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# Cladistic analysis of the pennatulacean genus *Renilla* Lamarck, 1816 (Coelenterata, Octocorallia)

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## Abstract

The genus *Renilla* is an interesting taxon for phylogenetic studies, which includes six species endemic to America with an anphiameric distribution (Pacific–Atlantic Ocean). A cladistic analysis of *Renilla* Lamarck, 1816 using eight characters from external morphology produced one cladogram (length 14,  $CI = 0.92$ ,  $RI = 0.87$ ), and the characters were polarized using *Echinoptilum macintoshii* Hubrecht, 1885 as an outgroup. In the cladogram the following phylogenetic sequence results: ((*R. koellikeri* (*R. muelleri*, *R. musaica*)) (*R. octodentata* (*R. reniformis*, *R. tentaculata*))).

**Keywords:** Coelenterata, Octocorallia, *Renilla*, cladogram, phylogeny.

## Introduction

Phylogenetic studies on Octocorallia, such as Gerhart (1983) and Schmidt (1972, 1974) are still few; although Williams (1994, 1995a,b) provided the first modern phylogenetic analysis of the pennatulacean octocorals.

Williams (1995b) in his preliminary assessment of the phylogeny of Pennatulacea states:

Williams (1994) provided several reasons why cladistic analyses for lower metazoans such as the Pennatulacea are often seemingly intractable, explaining the consequent paucity of cladistic work in the literature regarding these taxa. These are: a) the scarcity of useful characters and the difficulty of character analysis; b) a poorly represented and problematic fossil record, which makes identification and comparison with extinct groups difficult or impossible (Conway-Morris, 1991); c) difficulty of obtaining fresh material of many taxa for study (especially for application of molecular and genetic techniques); d) a high frequency of homoplasy (parallelisms, convergences, reversals); and e) unusually high degrees of intraspecific variability.

The family Renillidae is a group of pennatulacean octocorals that are very unlike other sea pens; for this reason it is very difficult to find a good outgroup. In the cladogram presented by Williams (1997) for various pennatulacean taxa, the genus *Renilla* occupies a basal position in the phylogeny of the Pennatulacea near the genera *Veretillum* and *Echinoptilum*, but in the other branch of the cladogram, because *Renilla* has bilateral symmetry and foliate rachis, these two synapomorphies locate the genus *Renilla* in the next upper level of the cladogram. Nevertheless, the family Echinoptilidae shares with the Renillidae more characters than other families of Pennatulacea (Table 1).

The genus *Renilla* is an interesting taxon for phylogenetic studies. It includes six species endemic to America and with an amphiamerican distribution (Pacific–Atlantic Ocean) (Zamponi and Pérez, 1995; Zamponi *et al.*, 1997; Pérez, 1999). On the other hand the genus *Echinoptilum* Hubrecht, 1885 also includes six species but is distributed through the Indo–West Pacific from Hawaii to eastern Africa (Williams, 1990).

## Materials and methods

The species analyzed were *Renilla muelleri* Kolliker, 1872; *R. reniformis* (Pallas, 1766); *R. koellikeri* (Pfeffer, 1886); *R. musaica* Zamponi and Pérez, 1995; *R. octodentata* Zamponi and Pérez, 1995; and *R. tentaculata* Zamponi, Pérez, and Capitoli, 1997. The characters were polarized using *Echinoptilum macintoshii* Hubrecht, 1885 as an outgroup. The collection numbers and data of species analyzed are listed in Appendix I.

The specimens examined are deposited in the invertebrate collections of the Argentine Museum of Natural Sciences “Bernardino Rivadavia” and Museum of La Plata, in the collections of coelenterates of the Laboratory of Cnidarian Biology (Marine Science Department, National University of Mar del Plata, Argentine), and also in the Laboratory of Ecology of Benthic Invertebrates (Fundação Universidade Rio Grande, Brasil).

### Phylogenetic methods

**Outgroup.** The genus *Echinoptilum* was here chosen as the outgroup to the genus *Renilla* on the following basis. These genera share some features such as: absence of axis; adjacent polyps freely distributed directly on the rachis; autozooids retractile in distinctive calyces armed with calicinal teeth; presence of sclerites, three-flanged spindles and colonies radially to bilaterally symmetrical. Within the genus *Echinoptilum*, *E. macintoshii* was the chosen spe-

**Table 1.** Data matrix used in the cladistic analysis of genus *Renilla*.  
0 = plesiomorphic; 1,2,3,4 = apomorphic

Species	Characters							
	1	2	3	4	5	6	7	8
<i>Echinoptilum macintoshii</i>	0	0	0	0	0	0	0	0
<i>R. koellikeri</i>	0	0	1	0	1	1	1	1
<i>R. muelleri</i>	0	1	1	1	1	3	1	1
<i>R. musaica</i>	0	0	1	1	1	3	1	1
<i>R. octodentata</i>	0	1	0	0	3	4	1	1
<i>R. reniformis</i>	1	0	0	0	2	2	1	1
<i>R. tentaculata</i>	2	0	0	0	2	1	1	1

cies because the shape of calyx teeth is similar to that of the genus *Renilla* in being conical to deltoid. Consequently, *E. macintoshii* is considered the pennatulacean taxon closest to the *Renilla* clade.

**Characters and polarity.** The characters used were derived from the external morphology (Table 1). Apomorphic character states were identified and polarized by outgroup comparison (Brooks and McLennan, 1991; Nixon and Carpenter, 1993) with the species *Echinoptilum macintoshii*. Multistate characters 1 and 5 were treated as additive multistate, in both characters we follow the logic sequence of the different states. Character 6 was treated as non-additive because we found it impossible to establish a sequence between different states. Analysis was carried out with Hennig 86 version 1.5 (Farris, 1988), applying the implicit enumeration option, and consistency (CI) and retention (RI) indices were calculated.

*List of characters.* The characters listed below are summarized in the matrix of table 1.

1. Peduncle length: (0) short, (1) long, (2) very long.
2. Sclerite length: (0) shorter on the peduncle, (1) uniform.
3. Color of the sclerites: (0) with color variation, (1) uniform color.
4. Medium dorsal tract free of polyps: (0) present, (1) absent.
5. Number of calicinal teeth: (0) with two teeth, (1) with five teeth, (2) with seven teeth, (3) with eight teeth.
6. Rachis shape: (0) digitiform, (1) heart-round, (2) kidney-heart-round, (3) kidney-horse-shoe, (4) kidney-bilobulate.
7. Sclerites: (0) three-flanged rods and ovals, (1) three flanged rods.
8. Polyp distribution: (0) all around the rachis, (1) dorsal only.

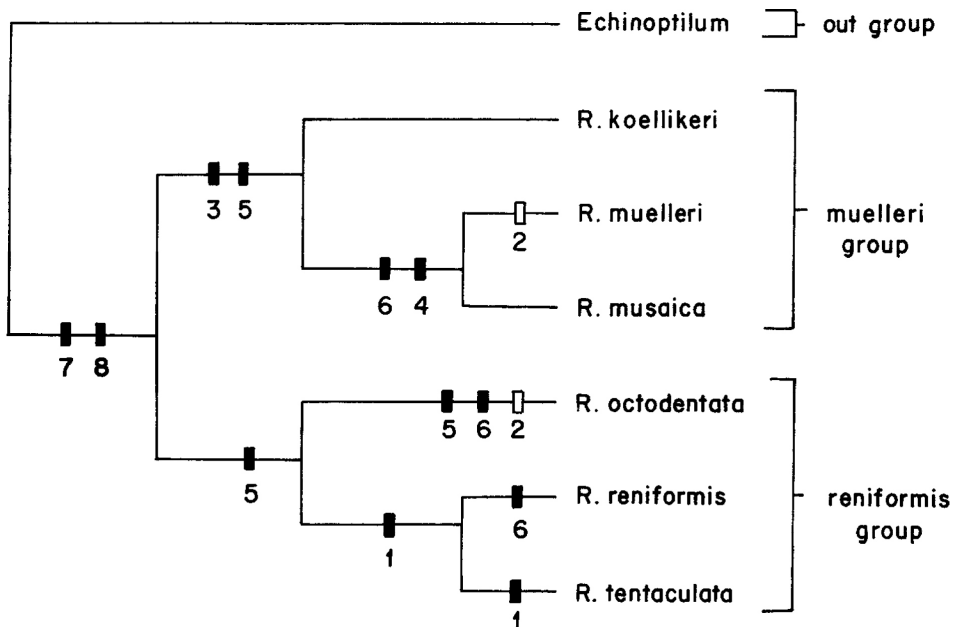
## Cladistic results

The analysis of the data matrix (Table 1) produced one cladogram with 14 steps, a consistency index  $CI = 0.92$  and retention index  $RI = 0.87$  (Figure 1).

The genus *Renilla* is defined for two synapomorphies: “sclerites with three-flanged rods” and “dorsal-polyp distribution.” The cladistic analysis allowed the identification of two lineages formed for: one, *R. koellikeri*, *R. muelleri* and *R. musaica*, defined for the synapomorphies “uniform color of the sclerites” and “number of calicinal teeth: 5”; and the other, *R. octodentata*, *R. reniformis*, and *R. tentaculata* defined for the synapomorphy “number of calicinal teeth: 7.” In the first group the species *R. koellikeri* and *R. musaica* are related for the synapomorphies “medium dorsal tract free of polyps present” and “rachis shape kidney-horse-shoe”; in the second group the species *R. reniformis* and *R. tentaculata* are related for the synapomorphy “peduncle long”; there is parallelism, “sclerites length uniform,” between *R. muelleri* and *R. octodentata*.

## Discussion

The species here assigned to the genus *Renilla* form a natural group defined by synapomorphies derived from the morphology. The cladogram obtained accords with the previous biological and taxonomic thinking (Zamponi and Pérez, 1995; Zamponi *et al.*, 1997; Pérez, 1999). Two groups are defined, one, “**muelleri group**” (*R. muelleri*, *R. koellikeri*, and *R. musaica*) and the other “**reniformis group**” (*R. reniformis*, *R. octodentata*, and *R. tentaculata*).



**Figure 1.** Cladogram of the genus *Renilla*. Node numbers refer to eight characters used in the analysis.

The next step for a further study of the genus *Renilla* will be to carry out a panbiogeographic study, and the combination of cladistics and panbiogeography may give us an approximation of the history of this interesting genus.

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## Appendix I. Material examined

The following list refers to specimens examined in the present study. Abbreviations are: ex., specimens examined; st., station; m, meters; DCM CP, Department of Marine Science Collection of Pennatulacea (University of Mar del Plata, Argentine); MACN, Argentine Museum of Natural Sciences “Bernardino Rivadavia” (Buenos Aires, Argentine)

*Renilla muelleri*. 20 ex., Vessel *Comodoro Rivadavia*, September 1938, st. 15, 37° 07' S 55° 22' W, depth 23 m., DCM CP 6.

*Renilla reniformis*. 15 ex., Vessel *Walther Herwig*, May 1978, st. 506, 41° 35' S 57° 53' W, depth 91–92 m, DCM CP 7.

*Renilla octodentata*. 4 ex., Vessel *Oca Balda*, May 1988, st. 37, 44° 48' S 65° 30' W, depth 65m, MACN no. 25397.

*Renilla koellikeri*. 12 ex., Survey Talude/87, November 1987, st. 23, 32° 38' 39" S 51° 12' W, depth 61 m, DCM CP 13.

*Renilla musaica*. 2 ex., Vessel *Presidente Mitre*, February 1955, 39° 59' S 56° 16' W, depth 100–200m, MACN no. 8528.

*Renilla tentaculata* 25 ex., Survey Diadema, August 1992, st. 02, 33° 44' 58" S 52° 41' 57" W, depth 23m, MACN 33815.