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**Two new species of the family Leptochitonidae
(Mollusca: Polyplacophora)
from the tropical and subtropical shallow waters
of the West Pacific**

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Two new species of the family Leptochitonidae, *Leptochiton pumilus* **sp. nov.** and *Terenoichiton nomurai* **sp. nov.** are described from the tropical and subtropical shallow waters of the West Pacific. *L. pumilus* from the Philippines and Papua New Guinea has a net-like sculpture on the shell which is rather rare feature in the genus. In this genus, so far only three species have hitherto been known in the tropical shallow waters, in contrast to more than 130 other extant species which are living in the deep cold waters and high latitudes. *T. nomurai* from Ryukyu Islands is the second representative of the genus *Terenoichiton* Iredale, 1914 which was recently reinstated for *Leptochiton norfolcensis* (Hedley et Hull, 1912), and is characterized by having rudiments of the insertion plates in all valves. *T. nomurai* closely resembles the type species, but differs in the arrangement of the aesthete pores on the granules of the tegmentum, and less developed rudiments of the insertion plates.

Key words: chitons, *Leptochiton*, *Terenoichiton*, new species, the Philippines, Japan, Papua New Guinea.

**Два новых вида семейства Leptochitonidae
(Mollusca: Polyplacophora)
из тропических и субтропических мелководий
западной Пацифики**

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Описаны два новых вида семейства Leptochitonidae, *Leptochiton pumilus* **sp. nov.** и *Terenoichiton nomurai* **sp. nov.** из тропических и субтропических мелководий западной Пацифики. *L. pumilus* с Филиппин и Папуа – Новой Гвинеи имеет сетчатовидную скульптуру на раковине, что является

довольно редким признаком в этом роде. В этом роде только три вида известны до настоящего времени в тропических мелководьях, в противоположность более чем 130 другим современным видам, которые живут в глубоких холодных водах и в высоких широтах. *T. nomurai* из островов Рюкю является вторым представителем рода *Terenochiton* Iredale, 1914, который был недавно восстановлен для *Leptochiton norfolcensis* (Hedley et Hull, 1912) и характеризуется наличием рудиментов инсерционных пластинок на всех щитках. *T. nomurai* сходен с типовым видом рода, но отличается расположением пор эстетов на зернах тегмента и менее развитыми рудиментами инсерционных пластинок.

Ключевые слова: хитоны, *Leptochiton*, *Terenochiton*, новые виды, Филиппины, Япония, Папуа Новая Гвинея.

The family Leptochitonidae Dall, 1889 belongs to one of the two orders of living chitons, Lepidopleurida that is regarded to be «basal» group [Buckland-Nicks, 2008; Sigwart, 2008] against larger and more diverse another order Chitonida. The family Leptochitonidae is originated in the Carboniferous, and comprises seven extinct and five extant genera [Sirenko, 2006, 2019]. Among 170 extant species of this family (Mollusca-base: <http://molluscabase.org/>), most species inhabit temperate or boreal areas, or cold deeper waters, except for the genus *Parachiton* Thiele, 1909 which is mainly distributed in the tropical shallow waters.

The genus *Leptochiton* Gray, 1847 is characterized by thin valves which are lacking insertion plates, and in most species, the shell surface is sculptured exclusively with minute granules. Among 140 extant species known in the world, only three species have hitherto been known from tropical shallow waters: *Leptochiton nierstraszi* (Leloup, 1981); *L. hiriensis* Schwabe et Lozouet, 2006; *L. muelleri* Sirenko et Schwabe, 2011 [Leloup, 1981; Schwabe, Lozouet, 2006; Sirenko, Schwabe, 2011; Sirenko, 2014]. They are very small; their maximum body length is 6.0 mm, 1.4 mm and 2.5 mm, respectively. One of the two new species described herein from the tropical shallow waters of the West Pacific is also very small, body length 2.5 mm, and considered to be assigned in the genus *Leptochiton*. This species has net-like sculpture on the intermediate and tail valves. The net-like sculpture is also shared by *L. hiriensis* and *L. muelleri*, but it is rather rare in the genus.

Another new species also has a net-like sculpture on the valves, but it is assigned in the genus *Terenochiton* Iredale, 1914 by its peculiar feature: presence of rudiments of the insertion plates in all valves. The genus *Terenochiton* is a monotypic. The type species, *Terenochiton norfolcensis* (Hedley et Hull, 1912), is known from shallow waters of Norfolk, Lord Howe and Kermadec Islands, which are located in the subtropical area of the South Pacific; Lord Howe Islands has fringing coral reef, and other two islands have no true coral reef, but have patches of hermatypic corals [Francis, 1993]. The present new species is distributed in coral reef area of Yaeyama Islands, Ryukyu Islands, the Northwest Pacific. Yaeyama Islands experience the most tropical condition in subtropical Ryukyu Islands [Reimer et al., 2019]. Instead of far distant distribution ranges of the two species, they surprisingly resemble each other in morphology.

Materials and methods

The specimens of *Leptochiton pumilus* sp. nov. examined here were collected in the expeditions carried out by Muséum national d'Histoire naturelle, Paris: «PAPUA NIUGINI», near Papua New Guinea in 2012 and «PANGLAO 2004», near the Philippines in 2004. Those of *Terenochiton nomurai* sp. nov. were collected during the surveys for juveniles of crown-of-thorns starfish, *Acanthaster planci* (L., 1758) by the late Dr. Tadashige Habe, and for cryptic crustaceans, by Dr. Keiichi Nomura, both in Yaeyama Islands, Okinawa, Japan in 1985 and 1991, respectively.

Several specimens were prepared for scanning electron microscope (SEM). They were boiled in 7% KOH for 2–5 minutes, then boiled twice in fresh water. Several valves (usually the valves I, IV, V and VIII), most part of the radular ribbon and a portion of the girdle were then chosen for a scanning electron microscope FEI SEM Quanta 250 Scan (The Thermo Fischer Scientific, Inc., MA, USA) for *L. pumilus*, and JEOL 6380LV (JEOL Co., Tokyo, Japan) for *T. nomurai*. The rest of the radula and the girdle were dried and put in Canada balsam for examination under the light microscope.

Figure 6L and 11A are schematic drawings of aesthete group on a granule to show the number and arrangement of the aesthetes (not to scale). Bathymetric ranges are reported as values between the shallowest and deepest stations as explained by Bouchet et al. [2008].

Abbreviations: BL – body length; stn – station; spm(s) – specimen(s); MNHN – Muséum national d'Histoire naturelle, Paris; NSMT – National Museum of Nature and Science, Tsukuba; ZISP – Zoological Institute, Russian Academy of Sciences, St. Petersburg.

Systematics

Class **POLYPLACOPHORA** Gray, 1821
Subclass **NEOLORICATA** Bergenhayn, 1955
Order **LEPIDOPLEURIDA** Thiele, 1909
Suborder **LEPIDOPLEURINA** Thiele, 1909
Family **Leptochitonidae** Dall, 1889
Genus *Leptochiton* Gray, 1847

Type species. *Chiton cinereus* (sensu) Montagu, 1803 (non Linnaeus, 1767) = *Leptochiton asellus* (Gmelin, 1791) *fide* Lovén [1846, p. 159], subsequent designation by Gray [1847, p. 168].

Genus distribution. Worldwide. Lower Carboniferous – Recent [Sirenko, 2013].

Leptochiton pumilus Sirenko et Saito sp. nov.
Figs. 1–6

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Type material. The holotype (MNHM IM-2013-2051), and two paratypes (MNHM IM-2013-49553, and IM-2013-850).

Type locality. Papua New Guinea, Kranket Island, west side, 05°11.8' S, 145°48.8' E, depth 7–15 m (Expédition PAPUA NIUGINI, stn PB12).

Fig. 1. *Leptochiton pumilus*, **holotype** (MNHM IM-2013-2051), Papua New Guinea, Kranket Island, Expédition PAPUA NIUGINI, stn PB12. BL 2.5 mm. **A** – valve I, dorsal view; **B** – valve II, dorsal view; **C** – valve VIII, dorsal view; **D** – valve IV, ventral view; **E** – valve II, detail of tegmentum surface of central area; **F** – valve II, rostral view; **G** – valve VIII, lateral view.

Fig. 2. *Leptochiton pumilus*, **paratype** (MNHM IM-2013-49553), the Philippines, Bohol Island, Maribohoc Bay, PANGLAO 2004, stn P1, BL 2.5 mm (B, D); **holotype** (MNHM IM-2013-2051). Papua New Guinea, Kranket Island, Expédition PAPUA NIUGINI, stn PB12, BL 2.5 mm (A, C). **A** – whole animal, lateral view; **B** – dorsal girdle scales; **C** – dorsal scales and intersegmental spicule; **D** – scales around girdle margin.

Material examined. **The Philippines**, Bohol Island, Maribohoc Bay, PANGLAO 2004, stn P1, 09°36' N, 123°45' E, depth 90–200 m, tangle nets from local fisherman, paratype (IM-2013-49553), 1 spm, BL 2.0 mm, 30.05.2004, coll. Panglao Marine Biodiversity Project; **Papua New Guinea**, Kranket Island, west side, Expédition PAPUA NIUGINI, stn PB12, 05°11.8' S, 145°48.8' E, depth 7–15 m, the holotype (IM-2013-2051), BL 2.5 mm, 11.11.2012; Madang, east of the airport, Expédition PAPUA NIUGINI, stn PD04, 05°12.6' S, 145°47.8' E, depth 5–18 m, paratype (IM-2013-850) and 1 spm (IM-2013-850), BL 2.0 mm, 07.11.2012; south of Sek Island, Expédition PAPUA NIUGINI, stn PD22, 05°06.3' S, 145°49.2' E, depth 12–20 m, 1 spm, BL 2.0 mm, 14–15.11.2012.

E t y m o l o g y. From the Latin *pumilus*, pygmean, because it is very small.

Fig. 3. *Leptochiton pumilus*, **holotype** (MNHM IM-2013-2051), Papua New Guinea, Kranket Island, Expédition PAPUA NIUGINI, stn PB12. BL 2.5 mm. **A** – dorsal girdle scales; **B** – central portion of radula, dorsal view; **C** – ditto, posterior view; **D** – central portion of radula, close up.

Diagnosis. Animal very small. Shell rather elevated; back rounded. Each granule on central area connected with four nearest granules by crosspieces and provided with five aesthete pores. Girdle dorsally densely covered with small, bent, imbricating, bluntly pointed scales which are ornamented with 11–13 strong bifurcated ribs. Radula with ca. 30 transverse rows of very small teeth; first lateral teeth longer than central tooth; head of major lateral tooth with two denticles.

Description. Animal very small, BL 2.5 mm in holotype (largest specimen); elongate-oval. Valves moderately elevated (dorsal elevation 0.43 in valve V), round-backed, not beaked. Color of tementum white.

Head valve semicircular. Intermediate valve rectangular; lateral margins rounded; anterior margin slightly convex; posterior margin nearly straight; lateral areas not raised. Tail valve high, narrower than head valve; mucro anterior; antemucronal slope short, convex; postmucronal slope long, concave.

Fig. 4. *Leptochiton pumilus*, **paratype** (MNHM-IM-2013-850), Papua New Guinea, Madang, east of the airport, Expédition PAPUA NIUGINI, stn PD4, BL 2.0 mm (A–D); **paratype** (MNHM-IM-2013-49553), the Philippines, Bohol Island, Maribohoc Bay, PANGLAO 2004, stn P1, BL 2.0 mm (E). **A** – valve III, dorsal view; **B** – valve III, rostral view; **C** – portion of radula, dorsal view; **D** – valve III, detail of tegmentum surface of central area; **E** – central portion of radula, dorsal view.

Tegmentum of head valve sculptured with 26 radial rows of closely set small, oval, flattened granules. Central areas sculptured with ca. 27 closely set longitudinal rows of oval granules; each granule connected with four nearest granules by crosspieces. Lateral areas sculptured with 6–7 radial rows of granules as head valve. Antemucronal area sculptured as central area with 18 longitudinal rows of granules. Postmucronal area sculptured as head valve with ca. 30 radial rows of oval granules. Each granule with one megal aesthete and four micraesthetes in front. Micraesthete pores slightly smaller than megal aesthete pores.

Articulamentum thin, white. Apophyses small, triangular, widely apart; jugal sinus shallow, wide.

Fig. 5. *Leptochiton pumilus*, **paratype** (MNHM-IM-2013-850), Papua New Guinea, Madang, east of the airport, Expédition PAPUA NIUGINI, stn PD4, BL 2.0 mm. **A** – scales around girdle margin; **B** – dorsal scales and intersegmental needle.

Girdle very narrow, dorsally densely covered with small, up to $45 \times 38 \mu\text{m}$ (in central part of perinotum) bent, imbricating, bluntly pointed scales, which are ornamented with 11–13 strong, bifurcated ribs; scales longer, narrower with fewer 7 ribs in intersegmental area, rare ribbed needles up to $90 \times 8 \mu\text{m}$ scattered among dorsal scales. Intersegmental area with long, up to $280 \times 10 \mu\text{m}$ ribbed needles. Marginal needles $90 \times 13 \mu\text{m}$, with 7 ribs on one side. Ventrally girdle covered with elongated flat scales; those near margin, distally obtusely pointed, $70 \times 20 \mu\text{m}$, with 5–6 long ribs on the ventral side; those in middle of girdle and near pallial groove shorter, $40 \times 17 \mu\text{m}$ and smooth.

Gills four short ctenidia per side in studied specimens, arranged from valve VII to anus.

Radula of holotype 0.8 mm long with 31 transverse rows of very small mature teeth. Central tooth elongate, with small blade at top. First lateral teeth longer than central one, bearing elongate, curved blade. Major lateral teeth with bidentate cusp; inner denticle much smaller than outer main one, which has an accessory protuberance on the outer side.

Distribution. Philippines and Papua New Guinea, depth 5–90 m.

Remarks. The paratype (IM-2013-49553) from the Philippines (90 m) has no accessory protuberance on the outer side of head of major lateral teeth of radula. The protuberance is probably remnant of the third denticle which was generally found in juvenile chiton. *Leptochiton pumilus* sp. nov. is much similar to *Leptochiton muelleri* Sirenko et Schwabe, 2011, but differs from the latter by having bifurcated ribs in dorsal scales (simple ribs in *L. muelleri*), four gills (six gills in *L. muelleri*), bidentate cusp of major lateral teeth (tridentate cusp in *L. muelleri*), and long first lateral teeth (short teeth in *L. muelleri*).

Fig. 6. *Leptochiton pumilus*, **holotype** (MNHM-IM-2013-2051), Papua New Guinea, Kranket Island, Expédition PAPUA NIUGINI, stn PB12. BL 2.5 mm (A–H, J, L); **paratype** (MNHM-IM-2013-49553), the Philippines, Bohol Island, Maribohoc Bay, PANGLAO 2004, stn P1, BL 2.0 mm (I); **paratype** (MNHM IM-2013-850), Papua New Guinea, Madang, east of the airport, Expédition PAPUA NIUGINI, stn PD4, BL 2.0 mm (K). A – intersegmental needle; B – dorsal girdle scale of intersegmental area; C – ribbed dorsal needles; D – dorsal girdle scale; E – marginal needle; F – ventral scale near girdle margin; G – ventral scale; H – central and first lateral teeth; I–K – heads of major lateral teeth; L – arrangements of granules and aesthete pores (schematic drawing). Scale bar 100 μ m.

Genus *Terenochiton* Iredale, 1914

Type species. *Lepidopleurus* (*Terenochiton*) *subtropicalis* Iredale, 1914 (= *Leptochiton* (*Leptochiton*) *norfolcensis* (Hedley et Hull, 1912) fide Kaas and Van Belle [1985]), by original designation.

Genus distribution. Norfolk, Lord Howe and Kermadec Islands, New Zealand; Iriomote and Kuroshima Islands, Ryukyu Islands, Japan. Recent [Sirenko, 2019].

Terenochiton nomurai Sirenko et Saito sp. nov.

Figs. 7–11

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Type material. The holotype (NSMT-Mo 79027), and paratype (NSMT-Mo 79028).

Type locality. Amitori Bay, Iriomote Island, Yaeyama Islands, Okinawa, Japan, 26°11.8' N, 130°48.8' E, on reef.

Material examined. **Japan**, NSMT-Mo 79027, the holotype, BL 6.0 mm, Amitori Bay, Iriomote Island, Yaeyama Islands, Okinawa, Japan, 26°11.8' N, 130°48.8' E, on reef, stn H-6 in the survey for juveniles of crown-of-thorns starfish, *Acanthoaster planci*, June–October 1985, T. Habe; NSMT-Mo 79028, paratype, BL 3.4 mm, Kuroshima

Fig. 7. *Terenochiton nomurai*, **A** – **holotype** (NSMT-Mo79027), Japan, Okinawa, Iriomote Island. BL 6.0 mm; **B** – **paratype** (NSMT-Mo 79028), Japan, Okinawa, Kuroshima Island. BL 3.4 mm. A, B – whole animals, arrow head indicating intersegmental needle.

Fig. 8. *Terenochiton nomurai*, **holotype** (NSMT-Mo79027), Japan, Okinawa, Iriomote Island. BL 6.0 mm. **A** – valve I, dorsal view; **B** – valve IV, dorsal view; **C** – valve IV, rostral view; **D** – valve VIII, dorsal view; **E** – valve VIII, lateral view; **F** – valve I, detail of tegmentum surface; **G** – valve IV, detail of tegmentum surface of central area, arrow head showing tubular extension for aesthete pore.

Island, Yaeyama Islands, Okinawa, Japan, 26°11.8' N, 130°48.8' E, interstice of dead coral block deeply embedded in sand on reef, stn 2 in the survey for small crustaceans, 21.06.1991, K. Nomura.

Fig. 9. *Terenochiton nomurai*, **holotype** (NSMT-Mo79027), Japan, Okinawa, Iriomote Id. BL 6.0 mm. **A** – valve I, ventral view; **B** – close up of square portion in A, showing rudiment of insertion plate; **C** – valve II, ventral view; **D** – close up of square portion in C, showing rudiment of insertion plate; **E** – same rudiment in D, slightly anterior view; **F, G** – valve VIII, rudiment of insertion plate, ventral and ventro-lateral views. r – rudiment of insertion plate.

E t y m o l o g y. Named after Dr. Keiichi Nomura, former director of the Kushi-moto Marine Park, Wakayama, Japan who collected the specimen, and kindly placed it at our disposal.

D i a g n o s i s. Animal small. Shells moderately elevated, carinated. Central and antemucronal areas with rather coarse net-like sculpture formed by connected granules. Each granule with 7 (5–9) aesthete pores. Articulamentum well developed, with rudiments

Fig. 10. *Terenochiton nomurai*, **A, B, D, E** – holotype (NSMT-Mo79027), Japan, Okinawa, Iriomote Island. BL 6.0 mm; **C, F** – paratype (NSMT-Mo 79028), Japan, Okinawa, Kuroshima Id. BL 3.4 mm. **A** – dorsal girdle scales; **B, E** – head of major lateral teeth; **C** – radula, dorsal view; **D** – central part of radula; **F** – marginal part of radula.

of insertion plates in all valves; those in head valve low, nodular. Girdle dorsally densely covered with small, bent, imbricating, round top scales which are ornamented with 6–8 strong bifurcated ribs; intersegmental area between valves with long, spicule which is curved near both ends. Radula teeth thin, with more than 75 transverse rows; head of major lateral tooth unicuspid.

Description. Animal small, BL 6.0 mm in holotype, elongate-oval. Valves moderately elevated (dorsal elevation 0.31 in valve V), carinated, not beaked. Color of tegmentum creamy white.

Head valve semicircular. Intermediate valve rectangular; lateral margins rounded; anterior margin slightly concave between apophyses; posterior margins nearly straight;

Fig. 11. *Terenochiton nomurai*, **holotype** (NSMT-Mo79027), Japan, Okinawa, Iriomote Island. 6.0 mm. **A** – arrangements of granules and aesthete pores (schematic drawing); **B** – dorsal girdle scale; **C** – intersegmental needle; **D** – marginal scale; **E** – ventral scale; **F**, **G** – ventral scale near girdle margin; **H** – central and first lateral teeth (semi-schematic drawing); **I**, **J** – head of major lateral tooth. Scale bars: 10 μ m for H–J, 20 μ m for B, D–G, 100 μ m for C.

lateral areas slightly raised. Tail valve rather low, narrower than head valve; mucro central; antemucronal slope convex; postmucronal slope slightly concave.

Tegmentum of head valve sculptured with 31 radial rows of raised, oval, closely set, small granules. Central areas sculptured with ca. 20 longitudinal rows of oval, semi-fused granules, which are also connected with nearest granules in neighboring rows by commarginal riblets, forming a coarse net-like sculpture as a whole. Lateral areas sculptured with 5–6 radial rows of granules as head valve. Antemucronal area sculptured as central area with 14 longitudinal rows of granules. Postmucronal area sculptured as head valve with 25 radial rows of oval granules. Each granule with one megal aesthete and 3 (2–4) micraesthetes on each side of anterior surface. Micraesthete pores slightly smaller than megal aesthete pore, which are occasionally open through short tubular extension (Fig. 8G, arrow head) in front. Micraesthete pores slightly smaller than megal aesthete pores.

Articulamentum well developed. Head valve with low nodular rudiments of insertion plates. Apophyses of intermediate and tail valves roundly projecting forward with wide jugal sinus, and connecting back in form of rudiments of unslitted insertion plates (on the right side of the tail valve, there is a very narrow slit between the apophysis and rudiment of insertion plate, but it is not detected in the left side).

Girdle narrow, dorsally densely covered with small, up to $75 \times 78 \mu\text{m}$, bent, imbricating, round topped scales which are ornamented with 7–9 strong bifurcated ribs, and spreading at base. Intersegmental area with long, up to $390 \times 19 \mu\text{m}$, smooth needle, which is curved near both ends. Marginal fringe of narrow scales, up to $73 \times 17 \mu\text{m}$, obtusely pointed, with 3–4 narrow ribs. Ventrally girdle covered with oval or nearly rectangular flat scales which are attaining $53 \times 25 \mu\text{m}$, smooth on surface or with faintly keeled.

Gills seven ctenidia per side in paratype.

Radula of holotype (BL 2.5 mm) ca. 1 mm long with at least 75 transverse rows of very small, thin teeth. Central tooth elongate, with pointed blade. First lateral teeth longer than central one, bearing elongate, curved blade. Major lateral teeth with unidentate cusp. Major uncinial teeth long with long, wide blade. Outermost marginal teeth wide, short.

Distribution. Only known from Yaeyama Islands, Okinawa, Japan, on reef.

Remarks. The genus *Terenochiton* was recently reinstated by the first author [Sirenko, 2019] from a synonym of *Leptochiton* [Van Belle, 1983; Kaas, Van Belle, 1985; 1998]. The peculiar feature of this genus is possession of the rudiments of insertion plates in all valves, by which the present specimens are assigned in this genus.

Terenochiton nomurai sp. nov. closely resembles *T. norfolcensis* by the sculpture of the tegmentum, girdle armature, and the shape of the radula, but differs from the latter by arrangement of the aesthete pores on the granules of the tegmentum, and less developed rudiments of the insertion plates. The aesthete pores of *T. nomurai* are arranged in peripheral portion of each granule, whereas they are arranged more or less medially on flatter granule in *T. norfolcensis*. The rudiments of the insertion plates are low, rather ambiguous in the head valve of *T. nomurai*, but they are much higher and prominent in that of *T. norfolcensis*.

Discussion

The present paper described two new species of the genera *Leptochiton* and *Terenochiton* in the family Leptochitonidae from the tropical and subtropical shallow waters. The genus *Leptochiton* has high species diversity, 140 species are known from the world (Molluscabase), but most of them inhabit higher latitude or deep waters, and only three species have hitherto been known from the tropical shallow waters in the world: *Leptochiton nierstraszi* (Leloup, 1981) from Madagascar; *L. hiriensis* Schwabe et Lozouet, 2006 from French Polynesia, Central Pacific; *L. muelleri* Sirenko et Schwabe, 2011 from Sri Lanka and Vietnam [Leloup, 1981; Schwabe, Lozouet, 2006; Sirenko, Schwabe, 2011; Sirenko, 2014]. Sirenko and Schwabe [2011] assumed that one of the main reasons for such a distribution of leptochitons is an inability to compete for resources with gastropods and more advanced groups of chitons. Based on the assumption by Sirenko and Schwabe [2011] and Sirenko [2015], the events which have formed the current distribution may be explained as follows: *Leptochiton* is one of the most conservative genera of the extant Polyplacophora. It is known from the Triassic and may be even from the Lower Carboniferous [Smith, 1960; Sirenko, 2013]. During that period, when developed chitons (e.g., Chitonida) were still absent, *Leptochiton* had probably wider distribution in various portions of the world seas. The species of this genus have also a wide bathymetric range, from the intertidal to ultraabyssal depths with some species showing eurybathy [Sirenko, 1977; Schwabe, 2008]. First developed chitons originated in the middle of the Mesozoic period [Smith, 1960; Sirenko, 2006] and began competing with the ancient leptochitons. Gradually toward the end of the Mesozoic, the majority of leptochitons were displaced from the warm and comfortable tropical waters into the cold deep and high latitude temperate waters. These are the areas that the most extant species of *Leptochiton* inhabit at present. Sirenko and Schwabe [2011] suggested that those tropical leptochitons' success of survival may be related to their very small body sizes and finding of niches. The maximum body length of *L. hiriensis*, *L. muelleri* and *L. pumilus* sp. nov. are 1.4 mm, 2.9 mm and 2.5 mm, respectively, and that of *L. nierstraszi* is 6.0 mm. Their very small body sizes appear to enable them to escape into very small pit or narrow interstices of substrates, such as coral pieces or blocks against predations or disturbance of the environment. *L. muelleri* is however often found on dead or living bivalve shells, as well as dead coral pieces or blocks on the bottom surface at the depth from 5–25 m, which are utilized also by other species of Chitonida. We need to obtain more information on their precise habitats to access their survival strategies.

The representatives of the genus *Terenochiton* may be also survivors in such competition. They may survive by the same way with those tropical *Leptochiton* species. They are also small; the maximum body size is 8.0 mm in *T. norfolcensis*, and 6.0 mm in *T. nomurai* sp. nov., and the latter lives in cryptic habitats: the holotype was sorted out from the sediment sample, coral rubbles collected from the bottom surface to 20 cm

depth in the surveys for juveniles of crown-of-thorns starfish, *Acanthaster planci*, and the paratype was found in the interstice of large dead coral block deeply embedded in sand on the reef in the survey for cryptic crustaceans. However, *T. norfolcensis* has a little larger body size, and seems to live in non-cryptic habitats where are utilized also by other species of Chitonida and gastropods, as in the case of *L. muelleri*. This allows us to discuss other possibilities for survival, such like the special features of *Terenochiton* may helped their survival: especially the presence of the rudiments of insertion plates, as well as more complicated sculpture of the tegmentum and the dorsal girdle scales, which are rather similar to those of Chitonida, or totally different way which may similar to that of *L. muelleri*.

Sirenko [1997] suggested that the development of the insertion plates occurred independently in multiple taxa in different geological periods in the order Lepidopleurina. *Terenochiton* may be one of such taxa, retain transitional features in evolution from Lepidopleurida to Chitonida. *Terenochiton* has also some features similar to those in the tropical shallow water *Leptochiton* species, such as the net-like sculpture of the tegmentum, which may suggest close relationship between them. In our opinion there is an evolutionary transformation series: *L. muelleri* – *L. pumilus* n. sp. – *T. nomurai* n. sp. – *T. norfolcensis*. Within this series there is a gradual development of rudiments of the insertion plates and unidentate head of major lateral tooth of radula. A molecular study is needed to access their phylogenetic relationship.

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