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Acanthophyllia deshayesiana (Michelin, 1850) Coral Species Is Not Synonym With *Cynarina lacrymalis* (Milne Edwards & Haime, 1848)

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Abstract

Acanthophyllia deshayesiana has a different habitat with Cynarina lacrymalis in the nature, but they have same character on living forms, diameter, and height of corallite. Both of these species are considered synonym, thus it needs verification study to describe whether it is synonym species or not based on morphological data. Eleven descriptive characters and seven morphometric characters were used to verify the synonym species of these coral. Descriptive data were performed by scoring method, while morphometric data were obtained from morphometric. Morphometric data were analyzed by Correspondence Analysis of Principal Coordinates (CAP) and Agglomerative Hierarchical Cluster (AHC), while descriptive data were analyzed by UPGMA (Unweight Pair Group Method with Arithmetic Mean). The result showed that both of these coral can not differentiate based on morphometric measurement. It can differentiate significantly based on descriptive characters, so both of these coral are not synonym.

Keywords: *synonym, morphometric, descriptive, Cynarina lacrymalis, Acanthophyllia deshayesiana*

Introduction

Generally, morphological pattern of organisms were influenced by genetic factors which are inherited from the parent. Heritable genetic information does not always provide significant influences, because there is environmental component that can influence the morphological pattern. The environmental response of each organism is different and can cause genetic mutations or slow growth. Organism will adapt to respond environmental changes.

One of organisms that have more responses to environmental changes is coral. High response of coral to environmental changes (Wolstenholme *et al.*, 2003; Marti-Puig *et al.*, 2014) have an impact on morphological pattern of the coral diversity, so it classified in a high plasticity organisms (Stefani *et al.*, 2008; Huang *et al.*, 2009; Schmidt-Roach *et al.*, 2012). The diversity of coral morphology gives a trouble to identify live coral and classification system in the coral taxonomy.

Classification and systematic of coral was done using traditional classification that is morphology of the skeleton (Wolstenholme *et al.*, 2003; Schmidt-Roach *et al.*, 2012; Arrigoni *et al.*, 2014b) and purposed to know their relationship and evolution (Stobart, 2000; Flot *et al.*, 2008; Casebolt, 2011). However, the observation and measurement of coral using skeleton showed intra species variation and a high plasticity (Stefani *et al.*, 2008). Therefore, there were many studies on the coral systematics by combining the morphological and molecular approach.

Morphological diversity causes difficulties on coral dead to be classified into one group and given the same name (Flot *et al.*, 2008; Schmidt-Roach *et al.*, 2012). For example coral *Cynarina lacrymalis* were usually considered as a synonym of *Acanthophyllia deshayesiana*. It was described by Best and Hoeksema (1987) in which had a same variation with *C. lacrymalis*. The similarities were solitary life, had a diameter of corallite 10 cm, calice relief 8 cm, tooth high in primary septal is 15 mm, epitheca well developed, and the corallum was strongly dentated. The holotype of *C. lacrymalis* is in MNHN (Muse´um National d'Histoire Naturelle, Paris, France) with Philliphines as local type of it.

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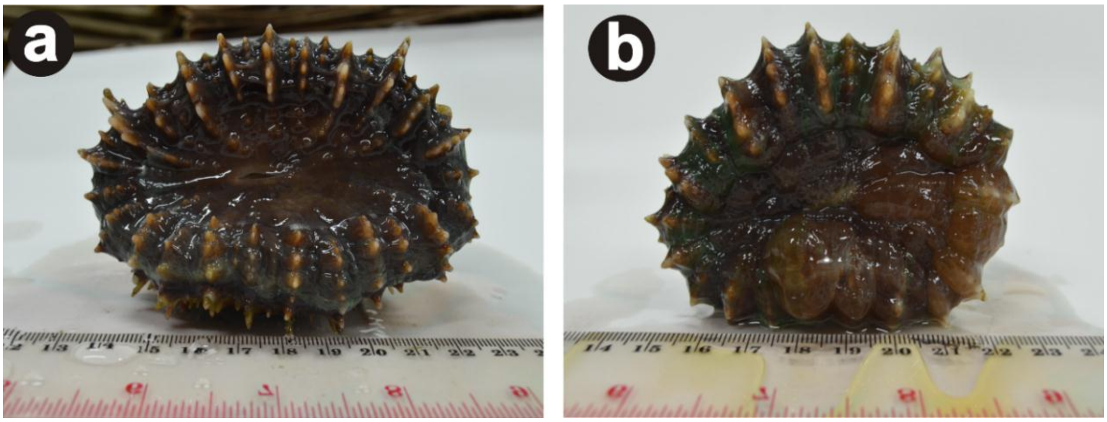
The synonym problem of species would impact on the trade regulation of ornamental coral and lead to legality. This study aimed to verify suspected synonym of two species, i.e. (*A. deshayesiana* and *C. lacrymalis*) based on morphological characters. Morphological characters used two characters in this study, consist of descriptive and morphometric characters. Those characters were assumed to be able differ and could be character identifier in the cladogram.

Materials and Methods

Seven corals of *C. lacrymalis* taken from Kalimantan and eight corals of *A. deshayesiana* taken from Makassar were used this study from Family *Mussidae* (Figure 1). Coral specimens were bleached in *sodium hyplocorite*, rinsed with freshwater, and air-dried for morphological analysis. Morphological analysis were consist of morphometric and descriptive characters (Oppen *et al.*, 2000; Wolstenholme *et al.*, 2003; Stefani *et al.*, 2008; Filatov *et al.*, 2013; Kitano *et al.*, 2014). Coral specimens were selected by the same size (the colony diameter range 4-8 cm).

Observations of descriptive characters were done by taking a picture using Canon powershoot D30. Morphometric characters used a caliper (accuracy 0.01 mm) as the reference length (Stefani *et al.*, 2008). Morphometric characters involved 7 characters (Figure 2 and Table 1) (Budd and Stolarski, 2009; Casebolt, 2011; Arrigoni *et al.*, 2012; Benzoni *et al.*, 2012; Budd *et al.*, 2012; Arrigoni *et al.*, 2014a; 2014b).



(a) (b)

Figure 1. The living conditions of corals: (a) *Acantophyllia deshayesiana*; (b) *Cynarina lacrymalis*

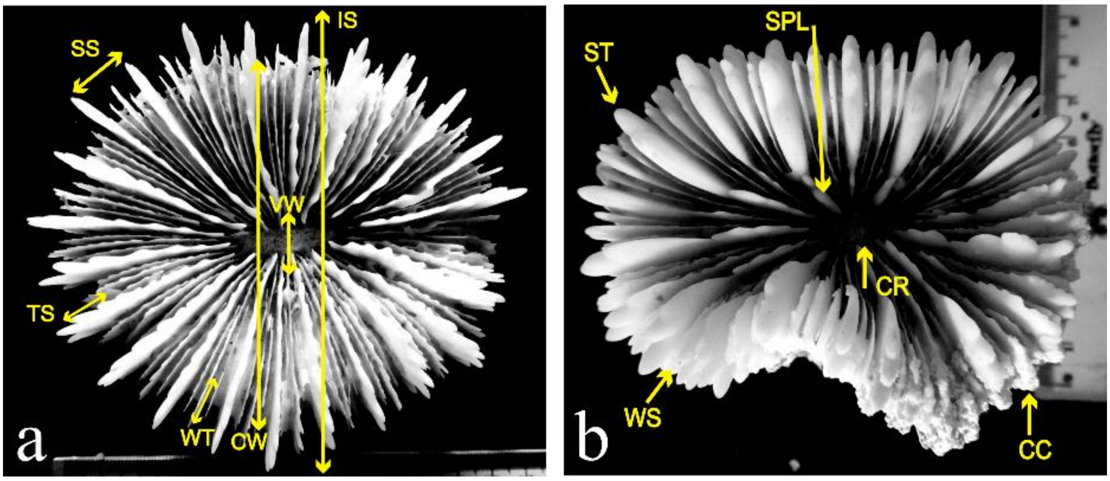


Figure 2. Corallite features were analyzed in morphological studies on *C. lacrymalis* & *A. deshayesiana*: a) morphometric characters; & b) descriptive characters. SS = Septa Spacing, TS = Tooth Spacing, IS = Individual Size, VW = Valley Width, CW = Calice Width, WT = Wall Thickness, ST = Septal Teeth, WS = Wall Structure, SPL = Septal or Paliform Lobes, CR = Calice Relief, and CC = Continuity of Costae.

Table 1. Morphometric characters which were used to measure corallite features

No.	Character	Description
1	Calice Width (CW)	Diameter of calice in corallite
2	Valley Width (VW)	Diameter of valley in corallite
3	Calice Relief (CR)	Corallite depth from valley
4	Tooth Height (first order septum) (TH)	Average of tooth height in first septa
5	tooth Spacing (first order septum) (TS)	Average of tooth spacing from one another tooth septa
6	Overall Wall Thickness (WT)	Wall thickness from corallite
7	Individual Size (IS)	Diameter of individual coral

Table 2. Descriptive characters used to describe corallite

No	Character	State	Code
1	Corallite Shape (CS)	plocoid	0
		subplocoid	1
		cerioid	2
		meandroid	3
		flabelloid	4
		phaceloid	5
		solitary	6
2	Septal Teeth (ST)	minute	0
		acute or small	1
		large	2
3	Budding Type (BT)	intramural	0
		extramural	1
		none	2
4	Continuity of Costae (CC)	continous	0
		dis-continous	1
5	Septal and Paliform Lobes (SPL)	pali	0
		sometimes paliform	1
		sometimes septal	2
		none	3
6	Columella Structure (CLS)	trabecular & continous	0
		trabecular & discontinous	1
		styliform	2
		lamellar	3
		absent	4
7	Wall Structure (WS)	parathecal	0
		septothecal	1
		septothecal or/and parathecal	2
		synapticulothecal	3
		none	4
8	Costae Pattern (CP)	equal	0
		unequal	1
9	Costae Dentation (CD)	fine	0
		short	1
		exsert	2
10	Costae Alignment (CA)	absent	0
		present	1
11	Coenosteum (CO)	absent	0
		smooth	1
		blistered	2

Descriptive characters involved 11 characters (Figure 2 and Table 2) (Budd and Stolarski, 2009; Casebolt, 2011; Arrigoni *et al.*, 2012; Benzoni *et al.*, 2012; Budd *et al.*, 2012; Arrigoni *et al.*, 2014a; 2014b).

Morphometric data were analyzed by Correspondence Analysis of Principal Coordinates (CAP), and hierarchical cluster by Agglomerative Hierarchical Clustering (AHC) to know the separation of species groups using XLSTAT 2015 (Wolstenholme *et al.*, 2003; Stefani *et al.*, 2008). Unweighted Pair Group Method with Arithmetic Mean (UPGMA) was used to analyze descriptive data using PAUP 4 (Swofford, 2002; Arrigoni *et al.*, 2012; Benzoni *et al.*, 2012; Arrigoni *et al.*, 2014b) to reconstruct phylogeny tree based on descriptive characters.

Results and Discussion

Morphometric characters

Based on the symmetric plot graph of CAP and AHC, there were five clades which interpret a relationship between morphometric characters with coral specimens, which was clade 1 (ACT3, ACT11, ACT7, ACT19, ACT21, ACT1, and ACT41), clade 2 (ACT10, CYN40, CYN39, and CYN48), clade 3 (ACT12, and CYN55), clade 4 (CYN45), and clade 5 (CYN59).

Clade 1 was grouped by Calice Width (CW), and Valley Width (VW) character. In addition, clade 1 was divided into small clades, namely the clade 1a (ACT11 and ACT1), and 1b (ACT21, ACT19, ACT7, ACT3, and CYN41). Clade 1b was subdivided into 1b1 (ACT21 and ACT19), and 1b2 (CYN41, ACT3, and ACT7). Clade 1a was closer grouping based on VW, while clade 1b was classified by CW (Figure 4). Calice and valley width always directly proportional to ratio was 1:0,25%, and the value for calice and valley width on *C. lacrymalis* was > 30mm (Budd and Stolarski, 2009). *Cynarina lacrymalis* is a large coral polyps that have the largest calice and valley width in Famili *Mussidae* compared to Genus *Favia* which had ranges between 9-15mm (Kongjandtre *et al.*, 2012).

Clade 2 was grouped by Calice Relief (CR) (Figure 3). Calice relief of these five corals were more related and had relatively same value was 18,770 mm to 22,650 mm. Calice relief on *C. lacrymalis* was classified to a very high category which was > 10 mm (Budd and Stolarski, 2009). Calice form is influenced by calice width, which the wider a calice, then the smaller its relief (Kongjandtre *et al.*, 2012; Huang *et al.*, 2014).

Clade 3 consisted of ACT12 and CYN55 which were grouped based on individual size (IS) (Figure 3). The CAP showed that position of ACT12 was a bit far from the group, however the AHC was in one group with an equal value of 99,77% (Figure 4).

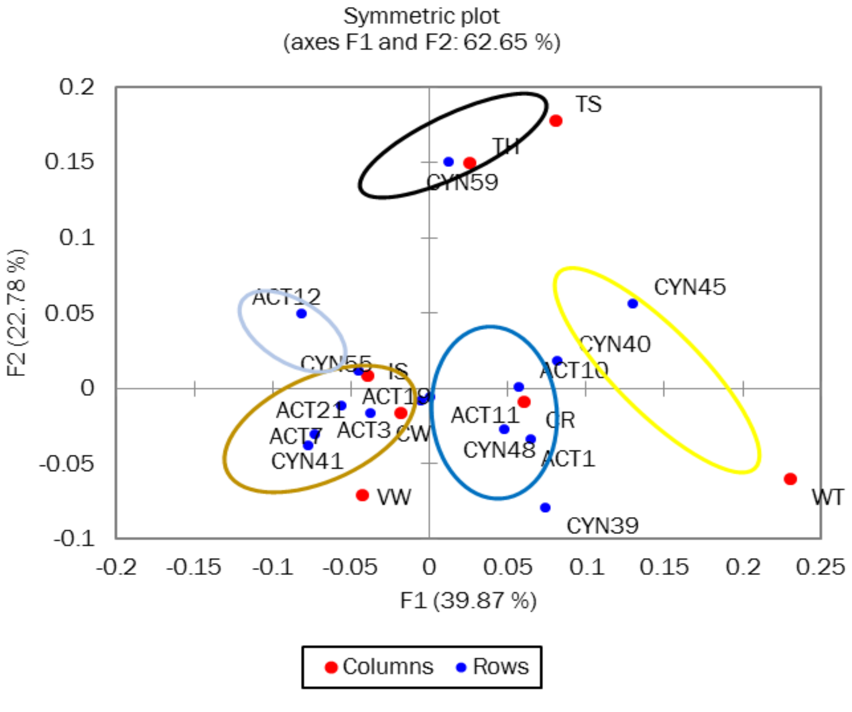


Figure 1. Grouping coral *C. lacrymalis* and *A. deshayesiana* based on morphometric characters using Correspondent Analysis of Principal Coordinates (CAP)

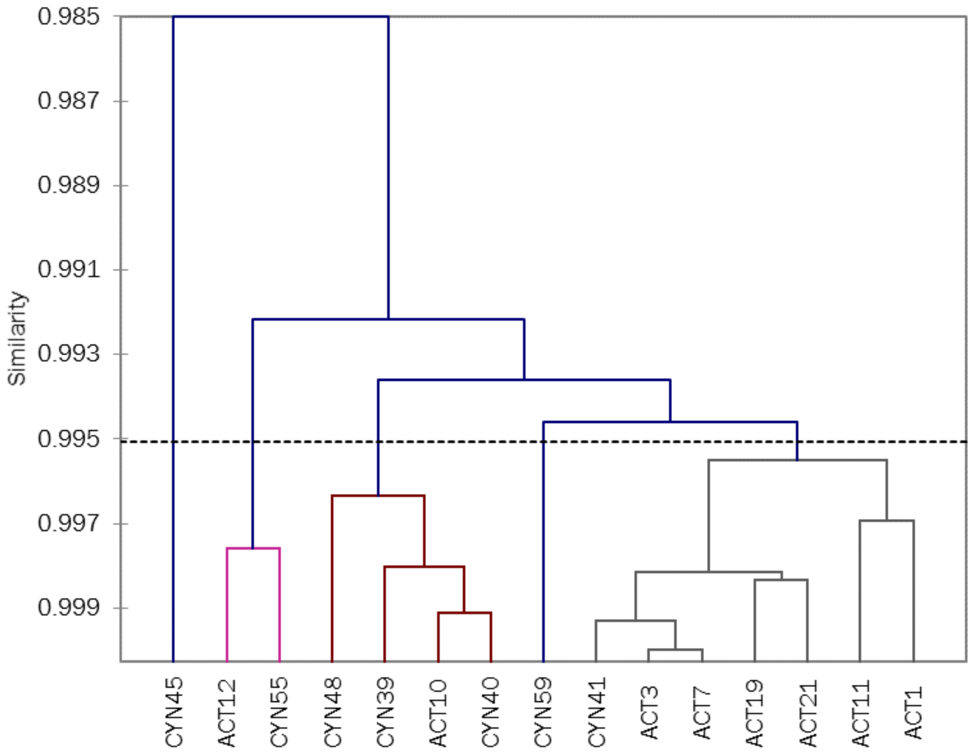


Figure 2. Dendogram of coral *C. lacrymalis* and *A. deshayesiana* based on morphometric characters using Agglomerative Hierarchical Clustering (AHC)

Individual size is directly proportional to the calice and valley width. In addition, individual size is strongly influenced by the age and growth of coral. The age and growth of coral that are more mature, it will have a wide valley and calice.

Clade 4 was CYN45 with a character grouping by wall thickness (WT). Wall thickness value of CYN45 was almost same with another specimen, however, the other morphometric characters did not influence the grouping of another specimen. Based on AHC result, CYN45 grouped itself because the value of the Calice Width (CW), Valley Width (VW), Tooth Height (TH), and Individual Size (IS) was very small, so that the level of similarity was low (98,5%). These conditions were almost same with clade 5 consisted of CYN59 with a character grouping were Tooth Height (TH) and Tooth Spacing (TS) on the first order septa. CYN59 had the same TH and TS value reltively in the amount of 5,342 mm and 5,624 mm. The TS value was measured at the highest tooth (first septa peak). The TS value of *A. deshayesiana* and *C. lacrymalis* had a range from 0,3 mm to 0,6 mm in the first septa (Figure 6). Both of these values had similar results obtained by Budd and Stolarski (2009) that value of distance between the teeth of *C. lacrymalis* was < 6 mm. The AHC result verified that CYN59 became monophiletic from clade 1, although this clade had an ancestor of CYN45. This result showed that morphometric characters could classify coral spesimens, although the clades were still unclear (Figure 3 and Figure 4). Because morphometric characters had a high plasticity and were influenced by environmental factors (Stefani *et al.*, 2008; Huang *et al.*, 2009; Schmidt-Roach *et al.*, 2012). Paz-García *et al.* (2015) reported that *Pocillopora damicornis* change into *P. inflata*, coincided with a storm of high and low turbidity. Corals could modify their morphology to cope with environmental change with variation between habitats over time (Prada *et al.*, 2008). Environmental changes in the sea (such as light, current patterns, sediment transport), force marine organisms to adapt with it (Hilbish, 1985; Doebeli and Dieckmann, 2003).

Descriptive characters

Descriptive character that differentiate between coral *C. lacrymalis* and *A. deshayesiana* were Septal Teeth (ST), Septa or Paliform Lobes (SPL), and Costae dentation (CD) (Table 3). Septal teeth (ST) on all of coral *A. deshayesiana* were big and point shaped, while *C. lacrymalis* finer and smaller (Figure 6). ACT21 had different shape,

Table 3. Difference of descriptive characters between *C. lacrymalis* with *A. deshayesiana*

Character	*C. lacrymalis*	*A. deshayesiana*
Corallite Shape	Solitary	Solitary
Septal Teeth	Large	Acute or small
Budding Type	None	None
Continuity of Costae	Continous	Continous
Septal and Paliform Lobes	Sometimes Paliform	Sometimes Septal
Columella Structure	Styliform	Styliform
Wall Structure	Synapticulothecal	Synapticulothecal
Costae Pattern	Equal	Equal
Costae Dentation	Short	Fine
Costae Alignment	Present	Present
Coenesteum	Smooth	Smooth

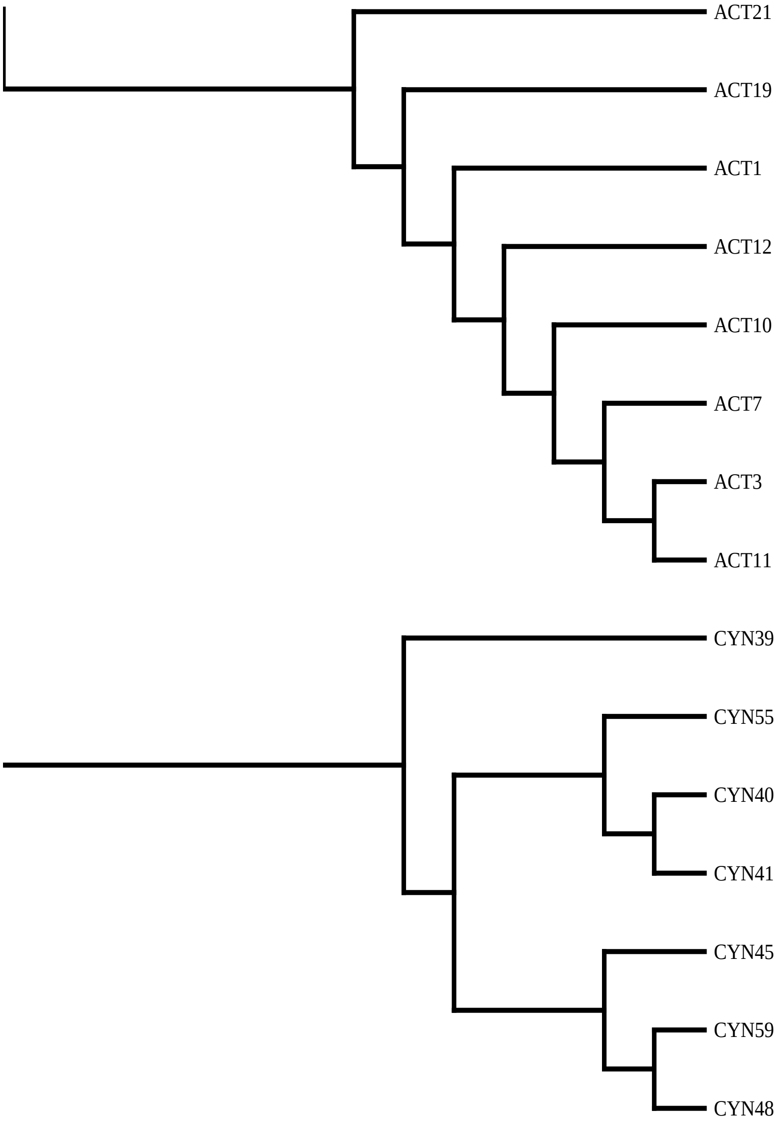


Figure 5. Cladogram based on descriptive characters with Unweighted Pair Group Method with Arithmetic Mean (UPGMA) method **Note.** *Description: ACT (Acanthophyillia deshayesiana); CYN (Cynarina lacrymalis)*

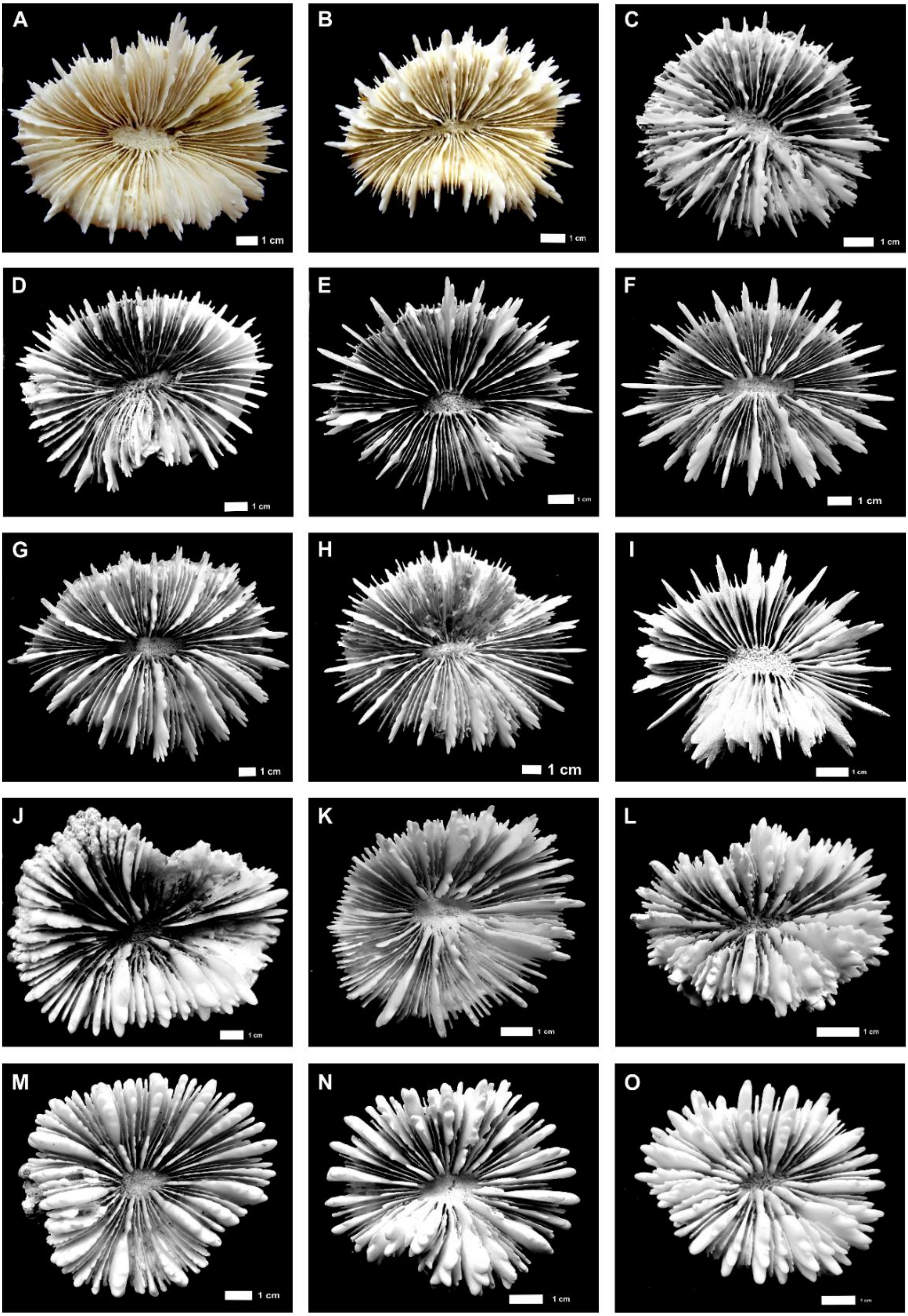


Figure 6. Comparison skeleton between *C. lacrymalis* with *A. deshayesiana*: **A-H**), *A. deshayesiana*; and **I-O**) *C. lacrymalis*

namely the septal teeth of thick and spiky, whilst CYN39 was large and spiky, which opposite descriptive.

Septal teeth in each genus is different to distinguish morphometric characters of Family *Faviidae* (Budd and Stolarski, 2011). Septal teeth differences were also found in Family *Faviidae* between the Atlantic and Pacific (Budd and Stolarski, 2009; Budd and Stolarski, 2011), so it is possible a different location is able to give changes on coral morphology. Existence of SPL also differ between coral *C. lacrymalis* with *A. deshayesiana. A. deshayesiana* had pali which develops into septa, while *C. lacrymalis* has very clearly formed pali. Exceptions were found in CYN39 which the pali developed into septa. Budd and Stolarski (2009) showed that septa and pali on coral *C. lacrymalis* well developed.

Generally, there has no pali in Family *Mussidae* like species *Scolymia cubensis, Scolymia vitiensi, Favia speciosa,* and *Favia cf.lizardensis*, but there are exceptions to *C. lacrymalis* becausethis unique coral has septal and well-developed pali (Budd and Stolarski, 2009; Kongjandtre *et al.*, 2012). Character to differenciate between *C. lacrymalis* with *A. deshayesiana* is Costae Dentation (CD). *A. deshayesiana* has fine of costae dentation, while *C. lacrymalis* has short of costae dentation.

The UPGMA results demonstrated a cladogram which forms the big and small groups. Phylogeny tree divides into 2 groups, namely group of *C. lacrymalis* and *A. deshayesiana* (Figure 5). Each coral had a different descriptive character, especially in *C. lacrymalis* which had a larger and blunt teeth shape, compared to *A. deshayesiana* with a thin and more pointed theeth shape (Figure 6). *Acantophyllia deshayesiana* with *C. lacrymalis* based on the descriptive character was able to distinguish clearly.

Conclusion

The study concludes that the groupings based on morphometric characters could not differentiate *C. lacrymalis* with *A. deshayesiana*, while the descriptive character grouping can already distinguish them separately.

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