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Short Communication

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PLATINUM
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The windowpane oyster family Placunidae Rafinesque, 1815 with additional description of *Placuna quadrangula* (Philipsson, 1788) from India

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Abstract: The Bivalvia family Placunidae Rafinesque, 1815 in India is reviewed in this paper based on previous literature and records. Additionally, the species *Placuna quadrangula* is described from the Indian sub-continent. Being an economically important family in this geographic region, this paper can be regarded as a baseline for further ecological, management and policy-related studies pertaining to *Placunidae* and other exploited species.

Keywords: India, *Placuna quadrangula*, Placunidae, Taxonomy.

Abbreviations: ANI—Andaman & Nicobar Islands | GOM—Gulf of Mannar | GOK—Gulf of Kutch | MBRC—Marine Biological Research Centre | NZC—National Zoological Collections | PB—Palk Bay | GBR—Great Barrier Reef | QGIS—Quantum Geographic Information System | ZSI—Zoological Survey of India | RUMF—Ryukyu University Museum, Fujukan.

Tamil Abstract: இந்தியாவில், 1851ல் இருந்த இருவழிபாட்டு குடும்பத்தினர், ப்ளாகுனிடே ரபின்ஸ்க் பற்றிய விபரம் இந்த கட்டுரையில் முந்தைய கால இலக்கியம் மற்றும் ஆவணங்களின் அடிப்படையில், மறு ஆய்வு செய்யப்படுகிறது. கூடுதலாக, பிளாகுனா குவாட்ரன்குலா என்ற இனம் பற்றி, இந்திய தீவகற்பத்திலிருந்தவாறு, விவரிக்கப்படுகிறது. இந்த புவியியல் சார்ந்த நிலப்பரப்பில் இருந்த, பொருளாதாரத்தில் முக்கியத்துவம் பெற்ற குடும்பமாக இருப்பதால், இக்கட்டுரையானது பிளாகுனிடே மற்றும் பிற அழிக்கப்பட்ட இனம் சம்பந்தமான, இனி தொடரும் சுற்றுச்சூழல் பராமரிப்பு மற்றும் கொள்கை சார்ந்த படிப்புகளுக்கு, ஒரு உறுதியான அடித்தளமான விஷயம் என கருதப்படலாம்.

The family Placunidae Rafinesque, 1815 is comprised of the genera *Placunanomia* and *Placuna*, the latter with seven accepted living species (Huber 2010). Distributed mostly within the Indo-West Pacific region

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(Matsukuma 1987), the genus *Placuna* Lightfoot, 1786 has a long documentary history, as it is commercially exploited for pearl production, food, lampshades and shell-craft items (Gallardo et al. 1995). From Indian waters, *Placuna placenta* (Linnaeus, 1758) (Image 1) is the only species that has been thoroughly studied due to its economic value (Laxmilatha 2015a). *Placuna sella* (Gmelin, 1791) now *P. ephippium* (Philipsson, 1788) was first reported from the Andaman & Nicobar Islands, India by Prashad (1932), followed by Gulf of Mannar, southeastern coast of India (Rao & Dey 2000; Venkataraman et al. 2004) and was later revised by Stella (2010) (Image 2) from the Mandapam coast (Adjacent to GOM). *Placuna ephippium* is also exploited, especially in the Bay of Banate, Philippines and its surrounding areas, and mainly known for its food value (Gallardo 1994). Currently, as per published reports, two species of *Placuna, P. ephippium* and *P. placenta* are reported from the Indian coast (Rao 2017) (Image 3). In this study we confirm the presence of a third species from India, *P. quadrangula* (Philipsson, 1788). This paper further attempts to distinguish all three species from the Indian coast based on morphology.

Materials and Methods

Five valves of *P. quadrangula* were collected from three different locations along the eastern coast of India (Table 1). The collected dry specimens were cleaned and preserved in zip-lock covers for further assessment. Identification to species level was made based on the characters provided by Lynge (1909) and Huber (2010). Specimens were deposited in the National Zoological Collections (NZC) repository in the Marine Biological Research Centre (MBRC), Zoological Survey of India (ZSI), Chennai. A single specimen of *P. placenta* deposited at (ZSI/MBRC) was assessed additionally. Measurements of specimens were recorded with Yuri Digital Calliper 200x0.01mm. Study area map was created using QGIS 3.6.3 Noosa.

Systematics

Order Pectinida Gray, 1854

Superfamily Anomioidea Rafinesque, 1815

Family Placunidae Rafinesque, 1815

Genus *Placuna* Lightfoot, 1786

Placuna is monomyarian, with low umbones, V-shaped crurae and pallial line, often obscured. Valves circular to sub-circular and laterally compressed. All the characters are common in the species observed from the Indian subcontinent, and a detailed species wise description is given below.

Placuna placenta (Linnaeus, 1758) (Image 1)

Description: Shell thin, very flat, roughly circular or subcircular in shape, inequivalve, periostracum absent. Inner surface smooth, outer surface lamellate, growth lines present. Transparent when juvenile, turning opaque with age. Lacking radial lines on the external surface. Crurae below the umbones, unequal in size, adductor muscle scar slightly anterior of midline. Pallial line obscure and non-sinuated. Specimen examined has a damaged or broken outline.

Distribution: Extends from Gulf of Aden in the west to Taiwan in the east (Matsukuma 1987; Huber 2010).

Placuna ephippium (Philipsson, 1788)

Description: Shell saddle-shaped with curved dorsal margin without periostracum. Growth lines visible. External colour purple brown/brownish with black shades to large red-purplish-blackish spots on the interior surface. Lacking radial lines on the external surface. Crurae prominent, equal in size and wideset. Single adductor muscle scar in the center of midline; purplish in colour.

Distribution: India to Australia (Matsukuma 1987; Huber 2010).

Remarks: See Discussion.

Table 1. Materials examined.

Locality	Coordinates (decimal)	No. of valves	Dimensions Lx WxH (mm)	Date of collection	Collected by	Deposition no.
Kottivakkam (Chennai)	12.966°N, 80.265°E	2	80.38 x 78.77 x 8.23; 57.83 x 49.48 x 4.88	28.ii.2015	GS	ZSI/MBRC/M.2004; ZSI/MBRC/M.2005
Serenity Beach, Kottakuppam (Puducherry)	11.976°N, 79.845°E	1	92.09 x 91.30 x 9.59	19.x.2015	RRD	ZSI/MBRC/M.2006
Kasimedu, Royapuram (Chennai)	13.123°N, 80.297°E	2	71.94 x 61.37 x 7.32; 50.55 x 47.71 x 4.91	13.iii.2016	RRD; GS	ZSI/MBRC/M.2007; ZSI/MBRC/M.2008

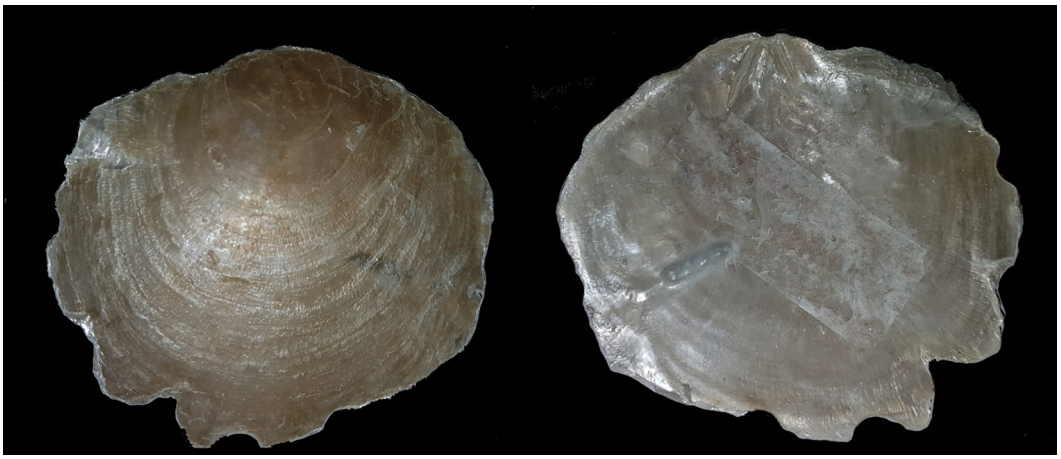

Image 1. Dorsal and ventral side of *Placuna placenta* collected from Mandapam (southern India) (Coll. by R. Rajkumar, ZSI/MBRC/M.1718/5854) (© Deepak Samuel).

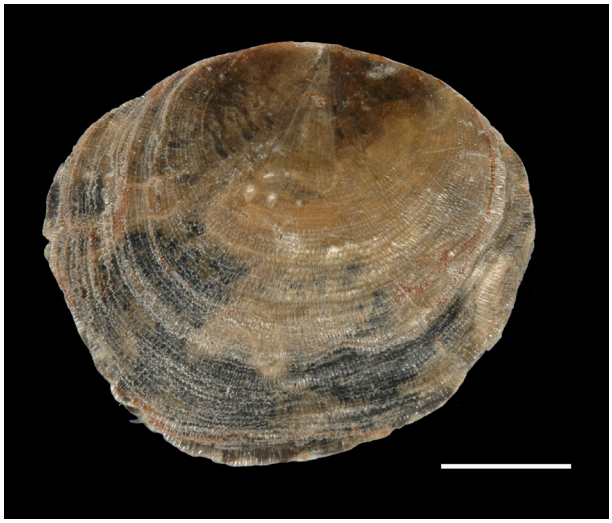

Image 2. Dorsal side of *Placuna ephippium?* collected from Mandapam (southeastern coast, India) (Scale = 2cm) (© C. Stella).

***Placuna quadrangula* (Philipsson, 1788)**
(Image 3. A–J)

Description: Shell thin, brittle, papery, laterally compressed but slightly concave (Image 3. A-J). Outline quadrangular, periostracum inconspicuous. Surface smooth, lamellate, growth lines fine with closely arranged radial threads. Externally pinkish to whitish with non-uniform white radial rays originating from umbones; internally pinkish to whitish. Prominent crurae of equal size. Adductor muscle scar centrally situated, rounded. Pallial line obscure and non-sinuated. Internal margins smooth. Internal and external surface of the specimens with attached fouling organisms.

Distribution: Present study – Tamil Nadu, Puducherry (eastern coast of India), Mergui Archipelago, Thailand, Indonesia, Philippines and Australia (Matsukuma 1987; Sanpanich 2011).

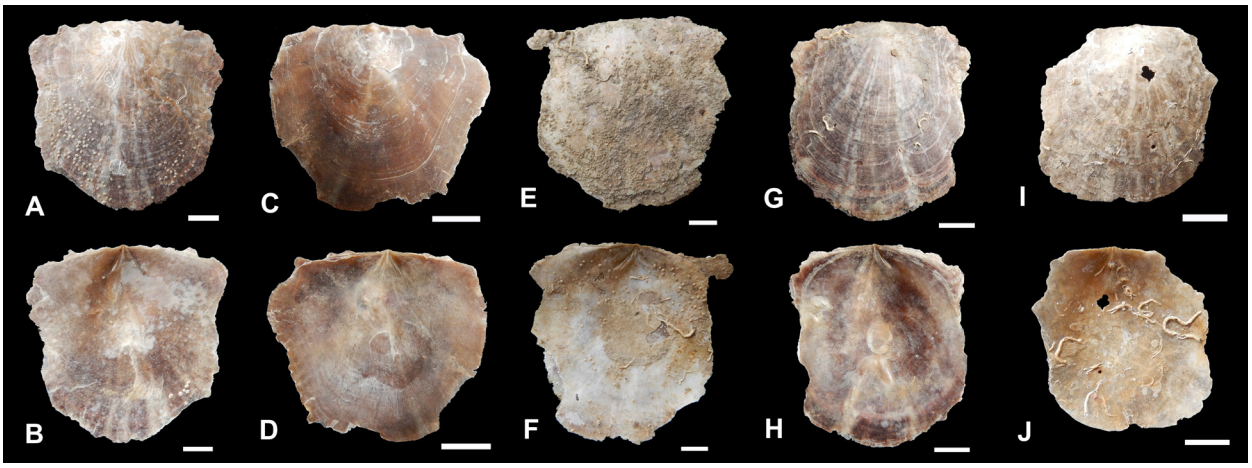

Image 3. (A–J) Specimens of *Placuna quadrangula* examined (Scale = 1cm). The white radial lines can be clearly seen in the dorsal side of the specimen A and G. (© Rocktim Ramen Das).

Remarks: The five examples collected from three different localities possess the typical radially rayed pattern.

Discussion

Comparative analysis among the *Placuna* species from India with some notes on other Indo-pacific species

The radial colour patterns originating from the umbones (Image 3) a typical character for *P. quadrangula* is emphasized in Huber 2010. Although confused with *P. ephippium* which is larger, the specimen described from Mandapam has no mention of purple muscle scar nor the color predominance in the shell as seen in Huber 2010. Rather it is described as "*almost transparent*" along with light brownish nature with black patches (Image 3) (see Stella 2010). The transparent nature fits well with *P. placenta* juvenile as observed in the collections of the Ryukyu Museum (RUMF-ZM-03693) and in Kouri Shell Museum, Okinawa (Rocktim Ramen Das, pers. obs.) but is known to turn white and shiny after maturity. The presence of brown radial rays in the latter from southeastern Asian specimens (see Matsukuma 1987) might be misleading and needs reassessment. *P. ephippium* lacks such brown radial rays and possesses large red, purplish-black spots on the interior region (Henk Dekker pers. comm.).

Life history of genus *Placuna*

A review of literature revealed that there is a limited amount of research based on the life history of genus *Placuna* with exclusive information available only for *P. placenta*. Adam Young (1980), who did an extensive study on the larval growth and development of *P. placenta*, revealed that the shells remain inequivalve and transparent from a very early stage. The author also revealed that from fertilized egg to the formation of spat, it takes about 10–11 days and the final sedentary phase is reached when around 600µm in size is reached during which several key morphological changes take place, viz., active foot appearance during larval metamorphosis. Narasimham (1984), who later studied the biology of *P. placenta* from the eastern coast of India (Kakinada Bay) (Figure 1) mentioned about the biannual spawning strategy of the species and based on the gonadal appearance and morphology divided the maturity into four stages, viz.: active, ripe, partially spawned and spent/resting. Interestingly, a recent observation from the coast of Sonmiani (Balochistan) indicated that *P. placenta* spawns all-round the year (Parveen et al. 2018) which contradicts the findings of Hornell (1909) and Moses (1939) whose studies were from a not so distant area of Okha, Gujarat, India (~400 km). This probably indicates the local environmental parameters like temperature, salinity and monsoonal characteristics can play an important role at regional scales (Ladja 2002).

Status of genus *Placuna* in India

Along the coast of India, the windowpane oyster (*P. placenta*) was initially reported by Hornell (1909a,b). In the 1970s, Narasimham documented its utilization due to its high economic value while Laxmilatha (2015) reviewed the economic value. Though the species is reported from various places of the Indian sub-continent (Table 3), it is commercially exploited only from specific areas along the coastline (Table 3). Exploitation of the species in areas of Gulf of Kutch was mainly for pharmaceutical purposes (Alagaswami & Narasimham 1973; Narasimham et al. 1993). Presently the exploitation levels are low in the Gulf of Kutch. In Kakinada Bay, *P. placenta* is regarded as one of the most important bivalve resources, but the stock is under threat due to overexploitation (Rao & Somayajulu 1996; Laxmilatha 2015b). Nauxim Bay in Goa had a minor fishery where the meat was locally consumed (Narasimham et al. 1993). Apart from the above-mentioned locations, the collection of windowpane oyster from the coastal waters of Tamil Nadu mainly for the pearl and shell craft industries. Vellapatti fishing hamlet near Tuticorin is the hub for the utilization of *P. placenta* in the cosmetic and paint industry. Rameswaram is famous for the windowpane oyster lampshades and mirrors. It is important to highlight that due to such activities, previous densely populated areas of *P. placenta* are lost (Tripathy & Mukhopadhyay 2015). The saddle-shaped oyster *P. ephippium* collected in Mandapam, Gulf of Mannar is also used in the production of a variety of curios/souvenirs, viz., trays, lampshades (Stella et al. 2010). The third species *P. quadrangula*, reported here is either invasive or has been overlooked over the past decade. It is important to highlight that Iredale in the scientific reports published related to the GBR expedition refers to a publication from the Bolten Museum dating back to 1798 which mentions *Ephippium anomia* (synonym *P. quadrangula*) from Tranquebar (now Tharangambadi, ~230km from Chennai). Further in-depth analysis revealed the information is related to its morphological characters, leaving the information regarding its geography being rather vague (see Iredale 1939; Röding 1906).

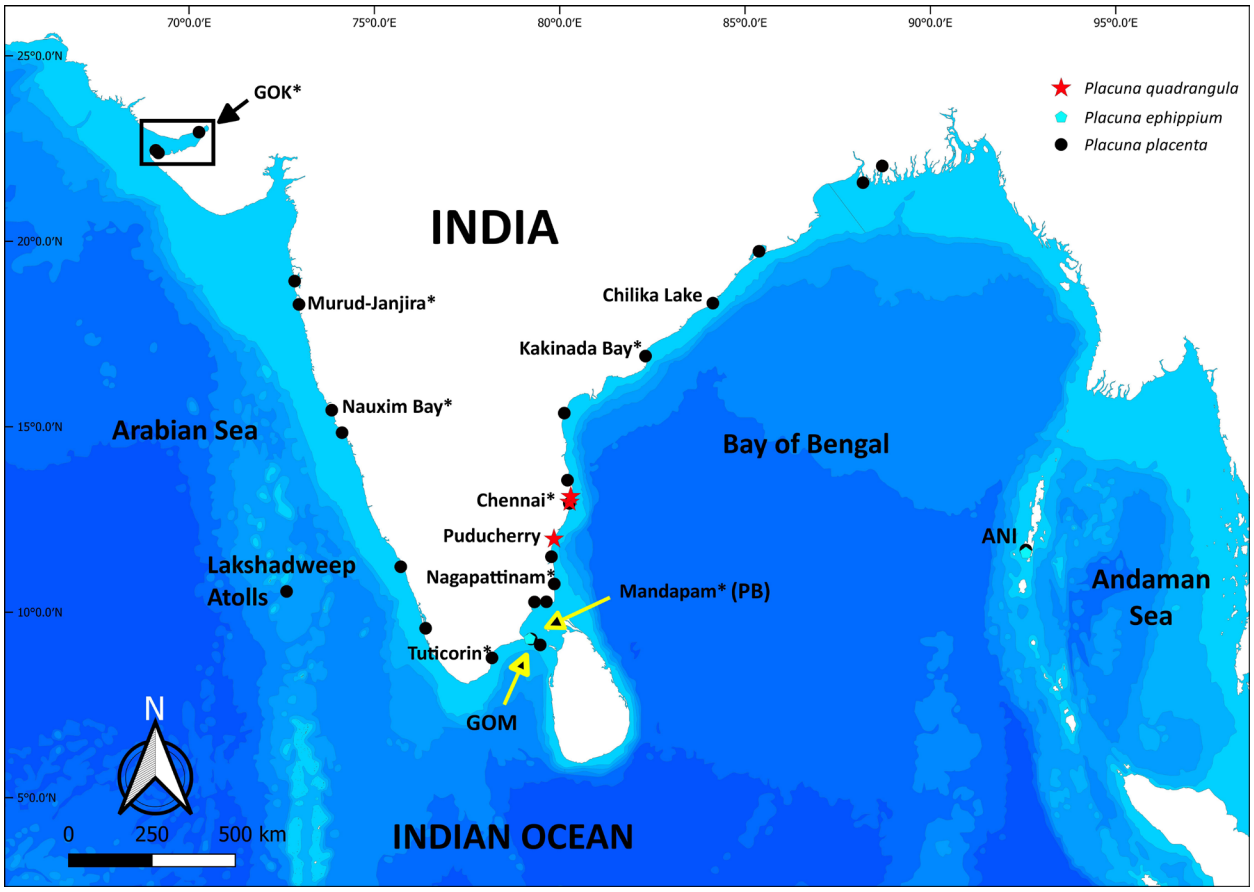

Figure 1. Distribution of genus *Placuna* along the Indian subcontinent. GOK=Gulf of Kutch; GOM=Gulf of Mannar; PB=Palk Bay; ANI=Andaman & Nicobar Islands; * Exploited Regions.

Table 2. Summary of important morphological features among the Indian *Placuna* species.

	Placuna placenta	***Placuna ephippium***	***Placuna quadrangula***
Morphology (Figure 2)	Roughly circular	Saddle shape with curved dorsal margin	Quadrangular, thin, papery
Colour	Semi-transparent (juvenile); opaque and white (adult).	Purplish, large spots in the interior region (Red, Purple or Black)	Pinkish to whitish, with prominent white radial lines.
Crurae (Figure 2)	V-shaped, narrow and unequal	V-shaped, wide apart and equal	V-shaped, wide apart and equal
Radial lines	Absent	Absent	Irregular radial lines originating from umbones
Pallial Line	Obscure	Obscure	Obscure
Posterior adductor muscle	Monomyarian	Monomyarian	Monomyarian
Adductor muscle scar	Slightly anterior of midline	Center of midline, purplish	Center of midline, rounded
Umbones	Low	Low	Low

Figure 2. Sketch of the V-shapes crurae and hinge shape: A—*P. quadrangula* | B—*P. placenta* | C—*P. ephippium*.

Table 3. Reports of genus *Placuna* from various parts of the Indian subcontinent*

Source	Locality/Region	Species
Hornell 1909b	Balapur Harbour, Beyt Island and Okha (Gujarat); Ennore (Tamil Nadu); Buckingham canal (Tamil Nadu); Pulicat lake (Andhra Pradesh)	*Placuna placenta*
Prashad 1932	Andaman Islands	*Placuna sella*+
Rai 1933	Bombay coast (Maharashtra)	*Placuna placenta*
Alagaswami & Narasimham 1973	Gulf of Kutch (Gujarat); Malabar coast, Vembanad lake (Kerela); Tuticorin**, Nagapattinam**, Kakinada bay** (Andhra Pradesh)	*Placenta placenta*++
Narasimham et al. 1993	Nauxim Bay** (Goa)	*Placenta placenta*++
Hameed & Somasundaram 1998	Gulf of Mannar (Tamil Nadu)	*Placenta placenta*++
Rao & Dey 2000	West Bengal	*Placuna placenta*
Venkataraman et al. 2004	Andaman & Nicobar Islands	*Placuna placenta*
Samuel et al. 2005	Dhanuskodi (Tamil Nadu)	*Placenta placenta*++
Stella et al. 2010	Mandapam** (Tamil Nadu)	*Placuna ephippium*
Boominathan et al. 2012, 2014	Kali River; Uttara Kannada district (Karnataka)	*Placuna placenta, Placenta placenta*++
Murugesan et al. 2013	Parangipettai (Tamil Nadu)	*Placenta placenta*++
Prabhu et al. 2013	Mallipattinam (Tamil Nadu)	*Placenta placenta*++
Thilagavathi et al. 2013	Muthupettai (Tamil Nadu)	*Placenta placenta*++
Bijukumar et al. 2015	Kavaratti Island (Lakshadweep)	*Placuna placenta*
Tripathy & Mukhopadhyay 2015	Murud-Jinjira** (Maharashtra); Pouchitra**, Raida**, Goomara** (GOK, Gujarat), Chennai**	*Placuna placenta*
Mahapatro et al. 2016	Chilika Lake (Odisha)	*Placuna placenta*
Rao 2017	Pindara Bay (Gujarat); Baitkal cove and Pavin halla (Karnataka); Pambam, Kundugal point (Tamil Nadu); Eatimukkala and Kalingapatnam (Andhra Pradesh); Jharkali and Jambu Island (West Bengal)	*Placuna placenta*
Ravinesh et al. 2018	Navi Mumbai (Maharashtra)	*Placuna placenta*
Present study	Chennai (Tamil Nadu); Kottakuppam (Puducherry)	*Placuna quadrangula*

*The information may be non-exhaustive +*Placuna sella* is the synonym of *Placuna ephippium* ++*Placenta placenta* is a group under which *Placuna placenta* was assigned by Gray 1849, thus can be regarded as a synonym in this context, **Exploited Areas

Conclusion

Placuna placenta is the only species under the genus that is listed (as *Placenta placenta*) under Schedule IV of the Indian Wildlife Protection Act, 1972. As mentioned in the act, "*No person shall hunt any wild animal specified in Schedules I, II, III, and IV except as provided under section 11 and section 12*". Furthermore, Section 11 and 12 allows for hunting only in special cases and with proper documents and permissions from the concerned government authority; however, surreptitious fishing of this species continues even in protected areas, e.g., Kakinada Bay (Coringa Wildlife Sanctuary) (Laxmilatha 2015a,b) apart from other areas as mentioned above. Moreover, the recent news of *P. placenta* being smuggled to western Asian and South American countries in alternate forms (Ravinesh et al. 2018) further highlights the urgent need to assess the genus. As our study highlights the morphological aspects of this genera, a thorough comparative assessment of the internal organs and the application of molecular methods should provide essential insights. On the other hand, biogeographical assessment of *P. quadrangula*, its ecology and its implications on *P. placenta* distributions is urgent. As the Indian Ocean is home to large and unknown malacofauna (see Das et al. 2017), continuous surveys to discover these understudied resources remains imperative.

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