

On the morphology and homology of the “central tooth” in the radulae of Turrinae (Conoidea: Turridae)

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ABSTRACT. Radular morphology was studied in detail in 64 species of 7 genera of Turrinae. It is suggested that the so-called “central tooth” is formed by a fusion of 3 teeth: the central one and a pair of lateral. A similar condition was found in some representatives of the subfamilies Cochlespirinae and Crassispirinae (Turridae).

The radular morphology, together with the shell characters is still the basis for discriminating the taxa of Gastropoda at the family level. For some of the groups, e.g. most of Caenogastropoda, the radula is rather conservative in terms of the number of teeth in a transverse row (most of the families possess a taenioglossan radula), while in others it is rather variable. Neogastropoda are characterized by 5 to one tooth in the transverse row, while most of them have only 3 teeth in a row.

The superfamily Conoidea is unique among neogastropods, since the variability of their radulae is comparable to the rest of the Neogastropoda. The most “complete” radular segment is found in the family Drilliidae, which have 5 teeth in a row, while representatives of other families have only 2-3 teeth in a row.

Radulae of a number of species of Turridae have been illustrated and described recently [Taylor *et al.*, 1993; Kantor, Taylor, 2002; Medinskaya, 2002] with the major emphasis on marginal teeth. In this family the marginal teeth are usually referred as “wishbone”. This ill-defined term was based probably on incorrect interpretation of the tooth as consisting of two separate limbs. It was demonstrated, that despite the obvious morphological variability of “wishbone” teeth it is a single blade-shaped unit with thickened edges and without separation between the two thickened limbs [Kantor, Taylor, 2002]. Contrary, little attention was paid to the central teeth in Turridae, and it is usually considered, that they either possess a large central tooth, or the tooth is missing. This strongly opposes Turridae to Drilliidae, that always have small central and a pair of comb-like lateral teeth.

Radula in the subfamily Turrinae has been illustrated for a number of species, mostly as line dra-

wings, by Powell [1966], while SEM micrographs of several species have recently been published by Medinskaya [2002]. Both authors characterized the radula of the species of the subfamily as consisting of wishbone marginal teeth and with or without a broad unicuspid central tooth with a needle-shaped cusp.

In the course of preparation of collective monograph on the Conoidea of New Caledonia region I examined in detail the radulae of 64 species of 7 genera (*Gemmula* Weinkauff, 1875, *Gemmuloborsonia* Shuto, 1989, *Lophiotoma* Casey, 1904, *Luce-rapex* Iredale, 1936, *Turridrupa* Hedley, 1922, *Turris* Röding, 1798, and *Xenuraturris* Iredale, 1929) out of 13 of the subfamily Turrinae, found in the New Caledonia region, some new for science and still undescribed. It became clear that the usual interpretation of the “central” tooth is incorrect and requires clarification.

The purpose of this paper is to demonstrate the variability of the “central tooth” of radula of Turrinae and to establish its homology.

Material and methods

In the current paper I deal with a small selection of the species (9 species illustrated). The radular morphology of these selected species covers the entire observed range of variability of the “central tooth” morphology. The material is stored in the Muséum National d’Histoire Naturelle, Paris, France (MNHN).

Radulae were extracted from dried specimens after re-hydration of the body. Radulae were cleansed in dissolved bleach, mounted on the clean glass slides, air-dried, coated with gold and examined with JEOL JSM 840A Scanning Microscope. The folding of the radular membrane was observed under highest magnification of the stereomicroscope while extending it for the SEM preparation.

Since some of the species mentioned below are not yet described, they are referred to under “working” numbers, which they bear in the collections of MNHN.

“SL” stands for the shell length, “AL” for length of the aperture (excluding siphonal canal).

The following species are illustrated in the current publication:

- Lophiotoma indica* (Röding, 1798), Vanuatu (SL 34.0 mm, AL 8.5 mm) (det. R.N. Kilburn – RNK)
- Gemmula rarimaculata* Kuroda et Oyama in Kuroda et al., 1971, MUSORSTOM 5, Coral Sea, sta. DW263, 25°21'S, 159°46'E, 150-225 m (SL 14.6 mm, AL 4.3 mm) (det. A.V. Sysoev – below AVS)
- Gemmula* sp. 3, MUSORSTOM 10, Fiji, sta. CP1354, 17°42.6'S, 178°55.0'E, 959-963 m (SL 25.4 mm, AL 6.5 mm) (det. AVS)
- Gemmula* sp. 8, NORFOLK 2, New Caledonia, sta. DW 2142, Bank Munida, 23°01'S, 168°17'E, 550 m (SL 17.7 mm, AL 4.8 mm) (det. AVS)
- Gemmula thielei* H.J. Finlay, 1930, HALIPRO 1, New Caledonia, sta. CP867, 21°26'S, 166°18'E, 720-950 m (SL 23.3 mm, AL 6.2 mm) (det. AVS)
- Gemmula unilineata* Powell, 1967, NORFOLK 2, New Caledonia, sta. DW 2097, bank Kaimon Maru, 24°44'S, 168°06'E, 580-583 m (SL 25.6 mm, AL 6.0 mm) (det. AVS)
- Turridrupa albofasciata* E.A. Smith, 1877, Atelier Lifou, Loyalty Islands, Lifou, sta. 1453, 20°54.5'S, 167°05.9'E, 35-50 m (SL 12.7, AL 5.0 mm) (det. RNK)
- Turridrupa* n.sp., Atelier Lifou, Loyalty Islands, Lifou, sta. 1464, 20°54.5'S, 167°05.9'E, 35-50 m (SL 22.6, AL 6.4 mm) (det. RNK)
- Turridrupa* sp. 6, New Caledonia, Sector des Belep, sta. 1148, 19°06.50'S, 163°30.10'E, 220 m (SL 20.0, AL 6.8 mm) (det. AVS)
- Turridrupa jubata* (Reeve, 1843), LAGON, New Caledonia, sta. DW808, 20°57.40'S, 165°29.60'E, 30 m (SL 29.1 mm, AL 8.3 mm) (det. RNK).

I refer below the “central tooth” sensu Powell [1966] and Medinskaya [2002] as “central formation” since its homology will be suggested in the end of the paper.

Results and discussion

In Caenogastropoda, the radular membrane is folded up longitudinally in the radular sac. The bends are situated between morphologically different groups of teeth, e.g. between central and lateral(s) and lateral(s) and marginal(s). In Neogastropoda with the reduced number of teeth, the bends (usually two; four in Olivellidae with 5 teeth in a transverse radular row – Fig. 1 A) are situated between central and lateral teeth. Exceptionally, the folding is not pronounced and the radula is nearly flat in the radular sac (some Fasciolaridae – Kantor, unpublished observations). In Drilliidae (Conoidea), which have 5 teeth in a transverse row, there is only one pair of bends on both sides of the central tooth [Sysoev, Kantor, 1989; Kantor, unpublished observations on 80 species of Drilliidae] (Fig. 1B).

Surprisingly in all studied Turrinae a single pair of bends is situated not between the “central formation” and the marginal teeth, but at both sides of the central cusp (Fig. 1D), if present (approximate position of the bends is shown by the dashed line on Fig. 2C). This

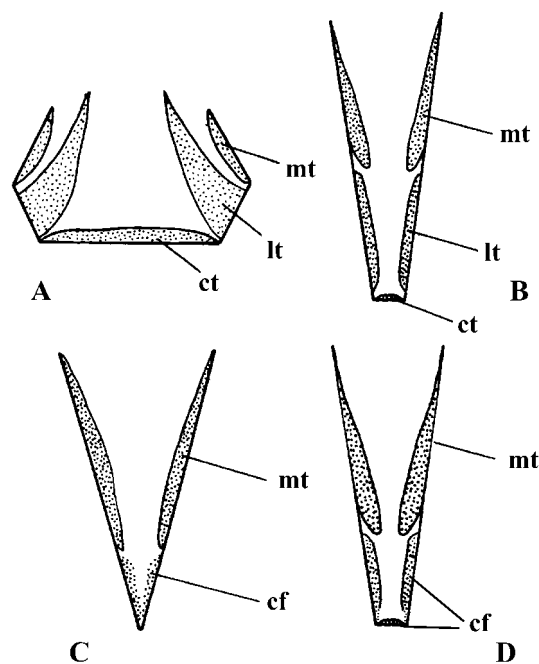


FIG 1. Diagrammatic representation of transverse sections of the radula in the radular sac to show the position of the longitudinal bends. A – Olivellidae. B – Drilliidae. C – *Antiplanex* (Turridae, Cochospirinae). D – Turrinae (Turridae). cf — central “formation”, ct — central tooth, lt — lateral tooth, mt — marginal tooth.

FIG 1. Схематическое изображение поперечного среза радулы в радулярном влагалище. А – Olivellidae. В – Drilliidae. С – *Antiplanex* (Turridae, Cochospirinae). D – Turrinae (Turridae).

suggested that the “central formation” is a flexible structure, and required a closer investigation.

In *Lophiotoma* the “central formation” is either absent, or extremely reduced and is represented by very weak periodically situated wrinkles on the subradular membrane (Fig. 2A-B). In *Gemmula* the central formation is variable and in some species (e.g. *Gemmula rarimaculata* – Fig. 2C-D or *G. thielei* – Fig. 3 C-D) at the first glance it looks like a well-defined broad unicuspid radular tooth with nearly rectangular base. Nevertheless, in other species of the genus (*Gemmula* sp. 3 – Fig. 2 E-F) it is seen that the central formation actually consists of three elements – the central cusp and paired toothless flaps, which adjoin, but not completely fuse with the central cusp (the gap is marked with the arrows on Fig. 2F). A more careful examination of *G. thielei* also revealed that at least in some parts of the radula the similar gaps can be observed (Fig. 3 D – arrows). These gaps are also seen in *Gemmula* sp. 8 (Fig. 3 B – arrows), in which the central cusp is weak. Remarkable is the radula of *G. unilineata*. In the anteriormost part of the radula, where it is deteriorating, it is clearly seen that the “central formation” is formed by 3 elements and the central cusp is dislodged from the membrane independently and prior to the lateral elements (Fig. 3 E-F).

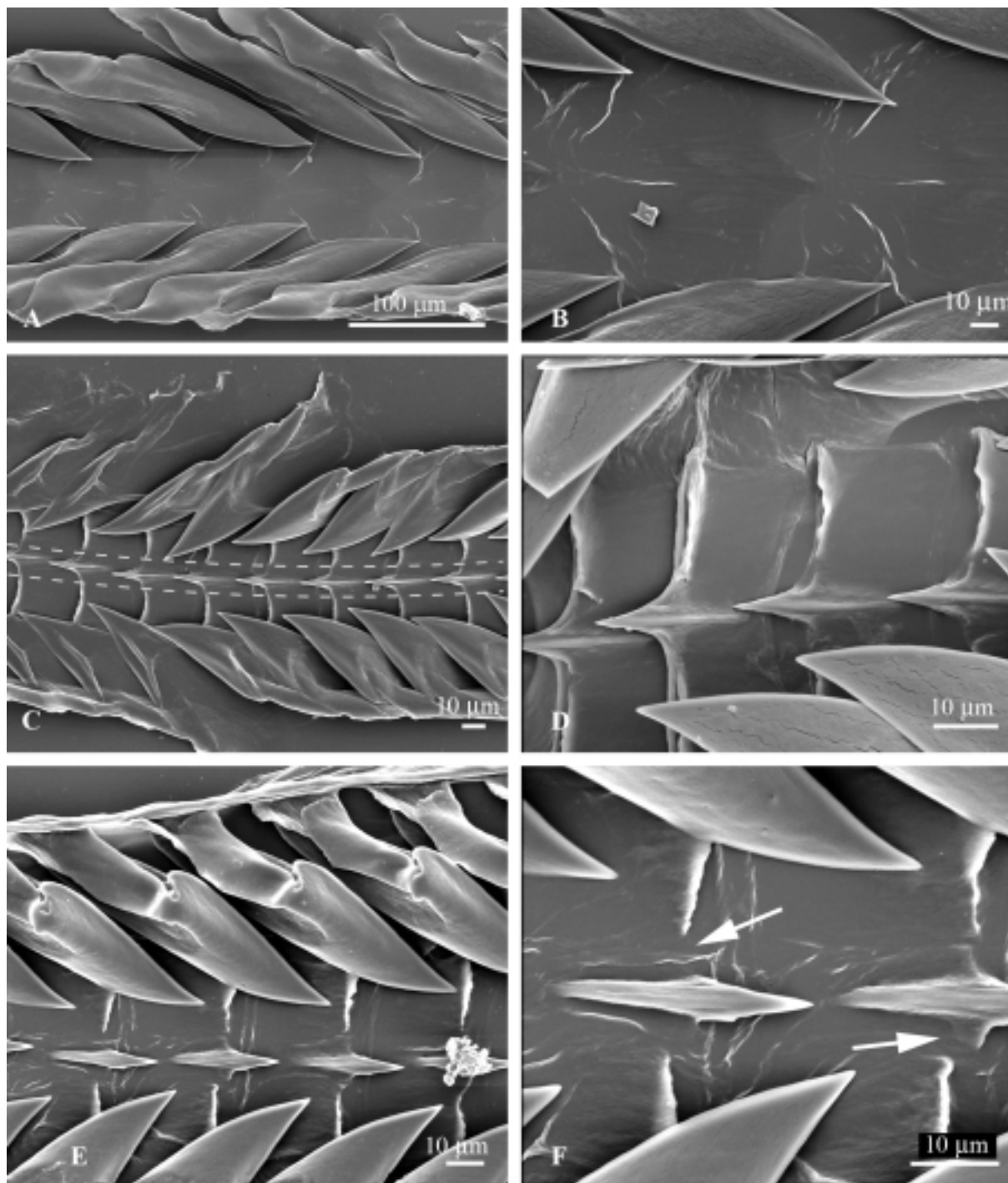


FIG. 2. Radulae of Turrinae. A-B – *Lophiotoma indica*. C-D – *Gemmula rarimaculata*. Dashed line shows the approximate position of the bends of the radular membrane. E-F – *Gemmula* sp. 3. Arrows indicate the incomplete fusion of the central cusp and lateral flaps.

РИС. 2. Радулы Turrinae. А-В – *Lophiotoma indica*. С-Д – *Gemmula rarimaculata*. Пунктирная линия показывает примерное положение продольных сгибов радулярной мембраны. Е-Ф – *Gemmula* sp. 3. Стрелками показаны участки неполного слияния центрального зубца и боковых лопастей.

In the genus *Turridrupa*, the situation is similar to that in *Gemmula*. There is a species, in which the “central formation” looks like a solid tooth (*Turridrupa albofasciata* – Fig. 4A-B), whereas in others it is clear that the “central formation” is formed of

three elements (*Turridrupa* n. sp. – Fig. 4 C-D, *T. jubata* – Fig. 4 G-H). [It should be noted that the statement of Medinskaya, 2002, that in *Turridrupa jubata* “the radula formed by two rows of wishbone-shaped flat marginal teeth”, is wrong. Although

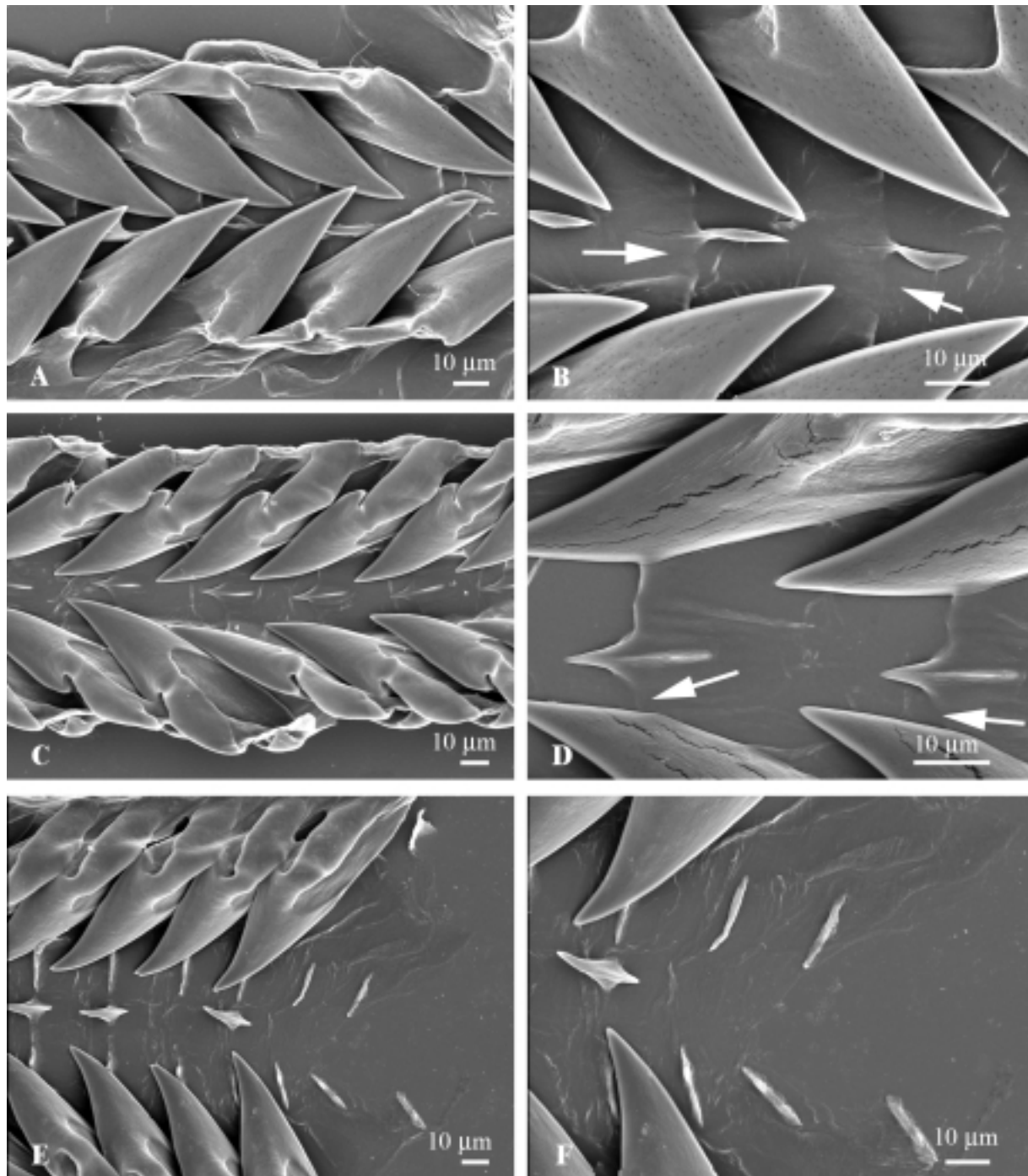
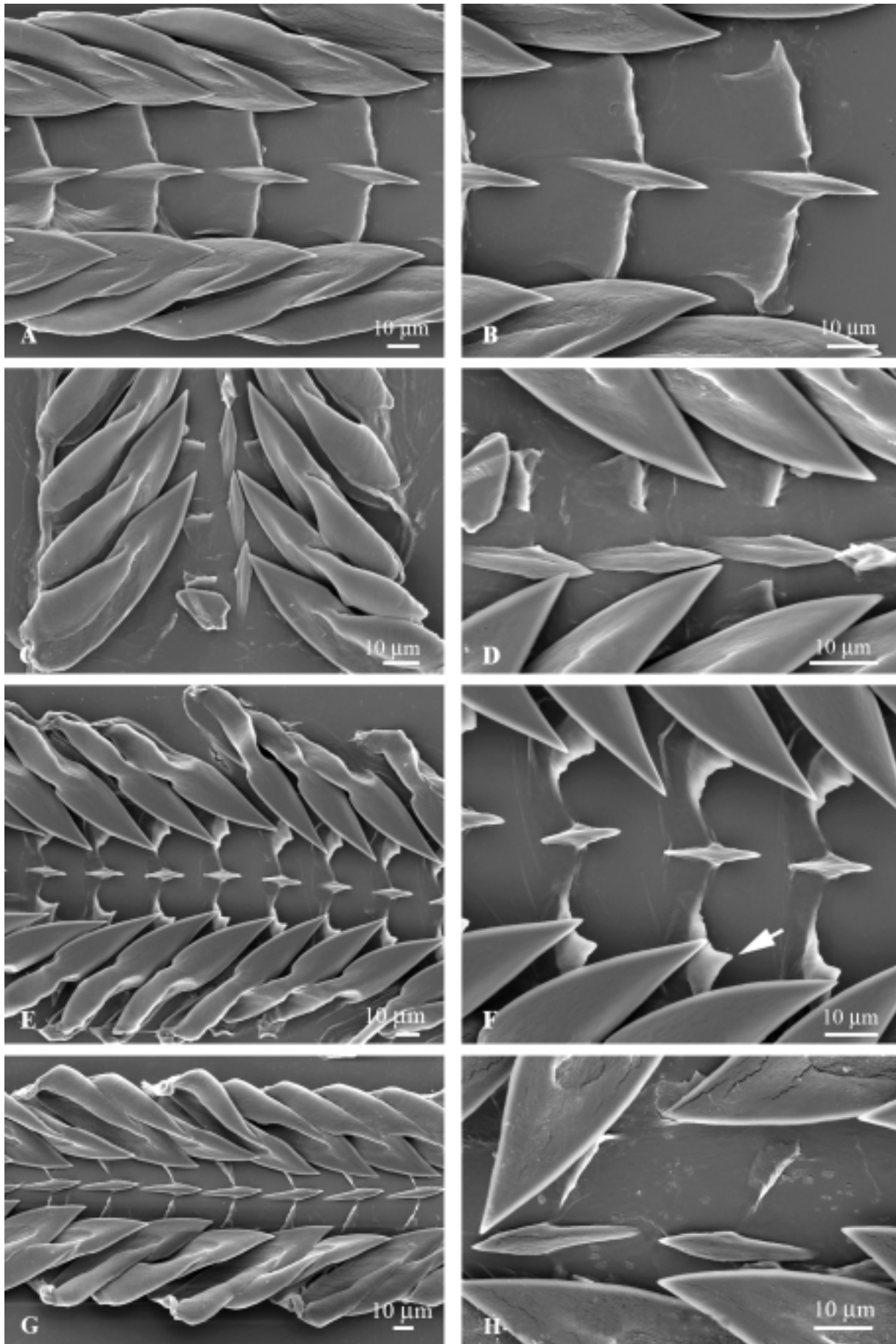


FIG. 3. Radulae of Turrinae. A-B – *Gemmula* sp. 8. C-D – *Gemmula thielei*. E-F – *Gemmula unilineata*. Arrows on B-D indicate the incomplete fusion of the central cusp and lateral flaps.

РИС. 3. Радулы Turrinae. A-B – *Gemmula* sp. 8. C-D – *Gemmula thielei*. E-F – *Gemmula unilineata*. Стрелками на B-D показаны участки неполного слияния центрального зубца и боковых лопастей.

FIG. 4. Radulae of Turrinae. A-B – *Turridrupa albofasciata*. C-D – *Turridrupa* n. sp. E-F – *Turridrupa* sp. 6. Arrow indicates the obtuse cusp on the lateral tooth. G-H – *Turridrupa jubata*.

РИС. 4. Радулы Turrinae. A-B – *Turridrupa albofasciata*. C-D – *Turridrupa* n. sp. E-F – *Turridrupa* sp. 6. Стрелкой показан тупой зубец на латеральном зубе. G-H – *Turridrupa jubata*.



the radula of the specimen, illustrated by her on Fig. 22 L is not properly extended, one can see a small central cusp on this photo]. In some species of *Turridrupa* the lateral elements of the “central formation” form a blunt cusp (*Turridrupa* sp. 6 – Fig. 4 F, marked by an arrow).

The similar to *Gemmula* condition is also found in the genus *Turris*. In some species (e.g. *Turris pagasa* Olivera, 1999) the central formation looks like a solid central tooth, while in the other (*T. cryptorrhaphe* Sowerby, 1825 and *T. cristata* Vera-Peláez, Vega-Luz et Lozano-Francisco, 2000) it produces an impression of three not completely fused teeth.

So, what is the homology of the “central formation” in Turridae? In my opinion, it is three completely or incompletely fused teeth: a narrow unicuspid central, similar in shape to that in Drilliidae, and two flat and broad lateral teeth, usually without any cusps, but sometimes forming an obtuse cusp (in the genus *Turridrupa*).

The strong “central formation” is present in some other Turridae. It was already suggested that the “central formation” in the genus *Antiplanes* (Cochlespirinae) is formed by the fusion of the two lateral teeth accompanied by complete reduction of the central one [Kantor, Sysoev, 1991] (Fig. 1 C). In two studied species of the genus *Comitas* (Cochlespirinae), *C. murrayolga* (Garrard, 1961) and *C. onokeana vivens* Dell, 1956, the composite nature of the “central formation” is also clearly seen [Kantor, Taylor, 2000]. While in the first one the central tooth is present, in the second it is very reduced. At the same time, in other genera of Cochlespirinae, namely

Cochlespira [Kantor, Taylor, 2000] and *Leucosyrinx* [Kantor, unpublished observations] the “central formation” seems to be a solid structure and at least in the latter genus the radular membrane is broadly folded with the bends positioned at both sides of the broad lateral flaps of the rectangular tooth.

In one species of Crassispirinae, *Crassispira* (*Crassiclava*) *turricula* (Sowerby, 1834), paired unusual in shape lateral teeth were found [Kantor et al., 1997, fig. 11 C-D]. Unfortunately, the pattern of folding of the membrane was not described. Very weak “central formations”, similar to that of *Lophiotoma* were found in a number of other Crassispirinae.

More observations on Cochlespirinae are necessary to clarify the homology of the “central formation” in Turridae, but the present data allow suggesting that the “central formation” is the product of fusion of three teeth, central one and two laterals, not only in Turridae, but at least in some Cochlespirinae as well. This means that the radula with 5 teeth in a transverse row is not confined to the family Drilliidae, but is present in the Turridae. Therefore the radula of Drilliidae is not fundamentally different from that of Turridae.

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- О морфологии и гомологии «центрального зуба» радулы Turridae (Conoidea)
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- РЕЗЮМЕ.** Детально исследована морфология радулы 64 видов 7 родов подсемейства Turridae (Turridae). Выдвинуто предположение, что так называемый «центральный зуб» представляет собой результат слияния трех зубов – узкого центрального и двух широких латеральных. Подобная морфология отмечена и у некоторых представителей других подсемейств Turridae — Cochlespirinae и Crassispirinae.