

# A new deep water species from the Philippines: *Profundiconus limpalaeri* sp. nov. (Gastropoda, Conilithidae)

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## ABSTRACT

*Profundiconus limpalaeri* sp. nov. is described from deep water material taken around Balut Island, Philippines. The new species had been previously misidentified as *Profundiconus cakobau* (Moolenbeek, Röckel & Bouchet, 2008) or *Kurodaconus darkini* (Röckel, Korn & Richard, 1993). The observed similarities and differences of these taxa with the new species are discussed.

## INTRODUCTION

The genus *Profundiconus* Kuroda, 1956 has been recently reviewed in Tenorio & Castelin (2016), and currently comprises 27 species living in deep water. The species in this genus are spread over the Indo-Pacific region, except for *Profundiconus emersoni* (Hanna, 1963), which occurs in the East Pacific region. However, the inclusion of this species in *Profundiconus* is only provisional (Tenorio *et al.* 2012). Due to their deep-sea habitat, these species are difficult to sample, and most of them are rare in collections with few exceptions. However, species of *Profundiconus* are relatively common in material dredged by research vessels in deep waters. To a lesser extent, small and medium-sized shells of still unnamed species of *Profundiconus* also surface occasionally in nets of fishermen working in deep-water. That is the case for a species caught by tangle nets at depths of 100–450 meters in the waters around Balut Island and the neighboring Sarangani Island in Southern Mindanao, Philippines. This species has been known for some time, and has been circulating around among dealers and collectors with the names “*Conus darkini*” or “*Profundiconus cf. cakobau*” (Raybaudi Massilia *in* Poppe 2008; Tenorio & Castelin 2016). We have now been able to gather a sufficiently large homogeneous sample of this new species to describe it. We have compared these specimens qualitatively and quantitatively with *Profundiconus cakobau* (Moolenbeek, Röckel & Bouchet, 2008), and also with *Kurodaconus darkini* (Röckel, Korn & Richard, 1993). Although we did not have access to preserved material in our lots, we have concluded that the specimens under study obtained from Balut Island are not conspecific with either *P. cakobau* nor *K. darkini*, and represent in fact a distinct, new species which is described hereby with the name *Profundiconus limpalaeri* sp. nov.

## MATERIAL AND METHODS

The taxonomy used in the present article follows Tucker & Tenorio (2009) with the updates and modifications included in Tucker & Tenorio (2013). Specimens were collected by local fishermen either by tangle nets, trawling or dredging, in depths ranging from 100 m to 500 meters.

We describe shell morphology using the terminology established in Röckel, Korn & Kohn (1995). For morphometric comparisons, adult shells selected among available specimens in several private collections, as well as in the collections of the MNHN, were measured with a digital caliper, and the measurements rounded to 0.1 millimeter. All measurements are in a spreadsheet, deposited as supporting information at <https://dl.dropboxusercontent.com/u/30741402/BIBLIOGRAPHY/XT12/limpalaeri.xls>. For comparison of shell morphometry, we have performed analysis of the covariance (ANCOVA) for different shell parameters namely maximum diameter (MD), height of the maximum diameter (HMD) and spire height (SH), using species hypotheses as factor, and shell length (S<sub>l</sub>) as covariate. Statistical tests were carried out using STATGRAPHICS 5.1, once all the measurement sets passed the normality tests.

## RADULAR PREPARATIONS

We use the terminology for radular morphology of Tenorio & Castelin (2016). Specimens of shells containing the dried animal inside were digested in concentrated aqueous potassium hydroxide for 24 hours. The contents were flushed out of the shell by injecting distilled water through the aperture of the shell by means of a syringe with an incurved needle. The resulting mixture was then placed in a Petri dish and examined with the binocular microscope. The entire radula was removed with fine tweezers and rinsed with distilled water, then mounted on a slide using Aquatex (Merck) Mounting Medium, and examined under the compound microscope. Photos were obtained with a Charge Coupled Device (CCD) camera attached to the microscope.

## Abbreviations

### *Museums and institutions*

MNHN: Muséum National d’Histoire Naturelle, Paris, France.

HMNS: Houston Museum of Natural Science, Houston, USA.

EM: Eric Monnier reference collection, Paris, France.

LL: Loïc Limpalaër reference collection, Haudivillers, France.

CR: Christophe Roux reference collection, Vitry sur Seine, France.

PK: Paul Kersten reference collection, Hoornaar, The Netherlands.

WJF: William J. Fenzan reference collection, Norfolk, Virginia, USA.

### *Other*

m: meter

mm: millimeter

Shell morphometry	Radular morphometry
S <sub>L</sub> maximum shell length	S <sub>L</sub> /T <sub>L</sub> shell length/radular tooth length
RD relative diameter	T <sub>L</sub> /AP <sub>L</sub> radular tooth size/anterior portion length
RSH relative spire height	100B <sub>L</sub> /AP <sub>L</sub> 100 x blade length/anterior portion length
PMD relative position of the maximum diameter	

**RESULTS**

**SYSTEMATICS**

Family CONILITHIDAE Tucker & Tenorio, 2009

Genus *Profundiconus* Kuroda, 1956

*Profundiconus limpalaeri* sp. nov. (Plate 1, Figs. 1–4; Plate 2, Figs. 1–4; Plate 3, Figs. 3–6)

*Conus darkini* – Poppe 2008: pl. 616, fig. 2, 3 & 5 (non *C. darkini* Röckel, Korn & Richard, 1993).

*Profundiconus* cf. *cakobau* – Tenorio & Castelin 2016: p. 23, fig. 9E (non *C. cakobau* Moolenbeek, Röckel & Bouchet, 2008).

**Type material:** Holotype and 7 paratypes. See table for details.

Type	Collection	Dimensions (mm)	Locality
Holotype	MNHN-IM-2000-32434	35.8 x 16.4	Balut Island, Southern Mindanao, Philippines, 300 m, trawled.
Paratype 1	EM	34.9 x 15.8	Balut Island, Southern Mindanao, Philippines, 100-150 m.
Paratype 2	CR	33.8 x 16.1	Balut Island, Southern Mindanao, Philippines, 200-300 m, dredged.
Paratype 3	PK	38.2 x 16.7	Sarangani Island, Southern Mindanao, Philippines, 300 m.
Paratype 4	HMNS	34.0 x 16.5	Balut Island, Southern Mindanao, Philippines, 200-250 m.
Paratype 5	WJF	32.0 x 15.0	Tinina, Balut Island, Southern Mindanao, Philippines, 500 m, by tangle net.
Paratype 6	WFJ	35.0 x 16.4	Balut Island, Southern Mindanao, Philippines.
Paratype 7	LL	36.0 x 16.9	Balut Island, Southern Mindanao, Philippines, 400 m.

**Material examined:** More than 10 additional specimens, mostly dead collected, have been studied; all of them from Balut Island, Southern Mindanao, Philippines, collected in deep water. These specimens are in private collections, most of them ex-collection Conchology Inc.

**Type locality:** Balut Island, Southern Mindanao, Philippines.

**Distribution and habitat:** To date, specimens have only been found at the type locality (Balut Island) and the neighboring Sarangani Island, in 100 to 450 m depth. Most specimens found correspond to empty shells. A few specimens have been collected alive, although the soft parts were not preserved for study.

**Etymology:** The species is named after Loïc Limpalaër, a French seashell collector, cone expert and a good friend, who co-described with the second author about 20 new species of cones.

**Description of the shell:** Morphometric parameters: L = 32–40 mm; RD = 0.56–0.65; RSH = 0.21–0.27; PMD = 0.81–0.88. Shell shape is ventricosely conical to conical. This is a moderately small to medium sized species. The spire is moderate to high, concave and slightly sigmoid in profile. The whorl tops are flat in cross section. The paucispiral protoconch of 1.5 whorls is white to creamy-yellow, porcellaneous and translucent, with a maximum diameter of 0.98 mm (Fig. 1). The early teleoconch whorls are white or tan, with small tubercles which disappear by whorl five. Early teleoconch whorls have three to four cords. The cords increase in number to six, seven or even more in late teleoconch whorls, but fade slightly in the outer whorls near the shoulder. The shoulder is angulated, with a weak ridge present. The sides of the shell are very slightly convex below the shoulder and then straight, becoming very slightly concave near the anterior end. The last whorl is smooth except for 8-9 spiral grooves around the basal quarter. The posterior notch is shallow and C-shaped. There is no anterior notch.

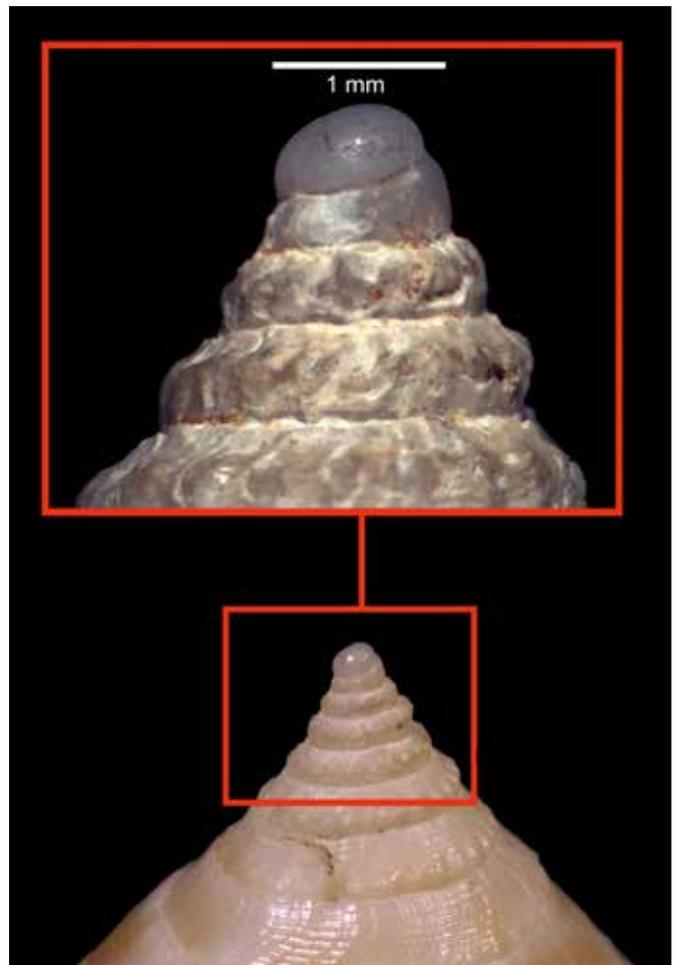


Fig. 1.- Protoconch and early teleoconch whorls of *P. limpalaeri* sp. nov. (Holotype, S<sub>L</sub> 35.8 mm).

Ground color white to very pale cream. Early teleoconch whorls often white, patternless. Alternating brown blotches starting about whorl 4-5, extending over the late spire whorls reaching the shoulder. Last whorl overlaid with large irregular axial brown blotches and streaks in variable amount. The pattern can be dense, covering most of the surface of the last whorl (i.e. Plate 2, Fig 4a; Plate 3, Fig. 6). In some specimens, the axial brown blotches are arranged forming also narrow interrupted spiral bars (i.e. Plate 1, Fig. 4a; Plate 2, Fig 2; Plate 3, Fig. 4). The columella is white. The aperture is bluish-white, usually stained with purplish-brown at the inner edge of the lip, especially towards the base. The aperture may be slightly transparent allowing the outer pattern of the shell to add color to the bluish-white aperture. The periostracum is yellowish, thin and transparent. The operculum (Fig. 2) received with paratype 5 is oval-shaped, yellowish and translucent. Its relative length corresponds approximately to 17% of the aperture height. It lacks the characteristic serrations on the outer margin observed in the operculum of other species in genus *Profundiconus* (Tenorio & Castelin 2016). Instead, it displays just rather gentle undulations on the margin. There is no absolute certainty, though, about whether or not this operculum actually belongs to the specimen corresponding to paratype 5.

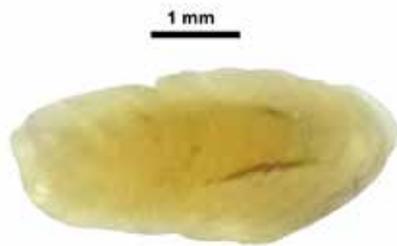


Fig. 2.- Operculum of *P. limpalaeri* sp. nov. received with paratype 5.

#### Living animal and radula:

Details about the living animal are unknown.

#### DISCUSSION

*Profundiconus limpalaeri* sp. nov. is most similar to *K. darkini* (Plate 3, Fig. 2) and to *P. cakobaui* (Plate 3, Fig. 1). *K. darkini* can be easily separated from *P. limpalaeri* sp. nov. by its larger adult size (51 – 87 mm versus 32 – 40 mm for *P. limpalaeri* sp. nov.), larger number of strongly tuberculated spire whorls (9 – 10 versus 5 in *P. limpalaeri* sp. nov.) and its multispiral protoconch of 3.5 whorls (paucispiral of 1.5 whorls in *P. limpalaeri* sp. nov.). It is important to point out that despite the external appearance of the shell, *darkini* is not a *Profundiconus*. A study of the radular morphology (Fig. 3A) indicated that it is a typical Conidae *sensu* Tucker & Tenorio (2009). The radular tooth is small: its total length relative to shell length  $S_L/T_L = 89-90$ . The anterior portion is much shorter than the posterior section of the tooth ( $T_L/AP_L = 2.9$ ). There is one barb and a rounded blade, covering approximately two-thirds (66%) of the anterior portion of the tooth. Serration with 18 to 23 small denticles arranged in two rows, ending in a small, rounded terminating cusp. Shaft fold absent. Basal spur present on top of the rounded base of the tooth. Recent molecular studies suggest that this species belongs to the same clade as *Kurodaconus luciae* (Puillandre, pers. comm.), and hence the attribution of *darkini* to genus *Kurodaconus*.

We are provisionally considering *limpalaeri* as a member of genus *Profundiconus*, pending confirmation by examination of radular morphology and/or DNA sequencing. On the other hand, we have been able to extract and examine the radular teeth of two specimens of *P. cakobaui*, confirming in this way the attribution of this species to genus *Profundiconus* (Fig 3B, C). The radular tooth is rather large: its total length relative to shell length  $S_L/T_L = 32-38$ . The anterior portion is

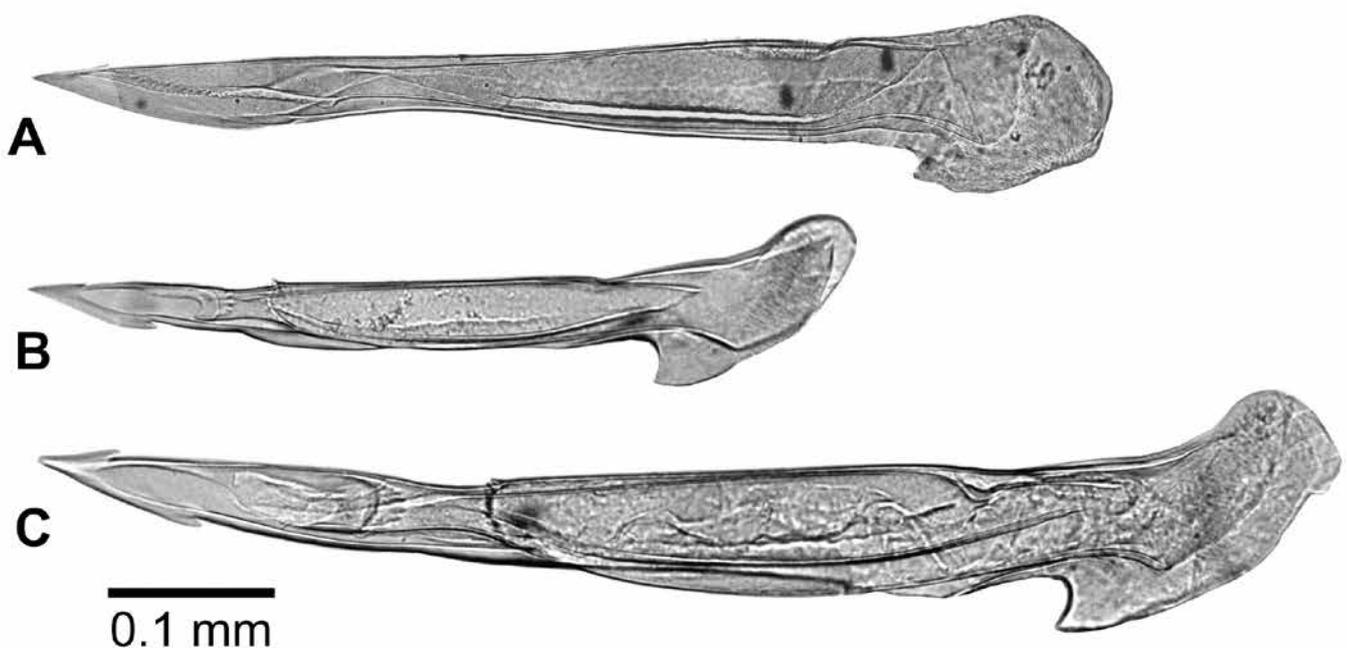


Fig. 3.- Radular teeth of: (A) *Kurodaconus darkini* (MNHN IM-2009-31324, Récif Pétrie, Nouvelle Calédonie, 448-464 m,  $S_L$  57.3 mm); (B) *Profundiconus cakobaui*, paratype (MNHN IM-2000-21033, Ride de Lau, Somo-somo Strait, Fiji, 414-510 m,  $S_L$  18.4 mm); (C) *Profundiconus cakobaui* (MNHN IM-2008-1243, Bligh Water, Fiji, 567-699 m,  $S_L$  24.8 mm).

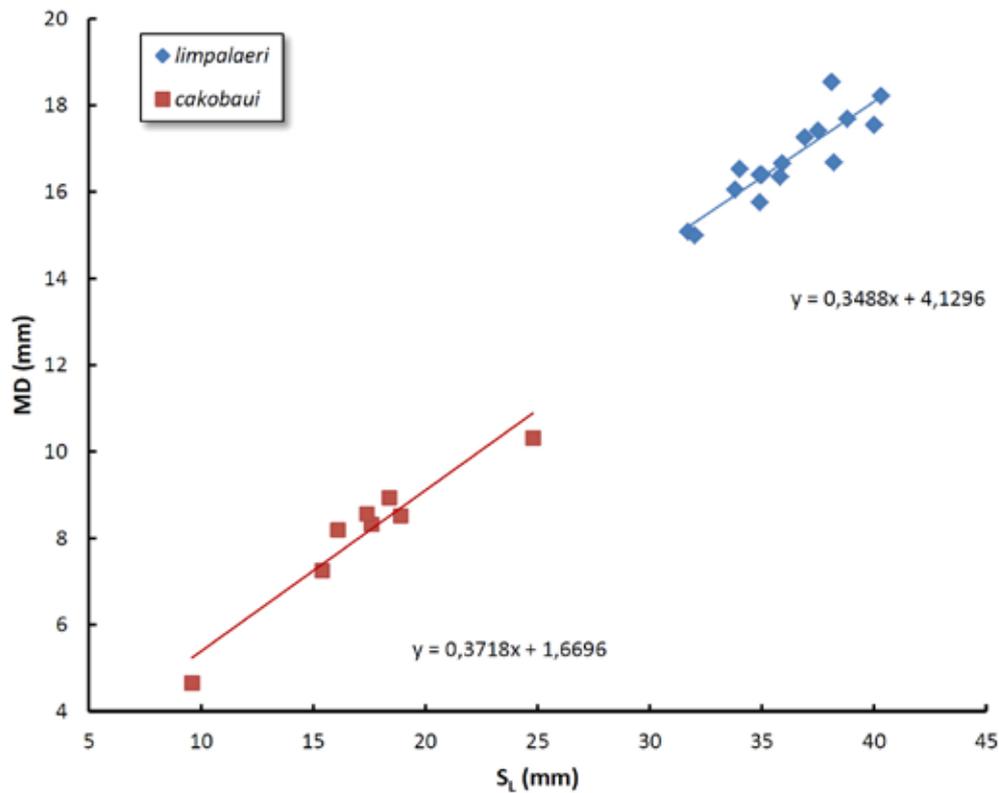


Fig. 4.- Plot of MD versus  $S_L$  for *P. limpalaeri* sp. nov. (◆) and *P. cakobai* (■).

much shorter than the posterior section of the tooth ( $T_L/AP_L = 3.2\text{--}3.8$ ). There is one barb and a pointed, well-defined blade, which covers 40 to 60% of the anterior portion of the tooth. There is an external cusp located at approximately the lower quarter of the anterior portion of the tooth, extending between 80% and 95% of the length of the anterior portion of the tooth. The external cusp is laterally expanded and serrated, with 6 denticles. Immediately below the waist, there is a characteristic fringe composed of closely spaced projections pointing towards the apex. Shaft fold is present. A large and prominent basal spur is present on top of the slanted base of the tooth. All these features of the radular tooth of *P. cakobai* are fully consistent with those reported for other species in genus *Profundiconus* (Tenorio & Castelin 2016).

*P. limpalaeri* sp. nov. and *P. cakobai*, known from Fiji and Tonga, exhibit an apparently similar shell shape, but they differ clearly in mean shell length. Comparison of mean  $S_L$  between the two species yields statistically significant results as expected: mean  $S_L$  for *P. limpalaeri* sp. nov. 36.1 mm; mean  $S_L$  for *P. cakobai* 17.4 mm ( $t = -13.5$ ,  $p = 3.93 \times 10^{-12}$ ;  $U = 128$ ,  $p = 0.0001$ ). ANCOVA (using  $S_L$  as covariate) indicates that there are no significant differences between these two species in SH ( $F = 2.98$ ,  $p = 0.099$ ) or HMD ( $F = 2.07$ ,  $p = 0.165$ ), but they differ in MD ( $F = 8.65$ ,  $p = 0.0078$ , Fig. 4).

Hence, *P. limpalaeri* sp. nov. has a significantly larger and broader shell in comparison with *P. cakobai*. Apart from these differences in size and shape, the pattern and general features of the shell of the two species are similar, including the paucispiral protoconch with tuberculated early teleoconch whorls. However, the cords on the teleoconch whorls of *P. cakobai* are less numerous than in *P. limpalaeri* sp. nov. (Fig. 5). In *P. cakobai*, the subsutural area is essentially smooth, and

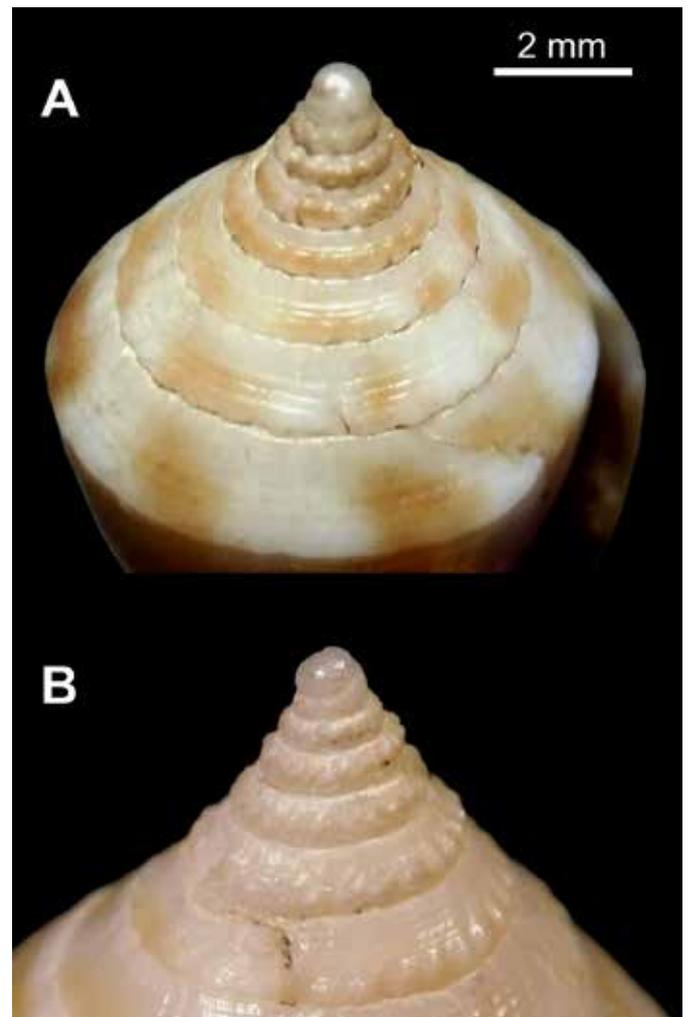


Fig. 5.- Comparative views at the same scale of the teleoconch whorls of: A) *P. cakobai* (Paratype, MNHN IM-2000-21033,  $S_L$  18.4 mm); B) *P. limpalaeri* sp. nov. (Holotype)

then showing 3-4 cords (Fig. 5A). In *P. limpalaeri* sp. nov., there are more cords, and these are more evenly distributed (Fig. 5B).

Apart from these morphological features, *P. limpalaeri* sp. nov. and *P. cakobau* are separated geographically by a distance of approximately 6300 kilometers. Since a paucispiral protoconch indicates a direct, non-planktonic mode of development, and the two taxa are reproductively isolated, there is support for the hypothesis of two separate species.

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Plate 1.- **1-4** *Profundiconus limpalaeri* sp. nov. Balut Is., Philippines. **1a-b**. Paratype 1, dorsal and ventral views, EM coll., 34.9 x 15.8 mm; **2a-b**. Holotype, dorsal and ventral views, MNHN IM-2000-32434, 35.8 x 16.4 mm. **3a-b**. Paratype 2, dorsal and ventral views, CR coll., 33.8 x 16.1 mm. **4**. Paratype 3, PK coll., 38.2 x 16.7 mm.



Plate 2.- 1-4 *Profundiconus limpalaeri* sp. nov. Balut Is., Philippines. 1a-b. Paratype 4, dorsal and ventral views, HMNS, 34.0 x 16.5 mm; 2a-b. Paratype 5 (w/p, w/o), dorsal and ventral views, WJF coll., 32.0 x 15.0 mm. 3a-b. Paratype 6, dorsal and ventral views, WJF coll., 35.0 x 16.4 mm. 4. Private coll., ex-Conchology, Inc., 36.9 x 17.3 mm.



Plate 3.- **1a-b.** Holotype of *Conus cakobau* Moolenbeek, Röckel & Bouchet, 2008, MNHN IM-2000-21030, Somo-somo Strait, South of Vanua Levu, Fiji, 426-487 m, 18.9 x 8.5 mm; **2a-b.** Holotype of *Conus darkini* Röckel, Korn & Richard, 1993, MNHN IM-2000-2568, E Cap des Pins, Ride des Loyauté, Nouvelle Calédonie, 575 m, 55.6 x 24.4 mm. **3-6** *Profundiconus limpalaeri* sp. nov. Balut Is., Philippines, private coll., ex-Conchology, Inc. **3.** 38.8 x 17.7 mm. **4.** 38.1 x 18.5 mm. **5.** 35.9 x 16.7 mm. **6.** 37.5 x 17.4 mm.