

Octopus kapalae, sp. nov.: A New Species of *Octopus* from South-eastern Australia

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Octopus kapalae, sp. nov. is described from preserved specimens housed in the Australian Museum, Sydney. The species is found on the edge of the continental shelf off south-eastern Australia, at depths between 176 m and 503 m. The possession of large eggs suggests the young hatch as miniature adults and do not disperse widely. The species may be endemic to the region.

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INTRODUCTION

Over the last thirty years there has been a sizeable increase in our knowledge of octopus (Octopodidae) systematics. Most recent research on the Australian Octopodidae has focused on tropical (Norman 1992a, 1992b, 1992c, 1993a, 1993b, 1993c, 2000, 2001; Norman and Finn 2001) and southern temperate regions (Stranks 1990, 1996, 1998; Stranks and Norman 1992). Despite this, the general taxonomy of the Octopodidae worldwide remains comparatively poorly known, with many undescribed or inadequately defined species (Dunning et al. 1998; Norman and Hochberg 2005; Norman et al. 2016). Norman and Hochberg (2005) suggested a major revision of the group, giving detailed and accurate descriptions of all species.

Nominal *Octopus* spp. currently known to inhabit south-eastern Australia include: *O. australis* Hoyle 1885; *O. bulbus* Norman 2001; *O. micros* Norman 2001; *O. pallidus* Hoyle 1885; *O. pyrum* Norman et al. 1997 and *O. tetricus* Gould 1852 (Reid, 2016). This paper describes a previously unidentified species of *Octopus* captured off the coast of south-eastern Australia. It is one of a number of undescribed species reported from the FRV 'Kapala' collections between 1971 and 1979. The description is based on the qualitative and quantitative analysis of preserved

specimens. The findings in this paper unveil the unique suite of morphological attributes that show that *O. kapalae*, sp. nov. differs from all other species described from this region and elsewhere.

MATERIALS AND METHODS

The sixteen specimens studied (thirteen male and three female) are housed at the Australian Museum, Sydney. Specimens were collected from the continental shelf on the FRV 'Kapala', between 1971 and 1979, fixed in 10% seawater/formalin and stored in 70% ethanol.

Measurements and indices follow Roper and Voss (1983) and Huffard and Hochberg (2005), except for sucker counts; these included all suckers rather than those on the basal half of the arms. Measurements obtained for each specimen include: arm length, AL (1-4); arm width, AW; calamus length, CL; egg length, EgL; free funnel length, FFuL; funnel length, FuL; gill length, GL; head width, HW; hectocotylied arm length, HcA; ligula length, LL; mantle length, ML; mantle width, MW; sucker counts, SC(1-4, Hc); sucker diameter, SD; spermatophore length, SpL; spermatophore width, SpW; total length, TL; and web depth, WD (A-E). Indices were derived from these data as described in the Appendix. Indices are

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expressed as minimum–~~mean~~–maximum (standard deviation, SD), in millimetres. All measurements were taken from the left side of each specimen. If a structure was damaged on that side, its opposite member was used.

The digestive tract and male and female reproductive tracts of some specimens were dissected for inspection and illustration. The buccal mass was soaked in a saturated solution of potassium hydroxide (KOH) to soften the surrounding tissue for removal of the upper and lower beak and radula using forceps and a fine brush. The beak was photographed using a light microscope and, following cleaning, the radula was air-dried, gold-coated, and examined and photographed using a Zeiss Evo LS15 Scanning Electron Microscope equipped with a Robinson Backscatter detector. Spermatophores from seven males only were measured to avoid excessive damage to type material.

TAXONOMY

Octopus kapalae, sp. nov.
(Figs 1–6, Tables 1, 2)

Material examined

Holotype: ♂ 49.5 mm ML, New South Wales, east of Grafton, 29°55'S, 153°40'E to 29°48'S, 153°42'E, 375 m, 10 Oct. 1975, coll. K.J. Graham on FRV 'Kapala' K75-09-01 (AM C.559063).

Paratypes (15): New South Wales: ♂ 53.5 mm ML, east of Grafton, 29°55'S, 153°40'E to 29°48'S, 153°42'E, 375 m, 10 Oct. 1975, coll. K.J. Graham on FRV 'Kapala' K75-09-01 (AM C.476227); 3♂ 30–35 mm ML, ♀ 30 mm ML, off Port Stephens, 32°50'–49'S, 152°41'–42'E, 274 m, 6 Dec. 1978, coll. K.J. Graham, W. Rudman and P.H. Colman on FRV 'Kapala' K78-26-10 (AM C.156202); ♂ 48.5 mm ML, off Sydney, 32°57'S, 152°35'E, 503 m, 1 Nov. 1972, coll. K.J. Graham on FRV 'Kapala' K-06-18 (AM C.476333); ♂ 35 mm ML, east of Norah Head, 33°33'S, 151°59'E to 33°28'S, 152°04'E, 384 m, 26 May 1976, coll. K.J. Graham on FRV 'Kapala' K76-07-01 (AM C.476325); ♂ 37 mm ML, off Sydney, 33°36'–44'S, 151°57'–52'E, 384 m, 13 Oct. 1976, coll. K.J. Graham on FRV 'Kapala' K76-16-02/3 (AM C.476316); ♀ 25 mm ML, 33°46'S, 151°43'E, 96 fathoms [176 m], 5 Dec. 1977, coll. FRV 'Kapala' K77-23-01 (AM C.476314); ♂ 48.5 mm ML, off Broken Bay, NSW 33°47'–41'S, 151°48'–51'E, 348 m, 25 Jul. 1979, coll. K.J. Graham on FRV 'Kapala' K79-09-03 (AM C.476230); 4♂ 36.0–42.0 mm ML, 30 ml [48.28 km] SSE of Sydney, 34°15'20''S,

151°25'21''E, 247 m, 28 Jun. 1971, coll. K.J. Graham on FRV 'Kapala' K71-10-02 (AM C.476226); ♀ 31 mm ML, off Port Kembla, 34°24'S, 151°19'E, 278 m, 13 Dec. 1978, coll. K.J. Graham and W.F. Ponder on FRV 'Kapala' K78-27-08 (AM C.476311).

Diagnosis

Small to medium-sized species; ventro-lateral mantle ridge incomplete. Arm formula usually 2>3>4>1 or 2>3>1>4 in both sexes. Funnel organ W-shaped. Gills with seven lamellae per demibranch. Suckers medium-sized with some slightly enlarged from pairs 10–15, on arms 2 and 3 in both sexes (slightly larger in males). Hectocotylus small (5.8–9.2% of hectocotylised arm length), cylindrical, and dorso-ventrally flattened. Pigmentation: randomly scattered, dark orange papillae on the dorsal mantle, around eyes and on the dorsal surfaces of the arms (preserved specimens). Large papilla over each eye.

Description

The following description is based on the examination of thirteen male and three female specimens. Counts and measurements for individual animals are given in Tables 1 and 2.

Small to medium-sized species; ML males 30–40.3–53.5 (SD, 7.3), females 25–28.7–31 (SD, 3.2). Mantle round, slightly elongate to ovoid, saccular, with firm muscular walls; MWI males 43–61.6–87 (SD, 11.8), females 71–80.9–92 (SD, 10.4) (Figs 1a and 1b). Head narrow; HWI males 33–46.2–61 (SD, 8.7), females, 53–59.5–63 (SD, 5.5). Eyes moderately prominent. Funnel-organ W-shaped; thick, fleshy (Fig. 2a); median and lateral limbs similar length. Arms long, slender, differ in relative lengths, in both sexes; arm formula usually 2>3>4>1 or 2>3>1>4 in both sexes (variable, but lateral arms always longer than dorsal and ventral arms). Second arm usually longest; ALI2 males 263–327.9–417 (SD, 42.9), females 306–403.7–528 (SD, 113.2). Third right arm of males hectocotylised, shorter than the opposing third arm; HcAI 221–260.3–340 (SD, 38.0) v. OAI 68–78.1–84 (SD, 5.8). All arms approximately equal width; AWI males 15.1–17.9–22.0 (SD, 2.4), AWI

Table 1 (NEXT PAGE) Measurements (mm), counts and indices for 13 male *Octopus kapalae*, sp. nov. For definitions of counts, measurements and indices, see Appendix. Indices are shown in brackets. Missing values are indicated by a dash (–).

* Specimen (AM C.476226) missing several arms, each severed at outer rim of web.

	Holotype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM	Paratype AM
	C.559063	C.156202	C.156202	C.476325	C.156202	C.476226	C.476316	C.476226	C.476226	C.476226*	C.476333	C.476230	C.476227
TL	205	153	154	133	160	173	200	165	186	185	191	215	241
ML	49.5	30	34	35	35	36	37	37.5	37.5	42	48.5	48.5	53.5
MW	30 (61)	26 (87)	26 (76)	15 (43)	26 (74)	22 (61)	23 (62)	23.5 (63)	23 (61)	23.5 (56)	23.8 (49)	27 (56)	28 (52)
HW	20.5 (41)	18.3 (61)	20.5 (60)	13.5 (39)	17.6 (50)	19.4 (54)	18 (49)	18.5 (49)	17 (45)	17 (40)	16 (33)	18 (37)	22 (41)
FuL	17 (34)	13 (43)	14.5 (43)	13.6 (39)	14 (40)	17 (47)	19.3 (52)	16 (43)	17 (45)	20 (48)	18.3 (38)	18 (37)	20 (37)
FFuL	11 (22)	7 (23)	7.5 (25)	5.5 (16)	6.3 (18)	7.4 (21)	8 (22)	7.5 (20)	9 (24)	9 (21)	8.5 (18)	12 (25)	13 (24)
WDA	18.5	18	18.5	11.1	15	14.5	16	15	17	-	20	17	22
WDB	25 (15)	21	21.5	12.8	19	18	20	22.5	17	-	22.8	23	26
WDC	25	24	22.1	14.1	18.5	22 (17)	22 (16)	21.5	20	24	28.3 (20)	27 (19)	33 (18)
WDD	22	25.5 (20)	25 (20)	15 (16)	21 (18)	20	19	23 (17)	19	30 (22)	27	23	26
WDE	21	19	17.5	12.8	14	17.5	16	16	23 (18)	21	22.4	18	21
WF	B=C>D>E>A	D>C>B>E>A	D>C>B>A>E	D>C>B=E>A	D>B>C>A>E	C>D>B>E>A	C>B>D>E=A	D>B>C>E>A	E>C>D>A=B	-	C>D>B>E>A	C>B=D>E>A	C>B=D>A>E
AL1	150 (303)	109 (363)	109 (320)	81 (231)	95 (271)	110 (306)	92 (249)	99 (264)	86 (229)	-	110 (227)	116 (239)	150 (280)
AL2	152 (303)	125 (417)	114 (335)	92 (263)	116 (331)	132 (367)	140 (378)	110 (293)	117 (312)	-	145 (299)	144 (297)	182 (340)
AL3	162 (327)	128 (427)	122 (359)	96 (274)	120 (343)	124 (344)	129 (349)	134 (357)	125 (333)	138 (329)	130 (268)	140 (289)	179 (335)
HcA	127 (257)	102 (340)	101 (297)	81 (231)	100 (286)	86 (239)	103 (278)	94 (250)	85 (227)	-	107 (221)	115 (237)	139 (260)
AL4	148 (299)	114 (380)	112 (329)	85 (243)	100 (286)	100 (278)	109 (295)	111 (296)	91 (243)	125 (298)	95 (196)	130 (268)	140 (262)
AF	3.2,1.4	3.2,4.1	3.2,4.1	3.2,4.1	3.2,4.1	2.3,1.4	2.3,4.1	3.4,2.1	3.2,4.1	-	2.3,1.4	2.3,4.1	2.3,1.4
AW	9.5 (19.2)	6.6 (22.0)	6.4 (18.8)	5.3 (15.1)	7.4 (21.1)	7 (19.4)	7.5 (20.3)	6.2 (16.5)	6 (16.0)	7 (16.7)	7.3 (15.1)	7.5 (15.5)	9 (16.8)
SD	4 (8.1)	3.4 (11.3)	4.2 (12.4)	3.2 (9.1)	3.5 (10.0)	4.3 (11.9)	3.3 (8.9)	3.1 (8.3)	3.5 (9.3)	4.5 (10.7)	3.9 (8.0)	4.5 (9.3)	4.5 (8.4)
SC1	99	116	114	102	116	98	97	112	116	-	106	120	96
SC2	126	-	122	100	138	134	126	126	142	-	118	152	144
SC3	128	140	132	102	124	136	148	128	129	111	112	153	161
SCHc	95	92	90	84	86	81	88	82	76	-	84	90	99
SC4	109	120	116	76	110	98	105	104	124	110	72	145	122
GiLc	7	7	7	7	7	7	7	7	7	7	7	7	7
GL	18 (36.4)	8.5 (28.3)	9.5 (27.9)	10.6 (30.3)	9 (25.7)	9.6 (26.7)	15 (40.5)	9.4 (25.1)	12 (32.0)	17 (40.4)	13 (26.8)	18.7 (38.6)	19.5 (36.4)
LL	9.1 (7.2)	7.2 (7.1)	7.4 (7.3)	6.5 (8.0)	7.5 (7.5)	6.5 (7.6)	9.5 (9.2)	7.1 (7.5)	6.6 (7.8)	-	9.5 (8.9)	9.2 (8.0)	8.1 (5.8)
CL	2.6 (28.6)	2 (27.8)	2.2 (29.7)	2.2 (33.8)	2.5 (33.3)	2 (30.8)	3 (31.6)	2.2 (31.0)	2.3 (34.8)	-	2.5 (26.3)	3.2 (34.8)	2.1 (25.9)
SpL	-	-	-	29.5 (84.2)	-	36.3 (101)	50 (135)	42.0 (112)	49.0 (131)	-	47 (96.9)	-	38 (71.0)
SpW	-	-	-	0.7 (2.4)	-	1.0 (2.8)	1.0 (2.0)	1.0 (2.4)	1.0 (2)	-	1.0 (2.1)	-	1 (2.6)

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Table 2 Measurements (mm), counts and indices for three female *Octopus kapalae*, sp. nov.

For definitions of counts, measurements and indices, see Appendix. Indices are shown in brackets.

	Paratype AM C.476314	Paratype AM C.156202	Paratype AM C.476311
TL	160	146	98
ML	25	30	31
MW	20 (80)	27.5 (92)	22 (71)
HW	15.5 (62)	19 (63)	16.5 (53)
FuL	13.7 (55)	14.2 (47)	15 (48)
FFuL	6.5 (26)	7.3 (24)	8 (26)
WDA	16.7	18.5	11.5
WDB	21 (16)	20	16.6
WDC	20	23.5	20 (21)
WDD	16	25.5 (23)	17
WDE	11.5	18.2	14.5
WF	B>C>D>A>E	D>C>B>A>E	C>D>B>E>A
AL1	104 (416)	96 (320)	70 (226)
AL2	132 (528)	113 (377)	95 (306)
AL3	116 (464)	105 (350)	82 (265)
AL4	95 (380)	85 (283)	78 (252)
AF	2,3,1,4	2,3,1,4	2,3,4,1
AW	6.8 (27.2)	6 (20.0)	6.5 (21.0)
SD	2.5 (10.0)	2.5 (8.3)	2.5 (8.1)
SC1	131	126	85
SC2	125	147	138
SC3	129	128	132
SC4	118	128	122
GiLC	7	7	7
GL	9.3 (37.2)	9.2 (30.7)	8 (25.8)
EgL	4.3 (17.2)	6.1 (20.3)	5.5 (17.7)

females 20.0–22.7–27.2 (SD, 3.9). Total number of suckers on normal arms 72–161. Hectocotylied right arm with fewer suckers than opposite left arm; SCHc 76–87.3–99 (SD, 6.4) v. SC3 102–131.1–161 (SD, 17.0). All arms with uniserial suckers from rows one to four, remaining sucker rows biserial. Normal sucker diameter small; ASIn males 8.0–9.7–12.4 (SD, 1.5), females 8.1–8.8–10.0 (SD, 1.7). Largest suckers occur between rows 10–15 on arms 2 and 3; slightly larger in males than females. Web depth moderate; WDI males 15–18.8–22 (SD, 2.0), females 16–19.8–23 (SD, 3.5); WF variable (Tables 1 and 2), with dorsal and ventral webs shallower than lateral webs. Gills moderate to large; GLI males 25.1–31.9–40.5

(SD, 5.9), females 25.8–31.2–37.2 (SD, 5.7) with seven lamellae per demibranch.

Copulatory organ small on hectocotylied arm, LLI 5.8–7.7–9.2 (SD, 0.9), cylindrical and dorso-ventrally flattened, terminating in a blunt point. Ligula groove lacks clear transverse grooves. Spermatophore groove well developed; calamus distinct; CaLI 25.9–30.7–34.8 (SD, 3.1) with inverted V-shaped distal margin and deep median groove (Fig. 2b).

Digestive tract: typical *Octopus* digestive tract (Fig. 2c). Large buccal mass with pair of medium-sized anterior salivary glands joined by salivary ducts to posterior portion of buccal mass; posterior salivary glands triangular. Narrow oesophagus followed by crop diverticulum; stomach wide. Spiral caecum connected by two ducts to large digestive gland; ink sac embedded in digestive gland surface. Intestine long, curved, ending in muscular rectum. Beak strong; upper beak with prominent rostrum and small hood (Fig. 3a), lower beak with large crest and thickened wings (Figs 3b and 3c). Radula with seven teeth in transverse rows (Fig. 4a). Rhachidian tooth with 1–2 symmetrical lateral cusps (Figs 4a and 4b) migrating from medial to lateral position over six rows. First lateral teeth narrow with single cusp displaced towards second lateral teeth. Second lateral teeth with large pointed cusp displaced toward midline of radula ribbon (Fig. 4c). Marginal plates small, flat, rectangular (Fig. 4a).

Male reproductive tract: testis small, broad in mature males; vas deferens narrow, long, highly coiled and wrapped in membranous sac, opens into long spermatophore gland with distinct recurved coil; accessory gland robust, reflexed distally (Fig. 5a). Spermatophoric gland and accessory gland opening into spermatophore storage sac. Blunt appendix at junction of spermatophore storage sac and spermatophoric ducts. Terminal organ short, tubular; diverticulum spherical (Fig. 5a). Spermatophores long and narrow; SpLI 71.0–104.4–135.0 (SD, 23.4); SpWI 2.0–2.3–2.8 (SD, 0.3) (Fig. 5b). Up to three well-developed spermatophores in storage sac of mature males. Spermatophore has large number of sperm chord whorls (54 in the illustrated specimen), short midsection and a very long cap thread. Oral cap with ill-defined internal structure (Fig. 5c).

Female reproductive tract: large ovary with two oviducts protruding anteriorly, each with oviducal gland (Fig. 5d). Eggs relatively large and cylindrical; EgLI 17.2–18.4–20.3 (SD, 1.7).

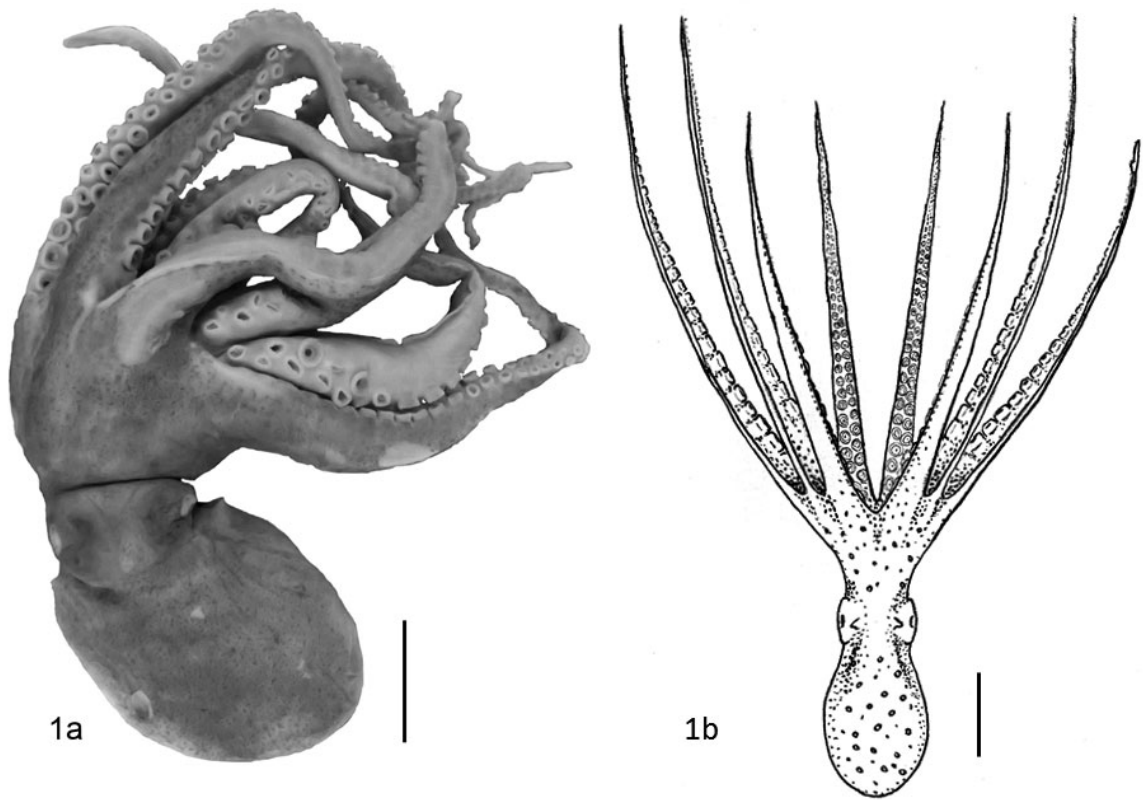


Figure 1. *Octopus kapalae*, sp. nov.: (a) photograph of holotype ♂ 49.5 mm ML (AM C. 559063), dorsal view, scale bar 2 cm; (b) stylised dorsal view, scale bar 2 cm.

Integument: colour in life unknown. Colour in preserved specimens varying from pinkish white to dark brown on dorsal surface and from cream to brownish purple ventrally. Skin relatively smooth in texture, however, dorsal surfaces of mantle, head and arms covered with low papillae of varying sizes that are more concentrated on the mantle, posterior to eyes and at the basal region of the arms. Papillae appear as distinctive orange spots in preserved specimens with larger papillae forming a bumpy texture on the integument (Figs 1a and 1b). One large papilla dorsal to each eye.

Type locality

Australia, New South Wales, east of Grafton, 29°55'S, 153°40'E to 29°48'S, 153°42'E.

Distribution

Edge of the continental shelf off the coast of south-eastern Australia. Depth range 176–503 m (Fig. 6).

Etymology

The species name, *kapalae*, is derived from the

NSW Fisheries vessel name, FV 'Kapala' from which all the specimens described here were obtained. Gender feminine.

Remarks

Within the Octopodidae, this taxon has closest affinities with the genus *Octopus* Cuvier, 1797, as defined in Norman et al. (2016:40): in having arms ~3–5 times the mantle length, lateral arms longer than the rest, and with deepest webs, and in possessing two series of arm suckers, with those on the lateral arms larger (albeit slightly) than those on the dorsal and ventral arms, and a W-shaped funnel organ. The number of gill lamellae is within the range given for the genus. However, *O. kapalae* appears to lack the conspicuous diamond arrangement of primary papillae on the mantle, characteristic of *Octopus*, and has one large papillae above each eye. It is not possible to determine whether the absence of these traits is due to the nature of preservation. In addition, the skin lacks the distinct patch and groove system that forms a reticulate pattern that is typical in *Octopus*. In contrast, the skin in *O. kapalae* is smooth, with distinctive scattered papillae. Until the octopodid

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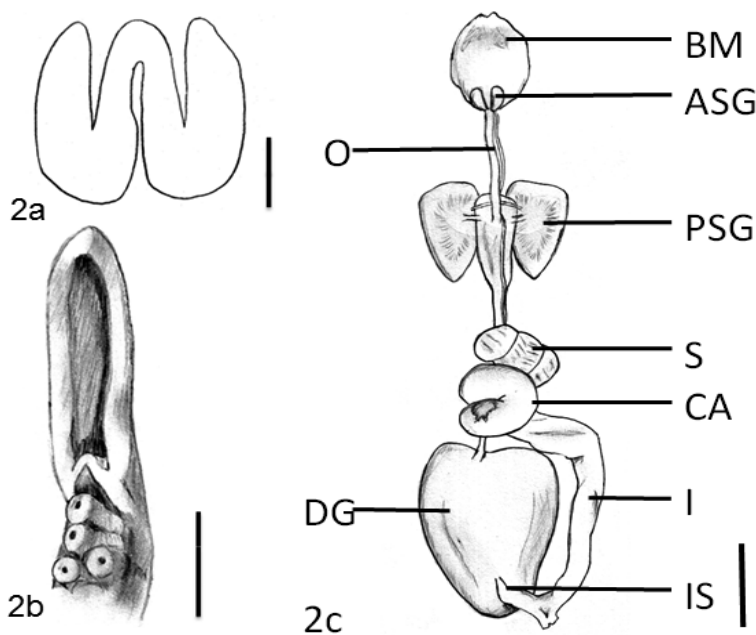


Figure 2. *Octopus kapalae*, sp. nov.: (a) paratype ♂ 37.5 mm ML (AM C.476226), funnel organ, scale bar 4 mm; (b) paratype ♂ 53.5 mm ML (AM C.476227), hectocotylus, scale bar 3 mm; (c) paratype ♂ 37 mm ML (AM C.476316), digestive tract, scale bar 1 cm. ASG, anterior salivary gland; BM, buccal mass; CA, caecum; DG, digestive gland; I, intestine; IS, ink sac; O, oesophagus; PSG, posterior salivary gland; S, stomach.



Figure 3. *Octopus kapalae*, sp. nov.: (a) paratype ♂ 53.5 mm ML (AM C.476227), upper beak lateral view, scale bar 5.5 mm; (b) lower beak lateral view, scale bar 2.8 mm; (c) lower beak ventral view, scale bar, 2.8 mm.

genera are better defined, *O. kapalae* is described among the taxa recognised as ‘unplaced *Octopus*’ as designated in Norman et al. (2016). Its correct generic placement can only be properly determined following a comprehensive phylogenetic analysis of *Octopus*, preferably including both morphological and molecular characters. Unfortunately, as far as we are aware, no tissue suitable for sequencing is currently available for *O. kapalae*. The specimens studied here were all originally formalin-fixed, thus not suitable for molecular examination using currently available techniques.

A combination of characters distinguish *O. kapalae* from the six other nominal *Octopus* species known to inhabit the coast of south-eastern Australia (see Introduction). These include: the W-shaped funnel organ, seven gill lamellae, a skin pattern of low orange papillae and a large papilla over each eye, an incomplete ventro-lateral mantle ridge, an arm formula usually 2>3>4>1 or 2>3>1>4 and a cylindrical, dorso-ventrally flattened ligula.

Octopus australis differs from *O. kapalae* in possessing a V-shaped funnel organ and a relatively shorter and more robust club-like hectocotylus, with minute papillae along the groove that are absent in *O. kapalae* (Tait 1982; Stranks and Norman 1992).

Octopus kapalae is similar to *O. bulbus* but the hectocotylised arm of *O. bulbus* differs from that of *O. kapalae* in relative length (OAI 56 v. 68–84) and the two taxa differ in ligula morphology, with that of *O. bulbus* (and in giving the species its name) being very swollen and bulb-like. (To ensure this was indeed the case, an *O. bulbus* paratype (MV F.87068) was examined to confirm this difference.) The spermatophores have 24 sperm cord whorls compared with >50 in *O. kapalae*. The first pair of arms are the longest in *O. bulbus*, rather than the second or third pairs

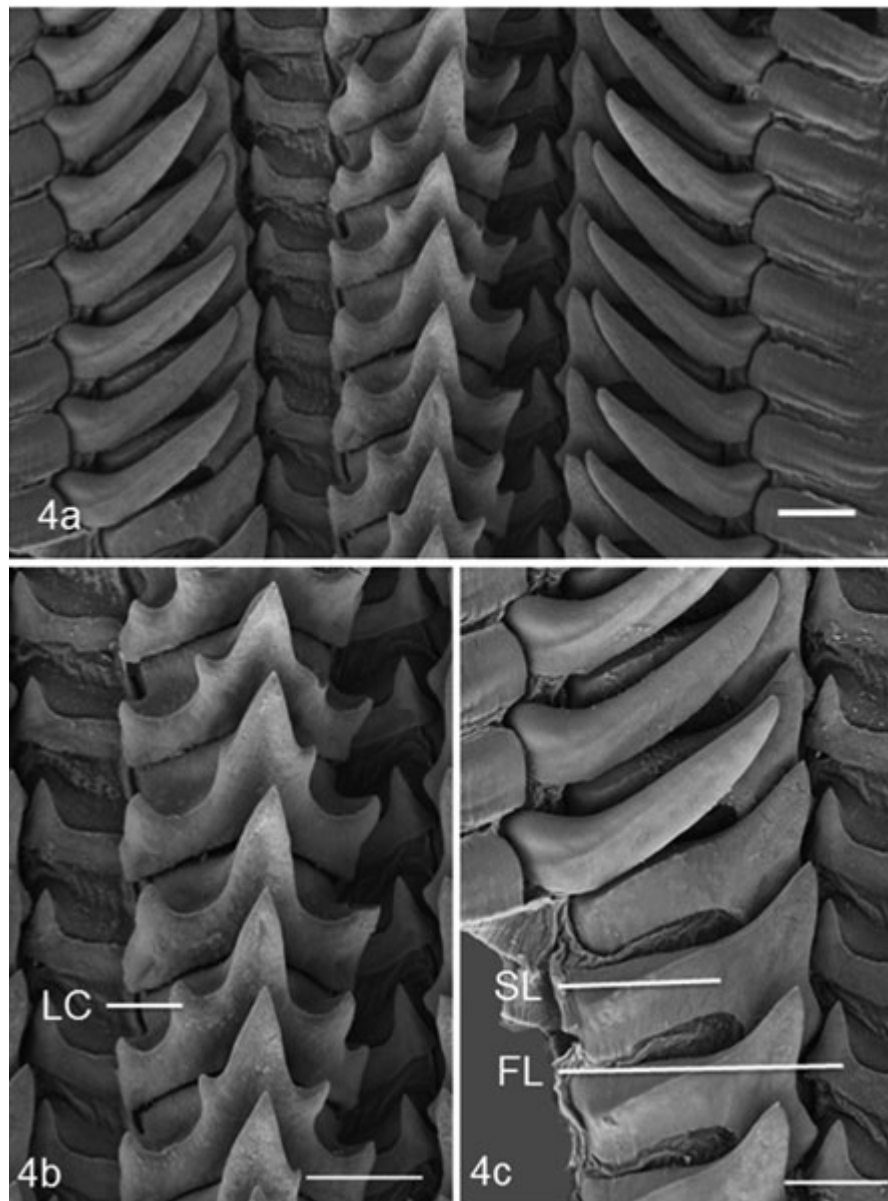


Figure 4. *Octopus kapalae*, sp. nov.: (a) paratype ♂ 53.5 mm ML (AM C.476227), transverse view of unused portion of radula ribbon, scale bar 100 µm; (b) enlargement of rhachidian tooth row, scale bar 100 µm, LC, lateral cusp; (c) enlargement of lateral teeth, scale bar 100 µm, FL, first lateral teeth; SL, second lateral teeth.

in *O. kapalae*, and are 4.9–5.6× the mantle length, while in *O. kapalae* the longest arms are usually less than 5× the mantle length. The number of arm suckers (~190) is much greater than that of *O. kapalae*, which has a maximum of 161 in the examined specimens. The rhachidian tooth of *O. bulbosus* has 2–3 lateral cusps on each side (Norman 2001), as opposed to 1–2 in *O. kapalae*.

Octopus micros is a pygmy octopus, smaller than *O. kapalae* (maximum ML 25.0 v. 57.5). The arms

are approximately equal length in *O. micros*. The colouration differs between these species, with *O. kapalae* lacking the white spots and diamond shaped pattern of papillae on the dorsal mantle of *O. micros* (Norman 2001).

Octopus pyrum has a pear-shaped ligula with a distinct spermatophore guide bordered by flattened papillae or digits of skin, which clearly distinguishes it from *O. kapalae*. Several traits of *O. pyrum* are absent in *O. kapalae*, including a lateral ridge, obviously

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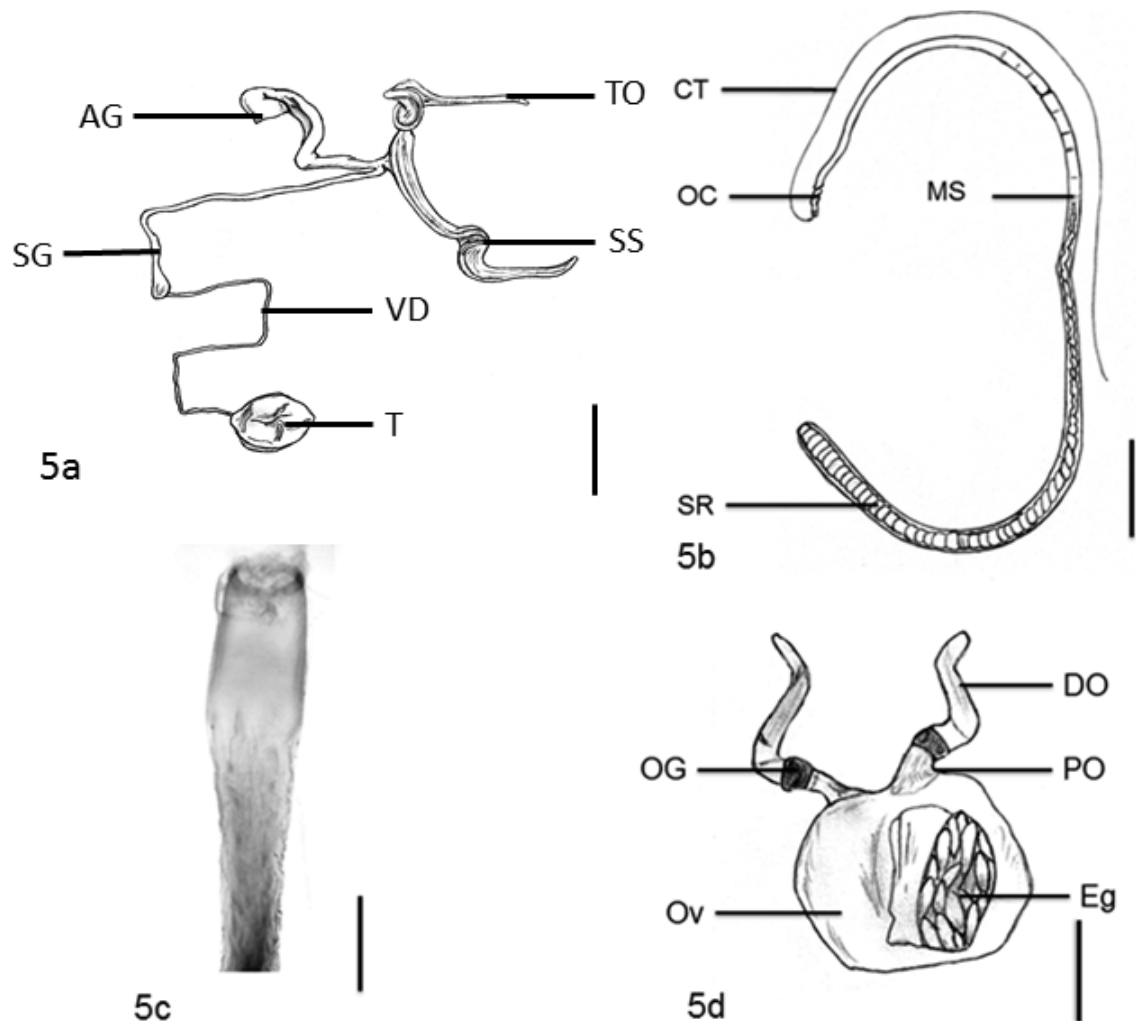


Figure 5. *Octopus kapalae*, sp. nov.: (a) paratype ♂ 37 mm ML (AM C.476316), male reproductive tract, scale bar 2 cm, AG, accessory gland; SG, spermatophoral gland; SS, spermatophore storage sac; T, testis; TO, terminal organ; VD, vas deferens. (b) spermatophore, same specimen, scale bar 5 mm, CT, cap thread; MS, mid-section; OC, oral cap; SR, sperm reservoir; (c) paratype ♂ 48.5 mm ML (AM C.476230), oral cap enlargement, scale bar, 0.5 mm; (d) paratype ♀ 30 mm ML (AM C.156202), female reproductive tract, scale bar 1 cm, DO, dorsal oviduct; Eg, eggs; OG, oviductal gland; Ov, ovary; PO, proximal oviduct.

enlarged suckers in either sex, and a distinctive transverse band of chromatophores across the medioventral mantle and tip of the funnel. In addition, cream to gold leucophores and large chromatophores over the ventral digestive gland are conspicuous in *O. pyrum* (Norman et al. 1997; Norman et al. 2016).

Octopus pallidus differs from *O. kapalae* by possession of a V-shaped funnel organ, and conspicuous sub-parallel rows of 4–6 unbranched papillae on the dorsal mantle. The skin sculpture is clearly tile-like thus differing from *O. kapalae*, and there is a faint orange stripe present along the length of the dorsal arms in *O. pallidus* that can be seen in both live and preserved specimens (Stranks 1998).

Octopus tetricus differs from *O. kapalae* in adult size (ML 140 v. 57.5), the presence of enlarged suckers in *O. tetricus*, higher sucker counts on the hectocotyliised arms (SCHc 140–160 v. 76–99), and a small ligula (LLI 1–2 v. 5.8–9.2). *Octopus kapalae* has fewer gill lamellae than *O. tetricus* (GiLC 8–9 v. 7). The eggs of *O. tetricus* are much smaller than *O. kapalae* (EgL 2–3 v. 4.3–6.1) (Stranks 1998; Norman 2000).

Species complexes from south-east Asia are disregarded by comparisons with descriptions given in Norman and Sweeney (1997). In each case, the combination of low gill lamellae count, arm formula, integumentary characters and funnel organ and

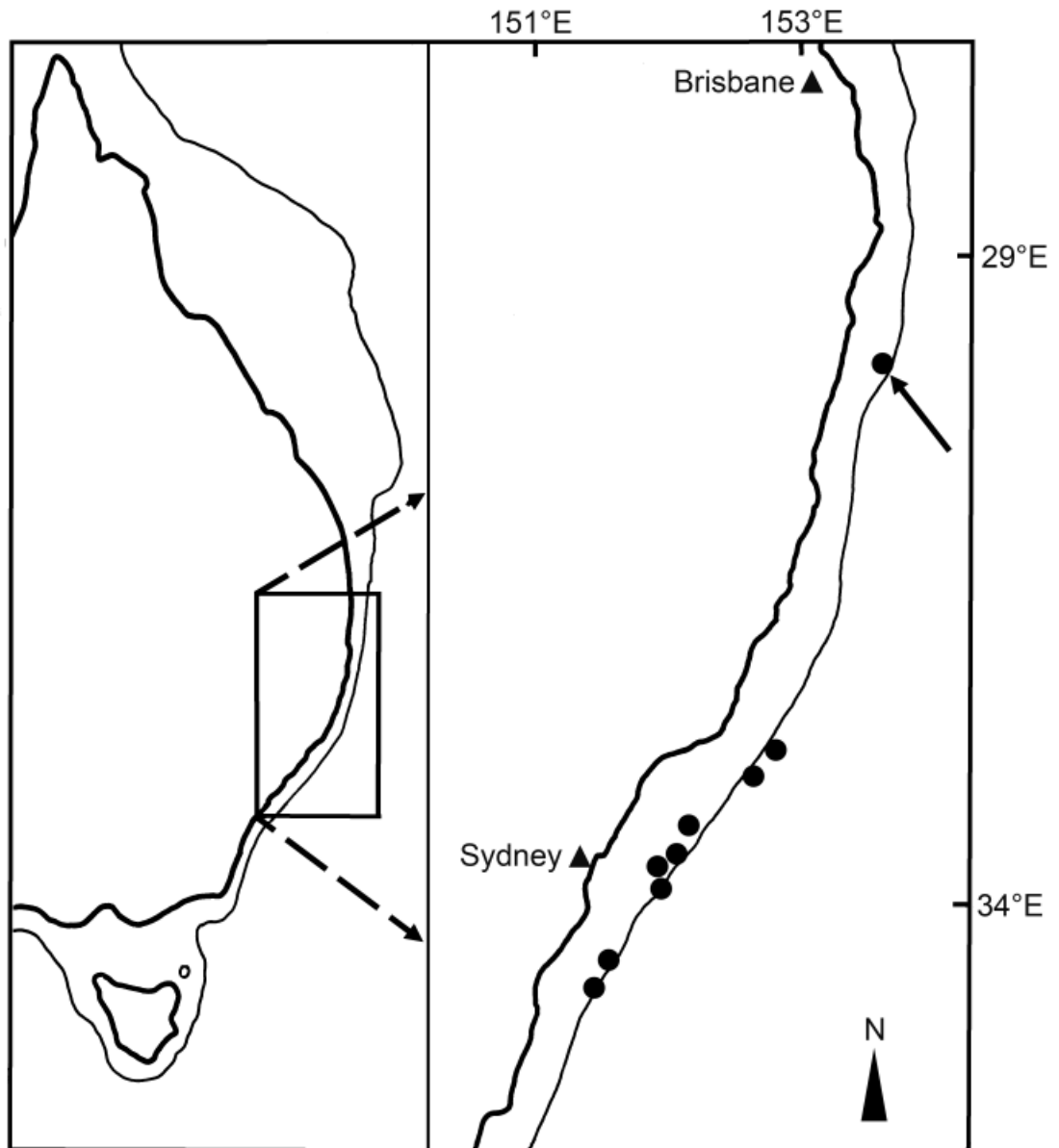


Figure 6. Distribution map of collection localities for *Octopus kapalae*, sp. nov. Line to right of continental margin represents edge of continental shelf. Arrow indicates the collection locality of the holotype.

copulatory organ morphology show that *O. kapalae* differs from each of these taxa. For the above reasons we are confident that *O. kapalae* is a species new to science.

Nothing is yet known of the ecology or behaviour of this species and the capture depth makes future observations in its natural habitat difficult. The possession of large eggs suggests that, as for other large-egged octopus species, development is probably direct, with the young probably settling soon after

hatching. This can place limitations on dispersal, suggesting that *O. kapalae* may be endemic to the region.

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APPENDIX

Definitions of counts, measurements and indices.

AF	Arm Formula (arm numbers ordered from longest to shortest).	SDI	Sucker Diameter Index: diameter of the largest sucker measured across the aperture from rim to rim as a percentage of mantle length.
ALI	Arm Length Index: length of arm measured from basal-most sucker to distal tip of arm as a percentage of mantle length.	SpLI	Spermatophore Length Index: length of spermatophore as a percentage of mantle length.
ASIn	Arm Sucker Index: diameter of largest arm sucker as a percentage of mantle length.	SpWI	Spermatophore Width Index: greatest width of spermatophore as a percentage of spermatophore length.
AWI	Arm Width Index: arm width at widest point on stoutest arm as a percentage of mantle length.	TL	Total Length: measured from the tip of the longest arm to the posterior end of the mantle.
CaLI	Calamus Length Index: length of the calamus measured from the distal-most arm sucker to distal arm tip as a percentage of ligula length.	WD	Web depth from mouth to midpoint of sector (web sectors: A, dorsal to dorsal-E, ventral to ventral).
EgLI	Length of egg as a percentage of mantle length.	WDI A-E	Web Depth Index: deepest sector of web as a percentage of the longest arm length (web sectors: A, dorsal to dorsal-E, ventral to ventral).
FFuI	Free Funnel Length Index: length of free funnel portion as a percentage of mantle length.	WF	Web Formula: web sectors ordered from deepest to shallowest.
FuLI	Funnel Length Index: funnel length as a percentage of mantle length.		
GiLC	Gill Lamellae Count: number of gill lamellae per demibranch (not including the medial terminal lamella).		
GLI	Gill Length Index: length of gill as a percentage of mantle length.		
HcAI	Hectocotylied Arm Index: length of hectocotylied arm as a percentage of mantle length.		
HWI	Head Mantle Width Index: greatest width of head as a percentage of mantle width.		
LLI	Ligula Length Index: length of ligula measured from the distal-most arm sucker to distal tip of the arm as a percentage of the length of the hectocotylied arm.		
ML	Mantle Length: dorsal mantle length measured from the midpoint between the eyes to the posterior end of the mantle.		
MWI	Mantle Width Index: greatest straight-line (dorsal) width of mantle as a percentage of mantle length.		
OAI	Opposite Arm Index: length of hectocotylied arm as a percentage of its fellow arm on the opposite side.		
SC	Sucker Count: total number of suckers on normal arms.		
SCHc	Sucker Count Hectocotylus: number of suckers on hectocotylied arm of male.		

