

# New Cones from North-West Madagascar (Gastropoda: Conidae)

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## ABSTRACT

The new species *Kioconus sakalava* sp. nov. is described from the material obtained during the MNHN expedition MIRIKY to North-West Madagascar. This species has been collected alive in 46 to 54 m deep. Its radula has been examined and a fragment of the *cox1* gene sequenced for two specimens. Molecular data suggest that the new species is sister to *Kioconus voluminalis*. Another new species, *Fusiconus levenensis* sp. nov. is also described from material obtained by dredging at Banc du Leven, off North-West Madagascar at 180–200 m depth. The description of this species is based upon two dead collected specimens. It is compared to *Turriconus praecellens* and *Fusiconus longurionis*.

## INTRODUCTION

The expedition MIRIKY, organized by the Museum National d'Histoire Naturelle (MNHN) and headed by Prof. Philippe Bouchet took place in June–July 2009, in the Mozambique Channel, North West of Madagascar. The objective of this survey was to prospect a submarine area of a region which has been little studied, in depths between 100 and 1200 m. The expedition (<https://expeditions.mnhn.fr/campaign/miriky>) took place in two successive legs from the island of Nosy Be, North-West Madagascar aboard the vessel *Miriky*, from which the expedition took its name. The *Miriky* (which is a malagasy expression for “nice”) is an old malagasy shrimper, with base at the port of Hellville in Nosy Be. The first phase of the campaign covered the area north of Nosy Be, as far as Cap d'Ambre, whereas the second phase covered the south of Nosy Be down to Majunga. Sampling was done by dredging and trawling. As a result of these sampling efforts, lots of samples of marine organisms were obtained, including cone snails. Among the specimens of cone snails retrieved during the expedition that we have examined, one lot attracted our attention, as we were not able to match satisfactorily the identity of the shells with that of any known cone species. Some shells in this lot resemble small specimens of *Kioconus voluminalis* (Reeve, 1843). Several individuals were collected in live condition, and this has allowed the study of the radula and DNA (*cox1* fragment). Morphological and molecular studies suggest that these individuals correspond actually to a new species, which is distinct from *K. voluminalis*, and is introduced hereby with the name *Kioconus sakalava* sp. nov. According to the taxonomy of Puillandre et al. (2015), the name of this taxon is *Conus (Splinoconus) sakalava* sp. nov.

We also studied other lots of specimens from the same area, but found during the late sixties and early seventies by French campaigns carried out in deep water at the Banc du Leven, located in the extreme North-West of Madagascar. Two individuals appearing to be members of a new species were found. These distinctive specimens were collected dead but in good

condition, and are provisionally placed in the genus *Fusiconus* da Motta, 1991 according to the shell features. In this work we introduce and describe this new species, under the name *Fusiconus levenensis* sp. nov. According to the taxonomy of Puillandre et al. (2015), this species would be included in family Conidae (i.e. not Conilithidae), with the name *Conasprella (Fusiconus) levenensis* sp. nov.

## MATERIAL AND METHODS

Taxonomy follows Tucker & Tenorio (2009) with the updates and modifications based on Tucker & Tenorio (2013). Most specimens studied were collected by dredging during campaign MIRIKY carried out by the MNHN off NW Madagascar, during 2009, at depths between 46–680 m. Some specimens were taken in Banc du Leven in the course of other french dredging campaigns carried out in 1969 and 1973. Distribution maps were generated using GeoMapApp (<http://www.geomapp.org>) using the general bathymetric map of the oceans as default basemap.

We describe shell morphology using the terminology established in Röckel et al. (1995). We also used the procedure described in Röckel et al. (1995) for counting the number of protoconch whorls. For morphometric comparisons, adult shells were measured with digital calipers, with measurements rounded to 0.1 millimeter. For comparison of shell morphology, analysis was performed using analysis of variance (ANOVA) for relative spire height (RSH), using species hypotheses as factor. Mean values of  $S_L$  were compared statistically (*t*- and *F*-tests). Statistical tests were carried out using STATGRAPHICS CENTURION XVII or PAST3 (Hammer et al., 2001), once all the measurement sets passed the normality tests.

We used the terminology for radular morphology of Tucker & Tenorio (2009), and the abbreviations in Kohn et al. (1999). The number of individuals for which the entire radula was examined is indicated in the description. Specimens of shells containing the dried animal inside were digested in concentrated aqueous potassium hydroxide for 24 h. The resulting mixture was then placed in a Petri dish and examined with a 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 a compound microscope. Photographs were obtained with a CCD camera attached to the microscope. SEM studies of protoconch were carried out at the MNHN by Sylvain Pont.

Partial DNA sequences of the mitochondrial cytochrome oxidase I (*cox1*) gene (Folmer et al. 1994) were extracted from GenBank (from the study of Puillandre et al. 2014, GenBank Accession Nos. in Fig. 4). The Neighbor-Joining (NJ) tree and the corresponding genetic distances were also supplied by N. Puillandre.

*Museums and private collections*

MNHN: Muséum National d'Histoire Naturelle, Paris, France.  
 INHS: Illinois Natural History Survey, John K. Tucker collection, Champaign, Illinois, USA.  
 EM: Eric Monnier reference collection, Paris, France.  
 MJT: Manuel J. Tenorio reference collection, Jerez, Spain.  
 dd: dead collected specimen(s)  
 lv: live collected specimen (s)  
 spm: specimen(s) doubtful if alive or dead collected  
 stn: station

<i>Shell morphometry</i>	
$S_L$ maximum shell length	AH aperture height
MD maximum diameter	RD relative diameter (= MD/AH)
SH spire height	RSH relative spire height (= SH/ $S_L$ )
HMD height of maximum diameter	PMD relative position of the maximum diameter (= PMD/AH)
W shell weight	RW relative shell weight (= W/ $S_L$ )

<i>Radular morphometry</i>	
$S_L/T_L$ shell length/radular tooth length	
$T_L/AP_L$ radular tooth size/anterior portion length	
$100B_L/AP_L$ 100 x blade length/anterior portion length	

**RESULTS**

**SYSTEMATICS**

Family CONIDAE Fleming, 1822  
 Genus *Kioconus* da Motta, 1991

*Kioconus sakalava* sp. nov. (Plate 1, Figs. 1–8; Plate 2, Fig. 3)

**Type material:** Holotype and 12 paratypes. The holotype is deposited in the Muséum National d'Histoire Naturelle, Paris, France, under the number MNHN-IM-2007-36725. See table 1 for details

**TABLE 1**

Type	Institution	Dimensions (mm)	Locality
Holotype	MNHN-IM-2007-36725	29.9 x 14.1	Baie Narendry, North-West Madagascar (MIRIKY Stn CP 3288), 14°31.9'S, 47°26.5'E, 46-54 m.
Paratype 1	MNHN-IM-2000-33615	27.4 x 13.2	same data as the holotype
Paratype 2	MNHN-IM-2000-33615	27.7 x 14.1	same data as the holotype
Paratype 3	MNHN-IM-2000-33615	24.4 x 11.7	same data as the holotype
Paratype 4	MNHN-IM-2007-33675	30.9 x 16.6	same data as the holotype
Paratype 5	MNHN-IM-2000-33615	28.8 x 14.1	same data as the holotype
Paratype 6	MNHN-IM-2000-33615	28.1 x 14.5	same data as the holotype
Paratype 7	MNHN-IM-2000-33615	25.8 x 12.5	same data as the holotype
Paratype 8	MNHN-IM-2000-33615	25.0 x 12.0	same data as the holotype
Paratype 9	MNHN-IM-2000-33615	26.4 x 12.7	same data as the holotype
Paratype 10	MNHN-IM-2000-33615	26.2 x 13.0	same data as the holotype
Paratype 11	MNHN-IM-2000-33615	28.7 x 13.1	same data as the holotype
Paratype 12	MNHN-IM-2000-33615	24.6 x 12.3	same data as the holotype

**Material examined:** A total of 18 specimens, collected off Baie Narendry (MIRIKY Stn CP 3288, 14°31.9'S, 47°26.5'E, 46–54 m, 3 lv, 7 spm, 6 dd), West of Nosy-Bé (MIRIKY Stn DW 3230, 13°25' S, 47°57' E, 71–158 m, 1 dd) and off Baie Mahajamba (MIRIKY Stn CP 3285, 14°47' S, 46°58' E, 512–680m, 1 dd) have been studied.

**Type locality:** Baie Narendry, North-West Madagascar (MIRIKY Stn CP 3288), 14°31.9'S, 47°26.5'E, 46–54 m.

**Distribution and habitat:** The species has been collected in the North West of Madagascar, in the Mozambique Channel between West of Nosy Bé and Baie de Mahajamba at depths ranging from 46 to 680 m (46 to 54 m for live collected specimens) (Fig. 1).

**Etymology:** Named after the Sakalava, an ethnic/cultural human group of Madagascar with a population of around one million. They occupy the Western edge of the Island from Toliara in the South to Sambirano in the North of the Island.

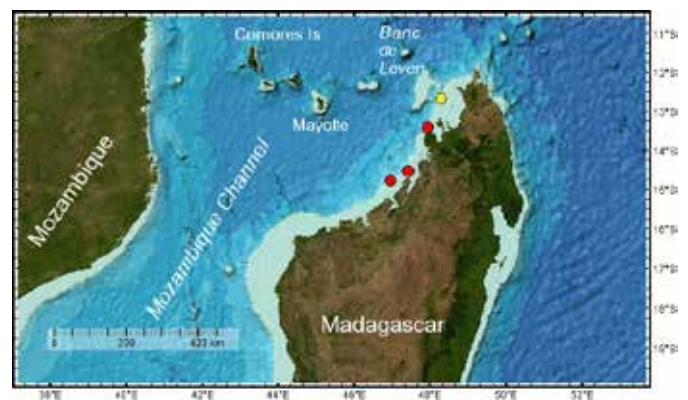


Figure 1.- Distribution map for *Kioconus sakalava* (red circles) and *Fusiconus levenensis* (yellow circle). Symbols indicate the points where each of the species have been collected.

**Description of the shell:** Morphometric parameters:  $S_L$  = 24–30 mm; mean  $S_L$  = 27.0 mm; RD = 0.57–0.62; RSH = 0.16–0.22; PMD = 0.93–0.98.

Shell moderately small, conical in profile. Protoconch is rather small (0.7 mm maximum diameter) and paucispiral of 2 whorls (Fig. 2). The shell has about 13 whorls; five early postnuclear whorls tuberculate, late teleoconch whorls smooth. Spire of

concave profile. Apex of the spire pinkish in color. Teleoconch whorls flat with numerous radial threads and very weak spiral striae. Suture deep and narrow. Shoulder sharply angulate with dark brown square dots. Last whorl sides straight or slightly concave. Basal area with six to seven closely-spaced spiral ribs. Aperture narrow and of uniform width. The pattern of the last whorl consist in intermittent irregularly spaced brown spiral lines, axial brown blotches and streaks and on an ivory white background. A lighter faint spiral band is present in the middle of the last whorl. The shells examined are very homogeneous in size and pattern (Plate 1). Operculum small and rounded.

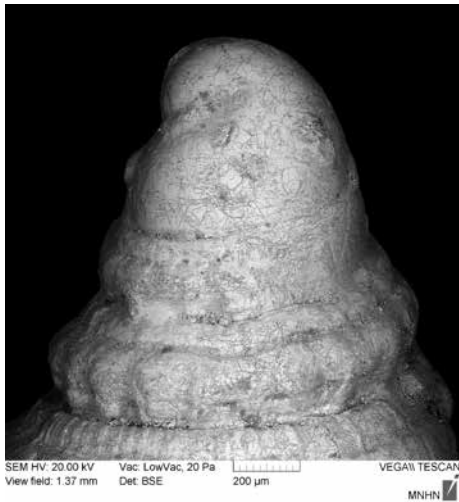


Fig. 2.- SEM micrograph of the protoconch and early postnuclear teleoconch whorls of paratype 5 of *K. sakalava* sp. nov.

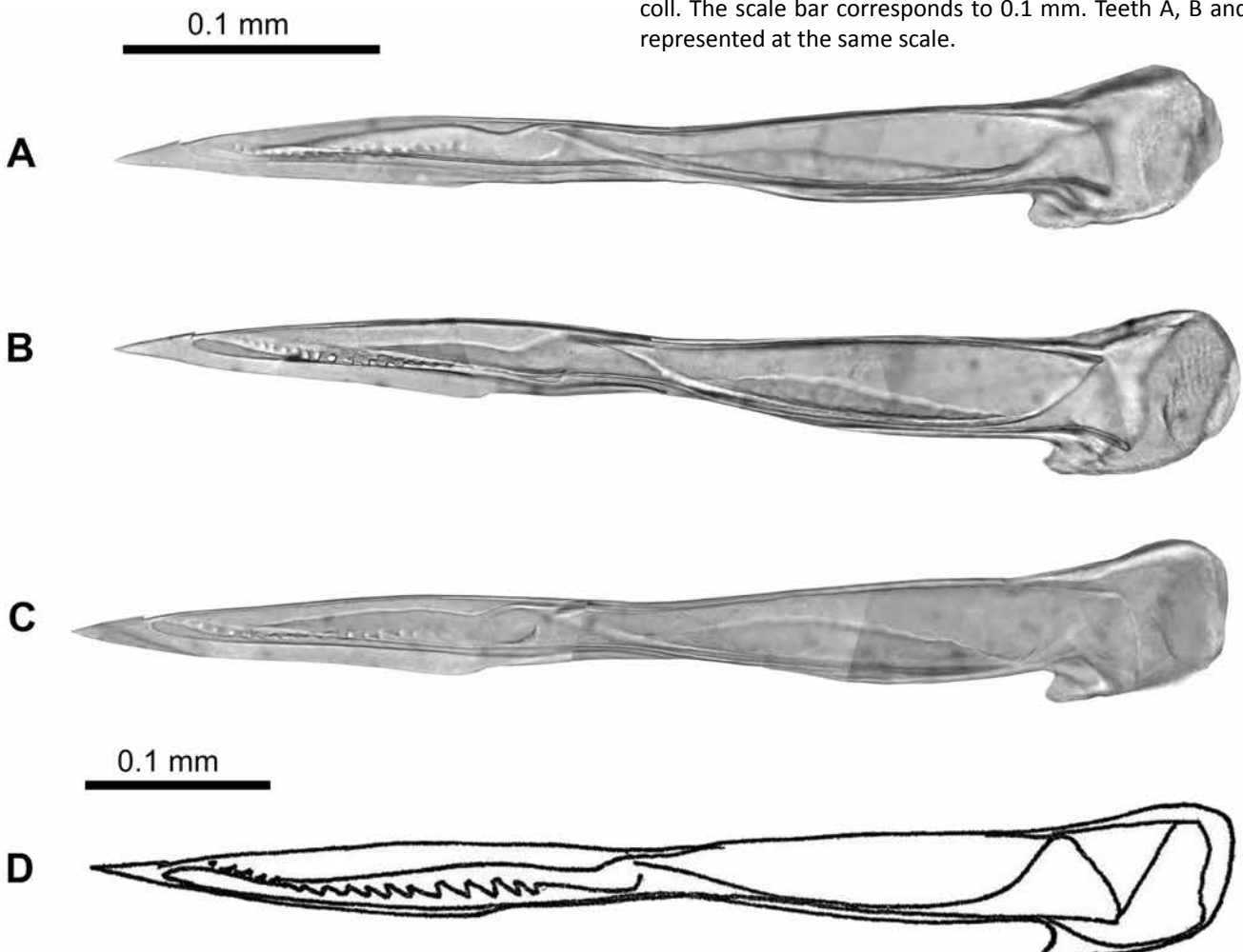
**Living animal and radula:**

Three living specimens have been collected, and radular and DNA analysis (fragment of *cox1* gene) performed. The details of the external morphology of the living animal are not recorded. Radula studied for the holotype, and for paratypes 1 and 2 (Fig. 3). 18 to 41 teeth in radular sac. Radular tooth of rather small relative size ( $S_L/T_L = 60-70$ ), slender, with a short barb, not very marked. Anterior section equal or very slightly shorter than the posterior section of the tooth ( $T_L/AP_L = 2.0-2.1$ ). Waist evident but not very pronounced. Blade rounded, covering about two thirds of the anterior section ( $100B_L/AP_L = 67\% \text{ to } 72\%$ ). Serration with 16 – 18 coarse denticles arranged in one row, ending in a small, rounded terminating cusp. Base with a strong spur.

**COMPARISON**

*K. sakalava* sp. nov. is very close to *K. voluminalis* (Reeve, 1843) in shell morphology. The latter attains a larger size (up to 70 mm), and the differences in mean shell length ( $27+/-1$  mm for *K. sakalava* sp. nov., and  $50+/-6$  mm for *K. voluminalis*) are statistically significant ( $t = -8,48164$ ,  $p = 1.55 \times 10^{-8}$ ). *K. sakalava* sp. nov. also exhibits higher RSH values compared to *K. voluminalis* (RSH = 0.16–0.22 versus RSH = 0.04–0.17). The differences in RSH are also statistically significant (ANOVA on RSH using species hypothesis as factor:  $F = 87.43$ ,  $p = 0$ ). These two species

Fig. 3.- Radular teeth of: *K. sakalava* sp. nov.: A) Holotype,  $S_L$  29.9.1 mm; B) Paratype 1,  $S_L$  29.9.1 mm; C) Paratype 2,  $S_L$  75.8 mm. D) *Kioconus voluminalis*,  $S_L$  38.9 mm, Thailand, E. Rolán coll. The scale bar corresponds to 0.1 mm. Teeth A, B and C represented at the same scale.



can be separated not only by the smaller shell length and more elevated spire, but also by the presence of strong striae on the sutural ramp of *K. voluminalis*. These are absent or obsolete in the case of *K. sakalava* sp. nov. The former shows a greater variability in pattern and colours compared to *K. sakalava* sp. nov. Moreover the distribution range of the new species seems to be restricted to the North Western part of Madagascar, whereas the range of *K. voluminalis* covers an area from the Philippines to Thailand. Hence, these species are allopatric, and the paucispiral protoconch suggests that *K. sakalava* sp. nov. is most likely endemic to Madagascar. According to Röckel et al. (1995), *K. voluminalis* has a protoconch of 2–2.25 whorls and a maximum diameter 0.9–1 mm. In the case of *K. sakalava* sp. nov. it is of 2 whorls and 0.7 mm in maximum diameter. However, it is unclear if these differences are significant. The radular morphology of *K. voluminalis* and *K. sakalava* sp. nov. is similar (Fig. 3), and hence not useful for separating these two species. *K. sakalava* sp. nov. and *K. voluminalis* are molecularly distinct. In a NJ tree based on a fragment of the cytochrome oxidase I (cox1) gene (Fig. 4), it appears that both species are distinct, separated by a genetic distance of ca. 10%. Some of the specimens sequenced are shown on Plate 1, Figs. 1 and 2, and Plate 2, Figs. 1 and 3.

Family CONILITHIDAE Tucker & Tenorio, 2009

Genus *Fusiconus* da Motta, 1991

*Fusiconus levenensis* sp. nov. (Plate 2, Figs. 4–5)

*Conus praecellens*.- Röckel et al., 1995: Plate 54, n° 13  
(not *Conus praecellens* A. Adams, 1855)

**Type material:** Holotype and one paratype, both dead collected. Holotype: MNHN-IM-2000-33618, 45.7 x 16.6 mm, Off NW coast of Madagascar, August 1973, Leg. A. Crosnier, 12°40.2'S, 48°18'E, 185–190 m. Paratype 1: MNHN-IM-2000-33619 (Coll. Quéreel), 45.2 x 15.9 mm, Banc du Leven, off NW Madagascar, 1969, 200 m.

**Material examined:** Only the type series was examined.

**Type locality:** Banc du Leven, off NW coast of Madagascar, 12°40.2'S, 48°18'E, 185–190 m.

**Distribution and habitat:** The species has been collected only in the Banc du Leven, off NW coast of Madagascar, between 185 and 200 m depth (Fig. 1).

**Etymology:** Named after the Banc du Leven, one of the largest banks in Madagascar covering an area of approximately 2500 km<sup>2</sup>. It is the locality where the new species has been found.

**Description of the shell:** Morphometric parameters:  $S_L = 45\text{--}46$  mm; mean  $S_L = 45.5$  mm; RD = 0.49–0.51; RSH = 0.28–0.29; PMD = 0.89–0.90.

Shell medium-sized, conical to narrowly conical in shape. The

spire is high and straight giving to the shell an elongated biconic appearance. The protoconch is small and apparently multispiral (more than 2.5 whorls). Although partially eroded, examination of the protoconch of paratype 1 with SEM did not show the presence of tubercle on the early teleoconch whorls (Fig. 5).

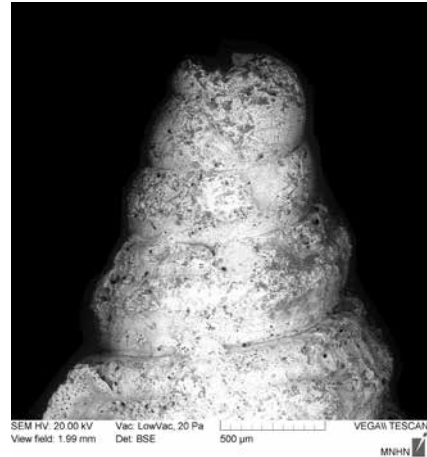


Fig. 5.- SEM micrograph of the protoconch and early postnuclear teleoconch whorls of paratype 1 of *F. levenensis* sp. nov.

Teleoconch sutural ramp flat or slightly convex, with radial threads crossing 1 broad central spiral groove in early whorls, showing a second narrower groove and a smooth ridge in later whorls (Fig. 6A). Deep posterior notch. Shoulder angulate. Last whorl covered with about 20 to 25 axially striate grooves and flat broad ribbons. Aperture white, narrow and of uniform width. Background color of the shell white, overlaid with three irregular spiral brown bands and with darker brown spots on the angulate shoulder and on the spire ridges. The spiral ribbons are patterned with rows of evenly-spaced square brown dots.

**Living animal and radula:**

The two specimens in MNHN collection were dead taken, so the animal, DNA and radula are unavailable.

**COMPARISON**

*F. levenensis* sp. nov. has been illustrated in Röckel et al. (1995), Pl. 54, Fig. 13 as *Conus praecellens* from Madagascar. However, an examination of the structure of the spire whorls of *Turriconus praecellens* allows immediate separation from *F. levenensis* sp. nov. (Fig. 5). *T. praecellens* exhibits teleoconch sutural ramp slightly concave with to 5–12 spiral grooves (Fig. 6B), whereas in *F. levenensis* sp. nov. the teleoconch sutural ramp is flat or slightly convex, with radial threads crossing one broad central spiral groove and a second narrower groove, and with a smooth ridge below (Fig. 6A). Additionally, *F. levenensis* sp. nov. is narrower-bodied than *T. praecellens* (RD = 0.49–0.51

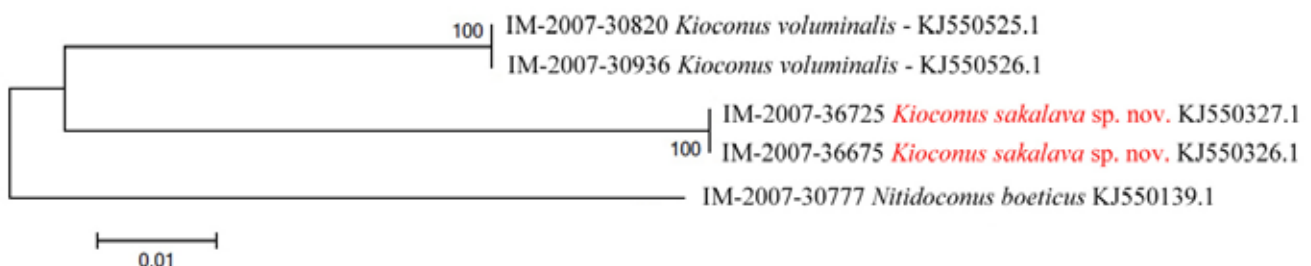


Fig. 4.- Neighbor-Joining (NJ) phylogenetic tree based on a subsample of the mitochondrial cox1 dataset produced by Puillandre et al. (2014). Bootstrap values are indicated for each node. Cox1 sequences were labelled using the MNHN voucher identification number, the species name and the Genbank accession number.

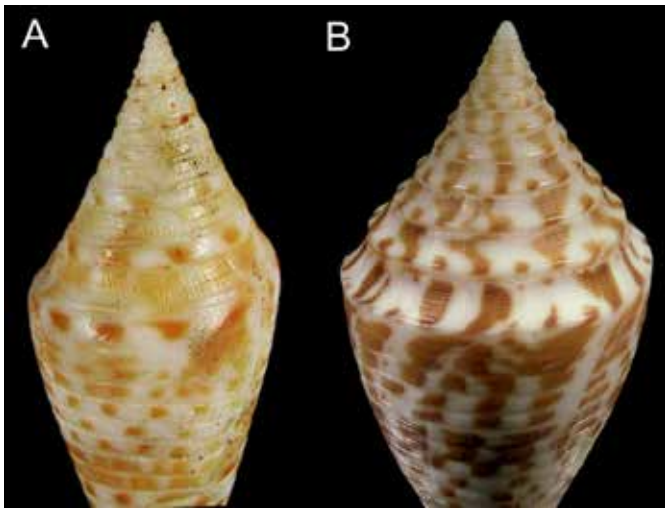


Fig. 6.- Detail of the spire whorls of: A) *Fusiconus levenensis* sp. nov., paratype 1; B) *Turriconus praecellens*, Phuket Is., Thailand, S<sub>1</sub> 49.1 mm, MJT coll.

versus 0.54–0.75). *F. levenensis* sp. nov. can be compared to the smaller *Fusiconus longurionis* (Kiener, 1850) from Mozambique, and to *Fusiconus kantanganus* da Motta, 1982 from East India and Thailand. The shells of *F. longurionis* are usually smaller in length than those of *F. levenensis* sp. nov., although there are not enough specimens of the latter to test whether these differences are significant or not. The shell of *F. longurionis* is narrower bodied than that of *F. levenensis* sp. nov. (RD = 0.39–0.45 versus 0.49–0.51). The first 5–8 postnuclear whorls in *F. longurionis* are distinctly tuberculate, but tubercles are absent in the case of *F. levenensis* sp. nov. Flat ribbons on the last whorl are usually narrower and more numerous in *F. longurionis* than in *F. levenensis* sp. nov. *F. kantanganus* has a more heavily sculpted last whorl, often with a beige ground color instead of white. There are also differences in the pattern of the shell, which for *F. levenensis* sp. nov. consists essentially of rows of evenly-spaced square brown dots, whereas in *F. longurionis* it is often reduced to axial brown streaks at both sides of center and below the shoulder.

A specimen figured in Röckel et al. (1995), Plate 72, figs. 5 and 6, as “*Conus* sp. n° 11” is similar in shape and pattern to *F. levenensis* sp. nov. This specimen was dredged in deep water at Saya de Malha bank, and it was stated to be in coll. Bondarev. Although similar in shape and size, it has a distinctive, colorful pattern. It might be related to *F. levenensis* sp. nov., but most likely represents a different, yet undescribed species.

#### ACKNOWLEDGEMENTS

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Plate 1: **1-9** *Kioconus sakalava* sp. nov. MNHN. Baie Narendry, North-West Madagascar (MIRIKY Stn CP 3288), 14°31.9'S, 47°26.5'E, 46-54 m. **1a-b**. Holotype, 29.9 x 14.1 mm; **2**. Paratype 4, 30.9 x 16.6 mm; **3a-b**. Paratype 1, 27.4 x 13.2 mm; **4a-b**. Paratype 2, 27.7 x 14.1 mm; **5**. Paratype 5, 28.8 x 14.1 mm; **6**. Paratype 8, 25.0 x 12.0 mm; **7**. Paratype 9, 26.4 x 12.7 mm; **8a-b**. Paratype 10, 26.2 x 13.0 mm; **9**. Paratype 11, 28.7 x 13.1 mm.



Plate 2: **1.** *Kioconus voluminalis*, MNHN IM-2007-30820, NW Malo Is., Vanuatu, 34.2 mm; **2.** *Kioconus voluminalis*, EM coll., Thailand, 63.7 mm; **3.** *Kioconus sakalava* sp. nov. MNHN-IM-2007-36725, Holotype, 29.9 mm; **4a-b:** *Fusiconus levenensis* sp. nov. MNHN-IM-2000-33619, Paratype 1, 45.2 mm; **5a-b:** *Fusiconus levenensis* sp. nov. MNHN-IM-2000-33618, Holotype, 45.7 mm; **6.** *Turriconus praezellens*, MJT coll., Phuket Is., Thailand, 49.1 mm; **7.** *Fusiconus longurionis*, INHS 44898, Quissico Bay, Mozambique, 37.8 mm; **8.** *Fusiconus kantanganus*, INHS 44982, Madras, India 33.5 mm.