

TEREBRIDAE

A quest for the
grand unifying theory
beyond the standard model

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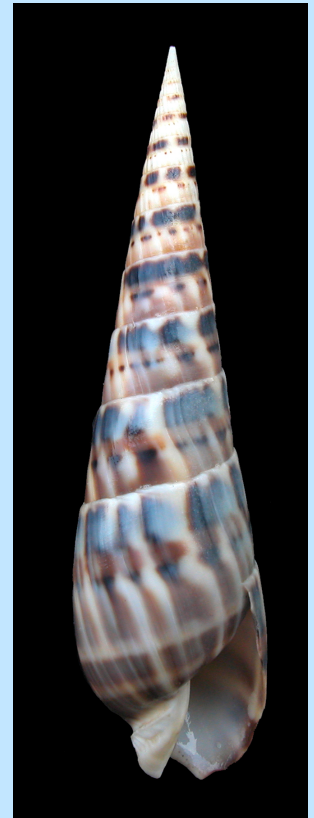
A drop into the Event Horizon **or**
can the three forces be unified?

Yves Terry

Definition of the Family

TEREBRIDAE Bruguière, 1789

- slender, pointed, multi-whorled and dextrally coiled shells ranging in size from a few mm's to 274 mm (WRS *Oxymeris maculata*).
- Sculpture ranges from smooth to complex structures of spiral and/or axial sculpture.
- Protoconch can consist of 1-5 whorls but no consistent direct relationship to dispersal.
- Fossils date back to the Eocene (56-34 mya)



Look-alikes

Cerithids



Potamids



Turritellidae



Turrids



Columbellidae



Pyramimitridae



Nassariidae



Habitat

- subtropical to tropical regions, from 0 to about 1000 m
- intertidal areas in sand (*Hastula*, *Euterebra*, *Duplicaria*) to continental slopes and seamounts
- largest biodiversity in the tropical coral triangle between 0 and 200 m in sand/coral(rubble)/mud
- most are **vermivore**: in most cases a wide range of species feed on a limited number of worms e.g. Vietnam, 100 x 100 m transect: 22 species feeding on 3 types of worms having 5 types of feeding mechanisms

Taxonomic situation of the Family

- broad spectrum molecular data suggests inclusion as subfamily into the Turridae s.s.
- but as the group is well-defined, recognizably uniform, historically treated as a family and yet very different in venom aspects from other turrids

= maintained as family by consensus

Taxonomic History of the Terebridae

Author		Genera	Subgenera	
Bruguière	1789	1	0	
H. & A. Adams	1853	1	4	
Tröschel	1866	4	0	
E. A. Smith	1873	1	4	
Cossmann	1896	5	5	
Dall	1908	3	6	use of 'sections'
Wenz	1943	7	+20	
Kuroda & Habe	1952	4	0	
Oyama	1961	8	0	
Burch	1965	3	0	
Miller	1971	3	2	feeding types (5)
Bratcher & Cernohorsky	1987	4	2	grouped species
Terryn	2007	14	0	informal groups
• <i>Retaining Dall's sections and Bratcher's 'groupings + introduction of new groupings</i>				
Aubry & Gargiulo	2013	10	2	
Present	2017	?	?	

400 valid species (Worms, 2016) but estimates go towards **5-600** species

Miller's feeding types (1971)

radula, poison gland presence and foregut anatomy

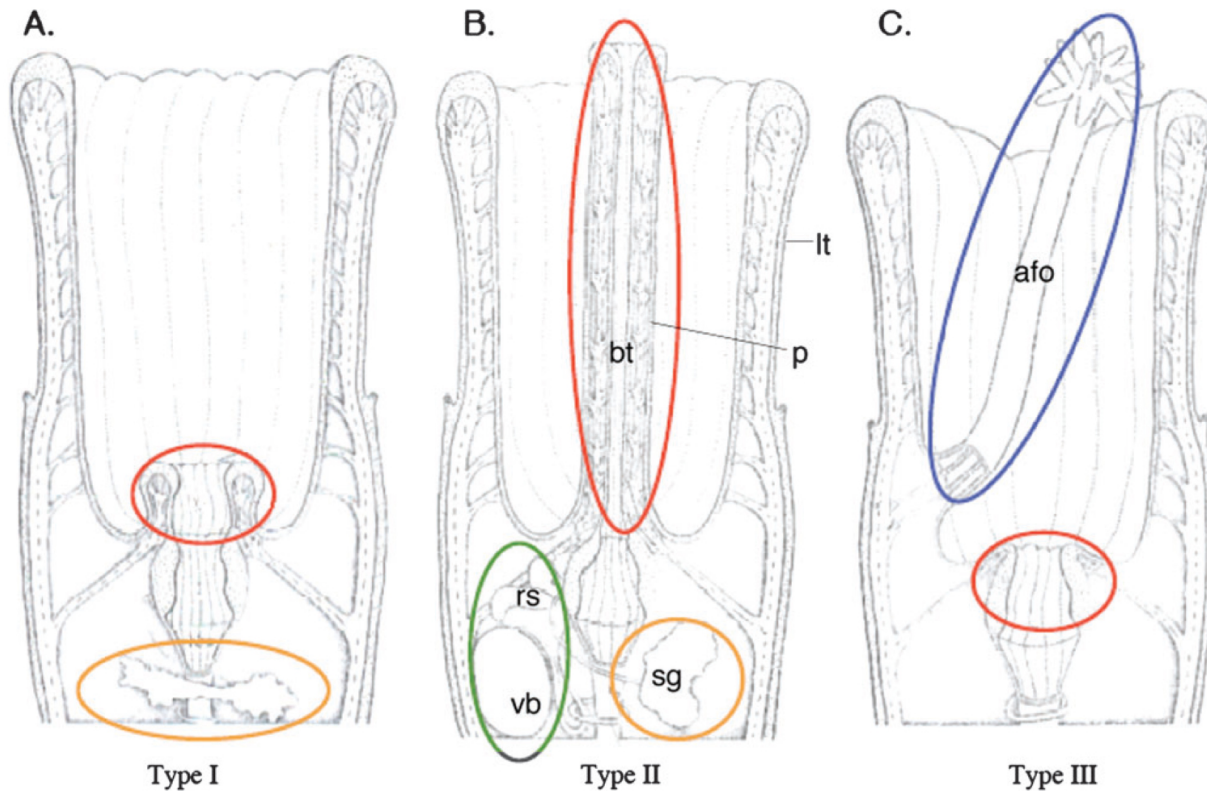


FIG. 1.—Schematic representation of Miller's foregut anatomy of the Terebridae. The three types of foregut anatomy Miller used to define feeding strategies within the Terebridae are depicted (Types I, II, and III). Anatomical features are labeled and highlighted in color: yellow = salivary glands (sg), red = buccal tube (bt), green = venom bulb (vb) and radular sac (rs), and blue = accessory feeding organ (afo). Also labeled are the proboscis (p), found only in Type II terebrids, and the labial tube (lt) (after Miller 1970).

Bratcher & Cernohorsky (1987)

- *Hastula*: *Hastula* s.s. & *Hastula* (*Impages*) = *Hastula* (DNA)
- *Duplicaria*
- *Terenolla*
- *Terebra* = all others

**subgrouping in *Terebra* is artificial and
virtually impossible**

Shells are too varied within the 'genus'

B&C, 1987: 33

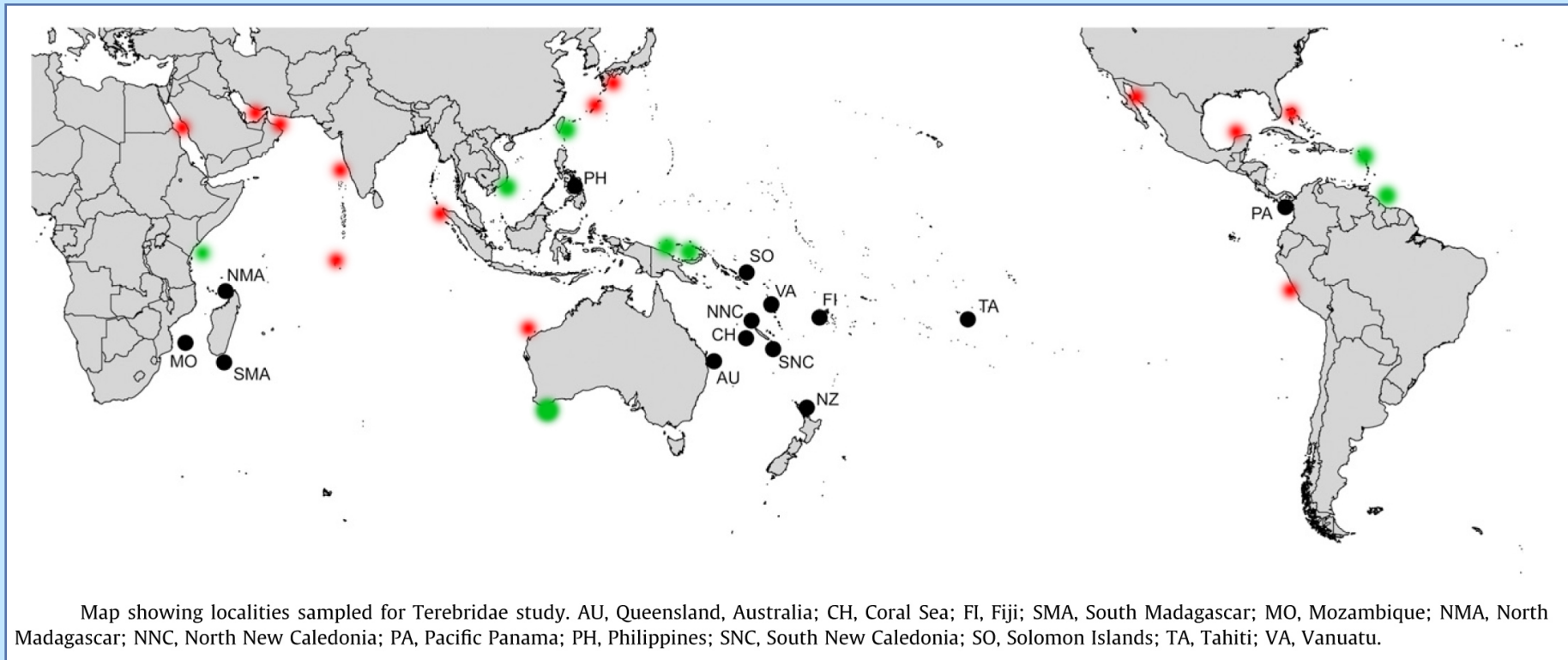
Terryn (2007-2008)

- *Hastula*
- *Impages*
- *Duplicaria*
- *Acus* (2008: preoccupied, replaced by *Oxymeris*)
- *Terenolla*
- *Terebra*
- *Myurella*
- *Cinguloterebra*
- *Hastulopsis*
- *Pristiterebra*
- *Pellifronia* (2008)
- + various, unnamed informal groupings = very artificial

Time for a first test

Current developments - MNHN

- 2000: study on shell morphology only, on mostly dry material from both historical and recent collecting, only a single paper on anatomy
- 2004 : start of barcode-project (Panglao'04, AURORA, EBISCO, etc)
- 2009 : first results with 100' s of samples
- 2012 : expanded results with 1000+ samples



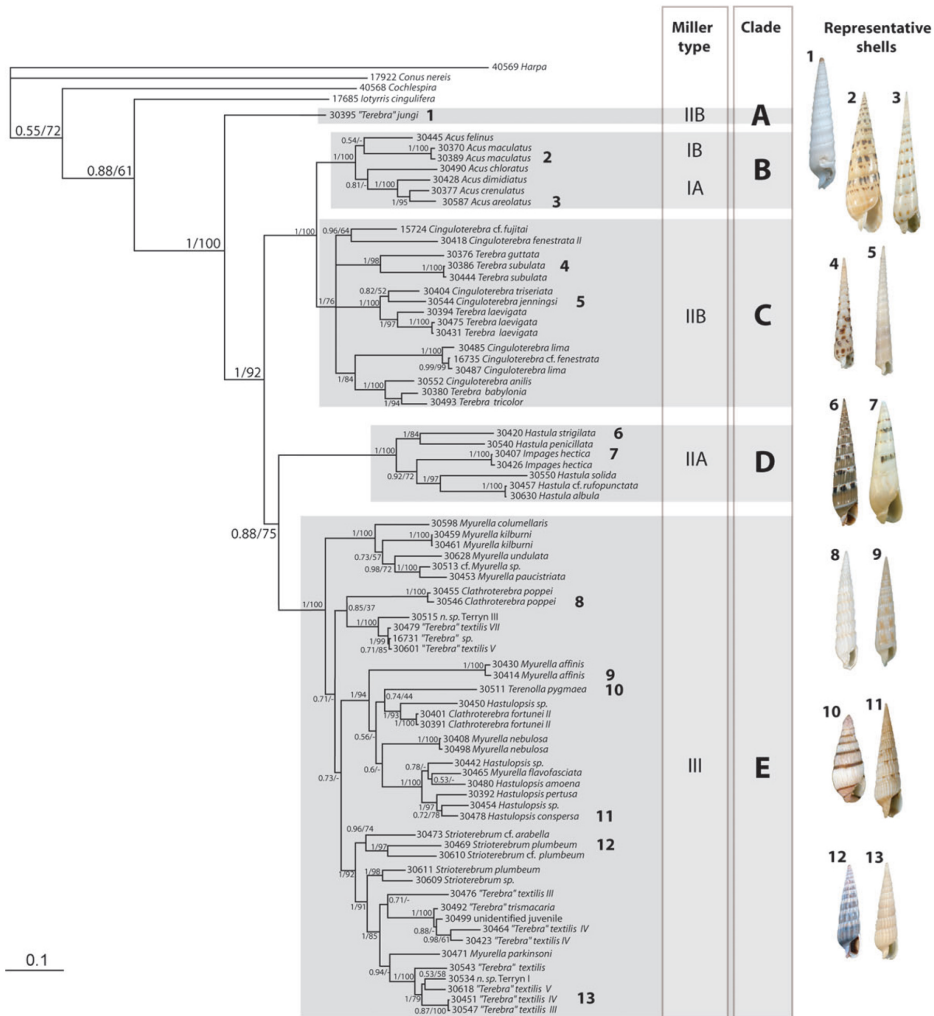


Fig. 2.—Combined phylogenetic tree. Consensus tree of ML analysis and BA using COI, 16S, and 12S data sets. PP and B are specified for each node. Miller types, IA, IB, IIA, IIB, and III, as described in the text are highlighted in the tree. Molecular analyses divide the Terebridae into five distinct clades, Clades A–E, indicated by the shaded gray areas. Representative shells, numbered 1–13, are shown for each clade. For clarity, multiple samples of the same species are shown only when there is a geographic difference, for example, 30370 and 30389 *Acus maculatus* from Panglao 2004 and Santo 2006 expeditions, respectively.

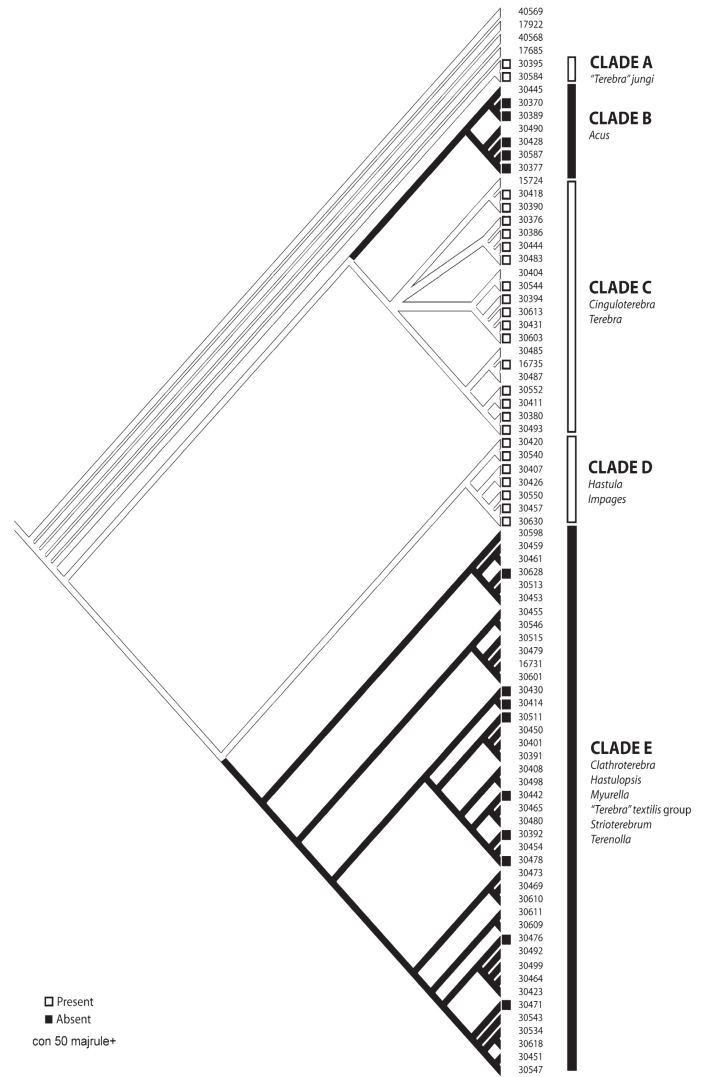
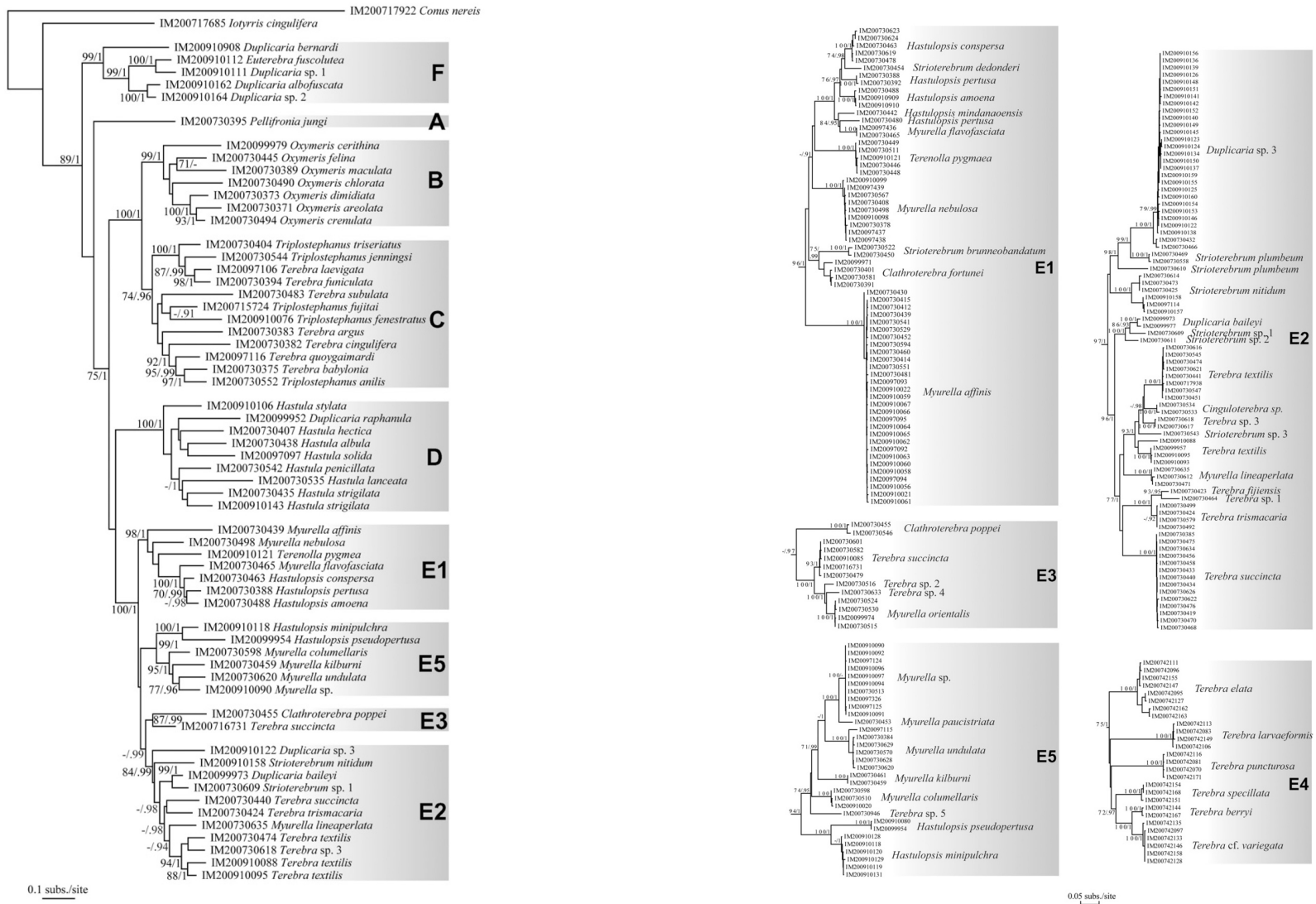


Fig. 3.—Possession of venom apparatus mapped onto Terebridae phylogeny. The presence or absence of a venom apparatus was mapped onto the molecular phylogeny of the Terebridae shown in figure 1. Terebrid species with a venom apparatus are indicated by a white box (□), whereas terebrid species without a venom apparatus are indicated by a black box (■). The map indicates that terebrids have independently lost the venom apparatus twice during their evolution.

2012



Likelihood phylogenetic tree obtained with 63 specimens sequences for the COI, 12S, 16S and 28S genes.

Fig. 6. Likelihood phylogenetic tree for the clades E1–E5. Bootstraps and Posterior Probabilities are indicated for each node (when B > 70% and PP > 0.90 respectively). For clarity purposes, intraspecific support values are not shown.

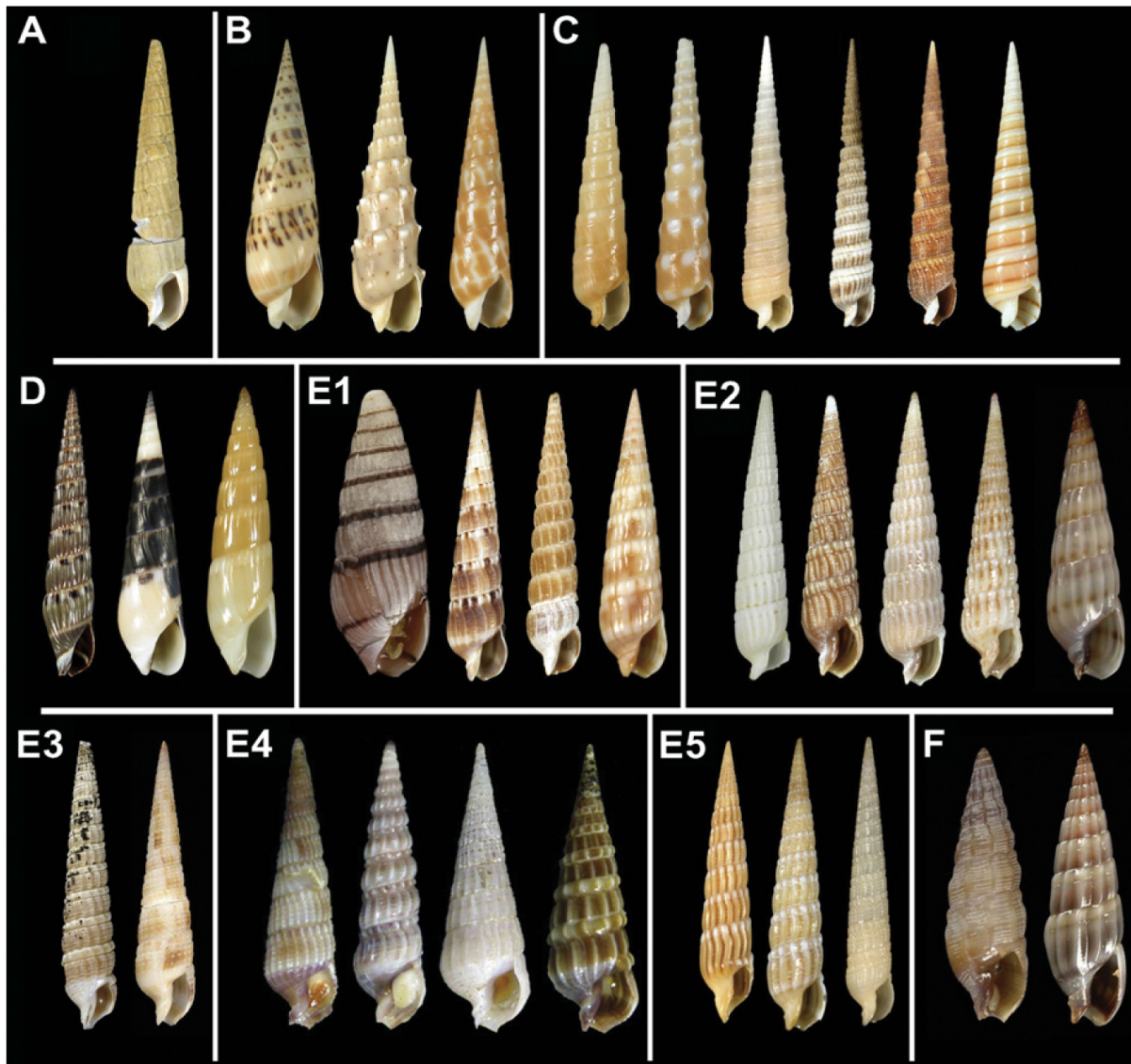


Fig. 7. Illustration of some specimens in each clade. From left to right: clade A: *Pellifronia jungi* IM_2007_30539; clade B: *Oxymeris maculata* IM_2007_30370, *Oxymeris crenulata* IM_2007_30377, *Oxymeris dimidiata* IM_2007_30379; clade C: *Terebra argus* IM_2007_30383, *Terebra guttata* IM_2007_30387, *Terebra funiculata* IM_2007_30394, *Triplostephanus fujitai* IM_2007_30482, *Terebra cingulifera* IM_2007_30485, *Terebra tricolor* IM_2007_30493; clade D: *Hastula strigilata* IM_2007_30416, *Hastula hectica* IM_2007_30426, *Hastula albula* IM_2007_30437; clade E1: *Terenolla pygmaea* IM_2009_10121, *Hastulopsis pertusa* IM_2007_30388, *Clathroterebra fortunei* IM_2007_30391, *Myurella affinis* IM_2007_30415; clade E2: *Terebra fijiensis* IM_2007_30423, *Terebra succincta* IM_2007_30433, *Terebra textilis* IM_2007_30451, *Myurella lineaperlata* IM_2007_30471, *Duplicaria* sp. 3 IM_2009_10151; clade E3: *Terebra succincta* IM_2007_16731, *Myurella orientalis* IM_2007_30515; clade E4: *Terebra elata* IM_2007_42111, *Terebra larvaeformis* IM_2007_42113, *Terebra puncturosa* IM_2007_42116, *Terebra berryi* IM_2007_42144; clade E5: *Myurella undulata* IM_2007_30384, *Myurella paucistriata* IM_2007_30453, *Terebra* sp. 5 IM_2007_30946; clade F: *Euterebra fuscolutea* IM_2009_10112, *Duplicaria albofuscata* IM_2009_10162.

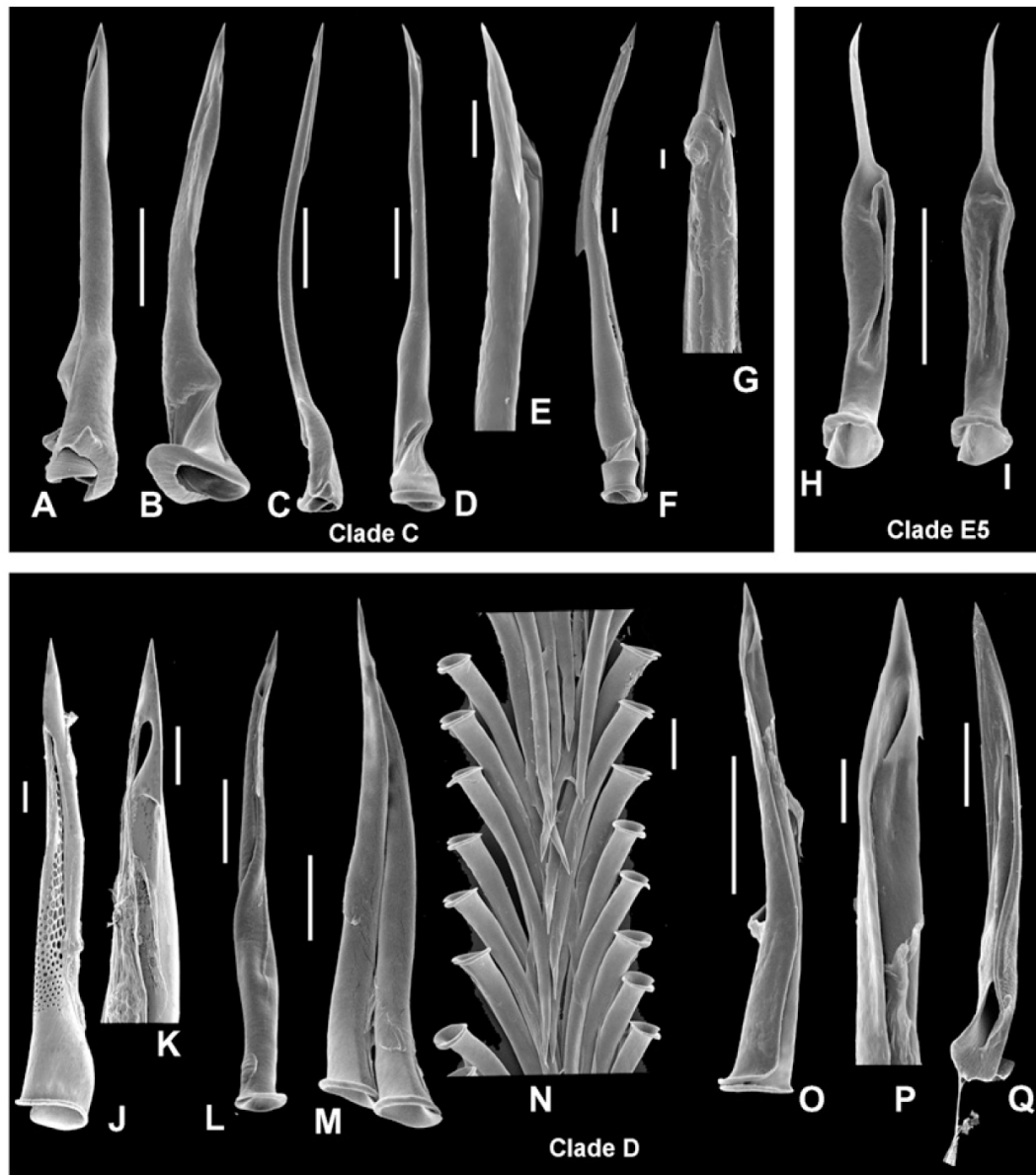


Fig. 3. Hypodermic (A–O) and semi-enrolled (Q) teeth in Terebridae. Clade C (A–G): A and B – *Terebra cingulifera* (IM_2007_30382); C – *Triplostephanus fenestratus* (IM_2007_30418); D–E – *Triplostephanus triseriatus* (IM_2007_30404); F–G – *Terebra guttata* (IM_2007_30376); clade E5 (H–I) – *Myurella kilburni* (IM_2007_30461); clade D (J–P): J–K – *Hastula hectica*, Philippines, Panglao Island; L – *Hastula lanceata* (IM_2007_30535); M–N – *Hastula penicillata* (IM_2007_30540), N – central part of the radular membrane; O–P – *Hastula strigilata* (IM_2007_30607); Q – *Hastula stylata* (IM_2009_10106). Scale bars: 50 μ m (except E, G, P – 10 μ m).

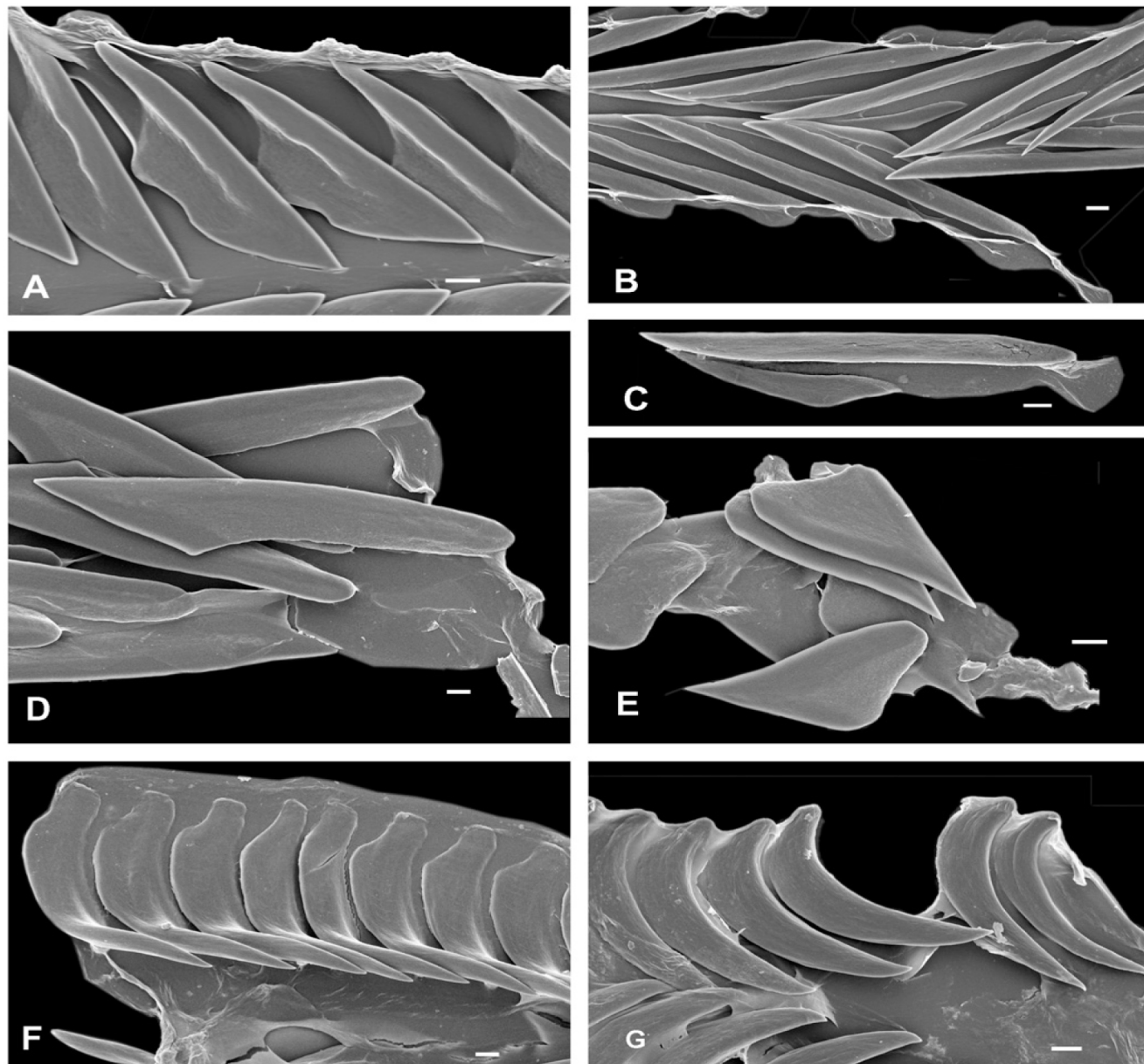
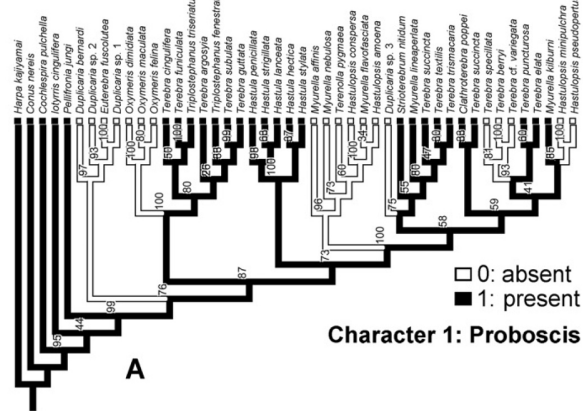
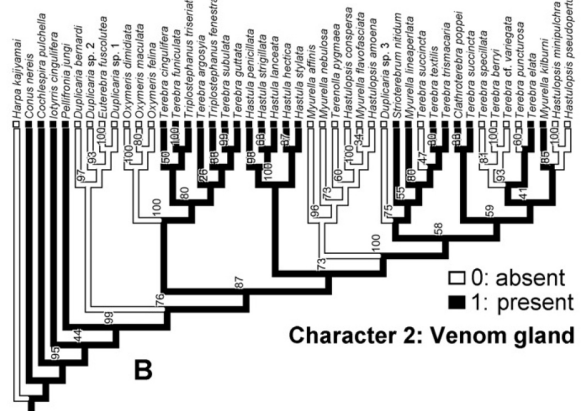


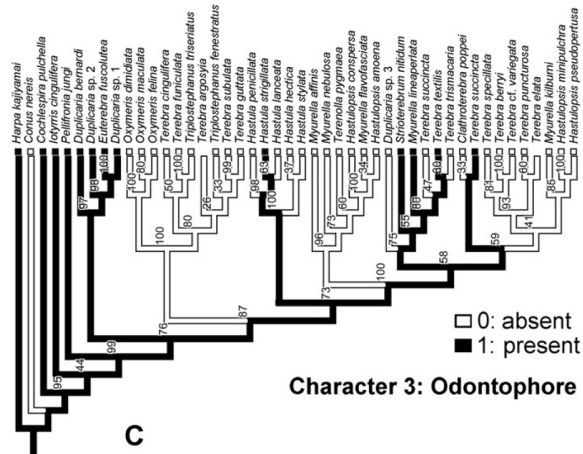
Fig. 2. Radula teeth of Terebridae. Duplex (A–C). Flat (D–E). Solid recurved (F–G). (A) *Pellifronia jungi* (IM_2007_30591), ventral view of radular membrane, only half shown; (B) *Clathroterebra poppei* (IM_2007_30546), ventral view of radular membrane; (C) *Terebra succincta* (IM_2007_30582), separate marginal tooth; (D) *Terebra trismacaria* (IM_2007_30579), ventral view of radular membrane; (E) *Myurella lineaperlata* (IM_2007_30635), group of teeth attached to the subradular membrane; (F) *Euterebra fuscolutea* (IM_2009_10133), ventral view of radular membrane, only half shown; (G) *Duplicaria* sp. 2 (IM_2009_10164), ventral view of radular membrane, only half shown. Scale bars – 10 μ m.



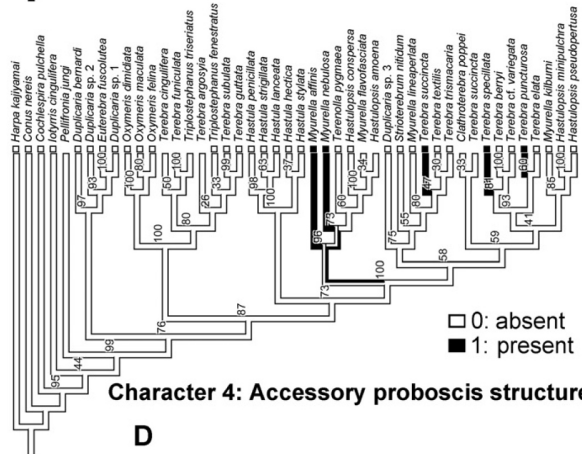
Character 1: Proboscis



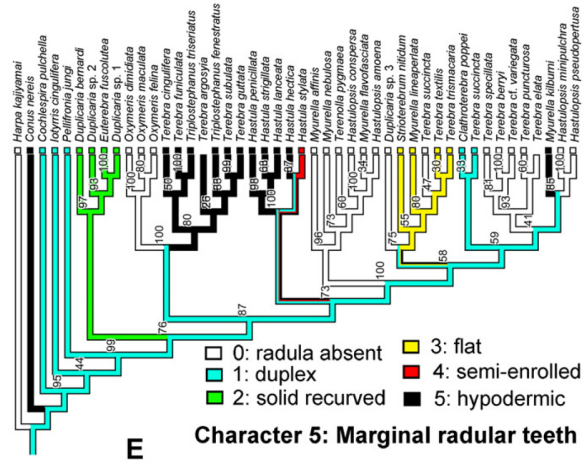
Character 2: Venom gland



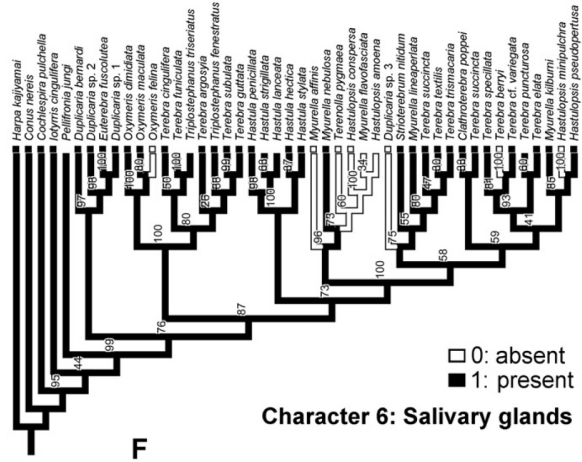
Character 3: Odontophore



Character 4: Accessory proboscis structure



Character 5: Marginal radular teeth



Character 6: Salivary glands