

# Phylogeny of corallimorpharians (Anthozoa; Cnidaria) based on mitochondrial genomes

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## Objectives and approach

Order Corallimorpharia, Carlgren, 1940, is a small and poorly understood anthozoan group. Corallimorpharians resemble actinarians in the absence of a calcareous skeleton, but have internal anatomies much more similar to those of scleractinians (den Hartog 1980). The phylogenetic position of corallimorpharians in relation to scleractinians is unclear and remains controversial (Fig. 1).

Corallimorpharia is classified into three or four families (Fig. 2). Systematic classification of this order is still controversial, mainly as a result of unclear original descriptions and the synonymisation of several genera and species (den Hartog 1980, Cha 2001; Table 1). This study is aimed at understanding corallimorpharian phylogeny by molecular phylogenetic analyses of whole mitochondrial (mt) genome sequences.

Figure 1 Phylogenetic hypotheses of relationship between order Corallimorpharia and Scleractinia

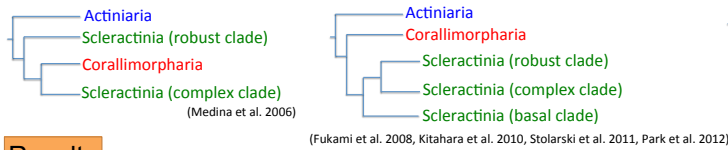


Figure 2 Systematics of Corallimorpharia based on morphology and ecophysiology.



(Photos: Chia-Min Hsu and Marcelo Kitahara)

## Results

Phylogenetic relationships of corallimorpharians were determined by using whole mt genome sequences from a total of 12 taxa.

Three distinct types of gene organisation were found in the corallimorpharian study (Fig. 3):

- (A) Most corallimorpharians were characterised by a common gene order;
- (B) The shallow water azooxanthellate species *Corynactis californica* had a distinct mt genome organisation;
- (C) Gene order in the deep-sea corallimorpharian *Corallimorphus profundus* was similar to the scleractinian pattern.

Table 1 Summary of the corallimorpharian classification schemes

Author	Families	Genera
Carlgren 1949	3 families	10 genera
Sideractiidae (Nectactis, Sideractis)	Corallimorphidae (Corallimorphus, Corynactis, Pseudocorynactis)	Actinodiscidae (Actinodiscus, Metrahadacis, Orinia, Paradiscosoma, Rhodactis)
den Hartog 1980	4 families, 7 genera	
Sideractiidae (Nectactis, Sideractis)	Corallimorphidae (Corallimorphus, Corynactis, Pseudocorynactis)	Ricordeidae (Ricordea) Upgrade Ricordea to family status
Cha 2001	3 families, 11 genera	
	Corallimorphidae (Corallimorphus, Corynactis, Nectactis, Pseudocorynactis, Sideractis) Group all azooxanthellate genera	Ricordeidae (Ricordea) Discosomatidae (Actinotryx, Amplexidiscus, Discosoma, Metrahadacis, Rhodactis)
Fautin 2006	4 families, 12 genera	
Sideractiidae (Nectactis, Sideractis)	Corallimorphidae (Corallimorphus, Corynactis, Pseudocorynactis)	Ricordeidae (Ricordea) Discosomatidae (Actinodiscus, Amplexidiscus, Discosoma, Metrahadacis, Rhodactis, Platyzoanthus) Upgrade Actinodiscus from Discosoma, Platyzoanthus from Rhodactis
WoRMS 2012	4 families, 11 genera	
Sideractiidae (Nectactis, Sideractis)	Corallimorphidae (Corallimorphus, Corynactis, Pseudocorynactis)	Ricordeidae (Ricordea) Discosomatidae (Amplexidiscus, Discosoma, Metrahadacis, Rhodactis, Platyzoanthus) Actinodiscus is invalid
This study	4 families, 11 genera	
Sideractiidae (Nectactis, Sideractis)	Corallimorphidae (Corallimorphus, Corynactis, Pseudocorynactis)	Ricordeidae (Ricordea) Discosomatidae (Actinodiscus, Amplexidiscus, Discosoma, Metrahadacis, Rhodactis)

Phylogenetic trees were constructed by Maximum likelihood analysis and Bayesian inference (Fig. 4).

1. Three groups were resolved corresponding to the gene orders:
  - (A) zooxanthellate corallimorpharians
  - (B) shallow water azooxanthellate corallimorpharian
  - (C) deep-sea azooxanthellate corallimorpharian
2. The validity of the family Ricordeidae;
3. All genera in Discosomatidae are valid;
4. *Corynactis* and *Corallimorphus* should be elevated to higher classification level;
5. Basal position of *C. profundus*.

Figure 4 Corallimorpharian mt genome phylogenetic tree

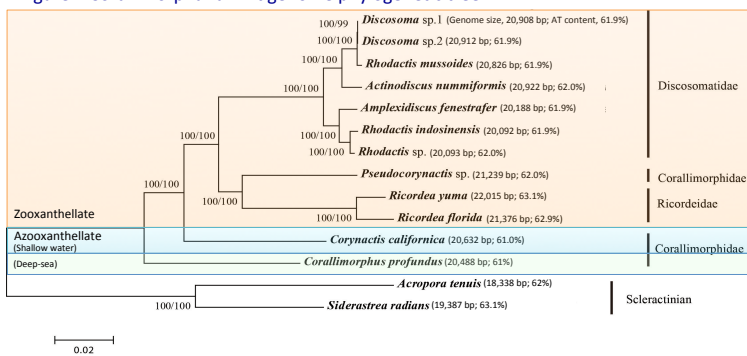
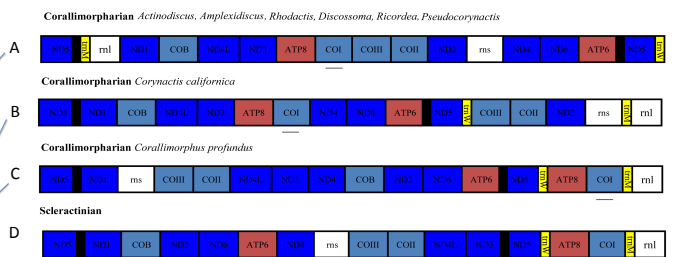


Figure 3 Corallimorpharian and scleractinian mt genome order



## Major conclusions

1. Gene order and phylogeny results support three corallimorpharian groups, revealing different evolutionary processes in corallimorpharians.
2. The similarity of gene order in *C. profundus* and scleractinians supports a close relationship between this corallimorpharian and scleractinians.
3. The family Discosomatidae contains most genera, the status of some of which is unclear. Results presented suggest that considerable diversity exists and that, in contradiction of den Hartog's view of lumping all Discosomatidae, most genera are likely to be valid.
4. In general, this study is consistent with there being 4-6 families and around 11 genera in the order Corallimorpharia.
5. Further analyses based on morphology and additional taxa (e.g. Sideractiidae) will be required to better understand relationships within the Corallimorpharia and between the various anthozoan lineages.

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