

# A new record of *Temnopleurus decipiens* (de Meijere, 1904) (Echinoidea, Temnopleuroida, Temnopleuridae) from Indian waters

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## ABSTRACT

The first report of the sea urchin (Echinodermata, Echinoidea) species, *Temnopleurus decipiens* (de Meijere, 1904) is given from Indian waters (Goa, west coast of India). A complete redescription of the species has been made based on test morphology using 27 phenotypic parameters. This species differs from the original description in that “the ocular plates do not reach the periproct margin.” A detailed comparison with another congener, namely *Temnopleurus toreumaticus* (Leske, 1778) revealed that apart from the position of the anus and the presence of a suranal plate, notable differences were also observed in the diameter of the apical system, plan of sutural pits, pore-pairs structure, ratio of spine length to maximum test diameter, and colour banding of the spines. Further, the paper provides a modified taxonomic key to all the seven extant species of the genus *Temnopleurus* L. Agassiz, 1841 with two additional characters.

## KEY WORDS

Sea urchin,  
*Temnopleurus*,  
morphology,  
first record,  
India.

## RÉSUMÉ

*Une nouvelle signalisation de Temnopleurus decipiens (de Meijere, 1904) (Echinoidea, Temnopleuroida, Temnopleuridae) dans les eaux indiennes.*

L'oursin de mer, *Temnopleurus decipiens* (de Meijere, 1904), est signalé pour la première fois dans les eaux indiennes (Goa, côte ouest de l'Inde). Nous redécrivons entièrement l'espèce sur la morphologie du test en utilisant 27 paramètres phénotypiques. Cette espèce diffère de la description originale par le fait que « les plaques oculaires n'atteignent pas la limite du/des périprocte(s) ». Une comparaison détaillée avec un autre congénère, *Temnopleurus toreumaticus* (Leske, 1778), a révélé qu'en plus de la position de l'anus et de la présence d'une plaque suranale, des différences importantes étaient aussi observées au niveau du diamètre du système apical, du plan des fossés suturaux, de la structure des paires de pores, du rapport entre la longueur des épines et le diamètre maximal du test, et des bandes colorées des épines. Notre article propose également une clé taxonomique modifiée, avec deux caractères additionnels, pour les sept espèces existantes du genre *Temnopleurus* L. Agassiz, 1841.

## MOTS CLÉS

Echinide,  
*Temnopleurus*,  
morphologie,  
premier enregistrement,  
Inde.

## INTRODUCTION

Sea urchins (Echinodermata, Echinoidea) inhabit sea grass beds, coral reefs (Nybakken & Bertness 2005), intertidal regions (Lawrence 2006), and feed on benthic invertebrates and algae (Norderhaug & Christie 2009). Among the various families of echinoids that inhabit the Indo-west Pacific, the Temnopleuridae A. Agassiz, 1872 comprise 14 genera and 25 species (Kroh & Mooi 2011; Kroh 2012) that are known for their comparatively wide distribution (Clark & Rowe 1971). Among the temnopleurid genera, *Temnopleurus* L. Agassiz, 1841, which comprises seven extant and one fossil species, is the most abundant (Mortensen 1943; Smith 2005; Schultz 2006; Kroh *et al.* 2011) and its distribution ranges from the east coast of Africa and Madagascar to Japan, Hawaii and Australia (Clark 1912; Mortensen 1943; Clark & Rowe 1971; Schultz 2006). Published literature on temnopleurid sea urchins (Mortensen 1943; Clark & Rowe 1971) suggests that the structure of apical system and peristome, arrangement of pore-pairs and sutural pits are the most important criteria for species identification. Information available for Indian waters (Bell 1888, 1889, 1902; Koehler & Vaney 1914; Sane & Chhappargar 1962; Clark & Rowe 1971; Schultz 2006; Sastry 2007) reveal the occurrence of only three temnopleurid species, namely *Temnopleurus toreumaticus* (Leske, 1778), *T. reevesii* (Gray, 1855) and *T. apodus* (A. Agassiz & Clark, 1906).

The present paper describes a new record of *Temnopleurus decipiens* (de Meijere, 1904) for the Indian region (Goa, west coast of India). This description is complemented by a comparative analysis of morphological characters present in *T. decipiens* and *T. toreumaticus* with their extant congeners using test characters (N = 22; *sensu* Coppard & Campbell 2006). Further, two additional morphological characters namely “spine length with respect to the test diameter” and “colour banding on spine” are used to differentiate the seven extant species of *Temnopleurus*.

## MATERIAL AND METHODS

### STUDY AREA

The coastal region of Goa, located on the central west coast of India, is dotted with rugged sea-cliffs

that continue into the sea as submerged rocky patches (Wagle 1993) and contains patchy coral reefs (Padate *et al.* 2010a). These habitats support a wide array of marine fauna and sustain stocks of several economically important (Ansari *et al.* 1995), as well as rare species (Padate *et al.* 2010 a, b). The near-shore seabed consists of silty-clay down to 50 m depth and sandy-silt from 50 to 100 m depth (Wagle 1993), with an average slope of 1.5 m/km until the 30 fathom contour (54.8 m). The submarine contours are approximately parallel to the coastline.

The present study area (Fig. 1) is located in the vicinity of the Sal estuary (between 15°00'N and 15°20'N latitudes and between 73°41'E and 74°00'E longitudes) that demarcates two different habitats, namely sandy shores in the north as well as exposed rocky shores, promontories and submerged rock in the south.

### SAMPLE COLLECTION

52 trawling stations were selected off Goa, west coast of India (Fig. 1), with a total effort of 86 hours of bottom trawls from January 2009 to April 2010 in order to assess the diversity and the community structure of demersal fauna. Trawl nets with a mesh size of 15 and 9 mm at mouth and cod end, respectively, were towed at a speed of c.3–4 km/h. The sampling duration was 1–3 h. The sea urchin specimens were obtained in bulk quantities during March–April 2009 and March–April 2010. However, only good quality intact specimens were taken to the laboratory for morphological examination (Table 1). These specimens were examined under a stereomicroscope (Olympus SZX9, Olympus, Japan) and morphological characters were recorded. Altogether, 37 sea urchins were identified down to family level using morphological features such as test texture, arrangement of ambulacral pore-pairs and structure of the Aristotle's lantern (Mortensen 1943; Clarke & Rowe 1971; Coppard *et al.* 2005; Smith 2005). Subsequently, species identification was carried out using external characters such as test colour, shape, arrangement of ambulacral pore-pairs, sutural pits near the peristome, form of apical system and periproct, position of anal opening and presence of a suranal plate. Morphological

parameters (see Abbreviations) were measured using electronic calipers (Absolute Digimatic) with an accuracy of 0.01 mm. The apical system as well as ambulacral and interambulacral plates were examined for identification and differentiation of the species (Mortensen 1943; Clarke & Rowe 1971; Schultz 2006). Further, seven morphological ratios were derived from these morphometric parameters following Coppard & Campbell (2006). All the photographs were taken using Nikon D60 Digital SLR camera.

ABBREVIATIONS

- AD apical disc diameter;
- GD gonopore diameter (*sensu* Coppard & Campbell 2006);
- GPH genital plate height;
- GPW genital plate width;
- HTD horizontal test diameter;
- PPD periproct diameter;
- PSD peristome diameter;
- SL spine length;
- VTD vertical test diameter.

SYSTEMATICS

Class ECHINOIDEA Leske, 1778

Subclass EUECHINOIDEA Bronn, 1860

Superorder CAMARODONTA Jackson, 1912

Order TEMNOPLUROIDA

Mortensen, 1942

Infraorder TEMNOPLEURIDEA

Kroh & Smith, 2010

Family TEMNOLEURIDAE A. Agassiz, 1872

DIAGNOSIS. — Test well sculptured, usually with distinct pits, troughs or pores at the angles of the sutures at least in juveniles and usually throughout life. Primary tubercles imperforate, with or without crenulation; those in ambulacral and interambulacral zones similar in size. Pore-pairs forming a simple adradial band which does not expand adorally. Apical disc dicyclic, peristome much larger than apical disc; buccal notches obsolete; Aristotle's lantern of the camarodont type. Periproct subcircular with smooth edges (periproctal plates not indenting apical ring); ambulacra trigeminate, with echinid-style compounding (Smith 2005).

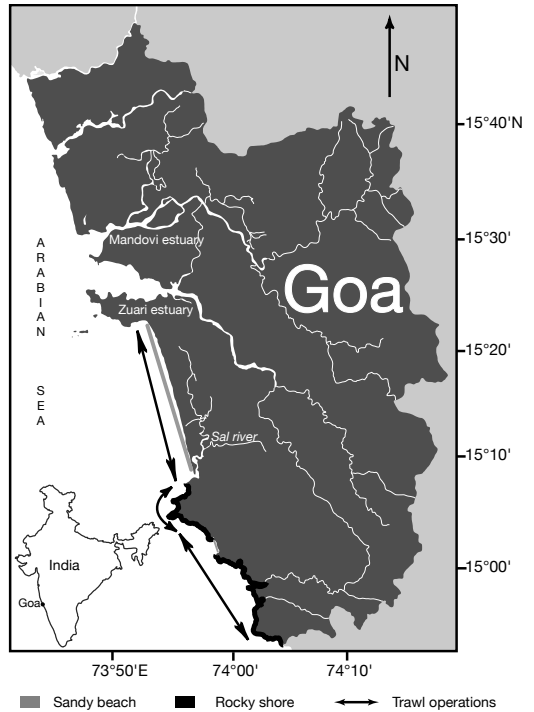


FIG. 1. — Map of studied area in India indicating trawl operations.

Genus *Temnopleurus* L. Agassiz, 1841

DIAGNOSIS. — Test profile hemispherical to subconical, rather thick-shelled with conspicuous crenulations, size often exceeding 40 mm HTD. Ambulacral plating trigeminate, pore-pairs arranged in near-vertical arcs forming a single adradial band; each compound plate comprising a single primary tubercle located closer to the pore zone and smaller perradial tubercles scattered randomly across the plate. Interambulacral plates with a central primary tubercle, smaller secondary and military tubercles scattered randomly over the remainder of the plate. Conspicuous pits and troughs present at the angle of sutures, usually with horizontal extensions; primary tubercles imperforate and distinctly crenulated. Peristome with 10 buccal plates and 10 buccal tube-feet, buccal notches very feeble. Periproct subcircular, usually with eccentric opening and some larger periproctal plates. Genital plates with tubercles forming a ring around the periproct (Mortensen 1943; Clarke & Rowe 1971; Smith 2005).

REMARKS

Observation of sea urchins collected during the present study revealed two forms of the genus

TABLE 1. — Details of sampling locations, depth and specimens examined.

Species	Date	Geographical location	Depth (m)	Number of specimens
<i>Temnopleurus decipiens</i> (de Meijere, 1904)	21.III.2009	15°04'N, 73°55'E	18	4
	04.IV.2009	15°05'N, 73°55'E	17	5
	18.III.2010	15°04'N, 73°56'E	20	3
	30.III.2010	15°03'N, 73°58'E	20	5
<i>Temnopleurus toreumaticus</i> (Leske, 1778)	21.III.2009	15°06'N, 73°56'E	10	6
	28.IV.2009	15°07'N, 73°54'E	15	8
	18.III.2010	15°09'N, 73°52'E	8	3
	30.III.2010	15°08'N, 73°53'E	10	3

*Temnopleurus* that prompted us to look into the systematics of both these forms. A review of published literature (Leske 1778; de Meijere 1904; Mortensen 1943; Clark & Rowe 1971; Smith 2005; Schultz 2006) resulted in the identification of two species *Temnopleurus decipiens* and *T. toreumaticus* in Indian waters.

### *Temnopleurus decipiens* (de Meijere, 1904)

*Genocidaris decipiens* de Meijere, 1904: 76, pl. 16, figs 264-266.

MATERIAL EXAMINED. — Off Betul fishing jetty, Goa, west coast of India, 15°04'N, 73°55'E, 17-20 m depth, 17 specimens, test diameter ranging from 5.4 to 21.30 mm.

Representative specimens are preserved in 70% ethanol and have been deposited as voucher samples (N = 16) at the Marine Biology Laboratory, Department of Marine Sciences, Goa University.

TYPE LOCALITY. — Labuan Badjo, Flores and Saleh Bay, Indonesia.

HABITAT AND DISTRIBUTION. — *Temnopleurus decipiens* has been reported from the Philippines, the eastern Indian Ocean (Clark & Rowe 1971; Marsh & Morrison 2004), the South China Sea (Lane et al. 2000) and Western Australia (Marsh & Morrison 2004; Fig. 6). Lane et al. (2000) reported this species from depths of 18-40 m around the coastal shelf waters of southern China. The present specimens of *T. decipiens* (as well as *T. toreumaticus*) were found to inhabit a sandy and muddy bottom at 15-20 m depth along the near-shore coastal waters of Goa, but were absent in all estuarine trawls.

### DESCRIPTION

Test small, dome-shaped (hemispherical), well sculptured with convex aboral surface; flattened oral surface with sunken peristome (Fig. 2A). HTD ranges from 5.42 to 21.30 mm ( $\mu = 14.60 \pm 4.78$  mm) and VTD from 2.74 to 12.92 mm ( $\mu = 8.22 \pm 3.15$  mm); test width about twice its height ( $\mu$  VTD/HTD ratio = 0.56:1). Test comprises of five pairs of alternately placed ambulacral and interambulacral plates, interambulacral plates placed at about the level of ambulacral plates (Fig. 2C). Colouration of the naked test light green to grey (Fig. 2C).

Ambulacral plates compound trigeminate, their pore-pairs bearing numerous tube feet (in living specimens) arranged in a straight line forming a single adradial band. Single primary tubercle of each ambulacral plate closed to the pore zone, surrounded by randomly scattered smaller secondary tubercles; tubercles imperforate and distinctly crenulated.

Interambulacral plates covering a slightly larger area of the test than the corresponding ambulacra. Each interambulacral plate having a central primary tubercle surrounded by smaller secondary and miliary tubercles that cover the remainder of the plate (Fig. 3A). Primary tubercles imperforate and distinctly crenulated. Wedge-shaped pits located at the angle of the suture, and arranged in a zig-zag manner along the middle of the interambulacrum; lateral extensions of the pits separating the interambulacral plates and reaching the pore-pair zone (Fig. 3B); sutural pits near the peristome also conspicuous (Fig. 3C).

Peristome large (PSD  $35.18 \pm 3.33\%$  of HTD), roughly circular in outline with very feeble buccal



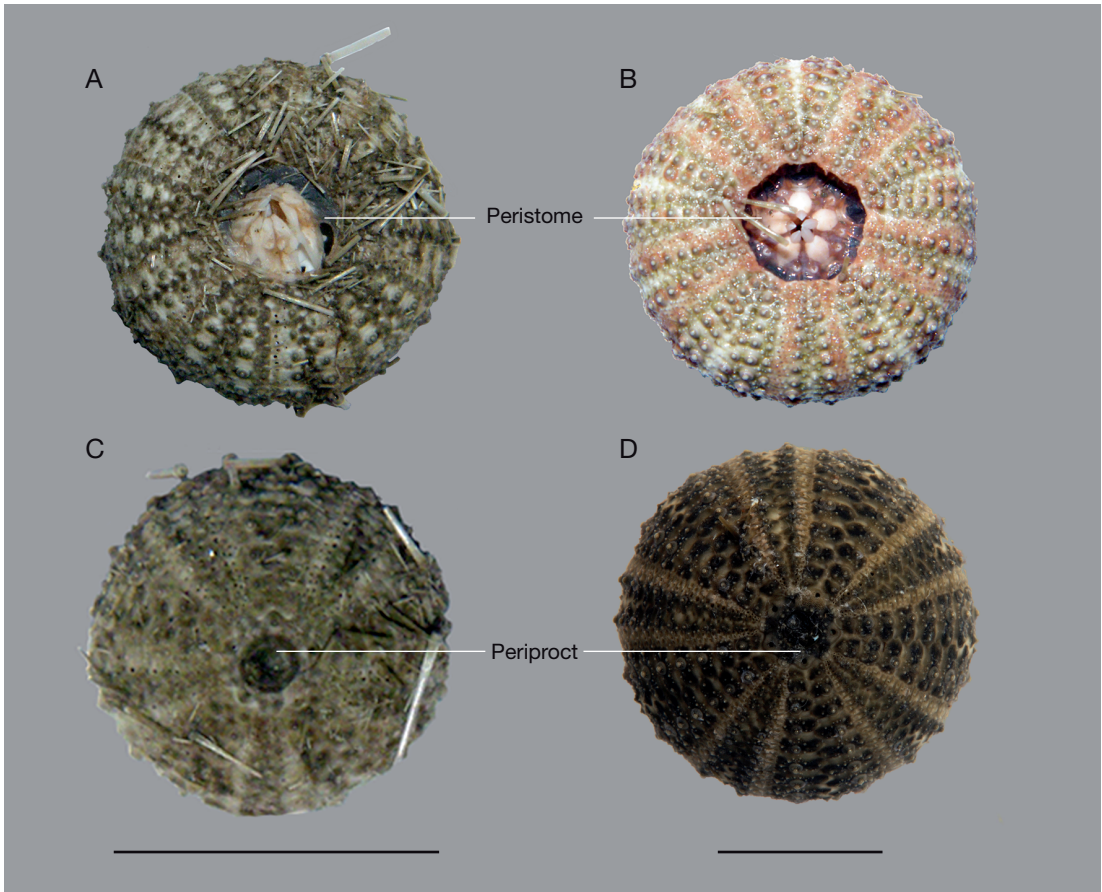


FIG. 2. — **A, B**, oral views of *Temnopleurus decipiens* (de Meijere, 1904) (**A**) and *Temnopleurus toreumaticus* (Leske, 1778) (**B**); **C, D**, aboral views of *T. decipiens* (**C**) and *T. toreumaticus* (**D**). Scale bars: 10 mm.

notches; covered with soft skin, comprising of five pairs of buccal plates with buccal tube feet emanating from them. Aristotle's lantern of the camarodont type (i.e., with a paired rod-like epiphysis bridging across the upper end of pyramid [Fig. 3D]).

Apical system dicyclic, relatively large, but smaller than the peristome (AD  $25.14 \pm 3.96\%$  of HTD). Apical system with four equal-sized genital plates and one larger genital plate with madreporite. Inner part of each genital plate with small tubercles, outer part naked. The number of tubercles varying with the size of the specimens: 1-2 tubercles in specimens  $< 5$  mm, whereas 3-4 tubercles in larger specimens. Genital plate wider than long (mean GPH:GPW

= 0.87:1). Gonopore roughly circular, approximately  $\frac{1}{3}$  of genital plate size (GD  $32.57 \pm 7.40\%$  of GPH) and located at the centre of each genital plate. Ocular plates oval-shaped, placed at the junction of two adjacent genital plates, not reaching the periproct margin; covered with 3-4 small tubercles. Conspicuous triangular pit present at the junction of the ocular plate with its two adjacent genital plates. Periproct roughly circular in outline, approximately  $\frac{1}{7}$  of maximum test diameter (PPD  $13.89 \pm 2.17\%$  of HTD), composed of brown plates; anal opening eccentric, located opposite genital plate "I". Sural plate conspicuous, located opposite the anus, covering approximately half the periproct (Fig. 3E).

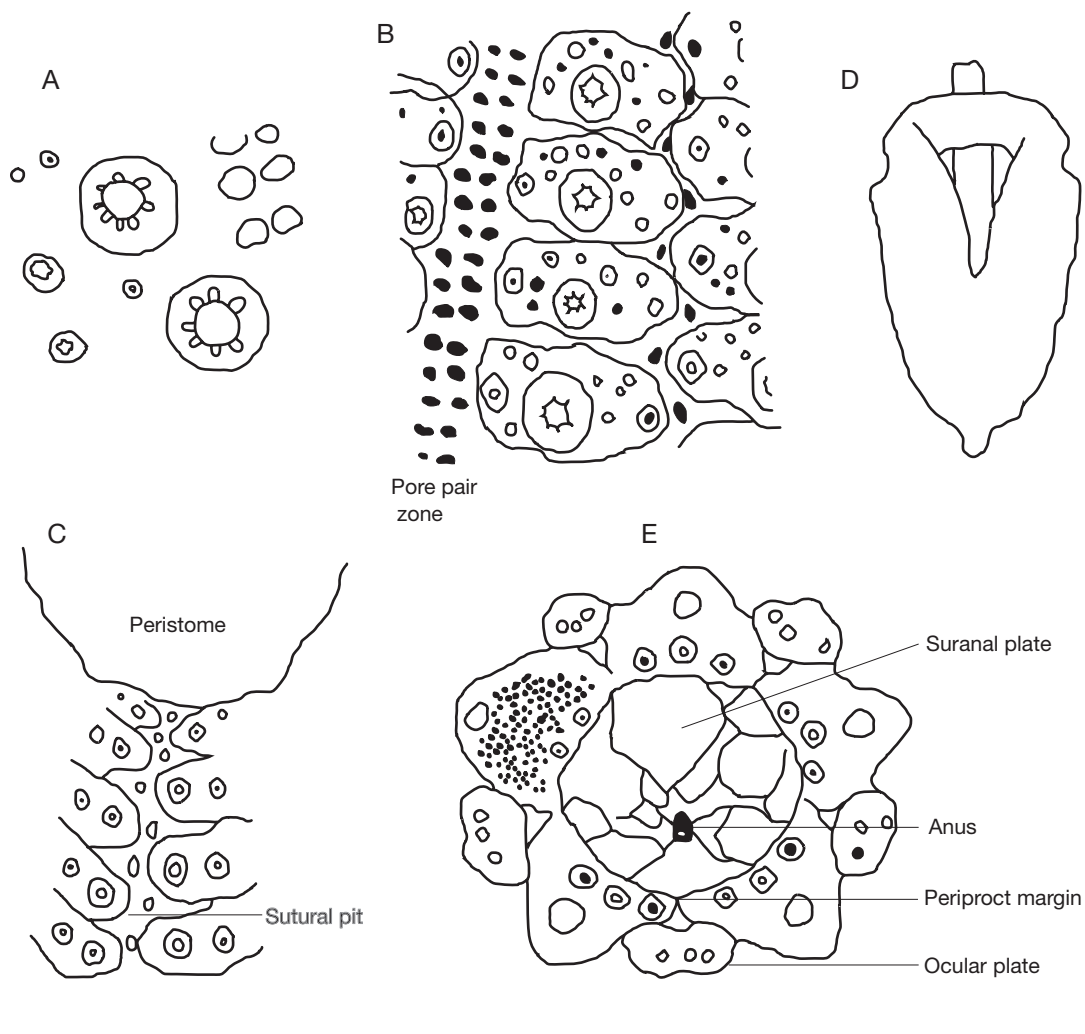


FIG. 3. — *Temnopleurus decipiens* (de Meijere, 1904): **A**, primary tubercle; **B**, interambulacrum; **C**, sutural pit near peristome; **D**, pyramid of Aristotle's lantern; **E**, apical system. Scale bar: 10 mm.

Spines thin, total length not exceeding maximum test diameter (SL  $61.80 \pm 11.74\%$  of HTD), their surface covered with fine longitudinal ridges. Spine colouration white with alternating reddish or purple bands (Fig. 4A).

*Temnopleurus toreumaticus* (Leske, 1778)

*Cidarid toreumatica* Leske, 1778: 155, 156, tab. X.

TYPE LOCALITY. — Unknown.

MATERIAL EXAMINED. — Off Betul fishing jetty, Goa, west coast of India,  $15^{\circ}04'N$ ,  $73^{\circ}55'E$ , 8–20 m depth, 20 specimens, test diameter ranges from 12.47 to 40.24 mm. Representative specimens are preserved in 70% ethanol and have been deposited as voucher samples (N = 19) at the Marine Biology Laboratory, Department of Marine Sciences, Goa University.

HABITAT AND DISTRIBUTION. — *Temnopleurus toreumaticus* is a fairly wide-spread species known to occur

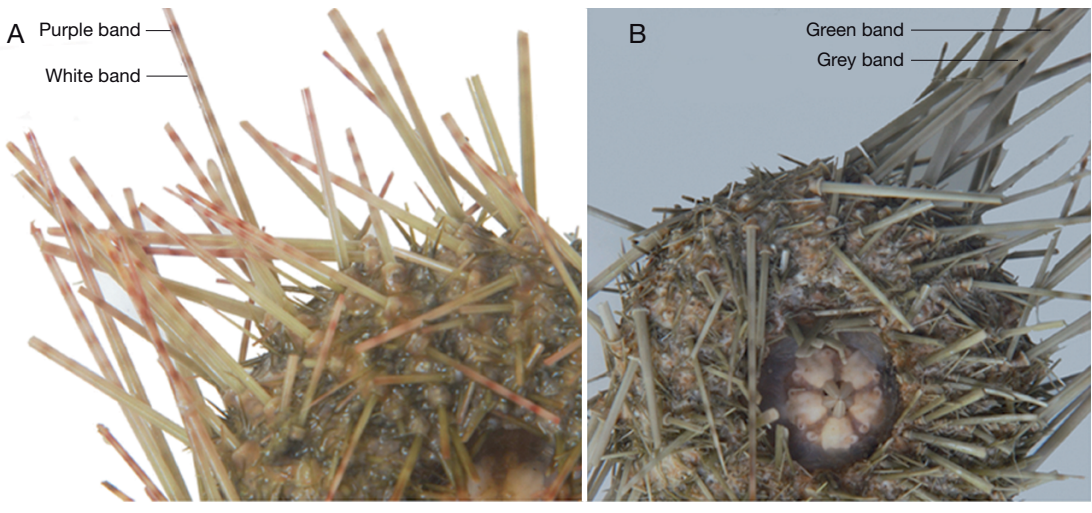


FIG. 4. — Banding on spines of: **A**, *Temnopleurus decipiens* (de Meijere, 1904); **B**, *Temnopleurus toreumaticus* (Leske, 1778). Scale bars: 10 mm.

in East Africa, Madagascar, the Persian Gulf, the Red Sea and on the east coast of Australia (Clark & Rowe 1971; Fig. 6). In Japan, this species is found from northern Honshu to southern Kyushu (Mortensen 1943; Schultz 2006). Kitazawa *et al.* (2007) studied the habitats of this sea urchin species in Shirikiwa Bay, Japan and showed that *T. toreumaticus* inhabits the intertidal and subtidal zones of muddy beaches and can also be found near rocky patches with rich assemblages of algae. Published reports for Indian waters (Ramsay 1885; Clark & Rowe 1971) suggest that this species is widely distributed and inhabits sandy and muddy substrata between 5–40 m depth.

#### DESCRIPTION

Test dome-shaped, rigid, well sculptured with a convex aboral surface; flattened oral surface with sunken peristome (Fig. 2B). HTD ranging from 12.47 to 40.24 mm ( $\mu = 33.92 \pm 7.34$  mm) and VTD from 6.68 to 25.82 mm ( $\mu = 20.59 \pm 5.23$  mm); test width about twice its height ( $\mu$  VTD/HTD ratio = 0.61:1). Test comprised of five pairs of alternately placed ambulacral and interambulacral plates, interambulacral plates placed at about the level of the ambulacral plates (Fig. 2D). Naked test displaying an olive green to dark grey colour (Fig. 2D).

Ambulacral plates compound trigeminate, their pore-pairs bearing numerous tube feet (in living specimens) and arranged in slightly vertical arcs forming a single adradial band. The single primary tubercle of each ambulacral plate close to the pore zone and surrounded by randomly scattered smaller secondary tubercles; tubercles imperforate and distinctly crenulated.

Interambulacral plates covering a slightly larger area of the test than the corresponding ambulacra. Each interambulacral plate having a central primary tubercle surrounded by smaller secondary and miliary tubercles that cover the remainder of the plate (Fig. 5A). Primary tubercles imperforate and distinctly crenulated. Wedge-shaped pits located at the angle of the suture, and arranged in a zig-zag manner along the middle of the interambulacrum; lateral extensions of the pits separating the interambulacral plates and reaching the pore-pair zone (Fig. 5B). In specimens larger than 25 mm HTD, these pits extending horizontally over the entire surface of the plate. However, sutural pits near the peristome inconspicuous (Fig. 5C).

The peristome is large (PSD  $34.26 \pm 1.87\%$  of HTD) and roughly circular in outline with very feeble buccal notches. It is covered with soft skin and comprises of five pairs of buccal plates with buc-

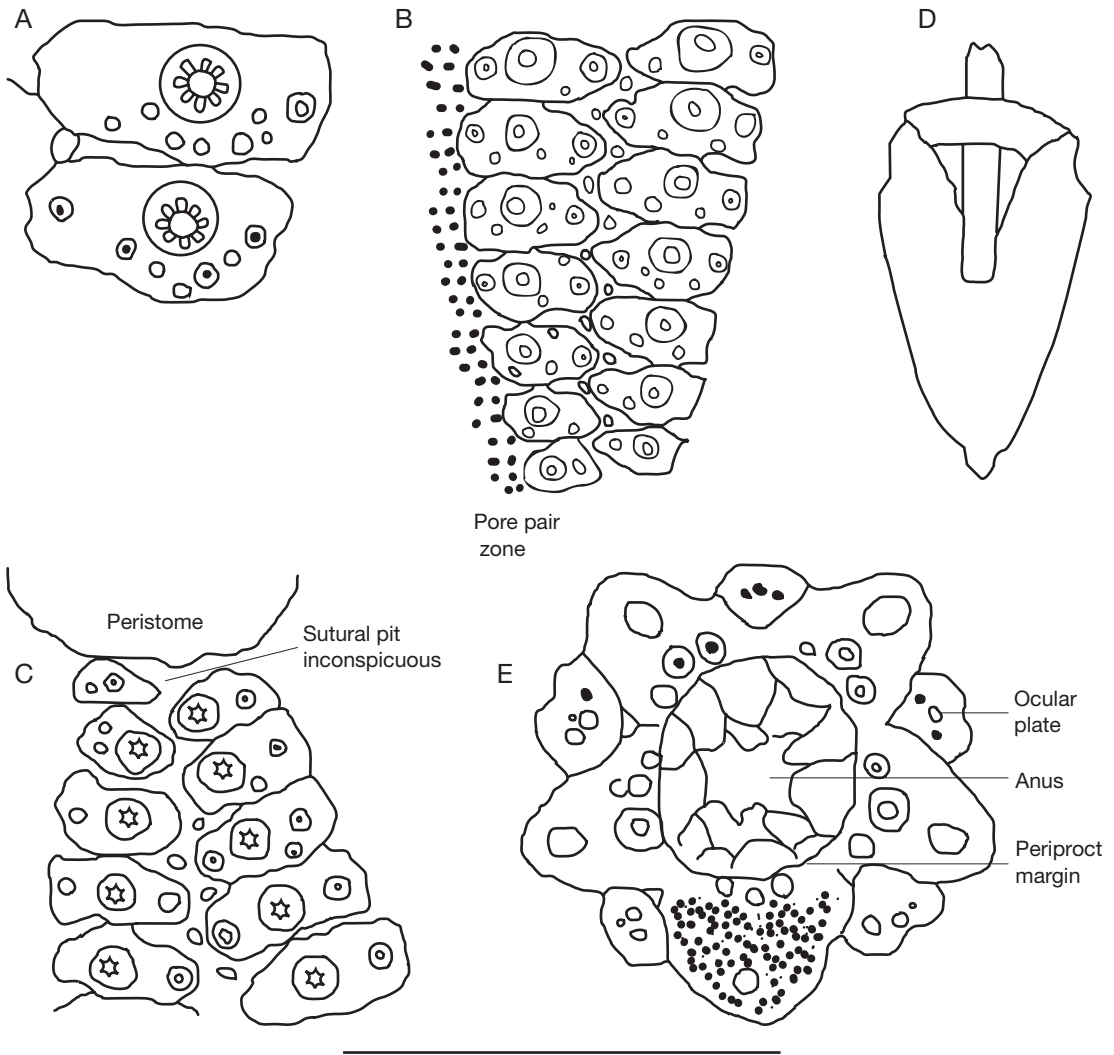


FIG. 5. — *Temnopleurus toreumaticus* (Leske, 1778): **A**, primary tubercle; **B**, interambulacrum; **C**, sutural pit near peristome; **D**, pyramid of Aristotle's lantern; **E**, apical system. Scale bar: 10 mm.

cal tube feet emanating from them. The Aristotle's lantern is of the camarodont type (i.e., with a paired rod-like epiphysis bridging across the upper end of the pyramid (Fig. 5D)).

Apical system dicyclic and smaller than the peristome (AD  $19.86 \pm 2.02$  % of HTD), with four equal-sized genital plates and one larger genital plate with madreporite. Inner part of each genital plate with small tubercles, outer part naked. The number

of tubercles varying with the size of the specimen: 1-2 tubercles in specimens < 12 mm, whereas 3-5 tubercles in larger specimens.

Genital plate wider than long (mean  $GPH:GPW = 0.82:1$ ). Gonopores roughly circular and approximately  $\frac{1}{3}$  of the genital plate's size ( $GD 35.21 \pm 5.98$  % of  $GPH$ ); located at the centre of each genital plate. Ocular plates oval-shaped and placed at the junction of two adjacent genital plates, but

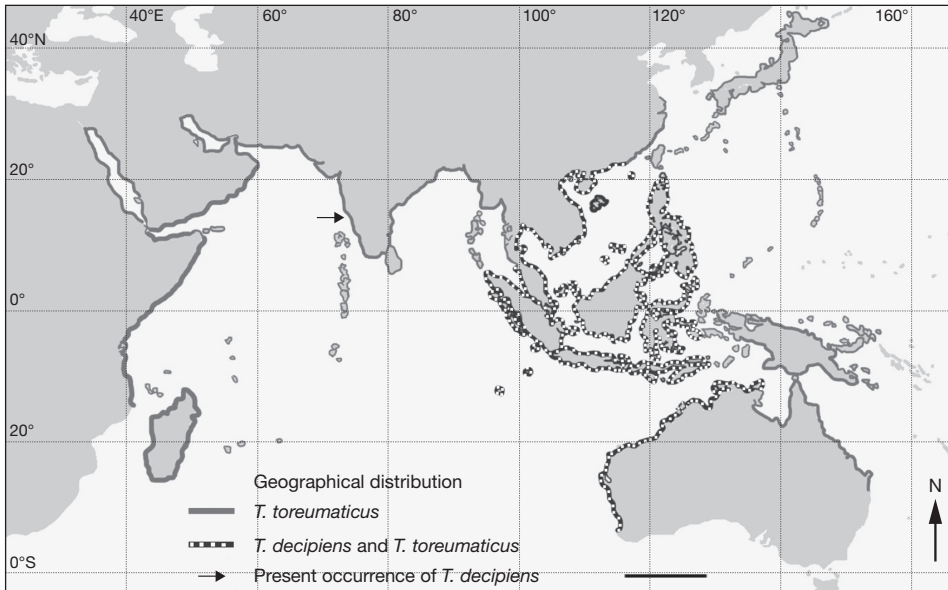


FIG. 6. — Geographical distribution of *Temnopleurus decipiens* (de Meijere, 1904) and *Temnopleurus toreumaticus* (Leske, 1778). Scale bar: 1 000 km.

not reaching the periproct margin. Ocular plates covered with 3–4 small tubercles. A small depression present at the junction of the ocular plate with its two adjacent genital plates. Periproct roughly circular in outline,  $\frac{1}{10}$  of maximum test diameter (PPD  $11.40 \pm 1.58$  % of HTD) and composed of dark brown plates. Anal opening located near the centre of the periproct; suranal plate absent (Fig. 5E).

Spines thick, with a total length not exceeding maximum test diameter (SL  $61.80 \pm 11.74$  % of HTD). Their surface covered with fine longitudinal ridges. Spine colouration grey with alternating greenish or brownish bands (Fig. 4B).

#### BRIEF DESCRIPTION OF OTHER SPECIES OF THE GENUS *TEMNOPLEURUS*

##### *Temnopleurus michaelsoni* (Döderlein, 1914)

HABITAT AND DISTRIBUTION. — Littoral zone down to 16 m depth along the western and southern coasts of Australia (Schultz 2006).

#### DESCRIPTION

Maximum test diameter 25 mm. Suranal plate distinct and rounded; anal opening eccentric in the periproct. Ambulacral pore-pairs arranged in a straight series. Deep sutural furrow continuous along the entire length of the sutures. Grooves in ambulacra and interambulacra are deeply depressed and separated. Primary spines short, less than half the test diameter, coloured reddish brown at the base changing to greenish at the tip (Mortensen 1943; Schultz 2006).

##### *Temnopleurus alexandri* (Bell, 1884)

HABITAT AND DISTRIBUTION. — Littoral zone down to 50 m depth (Schultz 2006) from the eastern Indian Ocean to the coasts of Australia (Clark & Rowe 1971).

#### DESCRIPTION

Maximum test diameter 80 mm. Genital plate with some larger tubercles at the inner edge, absence of distinct suranal plate and anal open-



ing near the centre of the periproct. Pore-pairs arranged in oblique arcs. Each interambulacral plate containing up to seven primary tubercles arranged in horizontal series. Sutural pits deep at the oral side. Spines short, pointed, less than half the test diameter, coloured greenish at the base, distally more purplish (Mortensen 1943; Schultz 2006).

*Temnopleurus hardwickii* (Gray, 1855)

HABITAT AND DISTRIBUTION. — Coastal waters from 5 to 35 m depth off Japan, Korean peninsula and northern China (Schultz 2006).

DESCRIPTION

Test rather strong with a maximum diameter of 46 mm. Apical system inflated; genital plate with numerous tubercles. Periproct large without distinct suranal plate; anus opening near the centre of the periproct. Pore-pairs arranged in a straight vertical series. Sutural pits and furrows deep, continuous over the oral side. Spines short, less than  $\frac{1}{4}$  of the test diameter, with dark brown colour at base and light brown at the distal end (Mortensen 1943; Schultz 2006).

*Temnopleurus reevesii* (Gray, 1855)

HABITAT AND DISTRIBUTION. — Coastal waters from 36 to 200 m depth (Clark 1912) in East Africa, Madagascar, the eastern Indian Ocean, the Philippines, Malaysia, China and Japan (Clark & Rowe 1971; Schultz 2006).

DESCRIPTION

Test fragile, hemispherical, test diameter 30–45 mm. Apical system with ocular plate “1” inserted. Anal opening strongly eccentric in the periproct with distinct suranal plate. Pore-pairs arranged in a straight vertical series. Sutural pits small, furrows shallow, continuous at the oral side as well. Spines short, about half the diameter of the test, with brownish to light greyish tinge (Clark 1912; Mortensen 1943; Schultz 2006).

*Temnopleurus apodus*  
(A. Agassiz & Clark, 1906)

HABITAT AND DISTRIBUTION. — Coastal waters from 100 to 325 m depth off Hawaii (Clark 1912), in the South China Sea (Lane *et al.* 2000) and on the east coast of India (Sastry 2007).

DESCRIPTION

Small-sized species with a maximum test diameter of 7 mm. Pore-pairs arranged in slightly vertical arcs. Apical system distinctly larger than peristome. Only five buccal plates present on peristome, madreporic pores few (12–14) in number. Suranal plate covering more than half the periproct, anal opening very eccentric. Primary spines slender and long, nearly equal to test diameter (Clark 1912; Mortensen 1943).

COMPARATIVE DIAGNOSIS

Our analysis of 27 morphological characters revealed significant differences between *T. decipiens* (N = 17) and *T. toreumaticus* (N = 20) with respect to the position of the anus, the presence of a suranal plate, the presence of sutural pits near the peristome and the arrangement of ambulacral pore-pairs. In addition, we observed subtle morphological differences with respect to the diameter of the apical system, the ratio of spine length to maximum test diameter and the colour banding on spines (Table 2). An attempt was made to compare our observations with the original description by de Meijere (1904) to provide a better picture of the taxonomy of these two species.

COMPARISON WITH THE ORIGINAL DESCRIPTION

De Meijere (1904) first described *T. decipiens* (originally as a *Genocidaris decipiens*) from sandy, coral and muddy bottom habitats down to 40 m depth from the Labuan Badjo, Flores and Saleh Bay, Indonesia. The specimens collected in the waters off Goa were found to resemble de Meijere’s description with regard to the morphological characters “presence of a distinct suranal plate”, “eccentric anal opening” and “zig-zag arrangement of sutural pits”. However, they differed from the original description by the pattern of the ocular plate arrangement, such that “none

TABLE 2. — Comparison of morphological characters of *Temnopleurus decipiens* (de Meijere, 1904) and *Temnopleurus toreumaticus* (Leske, 1778).

Morphological characters	<i>T. decipiens</i> (N = 17)	<i>T. toreumaticus</i> (N = 20)
<b>Test structure</b>		
Test colour	Olive green to light green	Olive green to grey
Test shape	Hemispherical	Hemispherical
Arrangement of ambulacral pore-pairs	Straight series	Slightly vertical arcs
Sutural pits near peristome	Conspicuous	Inconspicuous
Form of apical system	Dicyclic	Dicyclic
Form of periproct	Large circular, brown plates	Circular, black plates
Position of anal opening	Eccentric	Subcentral
Suranal plate	Present	Absent
Colour of spine	Purple white bands	Brown green bands
<b>Meristic counts</b>		
Number of median series tubercles on interambulacra	1	1
Number of tubercles present on the genital plate	1-3	3-5
<b>Morphometric measurements</b>		
Mean horizontal test diameter (HTD) (mm)	14.60 ± 4.78	33.92 ± 7.34
Mean vertical test diameter (VTD) (mm)	8.22 ± 3.15	20.59 ± 5.23
Mean peristome diameter (PD) (mm)	5.06 ± 1.59	11.57 ± 2.45
Mean apical disc diameter (AD) (mm)	3.53 ± 0.92	6.64 ± 1.31
Mean periproct diameter (PPD) (mm)	1.99 ± 0.67	3.77 ± 0.63
Mean genital plate width (GPW) (mm)	1.25 ± 0.38	2.37 ± 0.51
Mean genital plate height (GPH) (mm)	1.06 ± 0.30	1.92 ± 0.33
Mean gonopore diameter (GD) (mm)	0.35 ± 0.13	0.68 ± 0.19
Mean spine length (SL) (mm)	10.63 ± 4.90	21.75 ± 4.70
<b>Morphometric ratios</b>		
VTD (% of HTD)	55.15 ± 4.76	60.38 ± 6.17
% of spine length to the HTD	73.00 ± 11.61	62.00 ± 11.74
Peristome (% of HTD)	35.15 ± 3.33	34.26 ± 1.87
Apical system (% of HTD)	25.14 ± 3.96	19.86 ± 2.02
Periproct (% of HTD)	13.90 ± 2.17	11.40 ± 1.58
Diameter of gonopore ( % GPH)	32.56 ± 7.40	35.20 ± 5.98
Height to width ratio of the genital plate	0.86:1 ± 0.11	0.78:1 ± 0.09

of the ocular plates placed near the periproctorial margin reach the periproct” (Fig. 4E). Another marked difference was the large test size (21.3 mm HTD) as compared to the original description (7.0 mm HTD).

COMPARATIVE ANALYSIS  
OF THE GENUS *TEMNOPLÉURUS*

The distinctiveness of *T. decipiens* was asserted based on a comparison with our observations on *T. toreumaticus* and published descriptions of the other five congeners (Clark 1912; Mortensen 1943; Clark & Rowe 1971; Schultz 2006). Among the 27 morphological characters used in the taxonomic identification of species of the genus *Temnopleurus*,

seven parameters (i.e., anal position, presence of suranal plate, sutural pits near peristome, pore-pair arrangement, number of buccal plate in the peristome, colouration of the primary spine and length of the spine with respect to test diameter) were used for our comparative analysis (Table 3).

This analysis revealed that *T. decipiens* shares the character “eccentric anus” and “presence of suranal plate” with *T. apodus*, *T. reevesii* and *T. michaelseni* as opposed to “subcentric anus” and “absence of distinct suranal plate” in *T. toreumaticus*, *T. hardwickii* and *T. alexandri*. In addition, *T. decipiens* possessed “conspicuous sutural pits near peristome”, a character shared only with *T. reevesii*. Pore-pair arrangement was found to

be in “straight vertical series” among *T. decipiens*, *T. reevesii*, *T. hardwickii* and *T. michaelseni*, whereas the same was observed to be “arced” in *T. toreumaticus*, *T. alexandri* and *T. apodus*. In *T. apodus*, it was observed that it possessed “peristome smaller than apical system” and “five buccal plates”, whereas, the other species possessed “peristome larger than apical system” and “ten buccal plates”. A comparison of another major

character namely spine colouration revealed “purple to red” bands in *T. decipiens* and “brown to red” bands in *T. toreumaticus*. However, the other five species showed lack of colour bands on the spines. In addition, spine length in these species (*T. decipiens*, *T. toreumaticus* and *T. apodus*) was found to be “greater than half the test diameter” in contrast with “less than half the test diameter” in the other four species.

#### REVISED KEY TO THE EXTANT SPECIES OF THE GENUS *TEMNOPLEURUS* L. AGASSIZ, 1841

1. Anus located near the centre of the periproct (subcentral), suranal plate absent ..... 2  
— Anus located away from the centre (eccentric), distinct suranal plate present ..... 4
2. 3-4 primary tubercles present on each interambulacral plate ..... 3  
— 7-8 primary tubercles present on each interambulacral plate ... *T. alexandri* (Bell, 1884)
3. Primary spines long, equal to half of horizontal test diameter, banded with reddish or brown colour bands, pore-pairs arranged in arcs ..... *T. toreumaticus* (Leske, 1778)  
— Primary spines short, length less than  $\frac{1}{4}$  of the horizontal test diameter, spines never banded, pore-pairs arranged in a straight vertical series ..... *T. hardwickii* (Gray, 1855)
4. Peristome larger than apical system, containing 10 buccal plates with 10 buccal tube feet ... 5  
— Peristome smaller than apical system, containing five buccal plates with five buccal tube feet ..... *T. apodus* (Agassiz & Clark, 1907)
5. Primary spines short, less than half of the test diameter, not banded ..... 6  
— Primary spines long equal to  $\frac{2}{3}$  of the test diameter, banded with dark purple or red-coloured bands ..... *T. decipiens* (de Meijere, 1904)
6. Sutural pits deep, horizontal furrows deep and elongate, sutural pits at the oral side inconspicuous ..... *T. michaelseni* (Döderlein, 1914)  
— Sutural pits shallow, horizontal furrows shallow and not elongated, sutural pits at the oral side conspicuous ..... *T. reevesii* (Gray, 1855)

#### DISCUSSION

*Temnopleurus* is a well-studied echinoid genus distributed across the Indo-west Pacific region (Clark 1912; Mortensen 1943; Clark & Rowe 1971; Schultz 2006). This genus is comprised of seven extant and one fossil species. Four of the extant species (*T. decipiens*, *T. reevesii*, *T. apodus* and *T. michaelseni*) possessing an eccentric anus and a large suranal plate were initially included under subgenus *Toreumatica* Gray, 1855 (*sensu* Coppard *et al.* 2005). Recently, the subgenus *Toreumatica* has been accepted as the genus *Temnopleurus* (Kroh 2012). Among these, *T. decipiens*

is one of the least studied species in respect of its biogeographical distribution (Clark & Rowe 1971) due to limited occurrence. The present study records the occurrence of *T. decipiens* for the first time from the Indian coast. The present finding assumes significance as it not only updates information about a rare echinoid species but also extends its known geographical range to the central Indian Ocean. Our observation reveals the occurrence of two species of the genus *Temnopleurus* (*T. decipiens* and *T. toreumaticus*) in the near-shore waters of Goa. Review of published literature (Mortensen 1943; Clark and Rowe

TABLE 3. — Comparison of morphological characteristics of all seven extant species of the genus *Temnopleurus* L. Agassiz, 1841. Abbreviations: 1, Mortensen 1943; 2, Schultz 2006; 3, de Meijere 1904; 4, Clark 1912; HTD, horizontal test diameter.

Morphological characters	Position of the anus	Suranal plate	Sutural pits near peristome	Pore-pair arrangement	No of buccal plates	Banding on spines	Relative length of spine to HTD	Ref.
<i>T. toreumaticus</i>	Subcentral	Absent	Inconspicuous	Arced	10	Red or brown	> ½ HTD	1, 2
<i>T. hardwickii</i>	Subcentral	Absent	Inconspicuous	Straight series	10	Absent	< ½ HTD	1, 2
<i>T. alexandri</i>	Subcentral	Absent	Inconspicuous	Arced	10	Absent	< ½ HTD	1, 2
<i>T. decipiens</i>	Eccentric	Present	Conspicuous	Straight series	10	Purple or red	> ½ HTD	1, 3
<i>T. apodus</i>	Eccentric	Present	Inconspicuous	Arced	5	Absent	> ½ HTD	1, 4
<i>T. reevesii</i>	Eccentric	Present	Conspicuous	Straight series	10	Absent	< ½ HTD	1, 2
<i>T. michaelseni</i>	Eccentric	Present	Inconspicuous	Straight series	10	Absent	< ½ HTD	1, 2

1971; Coppard *et al.* 2005; Smith 2005; Schultz 2006) suggests morphological differences between these species in respect of position of the anus within the periproct and the presence of a suranal plate. However, we were able to discern marked differences in respect of sutural pits near the peristome and two morphometric ratios, % of AD to HTD and ratio of spine length to HTD (Table 2). Further, comparison of *T. decipiens* with its original description by de Meijere (1904) revealed that the present specimens differed from the type specimen with respect to size, and the position of ocular plate with respect to periproct margin. Therefore, our observations suggest that the size of *T. decipiens* ranges from 5 to 21 mm, and the position of the ocular plate with respect to periproct margin vary within the species.

A comparative analysis of the extant species of the genus *Temnopleurus* (Clark 1912; Mortensen 1943; Clark & Rowe 1971; Coppard *et al.* 2005; Smith 2005; Schultz 2006) was carried out using seven morphological parameters (Table 3). This analysis suggested that apart from the structure of periproct, arrangement of sutural pits and ambulacral pore-pairs, the number of tubercles on the plate also varies between the species of genus *Temnopleurus*. In this context, a revised taxonomic key to all the extant species of the genus *Temnopleurus* is provided with two additional characters: the primary tubercle count and relative spine length, to differentiate between the congeners. However, the fossil species *Temnopleurus latidunensis* Clegg, 1933 was not taken into consideration for taxonomic comparison as the description lacked details

of the structure of the periproct and the spines (Kroh *et al.* 2011).

### CONCLUSION

In summary, the present study reveals the first record of *T. decipiens* from the Indian waters, and an attempt has been made to compare its morphology with its congeners. Further, molecular studies pertaining to the nucleic acid homology would decipher phylogenetic and intra-species variability among this group.

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