Canal network reveals the growth pattern regulations of reef-building corals

Yixin Li[1], Tingyu Han[1], Kun Bi[1], Junyuan Chen[2], Jing Lu[3], Chunpeng He[1], and Zuhong Lu[1]

[1]State Key Laboratory of Bioelectronics
[2]Nanjing Institute of Geology and Palaeontology Chinese Academy of Sciences
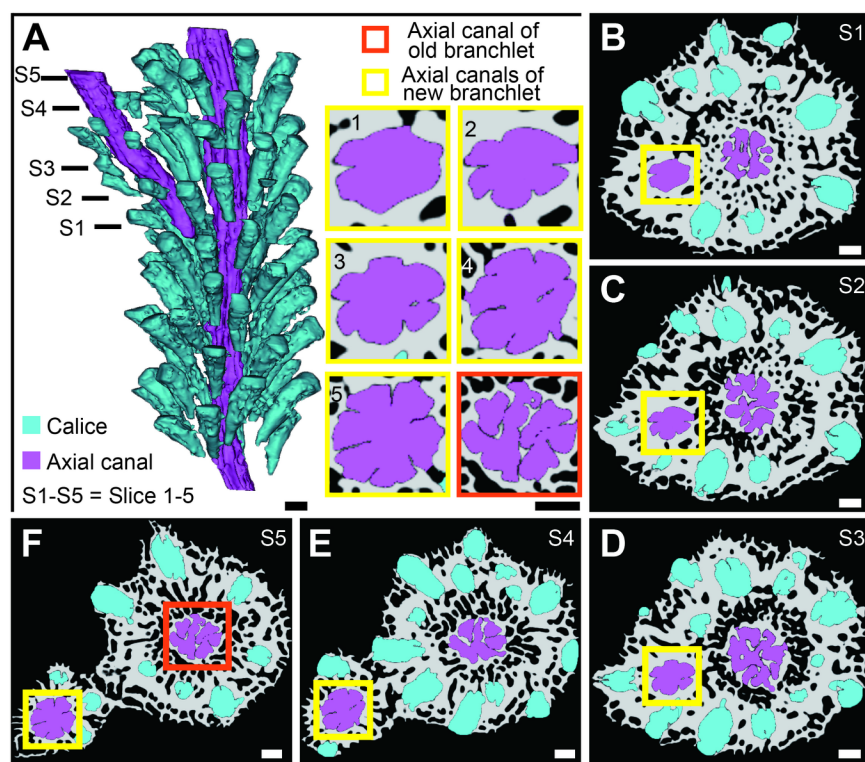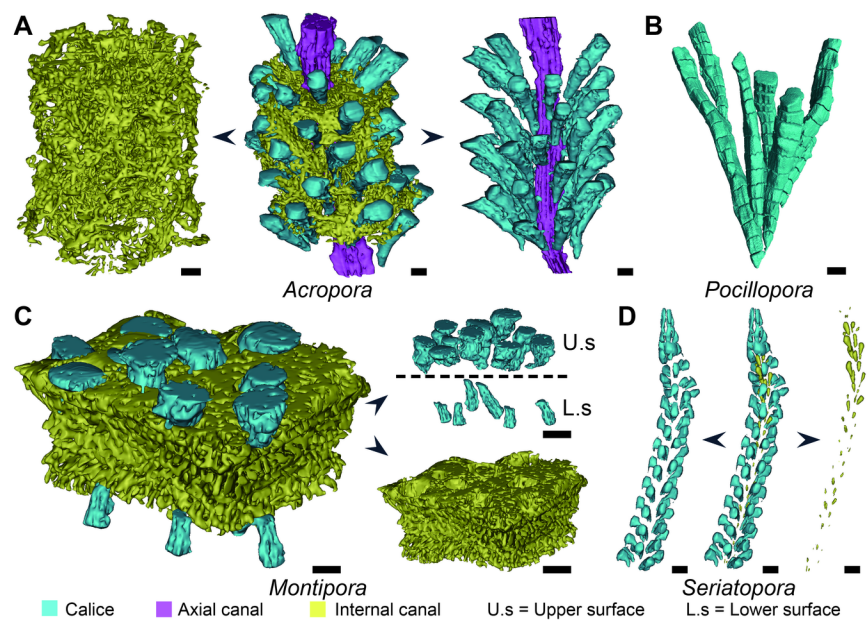[3]Key Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences
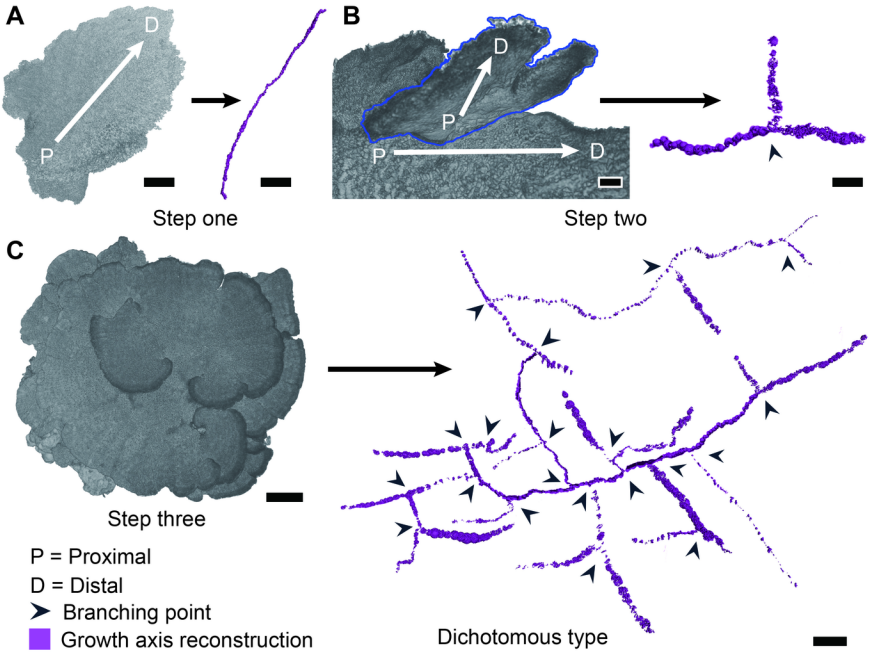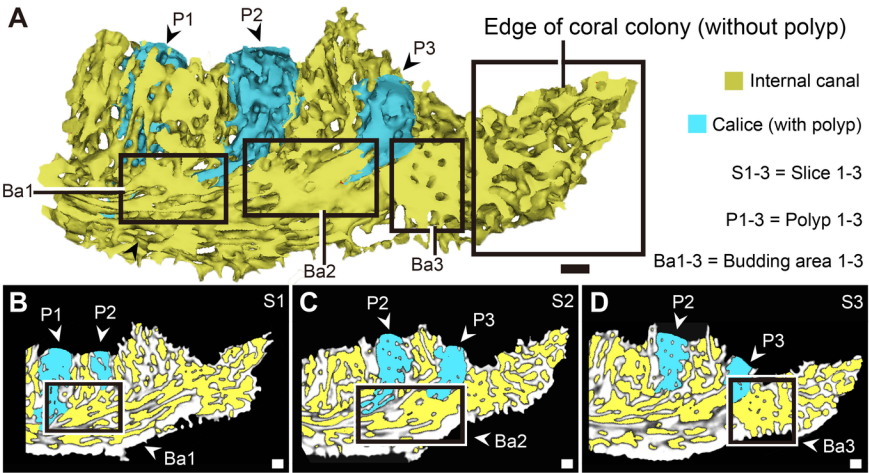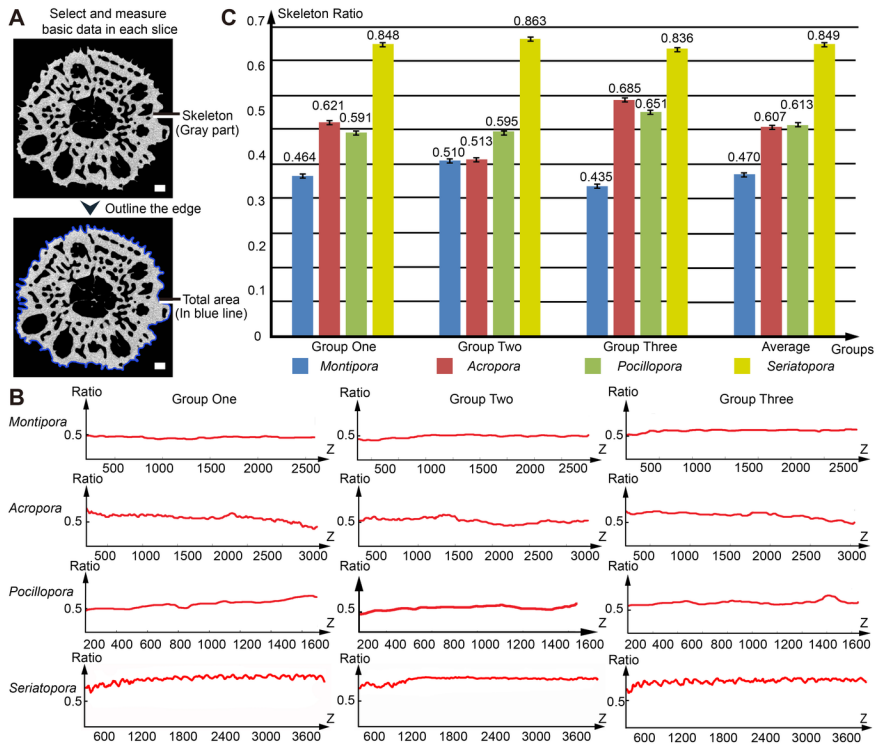
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Abstract

Acroporidae and Pocilloporidae are the predominant reef-building corals of Indo-Pacific coral reefs. Coral colony is the basic geometric construction of coral reef, while sustained formation of their calcium carbonate skeletons is the heart of healthy reefs. However, the reef forming strategies in coral growth is still obscure. In this study, we reconstructed 32 representative samples using high-resolution computed tomography and created canal networks inside skeletal data to investigate coral growth regulation and related parameters. In Acropora and Montipora colonies, the polyps are connected as an integral network by complex canals that perform and regulate physiological processes including budding, branching, and mineralising. Furthermore, we visualised coral growth axes and rings, revealing colony growth pattern regulation. We also drew a skeleton grey-gradient heat map and calculated coral skeleton ratios to reveal skeletal diversity, devising a method to quantitatively analyse coral growth. On the basis of the canal network reconstructions, we hypothesised coral growth strategies and compared the similarities and differences among the four genera. This work extends the knowledge of how corals grow their skeleton, what the major controls are and how skeletal growth varies amongst species, ensuring further protections of tropical coral reefs.

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A *Acropora*   **B** *Pocillopora*

C *Montipora*   U.s   L.s   **D** *Seriatopora*

■ Calice   ■ Axial canal   ■ Internal canal   U.s = Upper surface   L.s = Lower surface

A

S5 S4 S3 S2 S1

□ Axial canal of old branchlet
□ Axial canals of new branchlet

1 2 3 4 5

■ Calice
■ Axial canal
S1-S5 = Slice 1-5

B S1
C S2
D S3
E S4
F S5

2

A

Edge of coral colony (without polyp)

■ Internal canal
■ Calice (with polyp)
S1-3 = Slice 1-3
P1-3 = Polyp 1-3
Ba1-3 = Budding area 1-3

B P1 P2 S1
Ba1

C P2 P3 S2
Ba2

D P2 P3 S3
Ba3

A
D
P
→
Step one

B
D
P
P → D
→
Step two

C
→
Step three
Dichotomous type

P = Proximal
D = Distal
➤ Branching point
■ Growth axis reconstruction

A

Select and measure
basic data in each slice

Skeleton
(Gray part)

▼ Outline the edge

Total area
(In blue line)

C

Skeleton Ratio

Group One: Montipora 0.464, Acropora 0.621, Pocillopora 0.591, Seriatopora 0.848
Group Two: Montipora 0.510, Acropora 0.513, Pocillopora 0.595, Seriatopora 0.863
Group Three: Montipora 0.435, Acropora 0.685, Pocillopora 0.651, Seriatopora 0.836
Average: Montipora 0.470, Acropora 0.607, Pocillopora 0.613, Seriatopora 0.849

Groups

■ *Montipora* ■ *Acropora* ■ *Pocillopora* ■ *Seriatopora*

B

Ratio — Group One, Group Two, Group Three

Montipora
Acropora
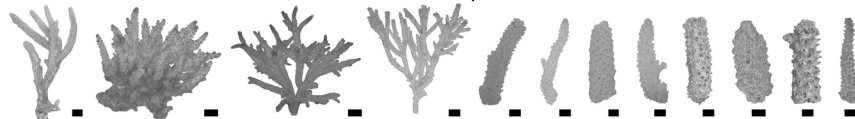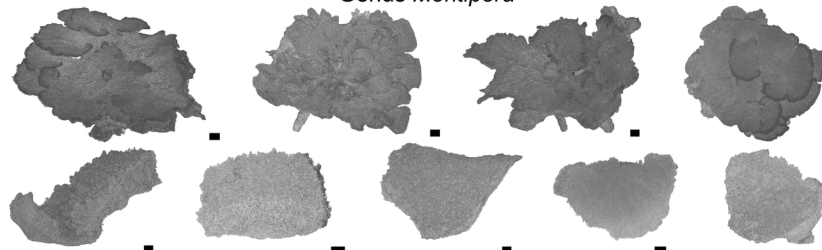*Pocillopora*
Seriatopora

HRCT Reconstruction Samples
Family *Acroporidae*
Genus *Acropora*

Genus *Montipora*

Family *Pocilloporidae*
Genus *Pocillopora*   Genus *Seriatopora*

4

A *Acropora* Calice

B *Pocillopora* Calice

C *Montipora* Calice

D *Seriatopora* Calice

T = Top View   F = Front View

■ Calice   ■ Internal canal   ■ Axial canal   □ Skeleton

Forming sequence

Pocillopora
Calice network

5
4
3
2
1

Budding

Budding sites
in calice network

□ Inverted cone shaped calice (budding site)   □ Inverted truncated-cone shaped calice

Figure legend: ■ Calice ■ Axial canal ■ Internal canal ■ Skeleton   R. Ac = Reconstructed axial canal   Ts = Truncation site   N = New slice   T = Truncated slice   O = Old slice

■ Growth axis reconstruction

Dichotomous   Polytomous   Divergent

Acropora

Montipora

Pocillopora

Seriatopora

Gray gradient

65000

60000

55000

50000

45000

40000

35000

30000

25000

20000

15000