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A New Species of Shallow Water Octopus, *Octopus laqueus*, (Cephalopoda: Octopodidae) from Okinawa, Japan

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Abstract A small octopus species new to science is described based on material collected from Okinawa Island, Japan. This species, *Octopus laqueus*, possesses the following characters: mature at small size (mantle length: 23.6–48.2 mm), arm formula of 4=3>2>1, thin web margins extending to arm tips, dark brown bands along the arms visible after fixation, a hectocotylized arm (third right arm) with 81–97 suckers, 5–6 gill lamellae, a pair of white spots on the dorsal mantle, and a pair of large papillae located just above each eye. Morphological comparison is presented between the new species and those of related Indo-West Pacific and Japanese taxa.
Key words: Octopodidae, octopus, Okinawa, Indo-West pacific, Japan.

Introduction

Ryukyu Islands are located at the periphery of the East China Sea between Kyushu and Taiwan. Okinawa Island is at the center of Ryukyu Islands and is in the northern limit of Indo-West Pacific zoogeographic region (Fig.1). Although the potential richness of octopus fauna in this region has been acknowledged (Nateewathana, 1997; Norman, 1991, 1992a–c, 1998, 2001; Norman and Hochberg, 1994, Norman and Sweeney, 1997; Norman and Finn, 2001), there has been little research on octopuses in the waters around Okinawa Island. Several octopuses are known from this region, i.e. *Octopue cyanea, O. ornatus, and O. oliveri* are important octopuses for local fisheries, and *Hapalochlaena fasciata*, and *H. lunulata* are notorious as venomous octopus (Okutani *et al.*, 1987; Kubodera, 1998). However, a recent survey suggests that systematic reevaluation is needed even in those common species. For example, *O. oliveri* from this region may be confused with *O.* (*Abdopus*) *aculeatus* (Kaneko, unpublished data) and two species of *Hapalochlaena* seem to be different from the typical individuals reported from Australian waters (Norman, pers. com.).

In this study, a small octopus species was found in the coastal waters of Okinawa Island. Morphological comparison between this octopus and those previously described from the Indo-West Pacific and mainland Japan indicate that this octopus is an undescribed member of the genus *Octopus*. As they are small in size and are not caught for commercial purposes, their existence has not previously been reported.

Materials and Methods

Field surveys were carried out at three sites; Cape Maeda, Ohdo beach and Bise beach in Okinawa Island from October to May in 2003 and 2004 (Fig.1). Twenty individuals were collected by hand from intertidal rocky reefs on low tide nights from October to March in Ohdo and Bise. Two additional individuals were collected by SCUBA diving off Cape Maeda at depths of 12 m to 18 m. All collected animals were exposed to low temperature (<5°C), fixed in 10% formalin, and preserved in 70% ethanol

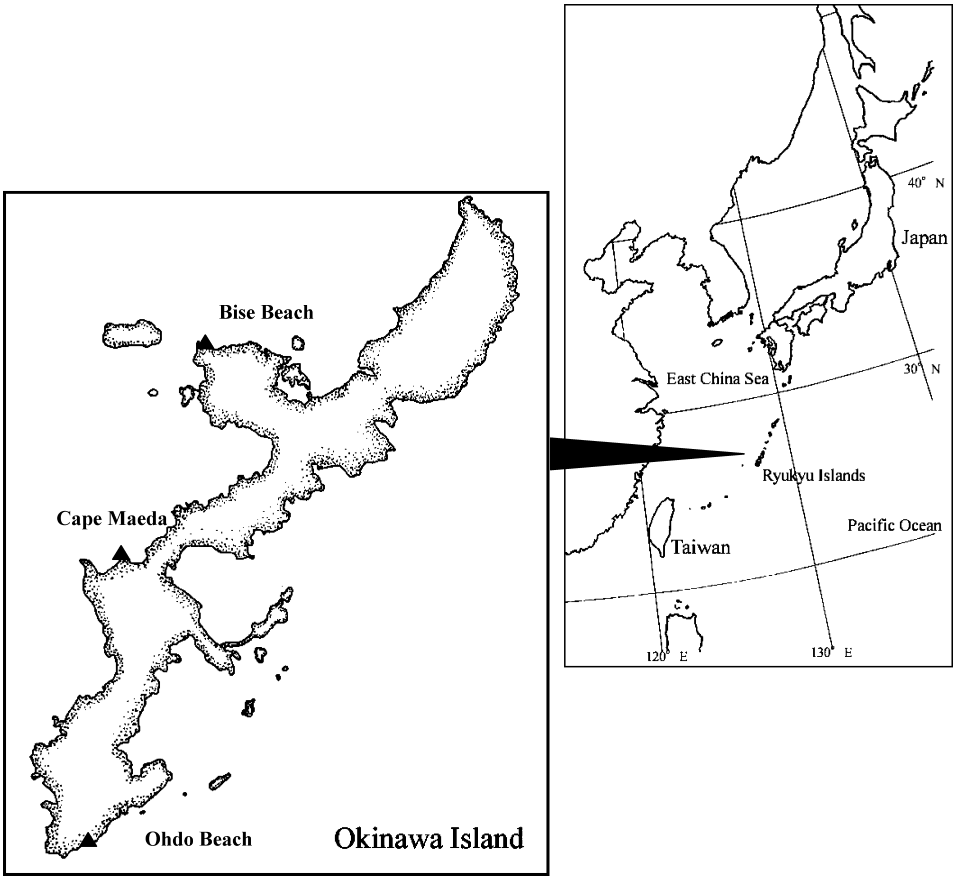

Fig. 1. Collecting sites of new species. (Cape Maeda: 26°23′N, 127°44′E, Bise beach: 26°40′N, 127°58′E, Ohdo beach: 26°07′N, 127°39′E)

(following Roper and Sweeney, 1983).

Counts and measurements were made from preserved materials following Roper and Voss (1983). Abbreviations and definitions were listed in Table 1.

Systematics

Family Octopodidae Orbigny, 1845

Octopus laqueus sp. nov.

Holotype: **Cape Maeda, (26°23′N, 127°44′E), Okinawa I.:** Male 33 mm ML, NSMT-Mo 75242, 11 m depth, 24 May 2003, collected by D. Ueno

Paratypes: **Ohdo Beach, (26°07′N, 127°39′E), Okinawa I.:** 1 male (M1), 32.5 mm ML, NSMT-Mo 75243, 1 female (F3), 25 mm ML, NSMT-Mo 75244, 0.1 m depth, 28 October 2003, collected by N. Kaneko; 1 male (M3), 27.1 mm ML, NSMT-Mo 75245, tide pool, 7 November 2003 collected by H. Noho; 1 male (M2), 30.2 mm ML, NSMT-Mo 75246, 0.1 m depth, 13 November 2003, collected by N. Kaneko; 1 male (M5), 6 mm ML, NSMT-Mo 75247, 23 December 2003, 0.1 m depth, collected by N. Kaneko, S. Iwanaga; 2 female (F1, F2), 40.2 mm ML and 32 mm ML, NSMT-Mo 75248, NSMT-Mo 75249, 0.1 m depth, 9 January 2004, collected by N. Kaneko; 1 female (F4), 37.9 mm ML, NSMT-Mo 75250 and 1 male (M4), 34.7 mm ML, NSMT-Mo 75251, 0.1 m depth, 7 February 2004, collected by N. Kaneko, S. Iwanaga, A. Ohba.

Bise Beach (26°40′N, 127°58′E), Okinawa I.:

Table 1. Definitions of measurements and indices (in accordance with Roper and Voss, 1983).

Terms	Definitions
Total Length (TL)	End of longest arm to posterior end of mantle.
Mantle Length (ML)	Midpoint between eyes to posterior end of mantle.
Mantle Width (MW)	The greatest straight-line (dorsal) width of mantle.
Head Width (HW)	Greatest width of head at level of eyes.
Arm Length (AL)	Beak to tip of arm.
Arm Width (AW)	Stoutest arm at mid-point of arm length.
Web depth	Mouth to midpoint of deepest sector between arms.
Enlarged Sucker Diameter	Largest enlarged arm sucker.
Funnel Length (FL)	The length of the funnel from the anterior funnel opening to the posterior border mea sured along the ventral midline.
Free Funnel Length	The length of the funnel from opening to the point of dorsal attachment to the head.
Ligula Length	Length of ligula measured from distal-most sucker to tip.
Calamus Length (CaL)	Length of calamus measured from last sucker to its distal tip.
Mantle Arm Index (MAI)	Mantle length as a percentage of longest arm.
Mantle Width Index (MWI)	Mantle width as a percentage of mantle length.
Head Width Index (HWI)	Head width as a percentage of mantle length.
Arm Width Index (AWI)	Arm width as a percentage of mantle length.
Web Depth Index (WDI)	Web depth as a percentage of longest arm.
Arm Sucker Index (ASIe)	Diameter of largest enlarged arm sucker as a percentage of mantle length.
Arm Sucker Index (ASIn)	Diameter of largest normal arm sucker as a percentage of mantle length.
Funnel Length Index (FLI)	Funnel length as a percentage of mantle length.
Free Funnel Length Index (FFuI)	Free funnel length as a percentage of mantle length.
Hectocotylized Arm Index (HcAI)	Length of hectocotylized arm measured from proximal-most arma ture, or defined proximal point, to tip as a percentage of mantle length.
Ligula Length Index (LLI)	Ligula length as a percentage of length of hectocotylized arm.
Calamus Length Index (CaLI)	Calamus length as a percentage of length of ligula length.
Spermatophore Length Index (SpLI)	Length of spermatophore as a percentage of mantle length.
Spermatophore Width Index (SpWI)	Greatest width of spermatophore as a percentage of spermatophore length.
Spermatophore Receiver Index (SpRI)	Length of sperm reservoir as a percentage of mantle length.
Penis Length Index (PLI)	Length of penis and diverticulum as a percentage of mantle length.
Opposite Arm Index (OAI)	Length of hectocotylized arm as a percentage of its fellow arm on opposite side.
Egg Length Index (ELI)	Length of egg as a percentage of mantle length.
Egg Width Index (EWI)	Greatest width of egg as a percentage of mantle length.

1 female (F5), 48.2 mm ML, NSMT-Mo 75252, 1 male (M6), 29.8 mm ML, NSMT-Mo 75253, 0.1 m depth, 21 February 2004, collected by S. Iawanaga.

Other specimens: **Ohdo beach, Okinawa I.:** 1 female and 1 male, 0.1 m depth, 4 March 2004, collected by N. Kaneko, S. Iwanaga, A. Ohba, Kadota. **Bise beach, Okinawa I.:** 3 female and 4 males, 0.1 m depth, 21 February 2004, collected by S. Iawanaga. **Cape Maeda, Okinawa I.:**1 female, 6.9 m depth, 30 December 2003, collected by Fujita.

Diagnosis. Small body and medium to long arms (3.0–4.9×ML), with an arm formula of 4=3>2>1. Webs between arms short in depth, (WDI: 17.2–34.9%, mean: 13.1–24.7%) and the web formula typically C>D>E=B>A but variable, sector A usually shallowest. Web partly transparent, extending as thin web margins to tip of arms. Arms banded in dark brown after fixation, animals typically white when alive. Male has enlarged suckers on the 2nd and 3 rd arms at level of 8 th to 16 th proximal sucker. Third right arm of male hectocotylized with 81–97 suckers and shorter than opposite arm (OAI: 66.1–83.7%, mean: 78%). Ligula small and narrow (LLI: 0.7–2.6%, mean: 1.5%; CaLI: 16.7–37.5%, mean: 28.1%). 5–6 gill lamellae per demibranch. Funnel organ W-shaped. Penis (terminal organ) linear (PLI: 12.6–32.3%, mean: 19.6%). Sper-

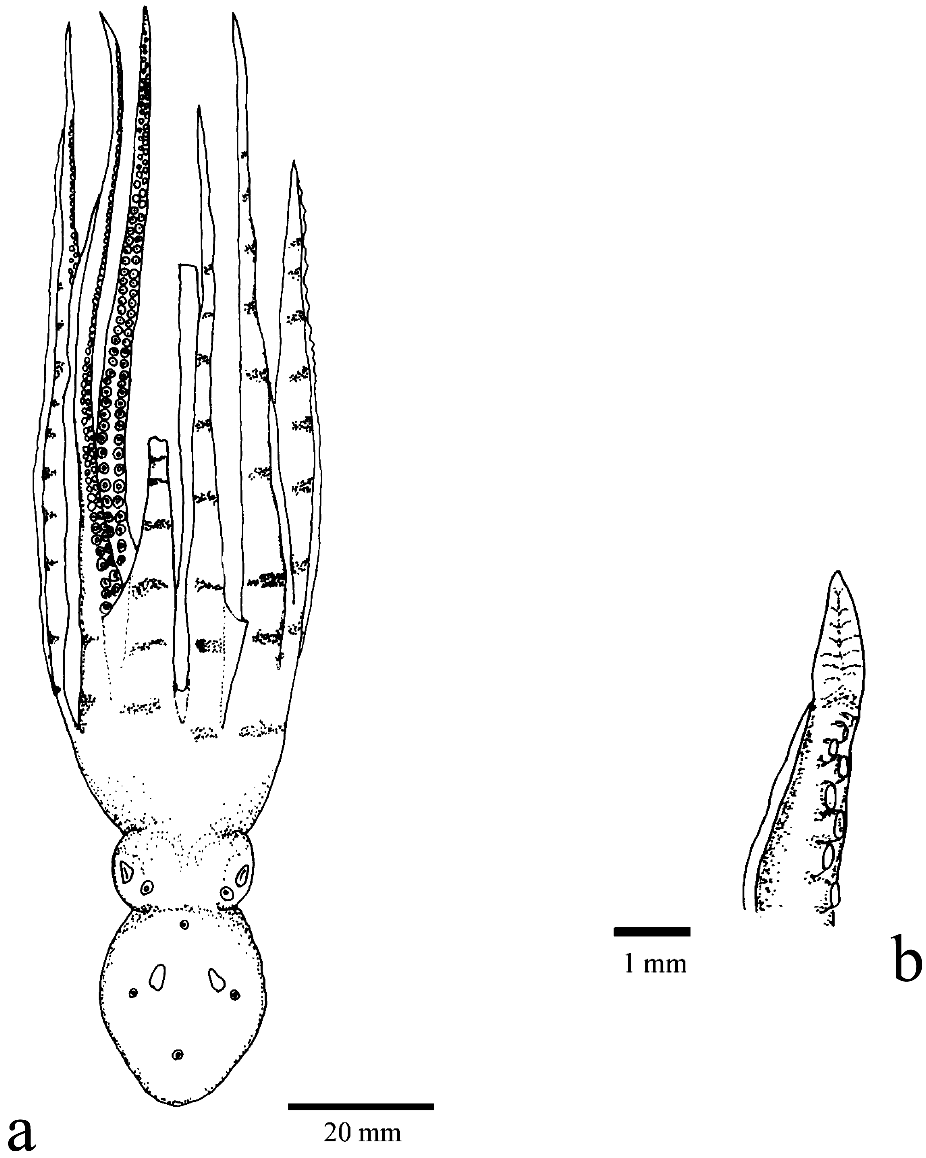

Fig. 2. a, Dorsal view of 33 mm ML male (holotype, NSMT-Mo 75242). b, Hectocotylus of the same specimen.

matophores short to moderate in length (SpLI: 17.5–64.6%, mean: 44.5%). Skin slightly textured with large papillae over dorsal surface and arms. Primary papillae on dorsal mantle in diamond arrangement. Pair of white spots present on dorsal mantle and single large papilla located above each eye.

Description. Measurements and indices of holotype specimen, 6 male paratypes and 5 female paratypes in Table 2. Holotype specimen is matured, Data of mean, maximum and minimum measurements in the description, Tables 2 and 3 include all 22 specimens examined. Dorsal view and hectocotylized arm of holotype shown in Fig. 2.

Small sized species (ML: 23.6–48.2 mm, mean: 33.8 mm) with ovoidal mantle (MWI: 48.1–76%, mean: 61.5%). Head narrower than mantle (HWI: 33.9–65.6%, mean: 50.8%) with pronounced large eyes. Funnel small to moderate (FLI: 33.2–

Table 2. Mesure ments, counts and indices of *Octopus laqueus* sp. nov. D=damaged, M=mature, SM=submature.

NSMT-	Holotype Mo 75242	Mo 75243	Mo 75246	Mo 75245	Mo 75251	Mo 75247	Mo 75253	Mo 75248
Sex and Maturity stage	♂(M)	♂(M)	♂(M)	♂(M)	♂(M)	♂(M)	♂(M)	♀(M)
Total length (mm)	155	146	152	139	201	225	140	213
Mantle length (mm)	33	32.5	30.2	27.1	34.7	40.6	29.8	40.2
Total weight (g)	20.6	19.7	17.9	15.6	26	22.2	17.9	48.8
Mantle width index (MWI) (%)	66.7	76	67.2	67.9	59.9	50.5	62.4	74.6
Head wodth index (HWI) (%)	57.6	61.5	65.6	55.4	52.7	42.9	54.4	51.5
Mantle arm index (MAI) (%)	27	28.8	25	23.4	21.3	22.2	27.9	22.5
Arm width index (AWI) (%)	12.1	11.1	13.6	11.1	13	8.1	12.1	11.9
Arm length index (ALI : R/L)1 (%)	293.9/D	255.4/298.5	317.9/317.9	369.0/372.7	391.9/351.6	D/374.4	305.4/315.4	D/375.6
Arm length index (ALI : R/L) 2 (%)	345.5/369.7	304.6/338.5	400.7/384.1	D/417	D	376.8/D	312.1/318.8	388.1/D
Arm length index (ALI : R/L) 3 (%)	239.4/309.1	270.8/347.7	311.3/384.1	332.1/428	351.6/452.4	298.0/450.7	281.9/D	445.3/420.4
Arm length index (ALI : R/L) 4 (%)	D/345.5	344.6/344.6	387.4/390.7	417.0/D	397.7/469.7	D/421.2	359.1/349.0	403.0/430.3
Web depth index (WDI) A (%)	5.7	12.4	14.9	20.7	12.3	13.7	18.7	11.2
Web depth index (WDI : R/L) B	16.4/13.9	17.7/21.2	19.8/19.0	D/27.6	18.4/19.6	15.3/17.5	19.6/21.5	14.5/14.5
Web depth index (WDI : R/L) C	15.6/17.2	20.4/19.5	24.0/17.4	27.6/29.3	20.2/23.3	21.3/27.3	20.6/28	20.1/18.4
Web depth index (WDI : R/L) D	11.5/13.1	20.4/17.7	19.8/21.5	21.6/D	17.8/22.7	17.5/21.3	23.4/21.5	16.2/19
Web depth index (WDI) E	11.5	22.1	18.2	–	22.1	17.5	18.7	17.3
Arm sucker index (normal-ASIn) (%)	7.3	10.2	10.3	10	10.4	7.6	11.1	8.5
Arm sucker index (enlarged-ASIe) (%)	12.7	16.5	14.6	15.5	13.5	11.3	13.4	–
Arm sucker count (ASC)	131–146	113–136	106–124	101–115	103–124	100–137	97–126	127–160
Funnel length index (FLI) (%)	37	40	52.3	33.2	46.4	35.5	63.8	49.8
Free funnel length index (FFuI) (%)	18.8	27.1	42.4	25.8	38.9	29.3	35.6	40.3
Gill lamellae count (GiLC)	5	5	6	6	6	6	5	5
Hectocotylized arm index (HcAI) (%)	239.4	270.8	311.3	332.1	351.6	298	281.9	–
Opposite arm index (OAI) (%)	77.5	77.9	81	77.6	77.7	66.1	–	–
Hectocotylized arm sucker count	86	85	87	87	97	81	87	–
Ligula length index (LLL) (%)	1.9	1.1	0.7	1.8	1	1.7	2.6	–
Calamus length index (CaLI) (%)	33.3	30	28.6	25	25	25	27.3	–
Penis length index (PLI) (%)	13.9	32.3	12.6	18.5	–	15.5	20.8	–
Spermatophore length index (SpLI) (%)	24.2	47.7	61.3	64.6	63.4	50.2	64.4	–
Spermatophore width index (SpWI) (%)	1.3	2.6	2.2	1.7	1.8	2	1.6	–
Spermatophore reservoir index (SpRI) (%)	40	34.8	35.1	33.1	36.4	38.2	40.1	–
Egg length index (EgLI) (%)	–	–	–	–	–	–	–	12.2
Egg width index (EgWI) (%)	–	–	–	–	–	–	–	3.7

Table 2. Mesure ments, counts and indices of *Octopus laqueus* sp. nov.

	Mo 75249	Mo 75244	Mo 75250	Mo 75252	Mean*	Max*	Min*
Sex and Maturity stage	♀(SM)	♀(SM)	♀(M)	♀(M)			
Total length (mm)	170	122	192	225	165.8	225	122
Mantle length (mm)	32	25	37.9	48.2	33.8	48.2	23.6
Total weight (g)	21.2	10.2	27.2	46.6	21.9	48.8	10.2
Mantle width index (MWI) (%)	70.9	68	59.9	56	61.5	76	48.1
Head wodth index (HWI) (%)	55.9	52	41.2	36.9	50.8	65.6	33.9
Mantle arm index (MAI) (%)	22.1	26.3	26.3	29.2	26.1	33.3	20.5
Arm width index (AWI) (%)	10.3	16	10.8	11.4	11.4	16	8.1
Arm length index (ALI : FR/L)1 (%)	384.4/309.4	308.0/320.0	271.8/D	D	316.4/326.4	449.2/487.3	232.0/271.8
Arm length index (ALI : FR/L) 2 (%)	D/415.6	328.0/336.0	372.0/337.7	315.4/321.6	341.0/351.0	400.7/417.0	275.8/288.9
Arm length index (ALI : FR/L) 3 (%)	412.5/453.1	360.0/380.0	366.8/343.0	319.5/334.0	329.2/380.2	445.3/453.1	239.4/309.1
Arm length index (ALI : FR/L) 4 (%)	418.8/415.6	376.0/336.0	379.9/372.0	327.7/342.3	376.3/377.9	461.9/474.6	297.2/334.4
Web depth index (WDI) A (%)	11	10.5	13.9	13.3	13.1	20.7	5.7
Web depth index (WDI : FR/L) B	17.9/17.9	15.8/17.9	13.2/17.4	17.6/19.4	18.4/19.9	24.1/27.8	13.2/14.5
Web depth index (WDI : FR/L) C	20.7/24.1	20.0/23.2	18.8/20.8	21.8/21.2	21.9/24.0	27.6/31.0	15.6/17.2
Web depth index (WDI : FR/L) D	22.1/22.1	21.1/21.1	25.0/22.9	23.6/26.7	21.6/22.4	28.4/34.9	11.5/13.1
Web depth index (WDI) E	22.8	17.9	21.5	17.6	20.8	27.5	11.5
Arm sucker index (normal - ASIn) (%)	7.8	8	7.4	7.3	8.6	11.1	5.8
Arm sucker index (enlarged - ASIe) (%)	–	–	–	–	13.8	16.2	11.3
Arm sucker count (ASC)	134–151	117–135	89–124	143–156	121	160	86
Funnel length index (FLI) (%)	53.4	48	48.5	41.1	44.9	63.8	33.2
Free funnel length index (FFuI) (%)	39.7	32	36.4	29.5	33.8	42.4	18.8
Gill lamellae count (GiLC)	6	5	5	5	5	6	5
Hectocotylized arm index (HcAI) (%)	–	–	–	–	306.6	356.7	239.4
Opposite arm index (OAI) (%)	–	–	–	–	78	83.7	66.1
Hectocotylized arm sucker count	–	–	–	–	87	97	81
Ligula length index (LLI) (%)	–	–	–	–	1.5	2.6	0.7
Calamus length index (CaLI) (%)	–	–	–	–	28.1	37.5	16.7
Penis length index (PLI) (%)	–	–	–	–	19.6	32.3	12.6
Spermatophore length index (SpLI) (%)	–	–	–	–	44.5	64.6	17.5
Spermatophore width index (SpWI) (%)	–	–	–	–	2.3	7.4	1.2
Spermatophore reservoir index (SpRI) (%)	–	–	–	–	36.2	40.1	31.3
Egg length index (EgLI) (%)			11.9	6.4	10.2	12.2	6.4
Egg width index (EgWI) (%)			2.9	2.4	3	3.7	2.4

* : Data include 12 type specimens and the other 10 specimens examined.

Table 3. Some characters of *Octopus laqueus* sp. nov. compared with similar taxa. AF=arm formula, WF=web formula. Data of *Octopus laqueus* sp.nov. includes 22 specimens.

	Data source	ML	Arm length	AF	Web depth (WDI%)	WF	Gill lamellae
Octopus laqueus sp. nov.	Present paper	33.8 mm	3.4–4.9×ML	4=3>2>1	13.1–24.7	C>D>E=B>A	5–6
O. (*Abdopus*) species group	Norman and Fin 2001	<70 mm	> 4×ML	3>4>2>1	9–20	C=D=E>B>A	5–7
O. aegina species group							
O. aegina Gray, 1849	Norman and Sweeney 1997	<62 mm	2–3×ML	3=4>2>1	<28.8	D>C=B>E>A	8–9
O. kagoshimensis Ortmann, 1888	Toll and Voss 1998	40 mm	2–4×ML	3=4=2>1*	22–30	D>B=C=E>A	7–10
O. marginatus Taki, 1964	Taki 1964	43 mm	3×ML	3>4=2>1	28	D>E>C>B>A	8–10
Pygmy species							
O. arborescens (Hoyle, 1904)	Toll 1998	<12 mm	2–3×ML	4>3=2>1*	26–50	–	5–6
O. bocki Adam, 1941	Adam 1941	21 mm	3×ML	4=3>2>1	29	C>D>E>B>A	5
O. filamentosus Blainville, 1826	Toll 1998	18 mm	7×ML	4>3>2>1	–	–	8 (?)
O. gardineri (Hoyle, 1905)	Toll 1998	12.5–18 mm	2–3×ML	4=3=2=1*	34.8	–	5
O. nanus Adam, 1973	Adam 1973	13 mm	–	4>2=3>1*	21	D>A>B>C>E	5
O. pumilus Norman and Sweeney, 1997	Norman and Sweeney 1997	<31 mm	2–3×ML	4=3=2>1	20.4–27.9	B=C=D=E=A*	6
O. parvus (Sasaki, 1917)	Sasaki 1929	20–36 mm	3–4×ML	2>3=4>1*	13.1–17.6	B=C=D>A=E	4–5
O. prashadi Adam, 1939	Jothinayagam 1987	33.9% of TL	1–2×ML	3>4>2>1	very deep	C=D>B=A=E*	9
O. tenebricus Smith, 1884	Stranks 1998	17–19 mm	3–4×ML	4=3=2>1*	14–18	C>D>B>A=E	7
O. vitiensis Hoyle, 1885	Toll and Voss 1998	15 mm	2×ML	3>2>4>1	–	–	–
O. warringa Stranks, 1990	Stranks 1998	<35 mm	2–4×ML	3>4>2>1	19–34	C>B=D>A=E	6–8
O. wolfi (Wülker, 1913)	Toll and Voss 1998	10 mm	2×ML	–	15	–	5
Additional species							
O. favonius Gray, 1849	Toll and Voss 1998	52 mm	0.3×ML	3>2>4>1	21	C>D>B=E>A	10
O. globosus Appellöf, 1886	Toll and Voss 1998	31–32 mm	–	2>4=1>3*	–	–	8
O. guangdongensis Dong 1976	Dong 1976	38 mm	7–8×ML	4=3=2=1	–	–	6–8
O. kermadecensis (Berry, 1914)	Berry 1914	<43 mm	3×ML	1>2>3=4	–	–	
O. microphthalmus Goodrich, 1896	Toll 1998	34–40 mm	4–7×ML	1>2>3>4	10–19	A>B=C=D=E*	7–9
O. nanhaiensis Dong, 1976	Dong 1976	30 mm	7–8×ML	1>2>3>4	–	–	8–10
O. oliveri (Berry, 1914)	Berry 1914	27–30 mm	3×ML	2=3>1=4	14–22	–	–
O. robsoni Adam, 1941	Adam 1941	28–60 mm	2–3×ML	4=3=2>1*	20–30.5	B=C=D=E>A*	8–10
O. tetricus Gould, 1852	Stranks 1998	55 mm	6–7×ML	2=3>4>1	25	C=D>B>A>E	–
O. winckworthi Robson, 1926	Robson 1926	32.8 mm	2×ML	–	14.3	C>D>B>A>E	10

* : variable in length or depth

63.8%, mean: 44.9%). Funnel organ W shaped.

Arms moderate to long (3.0–4.9×ML) and sub-equal in length. Arm formula generally 4=3>2>1; variable, dorsal arms usually shortest. No arm autotomy observed but arms regenerate when damaged.

Webs thin and moderately shallow (WDI: 17.2–34.9%, mean 13.1–24.7%). Narrow web margin, extend to near arm tips. Web formula generally C>D>E=B>A; variable usually sector A shortest.

Arms with two rows of suckers. Sucker count on normal arms between 86 and 160. Enlarged suckers occur in the second arm and third arm of males, the largest ones at level of 8 th to 16 th proximal sucker (ASIe: 11.3–16.2%, mean 13.8%; ASIn: 5.8–11.1%, mean 8.6%). The third right arm in males hectocotylized (Fig. 2b), shorter than the opposite arm (OAI: 66.1–83.7%, mean 78.0%). 81 to 97 suckers on hectocotylized arm. Ligula small, narrow and conical in shape. Ligula length ranges from 0.7 mm to 2.2 mm (LLI: 0.7–2.6%, mean 1.5%). Calamus length 0.2–0.6 mm (CaLI: 16.7–37.5%, mean 28.1%).

Gills with 5–6 lamellae per demibranch.

Anterior salivary glands moderate, about one third of the buccal mass diameter. Posterior salivary glands well developed, roughly same size as buccal mass. Crop diverticulum present, slightly thicker than oesophagus. Caecum coiled in approximately one and a half loose whorls. Stomach bipartite. Anal flaps present, and tiny. Digestive gland ovoid in shape. Ink sac well developed and embedded in ventral surface of digestive gland (Fig. 3a). Ink released by live animals dark brown in color.

Upper beak (Fig. 3b) with sharply hooked rostrum and short, small hood. Lateral wall broad with round inner margin. Lower beak (Fig. 3c) with short, pointed rostrum and narrow hood. Wings long and broad. Lateral walls narrow, concave at posterior margin.

Radula with seven transverse rows of teeth and two rows of marginal plates (Fig. 4). Rachidian tooth 1–2 lateral cusps on each side (typically 2) with two short small cusps on either side. First lateral teeth very small with a low triangular cusp. Second lateral teeth tall, scalene traiangular without cusp. Marginal teeth the longest, saber-like in shape, curved inwardly and twice as tall as second lateral teeth. Marginal plates peg-like in shape, flat and smooth.

Male reproductive tract illustrated in Fig. 5. Terminal organ (penis) linear and short (PLI: 12.6–32.3%, mean: 19.6%), with round diverticulum.

Spermatophores short to medium in length and narrow (SpLI: 17.5–64.6%, mean: 44.5%; SpWI: 1.2–7.4%, mean: 2.3%). 69 spermatophores in storage sac of 30.2 mm ML male. Ejaculatory apparatus 32–53 coils, spermatophore reservoirs about one third length of total spermatophore (SpRI: 31.3–40.1%, mean: 36.2%).

Female reproductive organ illustrated in Fig. 6. Ovary ovoid with long, thin oviducts. Oviducal glands round with approximately 20 radiating chambers, darkly pigmented. Ovary contains numerous small eggs (>1,000 estimate) (capsule length: 3.1–4.9 mm, width: 1.1–1.5 mm, EgLI: 6.4–12.2%, mean: 10.2%, EgWI: 2.4–3.7%, mean: 3%).

Body color of live animals usually pale purple or pink, changing to red or brown when alarmed. Color of preserved specimen dark brown. Dorsal white spots (sensu Packard and Sanders, 1971) present but size of spots varied individually, not always visible on preserved specimens. Dorsal surface slightly textured with irregular, rounded, low warts. Primary papillae on dorsal mantle form diamond pattern. Single large primary papilla present above each eye. All arms can produce with dark brown bands on the dorsal surface, which becoming clear after fixation but rarely observed in live animals. Photographs of a fixed specimen and a live animal shown in Fig. 7.

Etymology. The species name "*laqueus*" is taken after lace pattern on arm webs. *Sodefuri-dako* is offered to common Japanese name.

Life history. *Octopus laqueus* was collected from intertidal rocky reefs to depth of 18 m. They usually hide under the rocks during the day and are active at night, especially in winter. In the

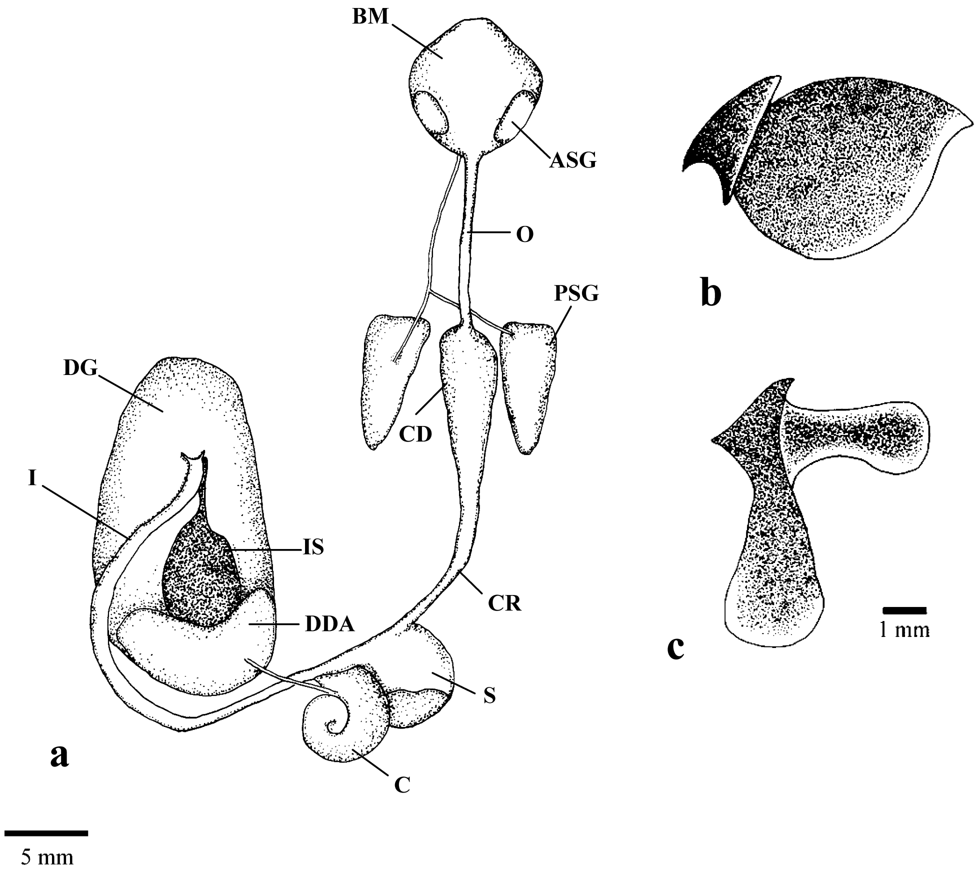

Fig. 3. a, Digestive tract of 40.6 mm ML male (NSMT-Mo 75247). ASG=anterior salivary glands, BM=buccal mass, C=caecum, CD=crop diverticulum, CR=crop, DDA=digestive gland ducts appendages, DG=digestive gland, I=intestine, IS=ink sac, O=oesophagus, PSG=posterior salivary gland, S=stomach. b–c, beaks of 32.1 mm ML male (other specimen). b, Upper beak, c, Lower beak.

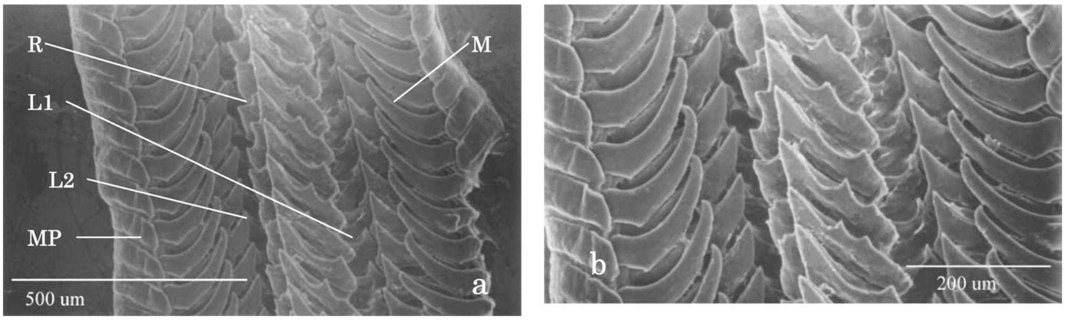

Fig. 4. a, b, Radula of 31.4 mm ML male. R: rachidian tooth, L1: first lateral tooth, L2: second lateral tooth, M: marginal tooth, MP: marginal plate.

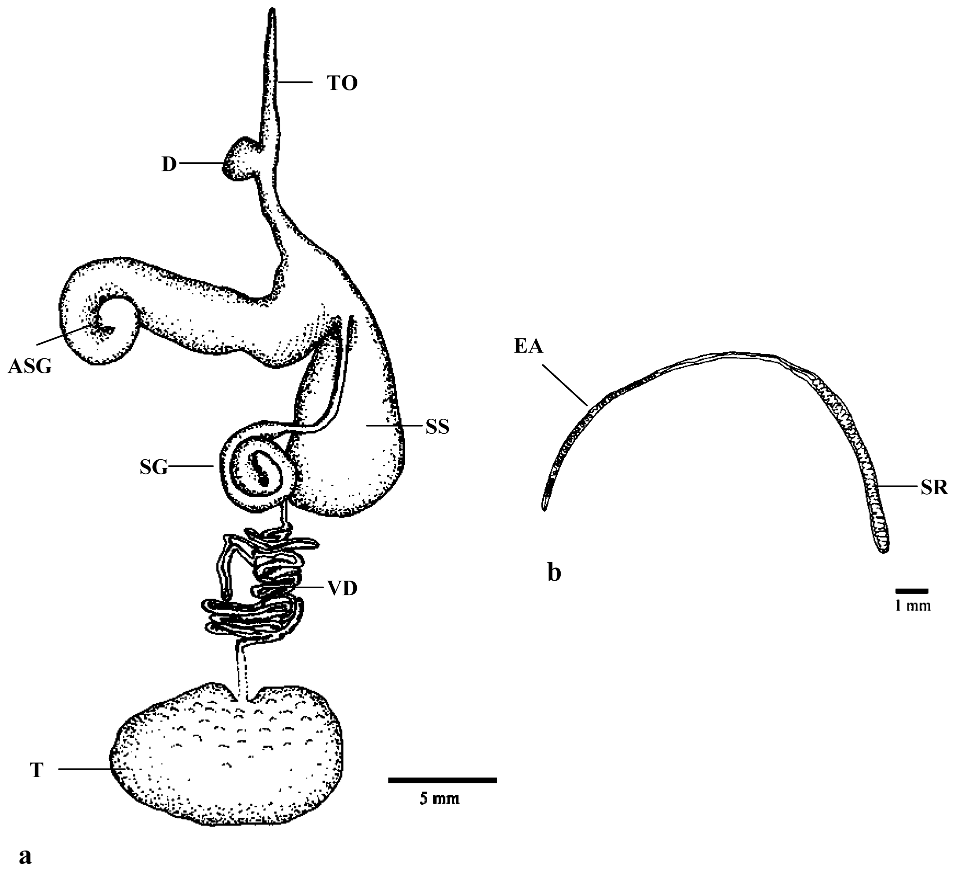

Fig. 5. a, Male reproductive organ of 36.1 mm ML male (NSMT-Mo 75251). ASG=accestory spermatophoric gland, D=diverticulum SS=spermatophore storage sac, SG=spermatophoric gland, T=testis, TO=terminal organ (penis), VD=vas deferens. b, Spermatophore from the same male. EA: ejaculatory apparatus, SR: sperm reservoir.

laboratory they consumed the crab *Thalamita prymna*, they may also consume crustaceans such as crabs or hermit crabs in nature. It was observed that *Octopus ornatus* captured this species as prey in the field.

Distribution. *Octopus laqueus* produces small eggs, which indicates that they may hatch out as planktonic juveniles (Boletzky, 1987). Although this species is known only from Okinawa Island at present, this species may be distributed throughout the Chinese-Japanese subtropical region (Kubodera and Lu, 2002).

Discussion

Comparison with related taxa. Genus *Octopus* includes more than 100 species varying from pygmies to large sizes and distributed around the world. Species in this genus share the following characters: two rows of suckers, right 3 rd arm of male hectocotylized, and presence of an ink sac. The new species described here is placed in the genus *Octopus* as it possesses all the above generic characters.

Octopus laqueus sp. nov. was compared to *Octopus* species reported from the Indo-West Pacific region and mainland Japan. For the comparison, species larger than 60 mm ML or species

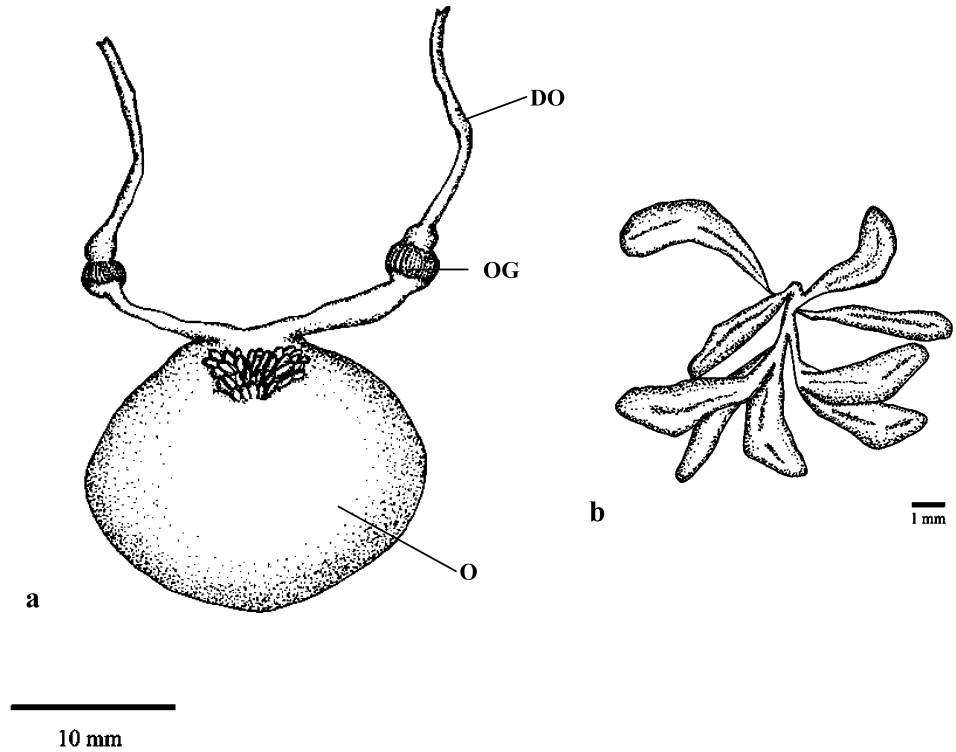

Fig. 6. a, Ovary of 40.0 mm ML female (NSMT-Mo 75250). DO=distal oviduct, OG=oviducal gland, O=ovary. b, Eggs from same female.

that possess ocelli on the webs were excluded. Twenty seven species, including two species groups were considered. Systematic character states (ML, AL, AF, WD, WF, Gill lamellae) of nominated species are summarized in Table 3, based mainly on original descriptions, and additionally Toll and Voss (1997), Norman and Sweeney (1997), Toll (1998) and Stranks (1998). Validity of these species generally following Sweeney and Roper (1998).

Octopus (*Abdopus*) Species Norman and Finn, 2001

Members of this subgenus are distributed in the tropical Indo-West Pacific region. Six species are included in this group and they share the following characters: small to medium size (ML< 70 mm), long arms (>4×ML), arm autotomy and regeneration close to the arm base, low gill lamellae count (5–7 lamellae per demibranch), small and narrow ligula (<6% of arm length), enlarged suckers on arms 2 and 3 in mature males, and highly textured skin with long branched primary papillae.

Octopus laqueus shows many of these characters but is distinct as it has generally shorter arms (3.0–4.9×ML) and lacks arm autotomy.

Octopus aegina species-group Robson, 1929

Members of this group are distributed throughout the warmer temperate to tropical waters of the Atlantic, Indian, and Pacific oceans (Robson, 1929). Members share the following characters: small to medium size (ML<80 mm), relatively short arms (2–3×ML), body ornamented by regular low, round papillae or regular raised patches defined by distinct grooves, diamond pattern of patches or papillae on the dorsal

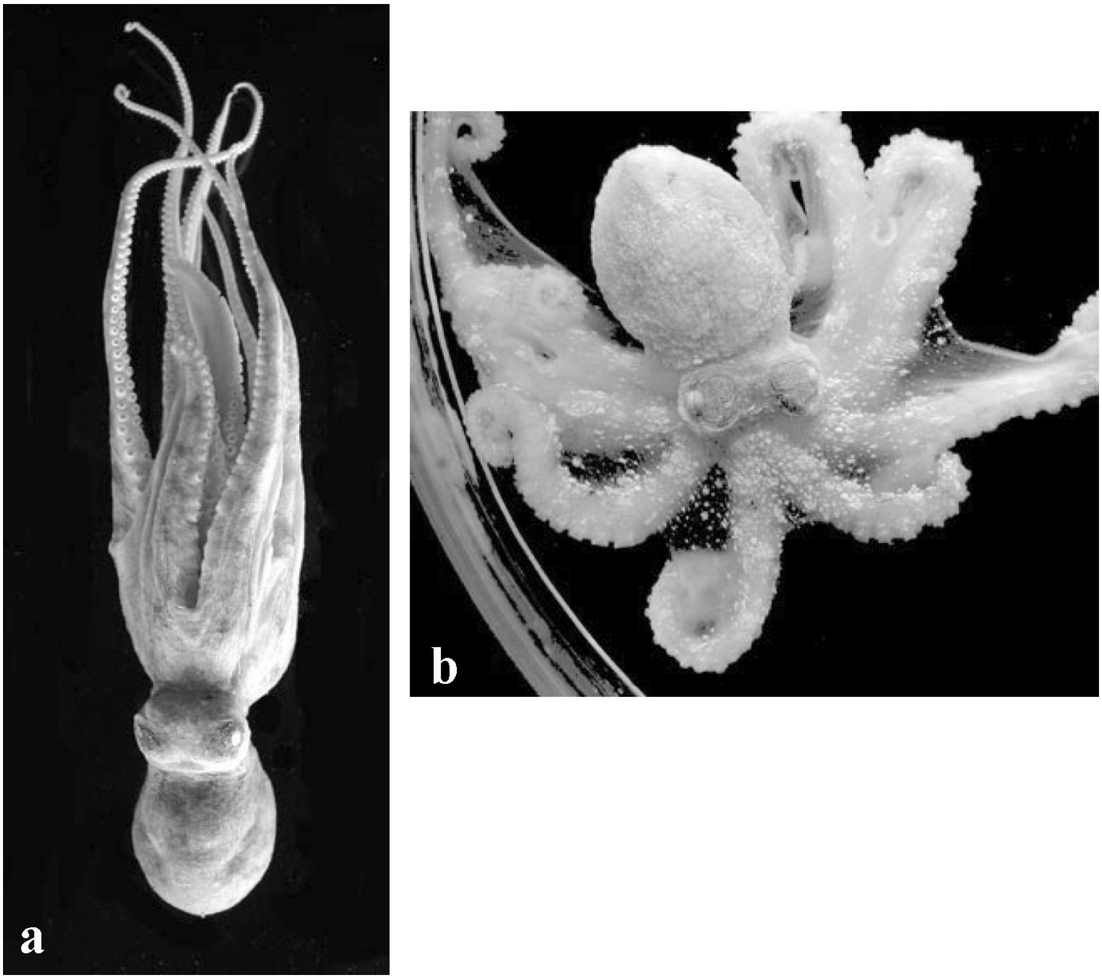

Fig. 7. *Octopus laqueus* sp. nov. a, holotype. b, live animal (NSMT-Mo 75242).

mantle, dorsal web shortest, and a moderate gill lamellae count (7–10). They are divided into two groups; species in the first group possess false eye spots (ocelli) on the web, those of the second lack ocelli. The latter group includes four species: *O. aegina* Gray, 1849, *O. burryi* Voss, 1950, *O. kagoshimensis* Ortmann, 1888, and *O. marginatus* Taki, 1964. *O. aegina* includes two synonym species *O. hardwickei* Gray, 1849 and *O. dollfusi* Robson, 1928 (Norman and Sweeney, 1997; Sweeney and Roper, 1998), and *O. marginatus* Taki, 1964 also includes a synonym species, *Octopus striolatus* Dong, 1976. *O. burryi* is distributed in the Atlantic ocean, so has been excluded from this comparison.

Octopus. laqueus is easily distinguishable from this group by having fewer gill lamellae (5–6), longer arms (3.0–4.9×ML), and less regular texture on the mantle.

Pygmy Species (sensu Norman and Sweeney, 1997)

The term “pygmy species” was used to define Octopuses that mature at small to tiny sizes (ML less than 30 mm). Twelve species have been reported from Indo-Pacific area and coastal waters of Japan: *O. arborescens* (Hoyle, 1904), *O. bocki* Adam, 1941, *O. filamentosus* Blainville, 1826, *O. gardineri* (Hoyle, 1905), *O. nanus*

Adam, 1973, *O. pumilus* Norman and Sweeney, 1997, *O. parvus* (Sasaki, 1917), *O. prashadi* Adam, 1939, *O. tenebricus* Smith, 1884, *O. vitiensis* Hoyle, 1885, *O. warringa* Stranks, 1990, and *O. wolfi* (Wülker, 1913).

Among them, *O. filamentosus, O. prashadi*, and *O. tenebricus* have a greater number of larger gill lamellae (7–8) than *O. laqueus* (5–6). *O. parvus* is distinct from *O. laqueus* by eggs, *O. parvus* produces smaller eggs (capsule length: 1.8 mm, width: 0.9 mm, EgLI: 4.0%, EgWI: 2.0%), while *O. laqueus* produces larger eggs (capsule length: 3.1–4.9 mm, width: 1.1–1.5 mm, EgLI: 6.4–12.2%, mean: 10.2%, EgWI: 2.4–3.7%, mean: 3%). *O. warringa* has coiled shape penis (3 lobes), while *O. laqueus* has linear shape. The remaining species mature at smaller than 21 mm ML and have shorter arms (<3×ML) than *O. laqueus* (3.0–4.9×ML).

Additional Species

Ten species, *O. favonius* Gray, 1849, *O. globosus* Appellöf, 1886, *O. guangdongensis* Dong, 1976, *O. kermadecensis* (Berry, 1914), *O. microphthalamus* Goodrich, 1896, *O. nanhaiensis* Dong, 1976, *O. oliveri* (Berry, 1914), and *O. winckworth*i Robson, 1926 were listed here as species that are not classified into any species groups. Although some of them lack gill lamellae counts, combination of gill lamella number and arm formula make them distinguishable from *O. laqueus*. Additionally, *O. kermadecensis* (Berry, 1914) is only known from the Kermadecs and *O. favonius* Gray, 1849, *O. globosus* Appellöf, 1886, *O. microphthalamus* Goodrich, 1896, and *O. winckworthi* Robson, 1926 are still unresolved species.

So far as morphological comparison, *Octopus laqueus* differs from all the other relative taxa hitherto described from Indo-West Paicifc and Japanese waters.

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