL; smallest juvenile a neonate 94 mm TL.

DISTRIBUTION.— Known from the continental slope off Western Australia from off the Dampier Archipelago (18°58' S, 116°01' E) to the Ashmore Terrace (13°25' S, 122°54' E) in depths of 308–504 m. A single specimen was collected further south off Shoal Point (28°06' S, 113°15' E) in 202–213 m.

ETYMOLOGY.— Combination of the Greek *pristis* (meaning saw) and the Latin *spina* (meaning thorn or backbone) in allusion to the rows of thorns on the midline of the disc and tail. Vernacular name: Sawback Skate.

REMARKS.— *Leucoraja pristispina* occurs well outside the primary range of its congeners which occur in the central western Atlantic, and in the eastern Atlantic through to the south-west Indian Ocean. It conforms to current definitions of *Leucoraja* (McEachran & Dunn, 1998), including most aspects of its clasper morphology except the clasper glans is not expanded and a pseudosiphon is absent. *Leucoraja pristispina* differs from all other species of the genus by a combination of disc shape, relative snout length, tail length and thickness, coloration, clasper size and shape, and in meristics. Only *L. fullonica*, *L. pristispina* and *L. compagno* from the southeastern Atlantic (off South Africa), have a plain coloured dorsal disc. Other species of *Leucoraja* have a dorsal disc with spotted or ocellated patterns or markings. Stehmann's type of *L. compagno*, which is based on a juvenile female of 292 mm TL, has a more pointed snout, larger midline thorns than in juvenile *L. pristispina*, fewer tooth rows (38 in the upper jaw vs. 47–55 in *L. pristispina*), and the dorsal disc is largely devoid of denticles (rather than having fine granular denticles uniformly covering the disc). *Leucoraja wallacei* also occurs off South Africa and has a distribution extending into the southwestern extremity of the Indian Ocean (Compagno *et al.*, 1989). It is a distinctive skate with clusters of bright yellow spots, higher tooth row counts than *L. pristispina* (59–69 vs. 47–55 in the upper jaw), separated dorsal fins (rather than mostly confluent), and it has denticles on the anteroventral margin of the disc (otherwise naked).

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in the quest for deepwater crustacean resources (i.e. prawns and scampi). We thank various scientists, crew and seagoing staff, particularly of the CSIRO research vessel, the FRV *Soela*, who were involved in collecting most of the types. We thank William White for his scientific input and helping to arrange this document. Thanks also to Alastair Graham for assembling data on Australian material, Louise Conboy for preparing images of the types, John Pogonoski for preparing radiographs, checking meristic information and editorial comments, and Dan Gledhill for helping with the morphometrics.

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New deepwater skates of the genus *Notoraja* (Rajoidei: Arhynchobatidae) from southern Australia and the eastern Indian Ocean

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ABSTRACT.— Three new skates of the genus *Notoraja* are described from material collected from southern Australia and the eastern Indian Ocean. *Notoraja azurea* sp. nov. occurs widely off southern Australia, *N. sticta* sp. nov. in the Great Australian Bight, and *N. lira* sp. nov. on the Broken Ridge, in the southeastern Indian Ocean. These species are similar in general appearance to each other and to three other *Notoraja* species that occur in the western Pacific and eastern Indian oceans, but differ mainly in a combination of disc width, snout and tail lengths, distribution of denticles and thorns, meristic features, and colour.

Key words. Arhynchobatidae – skates – new species – southern Australia – eastern Indian Ocean – *Notoraja*

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INTRODUCTION

The arhynchobatid genus *Notoraja* Ishiyama, 1958 was resurrected by Stehmann (1989) and comprises three valid nominal species, *N. tobitukai* (Hiyama, 1940) from Japan, *N. ochroderma* McEachran & Last, 1994 from northeastern Australia, and *N. hirticauda* Last & McEachran, 2006 from Western Australia. Two closely related species, *Insentiraja subtilispinosa* (Stehmann, 1989) from the Philippines and Indonesia and *I. laxipella* (Yearsley & Last, 1992) from northeastern Australia, initially assigned to the genus *Notoraja* (McEachran & Last, 1994; Compagno, 1999; Hoese *et al.*, 2006) have been provisionally reassigned to the genus *Insentiraja* (Compagno *et al.*, 2005; Last, unpubl. data) based in part on their relatively longer and more acute snouts, relatively large fleshy processes at the snout tip, more expanded nasal capsules, and dense covering of fine dermal denticles on ventral surface of the tail (Stehmann, 1989; Yearsley & Last, 1992). Members of the arhynchobatid genus *Brochiraja* (Last & McEachran, 2006), comprising 6 New Zealand species, also closely resemble species of *Notoraja* but possesses a unique bifurcated thorn on the anterior half of the rostrum (possibly absent in *B. aenigma*).

During a recent investigation of the Australian chondrichthyan fauna (Last & Stevens, 1994), 4 unidentified skate species belonging to the genus *Notoraja* were identified (i.e. *N. sp. A*, *B*, *C* and *D*) but were not formally named. Two of these species have since been described, i.e. *N. sp. B* as *N. ochroderma* and *N. sp. C*

as *N. hirticauda*. The remaining undescribed species of *Notoraja* (i.e. *N. sp. A* and *N. sp. D*) are described and figured below, together with a third species known from only a single specimen collected on Broken Ridge in the southeastern Indian Ocean.

METHODS

The descriptive format is based on McEachran & Fecchhelm (1982). Methods follow those outlined in the first paper of this special publication (Last *et al.*, 2008) and generally follow standards used for skates. However, note that in this study the measurement ‘pelvic-fin width’ was taken as the maximum width (rather than the distance between the points of articulation of the anterior pelvic-fin lobe). Main material of the 3 new species (i.e. *Notoraja azurea*, *N. lira* and *N. sticta*) is listed below. It includes the holotype and primary descriptive types (female and juvenile), as well as specimens from which meristic and/or morphometric information were obtained. Collection acronyms follow Leviton *et al.* (1985).

Notoraja azurea: holotype (CSIRO H 170–01); 5 morphometric and meristic paratypes (CSIRO H 162–01, CSIRO H 165–01, CSIRO H 167–01, CSIRO H 550–06 and CSIRO H 550–07).

Notoraja lira: holotype (CSIRO H 3174–08).

Notoraja sticta: holotype (CSIRO H 2954–01); 5 morphometric and meristic paratypes (AMS I 44550–001, CSIRO H 2227–01, CSIRO H 2955–01, CSIRO H 2957–01 and SAMA F 6833).

Notoraja azurea sp. nov.

Figs 1–6; Table 1

Notoraja sp. A: Last & Stevens, 1994: pp 304, 309–310, fig. 34.4, key fig. 35, pl. 50.

Holotype. CSIRO H 170–01, adult male 621 mm TL, east of Seymour, Tasmania, 41°43' S, 148°38' E, 877–950 m, 27 Jul 1982.

Paratypes. 10 specimens. CSIRO H 162–01, adult male 535 mm TL, CSIRO H 163–01, juvenile male 203 mm TL, west of Granville Harbour, Tasmania, 41°52' S, 144°28' E, 963–1100 m, 24 Jun 1983; CSIRO H 165–01, female 230 mm TL, east of Seymour, Tasmania, 41°43' S, 148°38' E, 877–950 m, 27 Jul 1982; CSIRO H 166–01, female 429 mm TL, south-west of King Island, Tasmania, 40°47' S, 143°32' E, 920–927 m, 16 Dec 1981; CSIRO H 167–01, adult male 537 mm TL, south-west of King Island, Tasmania, 40°37' S, 143°24' E, 930–935 m, 13 Oct 1983; CSIRO H 550–06, female 540 mm TL, CSIRO H 550–07, female 489 mm TL, west of Cape Sorell, Tasmania, 42°18' S, 144°39' E, 1120–1220 m, 17 May 1986; CSIRO H 622–05, female 226 mm TL, CSIRO H 622–07, juvenile male 357 mm TL, north-west of Kenneth Bay, Tasmania, 41°17' S, 144°02' E, 900–920 m, 14 May 1986; CSIRO H 1256–01, female 603 mm TL, east of Saint Patricks Head, Tasmania, 41°35' S, 148°41' E, 905–915 m, 02 Apr 1988.

Other material. 3 specimens. CSIRO H 789–08, juvenile male 193 mm TL, west of Nelson Bay, Tasmania, 40°58' S, 143°45' E, 820–872 m, 15 May 1986; CSIRO H 943–01, juvenile male 538 mm TL, east of St Marys, Tasmania, 41°38' S, 148°49' E, 1400–1440 m, 11 July 1986; CSIRO H 6409–01, female 645 mm TL, east of Saint Patricks Head, Tasmania, 41°51' S, 148°47' E, 1100–1200 m, 04 Aug 2006.

DIAGNOSIS.— A moderately large species of *Notoraja* with the following combination of characters: disc width 52.2–57.0% of TL; preorbital snout length 11.1–14.5% TL; pre-upper jaw length 12.0–14.2% TL; tail length from posterior margin of cloaca to tip of tail 56.3–61.7% TL; dorsal surface of disc largely free of dermal denticles and ventral surface of tail naked; thorns absent on rostrum; anterior half of tail with two main, irregular rows of thorns on dorsolateral aspect; oronasal pits absent; tooth rows number 32–43 in upper jaw and 32–39 in lower jaw; pectoral-fin radials number 66–69; trunk centra 25–27; predorsal caudal centra 76–80; rostral appendices about 71.2% of nasobasal length, subconical in cross section posteriorly and connected to rostral shaft at node; scapulocoracoid elongate and with slender and narrow anterior bridge; dorsal surface greyish blue, darker greyish brown ventrally.

DESCRIPTION.— Disc heart-shaped, 1.09 times as broad as long in holotype (1.12–1.18 times in paratypes); angle in front of spiracles 84–85° in adult males, 108–

109° in females, and 112° in juvenile female; anterior margin concave on either side of tip of snout, convex from anterior extension of propterygium to anterior margin of orbit, concave to level of spiracle, outer corner broadly rounded, and posterolateral margin moderately convex in males (Fig. 1); anterior margin slightly convex on either side of tip of snout, outer corners broadly rounded, and posterolateral margin moderately convex in females (Fig. 2). Axis of greatest width 58.4% (56.2–59.9% and 47.8–58.61% in male and female paratypes, respectively) of disc length. Snout tip with prominent long, fleshy and flattened process (Fig. 3). Preorbital snout length 4.02 (3.95–4.34 and 3.19–3.79) times orbit diameter, 5.38 (5.46–5.66 and 4.54–4.80) times interorbit width; pre-upper jaw length 2.36 (2.00–2.27 and 2.03–2.18) times internarial distance. Orbit diameter 1.34 (1.26–1.43 and 1.20–1.43) times interorbital width, and 1.83 (1.51–2.00 times and 0.92–2.04) times length of spiracles. Lateral nasal fold laterally expanded and rounded, with weak triangular process along lateral margin, posterior margin smooth (Fig. 4). Inner nasal fold (nasal curtain) well developed, broadly rounded and coarsely fringed along posterior margin. Upper and lower jaws slightly arched on either side of symphysis; upper jaw of males slightly indented at symphysis (not indented in female paratypes). Teeth with acutely pointed cusps and arranged in diagonal rows in mature males, and plate-like with short cusps and arranged quincuncially in females. Distance between first gill slits 1.58 (1.53–1.65 and 1.64–1.86) times as great as between nostrils; distance between fifth gill slits 1.01 (1.01–1.07 and 1.14–1.20) times as great as between nostrils.

Pelvic fins deeply incised with lobes connected by radials and membranes, anterior lobe moderately long, moderately narrow at base and tapering to blunt point; posterior lobe with convex lateral margins; anterior lobe 89.0% (81.2–83.8% and 96.9–100.7%) of posterior lobe. Tail narrow at base, depressed over length, slightly convex ventrally, and tapering gradually posteriorly, very slender toward tip; width at axils of pelvic fins 2.68 (2.03–2.61 and 2.14–2.65) times width at midlength of tail and 4.58 (3.37–5.30 and 3.65–4.78) times width at dorsal fin origin respectively; length from rear of cloaca 1.39 (1.29 and 1.37–1.61) times distance from tip of snout to rear of cloaca; width 1.67 (1.15–1.43 and 1.39–1.78) times height at axils of pelvic fin and width at first dorsal-fin origin 1.36 (1.25–1.46 and 1.29–2.13) times height; lateral tail folds originating anterior to tips of posterior pelvic-fin lobes, extending to distal half to distal fourth of epichordal caudal-fin lobe and broadening distally to slightly narrower than height of epichordal lobe of caudal fin. Dorsal fins of similar shape and size; rather short and moderately tall with evenly convex anterior margin, straight or slightly convex posterior margin and a pointed or acutely rounded tip; generally separated by short or moderate interspace, 1.25 (1.46–14.37 and 1.38–4.17) in length of first dorsal-fin base (Fig. 5). Epichordal caudal-fin lobe well developed, separated by short interspace

A



B



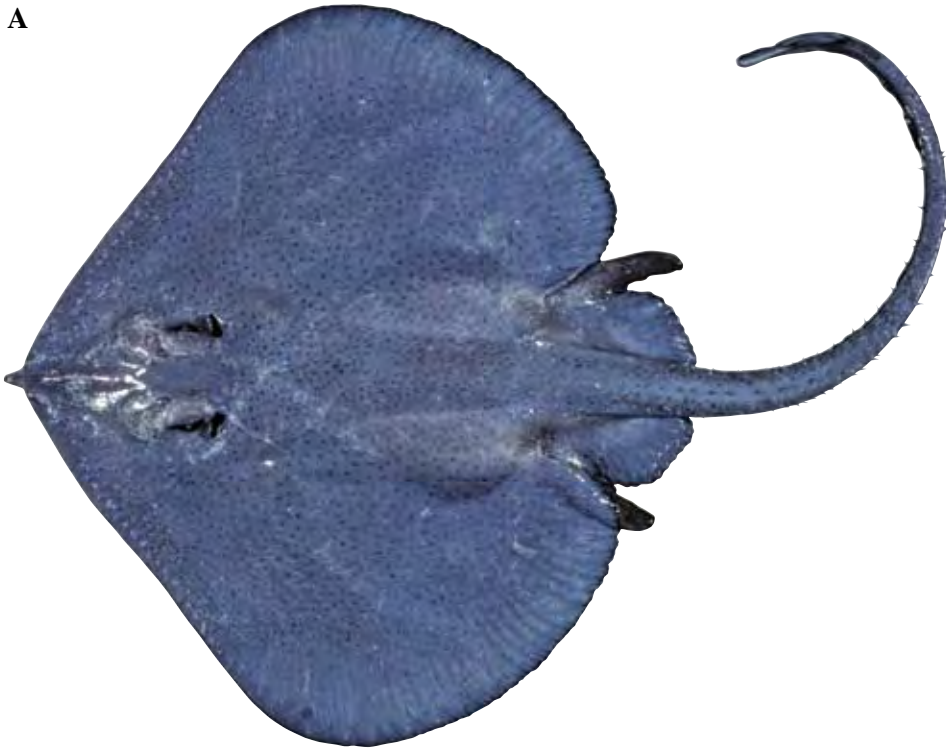
Figure 1. *Notoraja azurea* sp. nov., adult male holotype (CSIRO H 170–01, 621 mm TL, preserved): A, dorsal surface; B, ventral surface.

from and distinctly longer than second dorsal-fin base; hypochordal caudal lobe very low, originating near end of lateral fold, not confluent with epichordal lobe.

Adult specimens largely free of dermal denticles except along margin of disc at level of orbit and spiracles and along middle of disc. Juvenile specimen with denticles along anterior margin of disc, cranium, and along middle of disc. Holotype with single preorbital and postorbital thorns, single spiracular thorn on left side only, malar

thorns on head from just anterior of nasal capsules to mid orbit and on antero-medial half of pectoral fins, rectilinear patch of alar thorns on outer fourth of midlength of disc; 2 irregular rows of thorns on either side of midline of tail, and 1 row of thorns along midline of posterior half of tail. Malar thorns small, slightly larger than dermal denticles, with very broad bases, and erect and moderately recurved crowns. Alar thorns posteromedially oriented, with very elongated bases, oblique slightly recurved crowns and exposed on integument. Holotype with 7 irregular rows

A



B

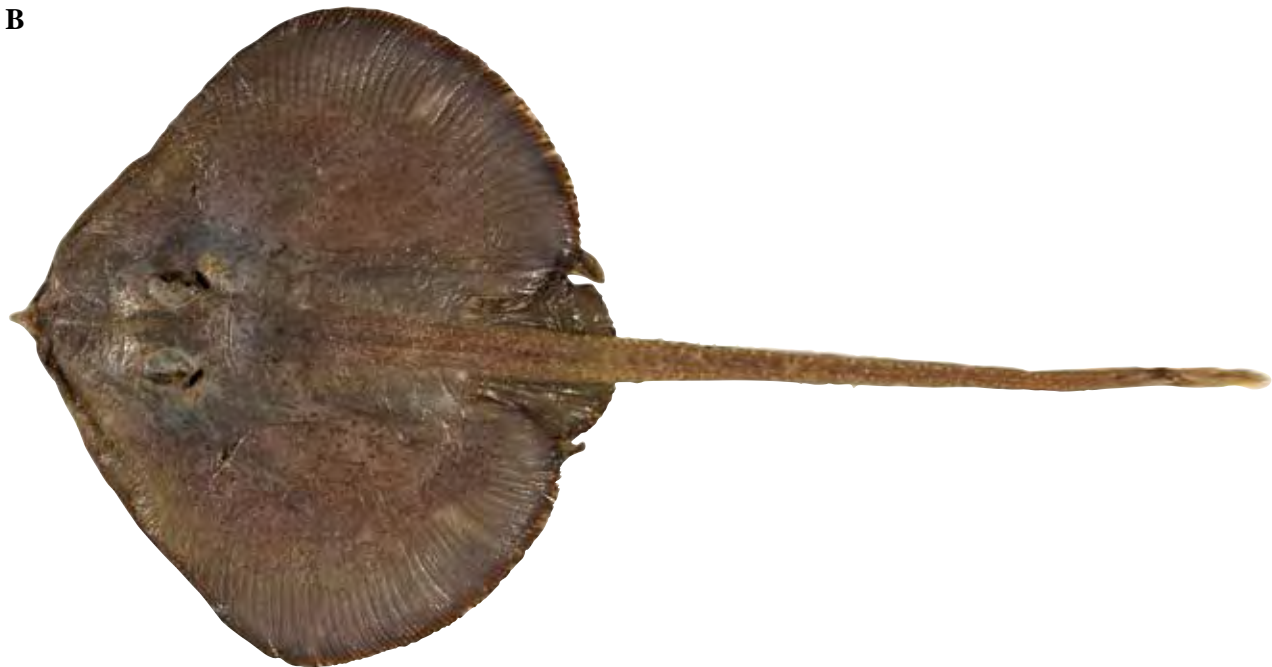


Figure 2. Dorsal surface of *Notoraja azurea* sp. nov.: A, female paratype (CSIRO H 1256–01, 603 mm TL, fresh); B, juvenile paratype (CSIRO H 165–01, female 230 mm TL, preserved).



Figure 3. Dorsal head of *Notoraja azurea* sp. nov., adult male holotype (CSIRO H 170–01, 621 mm TL), showing snout, orbito-spiracular and nuchal regions.

of alar thorns, paratype with 5. Tail thorns moderately compressed, with broad oval bases and erect, moderately recurved crowns (Fig. 6).

Rostral appendices largely free of rostral cartilage, elongate, flattened anteriorly and subconical in cross section distally; rostral cartilage very slender and uncalcified distally; precerebral fontanelle narrow to moderately narrow and extending onto rostral cartilage distinctly anterior to leading edge of nasal capsules; nasal capsules broad and oval, with basal fenestrae; internasal plate narrow; preorbital processes poorly developed to degenerate and not continuous with supraorbital crest; scapulocoracoid with slender and narrow anterior bridge, distance between pro- and mesocondyles less than distance between meso- and metacondyles, with two postventral foramina; scapular process slightly higher than dorsal margin of scapula; propterygium of pectoral girdle reaching rostral node; lateral prepelvic processes of pelvic girdle short.

Claspers very slender, glans depressed but little expanded, with components slit, cleft, pseudorhipidion, pela, projection, and spike; pela extends from hypopyle on ventral side of clasper groove, turns abruptly laterally and runs along outer surface of projection; projection

curved laterally and extending to near tip of clasper, with sharp pointed tip; spike disc-shaped with sharp, naked lateral and distal margins, ventral to projection and covered by sentina; clasper skeleton with dorsal marginal, two dorsal terminal; ventral marginal, ventral terminal, and accessory terminal 2 cartilages; dorsal terminal 1 cartilage band-shaped and extending from ventral medial to dorsal medial aspect of glans; dorsal marginal cartilage with distal extension forming pseudorhipidion, dorsal terminal 2 cartilage medially attached to distal margin of dorsal marginal cartilage and side of axial cartilage, distally separate and connected to tip of axial cartilage by connective tissue, terminal bridge lacking; ventral marginal cartilage fused with accessory terminal 1 cartilage to form projection, projection gently curved laterally and terminating as acute tip; ventral terminal cartilage ladle-shaped with pointed medial process, forming eperon and antero-medial process, articulating with ventral marginal cartilage; accessory terminal 2 cartilage attached to margin of ventral marginal cartilage and with disc-shaped distal process forming spike.

Meristics (n=6): Tooth rows in upper jaw 38 (32–43 in paratypes); lower jaw 37 (32–39). Pectoral-fin

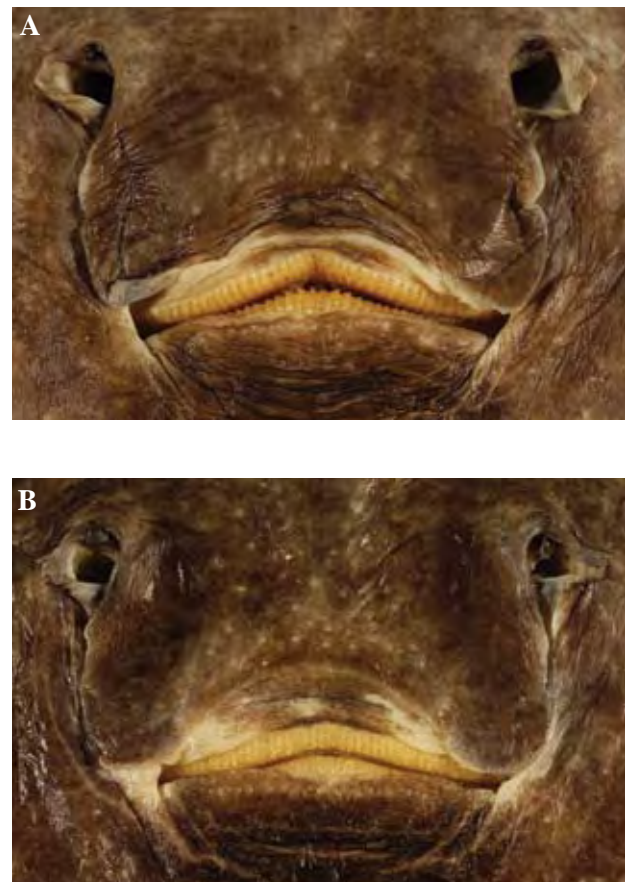


Figure 4. Ventral view of *Notoraja azurea* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 170–01, 621 mm TL); B, female paratype (CSIRO H 1256–01, 603 mm TL).



Figure 5. Lateral view of dorsal and caudal fins of *Notoraja azurea* sp. nov., adult male holotype (CSIRO H 170–01, 621 mm TL).

A



B



C



D



Figure 6. Thorns at tail midlength of *Notoraja azurea* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 170–01, 621 mm TL); C, dorsal and D, lateral view of female paratype (CSIRO H 1256–01, 603 mm TL).

propterygial radials 30 (29–32); mesopterygial radials 13 (10–13); metapterygial radials 26 (24–26); total radials 69 (66–69). Pelvic-fin radials males (n=3) 1 (1) + 17 (16–17); females (n=3) (1) + (17–19). Trunk 26 (25–27); predorsal caudal centra 80 (76–79); total predorsal centra 106 (103–104); centra between origins of dorsal fins 8 (7–8); diplospondylous centra 111 (107–110); total centra about 137 (133–136).

COLOUR (in preservative).— Dorsal surface pale greyish blue, often freckled with small slightly darker spots; tip of snout often paler; anterior pelvic-fin lobe dark greyish or black; clasper bluish, often white distally. Ventral surface dark greyish brown, slightly darker on chin; a darker longitudinal bar on each side of nasal curtain, bluish black around posterior disc margin; outline of nostrils, mouth, gill slits, tips of anterior pelvic-fin lobes and cloaca usually pale; clasper and ventral tail dark bluish grey; ampular pores and canals pale or white; paratype CSIRO H 1256–01 distinctly darker blue on dorsal surface.

SIZE.— Reaches at least 645 mm TL; smallest mature male 535 mm TL; smallest juvenile 193 mm TL.

DISTRIBUTION.— Reported by Last & Stevens (1994) from the Solitary Islands, New South Wales (ca. 30° S, 153° E), to Perth, Western Australia (ca. 32° S, 116° E) in 840–1120 m. Material examined from Tasmanian waters in depths of 765–1440 m.

ETYMOLOGY.— Derived from the French *azura* (blue colour) with reference to its striking, metallic blue dorsal coloration. Vernacular name: Blue Skate.

REMARKS.— *Notoraja azurea* is distinguished from the other species of the genus by a combination of its disc width, preorbital snout length, tail length, denticle and thorn patterns, numbers of tooth rows, pectoral-fin radials and vertebral centra, shape of rostral appendices, and colour pattern. It has a relatively narrower disc than another new species treated herein (52.2–57.0 vs. 55.2–62.5% TL in *N. sticta*), and a broader disc than *N. hirticauda* and *N. tobitukai* (47.3–51.3% TL); slightly longer preorbital snout length than *N. ochroderma* (11.1–14.5 vs. 11.4–12.5% TL); slightly longer tail than both other new species treated herein (56.3–61.7 vs. 54.3–58.2% in *N. lira* and *N. sticta*). Unlike *N. hirticauda*, *N. ochroderma*, and *N. tobitukai*, the dorsal surface of the disc is largely free of dermal denticles (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Unlike *N. hirticauda* and *N. tobitukai* the tail lacks multiple rows of bristle-like enlarged dermal denticles or small thorns on dorsal and ventral surfaces (Stehmann, 1989; Last & McEachran, 2006). *Notoraja azurea* has fewer tooth rows than *N. ochroderma* (32–43 vs. 44–49); has fewer pectoral-fin radials than *N. ochroderma* (66–69 vs. 79–84), but more than *N. hirticauda* (61–66); fewer trunk centra than *N. ochroderma* (25–27 vs. 30–32);

fewer predorsal caudal centra than *N. ochroderma* (76–80 vs. 87–89) but more than *N. sticta* and *N. tobitukai* (66–74) (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Posterior sections of rostral appendices are subconical as in *N. hirticauda*, *N. lira* and *N. sticta* (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Like the other species of *Notoraja*, except *N. hirticauda* and *N. ochroderma*, *Notoraja azurea* is darkly pigmented on both sides of its body. However, unlike other darkly pigmented species, it is pale greyish blue and often freckled with small slightly darker spots dorsally, and has light to white ampular poles and canals ventrally (Ishiyama, 1967; McEachran & Last 1994; Last & McEachran, 2006).

Dorsal and ventral coloration varies geographically so type material was selected from the same general region (i.e. off Tasmania). Specimens from New South Wales are consistently darker blue in dorsal coloration.

Notoraja lira sp. nov.

Figs 7–11; Table 1

Holotype. CSIRO H 3174–08, juvenile male 415 mm TL, Broken Ridge, Indian Ocean, 31°36' S, 95°02' E, 1050 m, 30 June 1992.

DIAGNOSIS.— A moderately large species of *Notoraja* with the following combination of characters: disc width 56.9% TL; preorbital snout length 15.4% TL; pre-upper jaw length 16.3% TL; tail length from posterior margin of cloaca to tip 54.3% TL; dorsal surface of disc largely free of dermal denticles; thorns absent on snout; regular row of thorns along midline of tail and two irregular rows of thorns on dorsolateral aspect of tail; ventral surface of tail naked; oronasal pits absent; tooth rows 36 in upper jaw and 33 in lower jaw; pectoral-fin radials 62–63; trunk centra 24; predorsal caudal vertebral centra 70; rostral appendices about 94.0% of nasobasal length, subconical in cross section posteriorly and connected to rostral shaft at node; pale bluish with white areas dorsally and ventrally.

DESCRIPTION.— Disc heart-shaped, 1.08 times as broad as long; angle in front of spiracles 92°; anterior margin slightly convex on either side of tip of snout to anterior extension of propterygia, slightly convex to level of orbits, slightly concave to level of spiracles, outer corners broadly rounded, and posterolateral margin slightly convex (Fig. 7). Axis of greatest width 58.8% of disc length. Snout tip with prominent long, narrow, fleshy, and flattened process (Fig. 8). Preorbital snout length 4.20 times orbit diameter, 4.95 times interorbit width; pre-upper jaw length 2.44 times internarial distance. Orbit diameter 1.18 times interorbital width, and 2.30 times length of spiracles. Lateral nasal fold laterally expanded and rounded, with weak triangular

A



B

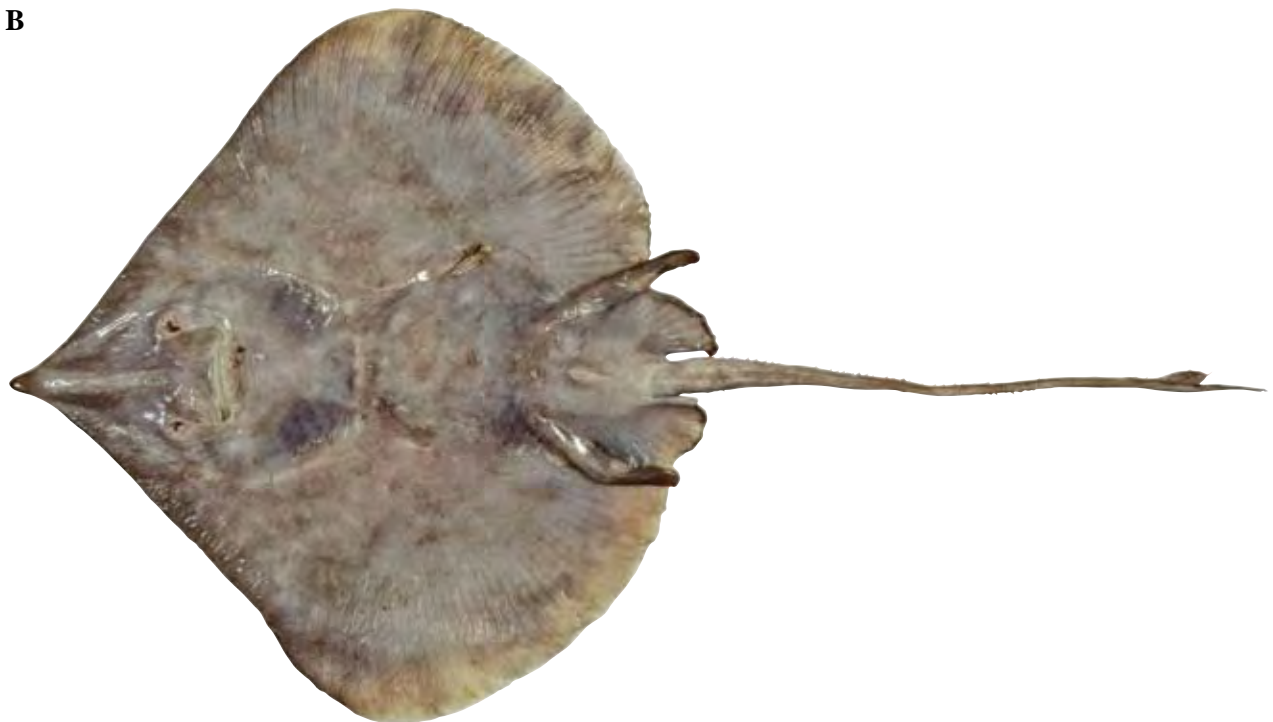


Figure 7. *Notoraja lira* sp. nov., juvenile male holotype (CSIRO H 3174-08, 415 mm TL, fresh): A, dorsal surface; B, ventral surface.



Figure 8. Dorsal head of *Notoraja lira* sp. nov., juvenile male holotype (CSIRO H 3174–08, 415 mm TL), showing snout, orbito–spiracular and nuchal regions.

process along lateral margin, posterior margin smooth (Fig. 9). Inner nasal flap (nasal curtain), well developed, broadly rounded, and coarsely fringed along posterior margin, with broad triangular process on antero-lateral margin. Upper and lower jaws slightly arched on either side of symphysis. Teeth plate-like with short cusps and arranged quincuncially. Distance between first gill slits 1.73 times as great as between nostrils; distance between fifth gill slits 1.10 times as great as between nostrils.

Pelvic fins deeply incised with lobes connected by radials and membranes, anterior lobe long, narrow at base and tapering to blunt point; posterior lobe with convex lateral margins; anterior lobe 97.1% of posterior lobe. Tail narrow at base, extremely slender; slightly depressed over length, convex ventrally, tapering posteriorly (posterior section of tail slightly desiccated); width at axil of pelvic fins about 4 times width at midlength and about 5.5 times width at dorsal fin origin respectively; length from rear of cloaca 1.19 times distance from tip of snout to rear of cloaca; width 1.77 times height at axils of pelvic fins, and width 1.11 times height at first dorsal-fin origin; lateral tail folds originating near mid tail length, extending to distal half to distal fourth of epichordal caudal-fin lobe and broadening distally to slightly narrower than height of epichordal lobe of caudal fin. Dorsal fins of similar shape and size; rather short and moderately tall

with evenly convex anterior margin, straight or slightly convex posterior margin and a pointed or acutely rounded tip; separated by short interspace, 3.22 in length of first dorsal-fin base (Fig. 10). Epichordal caudal-fin lobe well developed, separated by short interspace from and distinctly longer than second dorsal-fin base; hypochordal caudal lobe very low, originating near end of lateral fold, not confluent with epichordal lobe.

Dermal denticles occur in broad band along anterior margin of disc and on cranium. Single preorbital thorn located anterior to each orbit; complete row of thorns along midline of tail; 2 irregular rows of thorns along anterior third of tail and single irregular row along posterior two thirds of tail (Fig. 11). Median tail thorns moderately compressed, with oval bases and oblique, moderately recurved crowns; lateral tail thorns strongly oblique.

Rostral appendices largely free of rostral cartilage, elongate, flattened anteriorly and subconical in cross section posteriorly; rostral cartilage very slender and uncalcified distally; precerebral fontanelle narrow to moderately narrow and extending onto rostral cartilage distinctly anterior to leading edge of nasal capsules; nasal capsules broad and oval, with basal fenestrae; internasal plate narrow; preorbital processes poorly developed to degenerate and not continuous with supraorbital crest; scapulocoracoid with slender anterior bridge, distance between pro- and mesocondyles less than distance between meso- and metacondyles, with two postventral foramina; scapular process slightly higher than dorsal margin of scapula; propterygium of pectoral girdle reaching rostral node; lateral prepelvic processes of pelvic girdle short to moderately long.

Meristics (n=1): Tooth rows in upper jaw 36; lower jaw 33. Pectoral propterygial radials 26; mesopterygial radials 12; metapterygial radials 24–25; total radials 62–63. Pelvic-fin radials males (n=1) 1 + 17. Trunk centra



Figure 9. Ventral view of *Notoraja lira* sp. nov., juvenile male holotype (CSIRO H 3174–08, 415 mm TL), showing oronasal region and tooth band.



Figure 10. Lateral view of dorsal and caudal fins of *Notoraja lira* sp. nov., juvenile male holotype (CSIRO H 3174–08, 415 mm TL).

A



B



Figure 11. Thorns at tail midlength of *Notoraja lira* sp. nov., juvenile male holotype (CSIRO H 3174–08, 415 mm TL): A, dorsal view, B, lateral view.

24; predorsal caudal centra 70; total predorsal centra 94; centra between origins of dorsal fins 10; diplospondylous centra 114; total centra about 138.

COLOUR (in preservative).— Dorsal surface of disc and posterior pelvic-fin lobes semi-translucent, primarily pale blue with whitish areas around posterior margin of disc and at its apex; additional lighter areas around head and along midline of disc and tail; darker areas above abdomen and in branchial region; anterior pelvic-fin lobes greyish brown, darker than other parts of dorsal surface. Ventral surface similar to dorsal surface, mainly pale blue with paler areas around mouth, and on snout, anterior pelvic-fin lobes, posterior margin of disc, cloaca and tail.

SIZE.— Single juvenile male 415 mm TL.

DISTRIBUTION.— Southeastern sector of the Indian Ocean, from the Broken Ridge (31°36' S, 95°02' E) in 1050 m depth.

ETYMOLOGY.— Derived from the Latin *lira* (earth or ridge thrown up by a plough) in reference to its type locality, the Broken Ridge (SE Indian Ocean), which is an elevated plateau thrust upward at the juncture of two continental plates. Vernacular name: Broken Ridge Skate.

REMARKS.— *Notoraja lira* is distinguished from other species of the genus by a combination of its relative disc width, preorbital snout and tail lengths, denticle and thorn patterns, numbers of tooth rows, pectoral-fin radials and vertebral centra, shape of rostral appendices, and colour pattern. It has a relatively broader disc width than *N. azurea*, *N. hirticauda* and *N. tobitukai* (56.9% vs. 47.3–57.0% TL); slightly longer preorbital snout length than *N. azurea*, *N. hirticauda*, *N. ochroderma*, *N. sticta* and *N. tobitukai* (15.4% vs. 10.8–15.0% TL); shorter tail than *N. azurea*, *N. hirticauda*, *N. ochroderma*, *N. sticta* and *N. tobitukai* (54.3% vs. 54.9–61.7% TL) (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Unlike *N. hirticauda*, *N. ochroderma* and *N. tobitukai*, the dorsal surface of the disc is largely free of dermal denticles (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Unlike *N. hirticauda* and *N. tobitukai*, the tail lacks multiple rows of enlarged, bristle-like dermal denticles or small thorns on the dorsal and ventral surfaces (Ishiyama, 1967; Stehmann, 1989; Last & McEachran, 2006). *Notoraja lira* has fewer tooth rows in the upper jaw than *N. ochroderma* and *N. tobitukai* (36 vs. 43–49); has fewer pectoral-fin radials than *N. azurea*, *N. ochroderma*, *N. sticta* and *N. tobitukai* (62–63 vs. 65–84); fewer trunk centra than *N. ochroderma* (24 vs. 30–32); fewer predorsal caudal centra than *N. azurea* and *N. ochroderma* (70 vs. 76–89), but more than *N. tobitukai* (66) (Stehmann, 1989; McEachran &

Last, 1994; Last & McEachran, 2006). Posterior sections of the rostral appendices are subconical as in *N. azurea*, *N. hirticauda* and *N. sticta* (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Like the other species of *Notoraja*, except *N. hirticauda* and *N. ochroderma*, *Notoraja lira* is darkly pigmented on both sides of its body but, unlike the other darkly pigmented species, it is pale blue both dorsally and ventrally.

Notoraja sticta sp. nov.

Figs 12–17; Table 1

Notoraja sp. D: Last & Stevens, 1994: pp 304, 313, fig. 34.7, key fig. 36, pl. 51.

Holotype. CSIRO H 2954–01, adult male 543 mm TL, Great Australian Bight, South Australia, 33°49' S, 130°59' E, 902–938 m, 26 May 1992.

Paratypes. 6 specimens. AMS I 44550–001, adult male 525 mm TL, Great Australian Bight, South Australia, 33°30' S, 130°24' E, 842–927 m, 05 Nov 1989; CSIRO H 2227–01, adult male 533 mm TL, Great Australian Bight, South Australia, 34°16' S, 132°13' E, 820–851 m, 06 Nov 1989; CSIRO H 2955–01, female 627 mm TL, Great Australian Bight, 33°44' S, 130°39' E, 1018–1020 m, 30 May 1992; CSIRO H 2957–01, female 508 mm TL, Great Australian Bight, South Australia, 33°54' S, 131°33' E, 855–858 m, 9 Jun 1992; SAMA F 6810, juvenile male 271 mm TL, Great Australian Bight, South Australia, 35°10' S, 133°46' E, 1095–1200 m, 20 Nov 1989; SAMA F 6833, juvenile male 353 mm TL, Great Australian Bight, South Australia, 35°05' S, 133°44' E, 937–985 m, 10 Dec 1989.

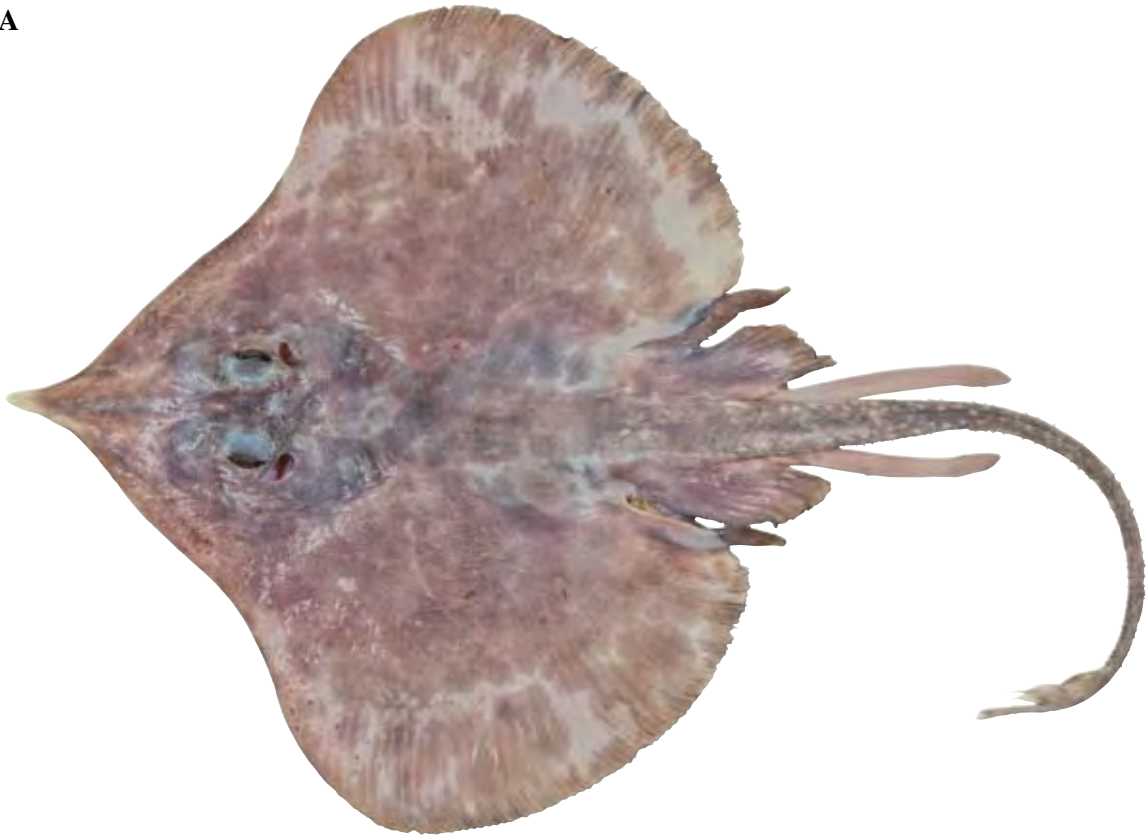
DIAGNOSIS.— A moderately large species of *Notoraja* with the following combination of characters: disc width 55.2–62.5% TL; preorbital snout length 12.7–15.0% TL; pre-upper jaw length 12.5–15.0% TL; tail length from posterior margin of cloaca to tip 54.9–58.2% TL. Dorsal surface largely free of dermal denticles; snout without thorns; two main, irregular rows of thorns on dorsolateral aspect of tail and additional median row of thorns on posterior half of tail; ventral surface of tail with large isolated denticles on posterior third, otherwise naked; oronasal pits absent; tooth rows 34–44 in upper jaw, 32–41 in lower jaw; pectoral-fin radials 65–68; trunk centra 25–27; predorsal caudal centra 72–75; rostral appendices about 80% of nasobasal length, subconical in cross section posteriorly and connected to rostral shaft at node; scapulocoracoid elongate and with slender anterior bridge; piebald, mainly whitish dappled with variably developed bluish grey blotches dorsally; dappled ventrally, usually with variably developed greyish brown blotches.

DESCRIPTION.— Disc heart-shaped, 1.08 times as broad as long in holotype (1.10 and 1.16–1.18 times in mature male, and female and juvenile paratypes,

respectively); angle in front of spiracles 84° (85–105° and 110–117°); anterior margin slightly convex on either side of tip of snout to anterior margin of orbit, slightly concave to level of spiracles, outer corners broadly rounded, and posterolateral margin moderately convex in holotype (Fig. 12) and other mature male paratypes; anterior margin slightly convex on either side of tip of snout to anterior margin of orbits, slightly concave to level of spiracles, outer corners broadly rounded, and posterolateral margin moderately convex in mature females (Fig. 13) and immature male. Axis of greatest width 57.2% (55.6–57.1% and 52.0–58.6%) of disc length. Snout tip with prominent long, narrow, fleshy, and flattened process (Fig. 14). Preorbital snout length 4.30 (3.71–3.91 and 3.29–3.79) times orbit length, 5.93 (5.18–5.48 and 4.56–4.91) times interorbit width; pre-upper jaw length 2.22 (2.15–2.20 and 1.91–1.95) times internarial distance. Orbit diameter 1.38 (1.40 and 1.20–1.49) times interorbital width, and 1.95 (2.21–2.32 and 1.76–2.27) times length of spiracles. Lateral nasal fold laterally expanded and rounded, with weak triangular process along lateral margin, posterior margin finely fringed. Inner nasal flap (nasal curtain), well developed, broadly rounded, and coarsely fringed along posterior margin, with broad triangular process on anterior lateral margin (Fig. 15). Upper and lower jaws slightly arched on either side of symphysis; upper jaw of males slightly indented at symphysis (not indented in female paratypes). Teeth with acutely pointed cusps and arranged in diagonal rows in mature males, and plate-like with short cusps and arranged quincuncially in females. Distance between first gill slits 1.57 (1.43–1.47 and 1.56–1.79) times as great as between nostrils; distance between fifth gill slits 1.01 (0.88–1.00 and 1.00–1.13) times as great as between nostrils.

Pelvic fins deeply incised with lobes connected by radials and membranes, anterior lobe moderately long, moderately narrow at base and tapering to blunt point; posterior lobe with convex lateral margins; anterior lobe 88.9% (87.2–94.1% and 87.1–100.6%) of posterior lobe. Tail narrow at base, depressed over length, slightly convex ventrally, and tapering gradually posteriorly, very slender toward tip; width at axil of pelvic fins 2.67 (2.17–2.22 and 2.10–2.50) times width at midlength and 4.79 (4.40–4.64 and 4.63–5.95) times width at dorsal-fin origin respectively; length from rear of cloaca 1.28 (1.26–1.29 and 1.22–1.39) times distance from tip of snout to rear of cloaca; width 1.72 (1.52–1.69 and 1.64–1.98) times height at axils of pelvic fins, and width 1.30 (1.19–1.20 and 1.12–1.46) times height at first dorsal fin origin; lateral tail folds originating anterior to tips of posterior pelvic-fin lobes, extending to distal half to distal fourth of epichordal caudal-fin lobe and broadening distally to slightly narrower than height of epichordal lobe of caudal fin. Dorsal fins of similar shape and size; rather short and moderately tall with evenly convex anterior margin, straight or slightly convex posterior margin and a pointed or acutely rounded tip; confluent (confluent

A



B



Figure 12. *Notoraja sticta* sp. nov., adult male holotype (CSIRO H 2954–01, 543 mm TL, fresh): A, dorsal surface; B, ventral surface.

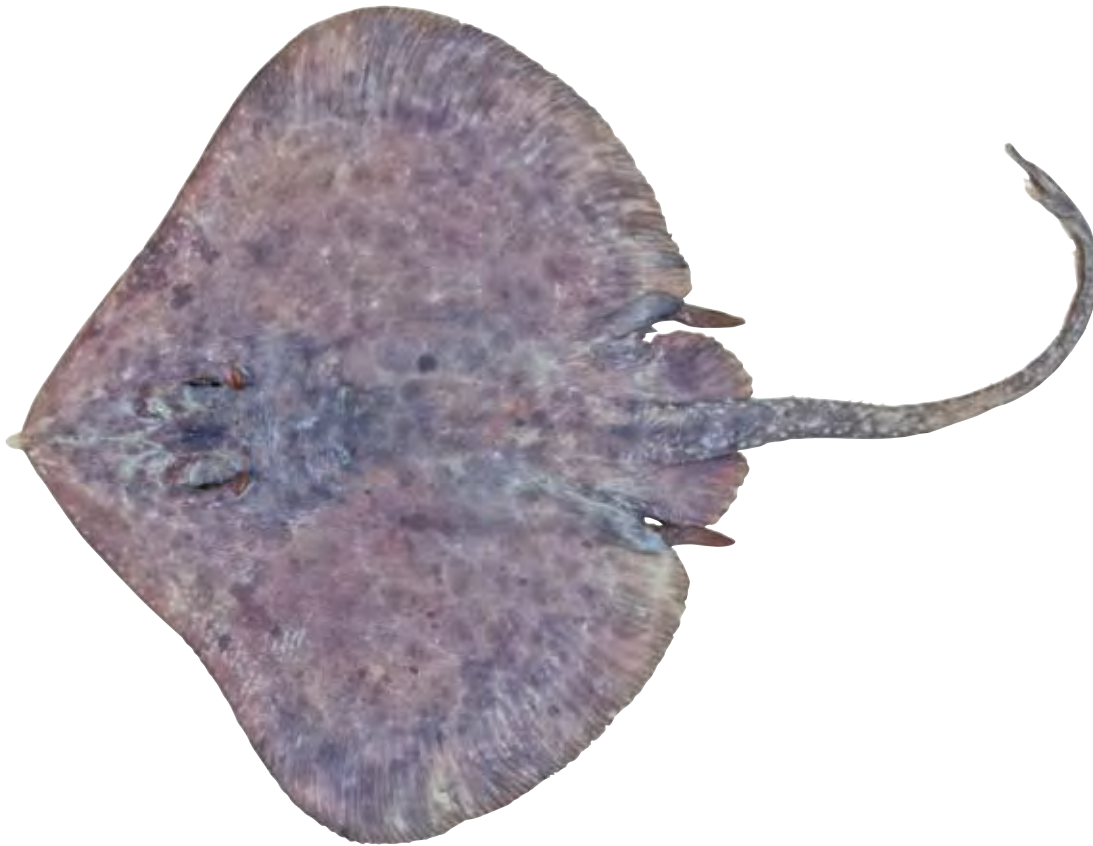


Figure 13. Dorsal surface of *Notoraja sticta* sp. nov., female paratype (CSIRO H 2955-01, 627 mm TL, fresh).

or separated by short interspace, 5.08 (2.31–2.44% and 1.00–3.91%) length of first dorsal-fin base) (Fig. 16). Epichordal caudal-fin lobe well developed, separated by short interspace from and distinctly longer than second dorsal-fin base; hypochordal caudal lobe very low, originating near end of lateral fold, not confluent with epichordal lobe.

Dermal denticles occur in broad band along anterior margin of disc, on cranium, and in broad band along midline from nuchal region to base of tail. Holotype with 2 preorbital and postorbital thorns, 1–2 spiracular thorns medial to each spiracle, malar thorns on head from just anterior to nasal capsules to mid orbit and on antero-medial half of pectoral fins, rectilinear patch of alar thorns on outer fourth of midlength of disc, 2 irregular rows of thorns on either side of midline of tail, and 1 row of thorns along midline of posterior half of tail (paratypes with 1–3 preorbital and 1–2 postorbital thorns, and 0–3 spiracular thorns, juvenile male paratype with nearly complete median series of thorns) (Fig. 17). Thorns moderately compressed, with oval bases and oblique, moderately recurved crowns. Malar thorns small, slightly larger than denticles, with very broad bases, and erect and moderately recurved crowns. Alar thorns posteromedially oriented, with very elongated bases, oblique slightly recurved crowns and exposed on integument. Holotype

with 9 irregular rows of 1–3 alar thorns, paratypes with 9–10 irregular rows of 1–3 alar thorns.

Rostral appendices largely free of rostral cartilage, elongate, flattened anteriorly and subconical in cross section posteriorly; rostral cartilage very slender and uncalcified distally; precerebral fontanelle narrow to moderately narrow and extending onto rostral cartilage distinctly anterior to leading edge of nasal capsules; nasal capsules broad and oval, with basal fenestrae; internasal plate narrow; preorbital processes poorly developed to degenerate and not continuous with supraorbital crest; scapulocoracoid with slender anterior bridge, distance between pro- and mesocondyles less than distance between meso- and metacondyles, with two postventral foramina; scapular process slightly higher than dorsal margin of scapula; propterygium of pectoral girdle reaching rostral node; lateral prepelvic processes of pelvic girdle short to moderately long.

Claspers very slender, glans depressed but little expanded, with components slit, cleft, pseudorhipidion, pela, projection, and spike; pela extends from hypopyle on ventral side of clasper groove, turns abruptly laterally and runs along outer surface of projection; projection curved gently laterally over length and extending to near tip of clasper, with sharp pointed tip; spike disc-shaped

Table 1. Morphometrics for the holotype of *Notoraja azurea* sp. nov. (CSIRO H 170–01), ranges for measured paratypes (n=5), and means for all morphometric types; the holotype of *Notoraja lira* sp. nov. (CSIRO H 3714–08); and the holotype of *Notoraja sticta* sp. nov. (CSIRO H 2954–01), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>N. azurea</i> sp. nov.			<i>N. lira</i> sp. nov.		<i>N. sticta</i> sp. nov.			
	Holotype	Paratypes		Mean	Holotype	Holotype	Paratypes		Mean
		Min.	Max.				Min.	Max.	
Total length (mm)	621	230	540		415	543	353	627	
Disc width	52.2	52.6	57.0	54.5	56.9	55.2	55.2	62.5	57.7
Disc length (direct)	48.0	44.5	49.3	47.7	52.9	51.2	49.7	53.1	51.0
Snout to maximum width	28.0	23.1	29.5	26.7	31.1	29.3	27.6	29.5	28.7
Snout length (preorbital direct)	13.9	11.1	14.5	13.3	15.4	15.0	12.7	14.8	13.9
Snout to spiracle	17.3	14.6	17.6	16.5	19.0	18.6	16.1	18.9	17.5
Head (dorsal length)	19.5	16.7	20.1	19.0	21.4	20.8	18.8	24.4	20.9
Orbit diameter	3.4	3.2	3.7	3.5	3.7	3.5	3.3	3.9	3.7
Orbit and spiracle length	4.3	4.2	5.0	4.4	4.3	4.6	4.3	4.7	4.6
Spiracle length (main aperture)	1.9	1.8	3.8	2.2	1.6	1.8	1.7	2.0	1.8
Distance between orbits	2.6	2.4	2.9	2.6	3.1	2.5	2.6	3.0	2.7
Distance between spiracles	4.8	4.8	5.3	5.0	5.8	5.2	5.2	5.4	5.3
Snout to cloaca (to 1st hemal spine)	41.9	38.3	43.7	42.0	45.7	43.9	41.8	45.1	43.6
Cloaca to D1	46.9	46.1	49.9	47.6	40.0	46.0	44.4	48.9	45.7
Cloaca to D2	50.6	49.0	53.7	50.8	45.2	48.9	47.3	53.2	49.3
Cloaca to caudal origin	54.8	53.8	57.4	54.8	49.9	52.5	51.1	56.3	53.1
Distance-cloaca to caudal-fin tip	58.1	56.3	61.7	58.0	54.3	56.1	54.9	58.2	56.4
Ventral snout length (pre upper jaw)	13.8	12.0	14.2	13.4	16.3	14.4	12.5	15.0	13.8
Prenasal length	11.3	9.0	11.5	10.7	13.2	11.7	9.6	11.6	11.0
Ventral head length (to fifth gill)	25.1	23.0	26.1	24.8	27.9	26.7	24.5	26.8	25.7
Mouth width	5.7	4.7	6.3	5.7	5.8	5.9	5.4	6.4	5.7
Distance between nostrils	5.8	5.5	6.7	6.2	6.7	6.5	6.4	7.3	6.7
Nasal curtain length	3.9	3.1	4.1	3.7	4.0	3.9	3.7	4.3	3.9
Nasal curtain (total width)	7.2	6.5	7.7	7.1	7.6	8.0	7.2	8.6	7.8
Nasal curtain (min. width)	4.6	4.4	4.5	4.4	4.8	4.6	4.2	5.0	4.5
Nasal curtain (lobe width)	1.4	1.1	1.5	1.3	1.3	1.9	1.2	1.9	1.7
Width of first gill opening	1.0	0.5	1.5	1.1	1.0	1.0	0.9	1.3	1.1
Width of fifth gill opening	0.9	0.4	1.1	0.8	0.7	0.5	0.7	1.1	0.8
Distance between first gill openings	9.2	10.3	11.3	10.3	11.6	10.2	9.4	11.5	10.6
Distance between fifth gill openings	5.9	6.7	7.6	6.8	7.3	6.5	6.2	7.3	6.8
Clasper (post cloacal length)	19.8	21.8	22.6	21.4	9.0	21.9	21.4	22.7	19.1
Length of anterior pelvic lobe	13.0	12.9	14.8	13.6	13.9	14.3	13.2	15.9	14.1
Length of posterior pelvic lobe	14.6	12.8	15.9	14.8	14.3	16.1	14.1	15.8	15.2
Pelvic base width	8.1	7.5	9.6	8.6	8.4	7.0	7.9	9.8	8.6
Tail at axil pelvic fins (width)	3.3	2.2	3.5	3.0	2.8	3.4	3.1	3.7	3.5
Tail at axil pelvic fins (height)	2.0	1.8	2.1	2.0	1.6	2.0	1.9	2.2	2.1
Tail at midlength (width)	1.2	1.1	1.4	1.2	0.7	1.3	1.4	1.7	1.5
Tail at midlength (height)	0.9	0.9	1.0	0.9	0.7	1.0	1.0	1.1	1.0
Tail at D1 origin (width)	0.7	0.6	0.8	0.7	0.5	0.7	0.6	0.8	0.7
Tail at D1 origin (height)	0.5	0.3	0.6	0.5	0.5	0.6	0.5	0.7	0.6
D1 base length	2.0	2.1	2.6	2.3	4.0	2.4	2.1	2.9	2.5
D1 height	1.4	1.1	1.3	1.2	1.1	1.4	1.0	1.5	1.3
D1 origin to caudal-fin tip	11.2	8.8	12.9	10.9	14.3	10.1	9.3	11.8	10.7
D2 origin to caudal-fin tip	7.5	6.5	8.7	7.5	9.1	7.2	5.0	8.0	7.1
Caudal-fin length	3.3	2.8	4.3	3.5	4.4	3.6	1.8	3.7	3.3



Figure 14. Dorsal head of *Notoraja sticta* sp. nov., adult male holotype (CSIRO H 2954-01, 543 mm TL), showing snout, orbito-spiracular and nuchal regions.

with sharp, naked lateral and distal margins, ventral to projection and covered by sentina; clasper skeleton with dorsal marginal, two dorsal terminal; ventral marginal, ventral terminal, and accessory terminal 2 cartilages; dorsal terminal 1 cartilage band-shaped and extending from ventral medial to dorsal medial aspect of glans; dorsal marginal cartilage with distal extension forming pseudorhipidion, dorsal terminal 2 cartilage medially attached to distal margin of dorsal marginal cartilage and side of axial cartilage, distally separate and connected to tip of axial cartilage by connective tissue, terminal bridge absent; ventral marginal cartilage fused with accessory terminal 1 cartilage to form projection, projection gently curved laterally and terminates as acute tip; ventral terminal cartilage ladle-shaped with pointed medial process forming eperon and antero-medial process articulating with ventral marginal; accessory terminal 2 cartilage attached to margin of ventral marginal cartilage and with disc-shaped distal process forming spike.

Meristics (n=6): Tooth rows in upper jaw 39 (34-44 in adult paratypes); lower jaw 39 (32-41). Pectoral propterygial radials 29-30 (28-31); mesopterygial radials 12 (11-12); metapterygial radials 26 (24-26);

total radials 67-68 (65-67). Pelvic-fin radials males (n=4) 1 (1) + 16 (15-16); females (n=2) (1) + (16-17). Trunk centra 26 (25-27); predorsal caudal centra 75 (72-74); total predorsal centra 101 (97-100); centra between origins of dorsal fins 6 (6-9); diplospondylous centra 105 (100-107); total centra about 131 (126-133).

COLOUR (in preservative).— Dorsal surface piebald, mainly whitish dappled with variably developed bluish grey blotches; extent of light and dark areas extremely variable between specimens, sometimes almost entirely pale with light blotching (AMS I 44550-001 and SAMA F 6810) to almost entirely blotched (CSIRO H 2955-01). Ventral surface equally well dappled, with greyish brown blotches (sometimes bluish grey); blotches varying in size from small spots to broad areas covering most of central disc (CSIRO H 2955-01), to almost entirely mottled; tail almost uniformly greyish brown or bluish brown, less mottled than its dorsal surface; claspers mostly pale, whitish; margins of nasal curtain, mouth, cloaca, dorsal fins and tail tip usually white.

SIZE.— Reaches at least 627 mm TL; adult males 525-543 mm TL, one male paratype still juvenile at 508 mm TL; smallest specimen 271 mm TL.



Figure 15. Ventral view of *Notoraja sticta* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 2954-01, 543 mm TL); B, female paratype (CSIRO H 2955-01, 627 mm TL).



Figure 16. Lateral view of dorsal and caudal fins of *Notoraja sticta* sp. nov., adult male holotype (CSIRO H 2954–01, 543 mm TL).

A



B



C



D



Figure 17. Thorns at tail midlength of *Notoraja sticta* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 2954–01, 543 mm TL); C, dorsal and D, lateral view of female paratype (CSIRO H 2955–01, 627 mm TL).

DISTRIBUTION.— Known only from the mid-continental slope of the Great Australian Bight, South Australia (33°30' S, 130°24' E to 35°10' S, 133°46' E), at depths of 820–1200 m.

ETYMOLOGY.— Derived from the Greek *stiktos* (meaning spotted or dappled) in reference to its strong blotched dorsal coloration. Vernacular name: Blotched Skate.

REMARKS.— *Notoraja sticta* is distinguished from the other species of the genus by a combination of its disc width, preorbital snout length, tail length, denticle and thorn patterns, numbers of tooth rows, pectoral-fin radials and vertebral centra, shape of rostral appendices, and colour pattern. It has a relatively broader disc width than *N. azurea*, *N. hirticauda* and *N. tobitukai* (55.2–62.5% vs. 47.3%–57.0% TL); slightly longer preorbital snout length than *N. ochroderma* and *N. tobitukai* (12.7–15.0% vs. 10.8–12.5% TL); shorter tail than *N. hirticauda* and *N. tobitukai* (54.9–58.2% vs. 58.3%–61.0% TL) (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Unlike *N. hirticauda*, *N. ochroderma* and *N. tobitukai* the dorsal surface of the disc is largely free of dermal denticles (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Unlike *N. hirticauda* and *N. tobitukai* its tail lacks multiple rows of enlarged, bristle-like dermal denticles or thorns on dorsal and ventral surfaces (Stehmann, 1989; Last & McEachran, 2006). Large *N. sticta* usually have a single row of prominent denticles along the midline of the posterior half of tail that are absent in *N. azurea*, *N. ochroderma* and *N. lira*. *Notoraja sticta* has fewer upper tooth rows than *N. ochroderma* (34–44 vs. 44–49); fewer pectoral radials than *N. ochroderma* (65–68 vs. 75–84) and more pectoral radials than *N. hirticauda* (61–66); fewer trunk vertebrae than *N. ochroderma* (25–27 vs. 30–32); fewer predorsal caudal centra than *N. azurea* and *N. ochroderma* (72–75 vs. 76–89), but more than *N. tobitukai* (66) (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Posterior sections of rostral appendices are subconical as in *N. azurea*, *N. hirticauda* and *N. lira* (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006). Like the other species of *Notoraja*, except *N. hirticauda* and *N. ochroderma*, *Notoraja sticta* is darkly pigmented on both sides of its body. However, unlike the other darkly pigmented species, it is piebald, whitish dappled with variable sized bluish grey blotches dorsally, and is dappled with greyish brown or bluish brown ventrally (Stehmann, 1989; McEachran & Last, 1994; Last & McEachran, 2006).

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A new species of round skate, *Irolita westraliensis* sp. nov. (Rajoidei: Arhynchobatidae), from northern Western Australia

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ABSTRACT.— The arhynchobatin skate genus *Irolita* consists of two allopatric species endemic to the continental shelf off southern and western Australia. The type species of the genus, *I. waitii* (McCulloch, 1911), is known to occur from Port Lincoln to Perth (southeastern Western Australia). A second, slightly smaller species, *Irolita westraliensis* sp. nov., occurs on the continental shelf of northwestern Australia from the Imperieuse Reef south to Exmouth Gulf. The new *Irolita* differs from *I. waitii* in having larger, non-aggregated bluish spots on upper disc, no orbital thorns, a more extended post-dorsal tail, fewer trunk vertebrae, fewer pectoral-fin radials, and a relatively longer, more slender, dark-banded tail.

Key words. *Irolita westraliensis* – Rajoidei – new species – Arhynchobatidae – Australia

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INTRODUCTION

Members of the Australian endemic skate genus *Irolita* Whitley, 1931, otherwise known as round skates, occur on the continental shelf from the Great Australian Bight to northwestern Australia. Their smooth and almost circular disc shape is unique within Australian skates (McCulloch, 1911). Two allopatric species are known, *I. waitii* (McCulloch, 1911) and an undescribed species referred to by Last & Stevens (1994) as *Irolita* sp. A. Last & Stevens (1994) record the range of *I. waitii* as from Geraldton (Western Australia) to Port Lincoln (South Australia), and *I. sp. A.* is thought to occur from off Shark Bay to Port Hedland. Both species occur primarily on the outer continental shelf. The aim of this paper is to provide a basic description of the new species. A more detailed review of the genus detailing the skeletal morphology of both species will be provided in a separate manuscript to follow.

METHODS

The descriptive format is based on McEachran & Fechhelm (1982), and meristic and morphometric methods are outlined in the first paper of this special publication on new Australian skates (Last *et al.*, 2008). Comprehensive body measurements were taken for the holotype (CSIRO H 3243–01) and five paratypes (CSIRO: CA 2800, CA 3793, H 1503–01, H 4069–01 and H 5189–01) of the new species. Measurements, expressed

as a percentage of total length (TL), are provided in Table 1. Radiographs of all type material were used to obtain counts of tooth rows, vertebrae, and pectoral and pelvic-fin radials. Vertebral counts were made using methods described by Hubbs & Ishiyama (1968) and Last *et al.* (2008); trunk counts include only monospondylous centra and whole synarcual centra (the anteriormost element is often fragmented). Morphometric and meristic data for paratypes are given in parentheses after the holotype in the description section. Materials examined are deposited in ichthyological collections of the Australian National Fish Collection, Hobart (CSIRO) and the Western Australian Museum (WAM).

Irolita westraliensis sp. nov.

Figs 1–6; Table 1

Irolita waitii: Sainsbury, Kailola & Leyland, 1985: pp 46, fig. *Irolita* sp. A: Last & Stevens, 1994: pp 303, 307–308, fig. 34.2, key fig. 30, pl. 48.

Holotype. CSIRO H 3243–01, adult male 348 mm TL, north-west of Port Hedland, Western Australia, 18°50' S, 117°40' E, 169 m, 06 Oct 1990.

Paratypes. CSIRO CA 2800, female 373 mm TL, north of Forestier Island, Western Australia, 19°04' S, 117°04' E, 200–202 m, 14 Apr 1982; CSIRO CA 2801, juvenile male 191 mm TL, south-west of Imperieuse Reef, Western Australia, 18°24' S, 118°29' E, 154–156 m, 28 Mar 1982;

CSIRO CA 3793, adolescent male 358 mm TL, north of Dampier Archipelago, Western Australia, 19°15' S, 116°40' E, 172 m, 25 Jan 1983; CSIRO CA 4216, female 356 mm TL, CSIRO CA 4217, female 275 mm TL, north of Dampier Archipelago, Western Australia, 19°13' S, 116°26' E, 192–194 m, 11 Aug 1983; CSIRO H 1503–01, adult male 353 mm TL, north-west of Port Hedland, Western Australia, 19°01' S, 117°24' E, 155–167 m, 04 Oct 1988; CSIRO H 4069–01, female 430 mm TL, north-west of Port Hedland, Western Australia, 18°39' S, 118°08' E, 142–150 m, 08 Sep 1995; CSIRO H 5189–01, adult male 344 mm TL, north of Exmouth Gulf, Western Australia, 21°33' S, 114°05' E, 209 m, 16 Nov 1998; WAMP 26193–004, female 422 mm TL, north of Dampier Archipelago, Western Australia, 19°17' S, 116°16' E, 170–172 m, 16 May 1978.

DIAGNOSIS.— A small *Irolita* with the following combination of characters: bluish spots on dorsal surface of disc not in dense aggregations; dark bands usually visible on tail; orbital thorns absent; snout to cloacal distance usually slightly shorter than tail; tail relatively narrow and thin in cross-section; caudal fin relatively long; posterior extremity of second dorsal fin well short of tail tip; distance from second dorsal-fin origin to tail tip exceeding 3.5 times width of mid-tail; minimum width of nasal curtain usually more than 2.5 times width of adjacent lobe; trunk centra 35–39; pectoral radials 87–94.

DESCRIPTION.— Disc 1.11 (1.05–1.10) times as broad as long; males weakly heart shaped, anterior margin initially convex, becoming weakly concave beside eye, posterior margin and corners broadly rounded; females subcircular; angle in front of spiracles 109° (109–112°). Axis of greatest width 0.52 (0.51–0.53) of disc length. Snout tip with small fleshy process; variable, mostly protruding slightly beyond anterior profile of disc. Head rather short, preorbital snout length 2.37 (2.49–2.91) times orbit length, 2.16 (2.06–2.34) times interorbit; pre-upper jaw length 1.21 (1.28–1.59) times internasal distance. Orbit diameter 0.91 (0.75–0.87) of interorbital width. Spiracle large, 1.44 (1.25–1.59) in orbit; pseudobranchial folds 13–14 (12–15). Nasal flap with expanded outer posterior margin, outer anterior margin weakly developed, inner margin almost regular; nasal curtain well developed, bilobed, narrowly rounded to angular, without fringe along posterior margin, deeply concave above symphysis of jaws, not usually overlapping mouth (rarely over mouth corner); internasal distance 1.92 (1.87–2.16) in distance between first gill slits, 1.00 (0.97–1.22) in distance between fifth gill slits. Upper and lower jaws arched slightly on either side of symphysis, more so in large males; upper jaw indented at symphysis in adult males; upper jaw teeth exposed, those of lower jaw mostly concealed. Teeth of mature males spear shaped with long, sharp, pointed cusps, recurved laterally away from symphysis in well defined rows; symphyseal teeth more compacted, slightly smaller; in

females and juveniles, teeth plate-like with short posterior cusps, arranged in quincunx.

Pelvic fins deeply incised, lobes separate; anterior lobe moderately long, moderately slender, depressed with a broadly rounded apex; posterior lobe more elongate, with broadly rounded outer margins; length of anterior lobe 0.76 (0.72–0.79) of posterior lobe. Tail narrow at base, taper pronounced initially, then gradually towards very slender tip, width at axils of pelvic fins 2.50 (1.76–2.33) times width at midlength of tail and 2.55 (1.69–2.61) times width at first dorsal fin origin respectively; tail length from rear of cloaca 1.11 (1.01–1.17) times distance from tip of snout to rear of cloaca; strongly depressed anteriorly, weakly convex on ventral surface, becoming more oval in cross section predorsally, strongly depressed below and behind dorsal fins, width 1.73 (1.66–2.00) times height at axil of pelvic fin, 1.50 (1.50–2.18) times height at first dorsal-fin origin; lateral tail folds weak anteriorly, about fifth of tail width posteriorly (better formed in adult females, about third tail width at widest point); postdorsal tail relatively long, protruding well beyond rear tip of second dorsal fin. Dorsal fins of similar shape and size (first dorsal-fin height 1.59 (1.65–1.81) in base length); fins rather short and low, slightly raked, with weakly convex anterior margins, broadly convex posterior margins, apices rounded; fins almost connected or separated by short, variable interspace, 2.83 (2.13–4.29) in length of first dorsal-fin base; rear tip of second dorsal well short of tail tip. Epichordal caudal-fin lobe minute; well separated from and length less than half length of second dorsal-fin base; hypochordal caudal lobe rudimentary, originating near end of lateral fold, confluent with epichordal lobe.

Dorsal surface of disc uniformly smooth, no thorns around eye; 58–67 (33–61) alar thorns in mature and adolescent males; small, sharp denticles on lateral upper margin of eyelid of most paratypes. Alar thorns in 2–5 indistinct rows, extending from just behind spiracle level at disc margin to almost halfway along posterior margin of disc; in more rows anteriorly; thorns prostrate, non retractable, directed slightly postero-medially; posterior thorns about an eye diameter from disc margin. Cusps of thorns very slender, sharp, oblique, and strongly recurved. Integument of ventral surface rather firm and smooth. Thorns on tail of holotype small (about 60), sharp, similar in size, raked with recurved tips, long-based, weakly compressed, almost subtriangular in lateral view, in up to 5 irregular rows; in 1–3 rows near midline along anterior half of tail; additional lateral thorns on posterior tail extending below dorsal fins as single row of large denticles; sparse covering of minute denticles on both fins, no fine denticles forward of dorsal fins; smallest specimen (191 mm TL) with only a single row of low subconical thorns along midline. Postdorsal tail and ventral tail naked.

Meristics (n=10): Tooth rows in upper jaw 41 (39–47); lower jaw 37 (38–45). Pectoral propterygial radials

Table 1. Morphometrics for the holotype of *Irolita westraliensis* sp. nov. (CSIRO H 3243–01), ranges for measured paratypes (n=5), and means for all morphometric types. Values are expressed as percentages of total length.

	<i>Irolita westraliensis</i> sp. nov.			
	Holotype	Paratypes		Mean
		Min.	Max.	
Total length (mm)	348	344	430	
Disc width	60.6	58.4	64.2	60.3
Disc length (direct)	54.6	53.8	58.4	55.5
Snout to maximum width	28.1	27.3	30.0	28.5
Snout length (preorbital direct)	11.3	11.0	12.1	11.5
Snout to spiracle	17.4	17.2	18.4	17.7
Head (dorsal length)	18.6	19.0	20.9	19.6
Orbit diameter	4.8	4.1	4.6	4.4
Orbit and spiracle length	7.2	6.4	7.1	6.8
Spiracle length (main aperture)	3.3	2.8	3.3	3.1
Distance between orbits	5.2	5.2	5.4	5.3
Distance between spiracles	7.3	6.8	7.5	7.1
Snout to cloaca (to 1st hemal spine)	47.2	46.0	49.7	47.9
Cloaca to D1	37.9	37.6	41.3	38.8
Cloaca to D2	43.6	42.5	46.8	44.1
Cloaca to caudal origin	49.6	48.2	52.0	49.7
Distance-cloaca to caudal-fin tip	52.3	50.1	53.9	51.8
Ventral snout length (pre upper jaw)	10.1	10.2	11.8	11.0
Prenasal length	7.5	7.1	8.4	7.9
Ventral head length (to fifth gill)	27.6	26.9	28.7	27.5
Mouth width	9.5	8.7	9.5	9.1
Distance between nostrils	8.4	7.4	8.4	7.9
Nasal curtain length	5.6	5.2	6.0	5.5
Nasal curtain (total width)	11.2	10.1	11.3	10.8
Nasal curtain (min. width)	6.1	5.5	6.1	5.7
Nasal curtain (lobe width)	2.1	1.7	2.3	2.1
Width of first gill opening	1.8	1.5	2.0	1.7
Width of fifth gill opening	1.2	0.9	1.2	1.1
Distance between first gill openings	16.1	15.4	17.1	16.0
Distance between fifth gill openings	8.4	8.1	9.3	8.8
Clasper (post cloacal length)	23.3	23.4	25.8	24.2
Length of anterior pelvic lobe	14.1	13.6	15.7	14.6
Length of posterior pelvic lobe	18.7	18.5	20.0	19.1
Pelvic base width	6.8	6.7	9.3	7.4
Tail at axil pelvic fins (width)	3.6	3.2	3.8	3.5
Tail at axil pelvic fins (height)	2.1	1.8	2.2	2.0
Tail at midlength (width)	1.4	1.6	1.9	1.7
Tail at midlength (height)	1.1	1.1	1.2	1.2
Tail at D1 origin (width)	1.4	1.4	2.0	1.7
Tail at D1 origin (height)	0.9	0.9	1.0	1.0
D1 base length	4.3	3.3	4.0	3.8
D1 height	2.7	2.0	2.3	2.2
D1 origin to caudal-fin tip	14.4	11.1	13.9	12.9
D2 origin to caudal-fin tip	8.6	6.4	8.1	7.6
Caudal-fin length	2.6	1.7	2.5	2.1

A



B

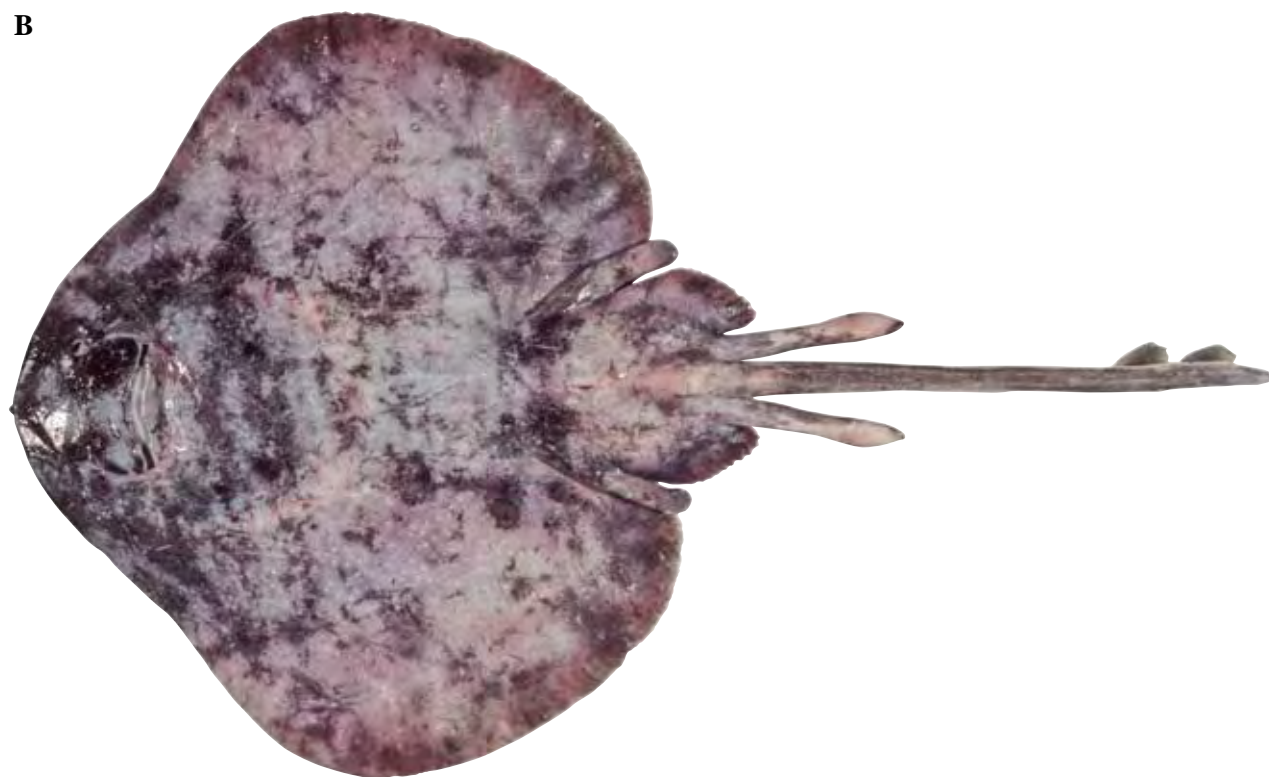


Figure 1. *Irolita westraliensis* sp. nov., adult male holotype (CSIRO H 3243–01, 348 mm TL, fresh): A, dorsal surface; B, ventral surface.



Figure 2. *Irolita westraliensis* sp. nov., female paratype (CSIRO H 4069–01, 430 mm TL): A, dorsal surface; B, ventral surface.



Figure 3. Dorsal head of *Irolita westraliensis* sp. nov., adult male holotype (CSIRO H 3243-01, 348 mm TL), showing snout, orbito-spiracular and nuchal regions.

40 (37-41); mesopterygial radials 16-19 (18-22); metapterygial radials 33-34 (30-33); total radials 90-92 (87-94). Trunk centra 35 (37-39); predorsal centra 97 (97-103); total centra about 137 (126-137).

COLOUR (based mainly on fresh colour photograph of holotype).— Dorsal surface yellowish brown with irregularly spaced bluish spots (each about 1.5-3 mm in length) over pectoral and pelvic fins; four larger spots (each about 5-6 mm in length, may become indistinct in preserved material) located on mid pectoral fin beside scapulocoracoid, and beside pectoral-fin insertions; dark bar between pectoral-fin insertions (may be faint or absent); larger, semi-symmetrical, dark brown blotches (containing clusters of diffuse-edged white spots) scattered over pectoral fin and posterior lobes of pelvic fins, these blotches most prominent on mid pectoral fin; anterior lobes of pelvic fins greyish pink, posterior lobes mostly brownish. Dark brown markings over orbital membrane; darker markings between orbit, and around suborbit from preorbit to anterior margin of spiracle. Dorsal tail brownish with five blackish bands (may become indistinct in preservative); anteriormost band broadest and darkest, located beside rear tips of posterior lobe of pelvic fin; second and third bands located forward of first dorsal fin (distance between them about half distance between first and second bands), two posterior bands located beneath first and second dorsal fins respectively; clasper shaft brownish, glans dusky

with whitish median band; lateral tail fold pale. Ventral surface dark greyish pink with darker blackish markings on head (irregular and variable between specimens), in holotype extending anteriorly to snout and posteriorly below chin, also at pectoral-fin insertions and irregularly over pectoral and pelvic fins; white-edged pores scattered over surface of disc, becoming indistinct or blackish after preservation; claspers greyish, distal half white; tail dark grey or black, tip whitish.

In preservative: Dorsal surface darker yellowish to greyish brown; clusters of white spots barely detectable; bluish spots often indistinct, very pale; banding on tail usually evident; dark markings around eye less pronounced in some specimens. On ventral surface, dark bluish pink areas becoming greyish blue, progressing to pale grey; lateral tail folds and sides of tail pale greyish or white (paler than dorsal and ventral surfaces); white pores either indistinct or dull grey. Cloaca mostly whitish.

SIZE.— Reaches at least 430 mm TL; adult males at 344-353 mm TL, larger male paratype still adolescent at 358 mm TL (CSIRO CA 3793); smallest individual 191 mm TL.



Figure 4. Ventral view of *Irolita westraliensis* sp. nov. showing oronasal region and tooth band: A, adult male holotype (CSIRO H 3243-01, 348 mm TL); B, female paratype (CSIRO H 4069-01, 430 mm TL).



Figure 5. Lateral view of dorsal and caudal fins of *Irolita westraliensis* sp. nov., adult male holotype (CSIRO H 3243–01, 348 mm TL).



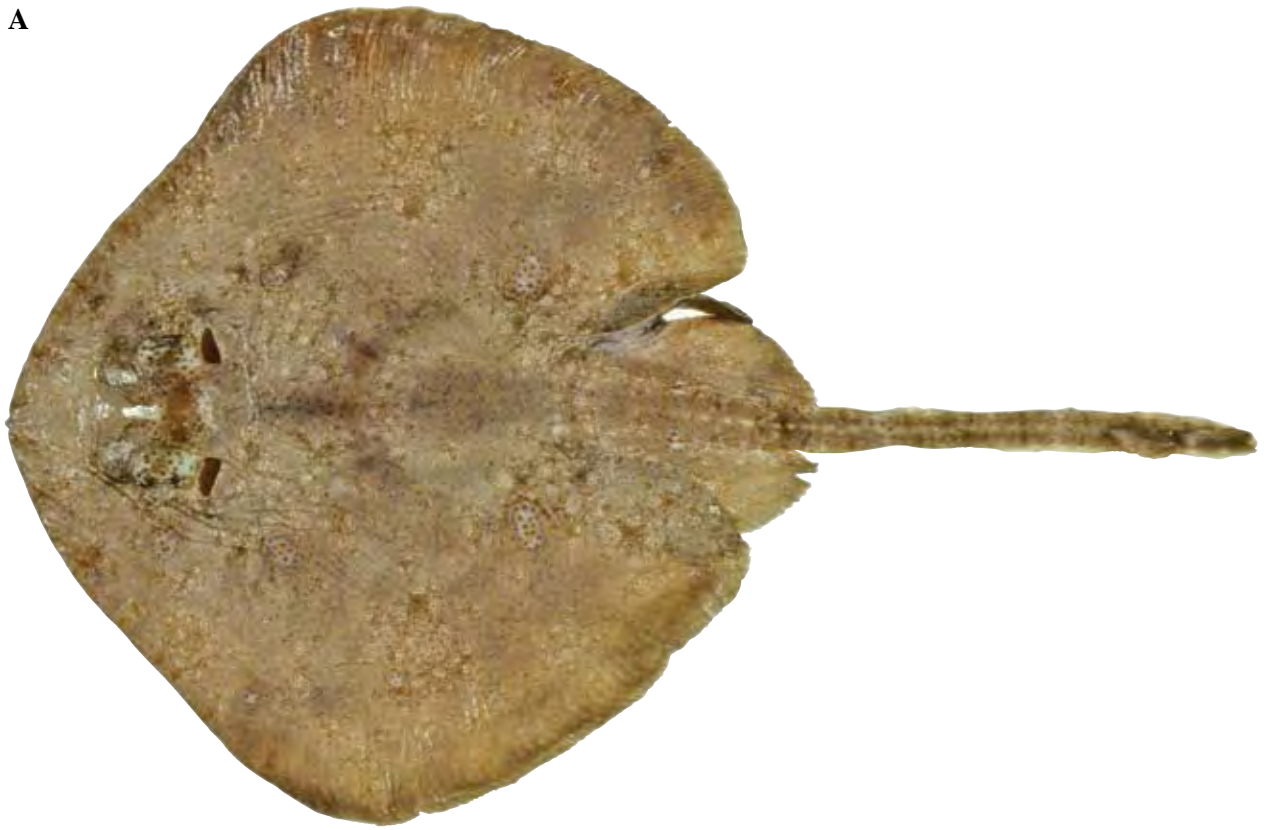
Figure 6. Thorns at tail midlength of *Irolita westraliensis* sp. nov.: A, dorsal and B, lateral view of adult male holotype (CSIRO H 3243–01, 348 mm TL); C, dorsal and D, lateral view of female paratype (CSIRO H 4069–01, 430 mm TL).

DISTRIBUTION.— Known from the outer continental shelf off Western Australia between Exmouth Gulf (21°33' S, 114°05' E) and Imperieuse Reef (18°24' S, 118°29' E) in 142–209 m.

ETYMOLOGY.— Based on the name of the Australian State (i.e. Western Australia), from where this species occurs. Vernacular name: Western Round Skate.

REMARKS.— *Irolita westraliensis* differs from *I. waitii* (Fig. 7) in having a less densely spotted dorsal colour pattern, fewer pectoral-fin radials (87–94 vs. 101–105), a more slender tail (1.4–1.9% vs. 2.3–3.6% TL at its midlength), a shorter disc (53.8–58.4% vs. 60.0–62.2% TL) and lacks thorns near the orbit (small thorns usually present in orbito-spiracular region in *I. waitii*). *Irolita westraliensis* also generally has fewer trunk vertebrae

A



B



Figure 7. Juvenile male of *Irolita waitii* (CSIRO H 2263–01, 316 mm TL): A, dorsal surface; B, ventral surface.

(35–39 vs. 39–43), a slightly shorter head (18.6–20.9% vs. 19.7–22.3% TL), and the rear tip of the second dorsal fin usually falls well short of the tail tip (rather than being subterminal). Other apparent differences between the two, include nasal curtain morphometry (i.e. minimum width narrower and lobes broader in *I. westraliensis*), epichordal caudal fin length (relatively longer in *I. westraliensis*), and width of fifth gill opening (wider in *I. westraliensis*). *Irolita waitii* appears to be a larger skate: the largest known specimen of *I. westraliensis* (i.e. 430 mm TL) is smaller than the size of first maturity of male *I. waitii* (i.e. about 460 mm TL in Last & Stevens, 1994).

Comparative material.

Irolita waitii: 8 specimens. CSIRO CA 3528, female 519 mm TL, south-east of Point Culver, Great Australian Bight, Western Australia, 33°17' S, 125°24' E, 52 m, 30 Nov 1981; CSIRO H 120–01, female 520 mm TL, north-west of Cape Leeuwin, Western Australia, 34°14' S, 114°42' E, 146 m, 23 Feb 1981; CSIRO H 131–01, adolescent male 467 mm TL, south of Point Culver, Great Australian Bight, Western Australia, 33°46' S, 125°24' E, 96–100 m, 29 Jul 1981; CSIRO H 132–01, female 307 mm TL, south of Point Culver, Great Australian Bight, Western Australia, 33°37' S, 124°48' E, 54 m, 28 Jul 1981; CSIRO H 133–01, female 509 mm TL, south of Recherche Archipelago, Great Australian Bight, Western Australia, 34°26' S, 123°42' E, 82–83 m, 26 Jul 1981; CSIRO H 2263–01, juvenile male 316 mm TL, south of Cape Leeuwin, Western Australia, 34°57' S, 114°56' E, 201 m, 09 Feb 1989; CSIRO H 2269–01, female 479 mm TL, south of Cape Leeuwin, Western Australia, 34°56' S, 114°59' E, 204 m, 09 Feb 1989; CSIRO H 6350–01, female 284 mm TL, north-west of Rottneest Island, Western Australia, 31°53' S, 115°16' E, 124 m, 10 Apr 2006.

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