



RITA CASTILHO

MARINE BIOGEOGRAPHY AND EVOLUTION

CORAL REEFS



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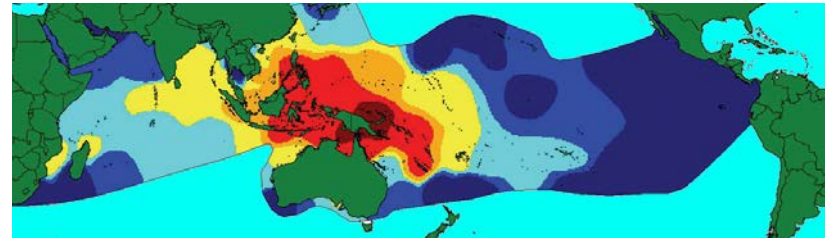
CORAL REEFS



DATING THE ORIGINS OF
CORAL REEF FISHES

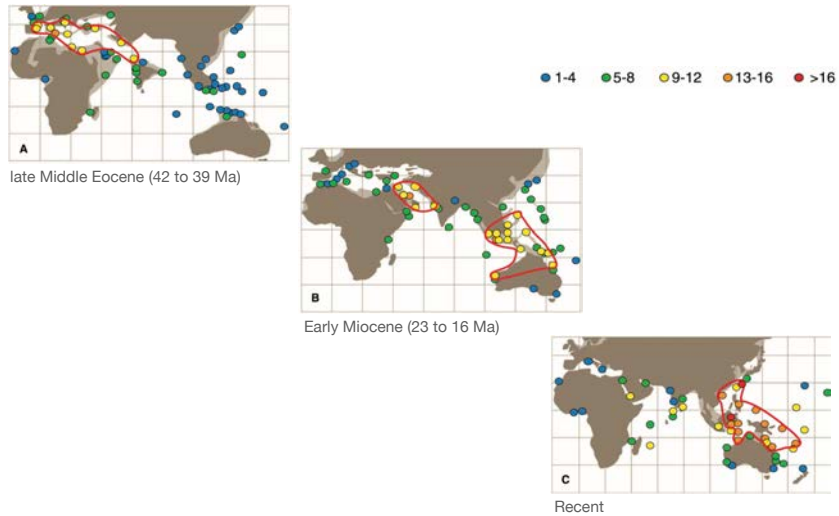
main source: Peter F Cowman

BACKGROUND: MARINE BIODIVERSITY HOTSPOT



IAA = Indo-Australian Archipelago

BACKGROUND: THE HOPPING HOTSPOT

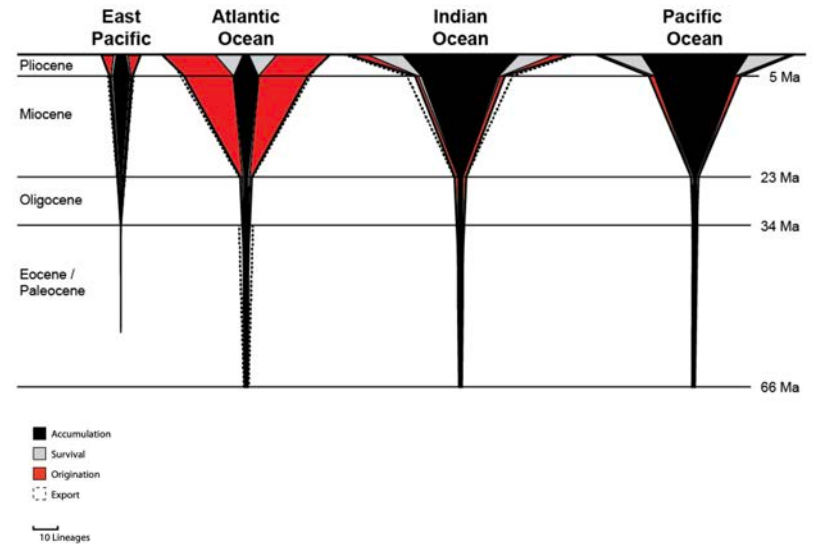


Large benthic foraminifera

The antiquity of the taxa in the modern Indo-Australian Archipelago hotspot emphasizes the role of pre-Pleistocene events in shaping modern diversity patterns.

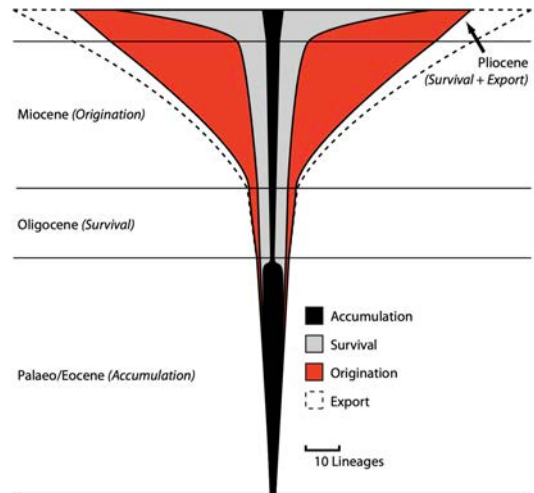
Renema et al. 2008

BACKGROUND: ROLE OF THE IAA HOTSPOT



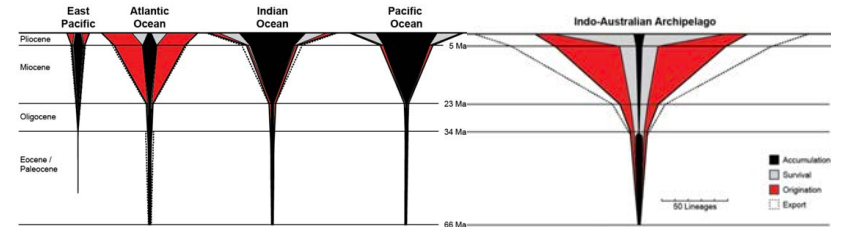
Cowman and Bellwood 2013

BACKGROUND: ROLE OF THE IAA HOTSPOT



Cowman and Bellwood 2013

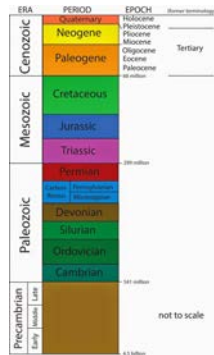
BACKGROUND: ROLE OF THE IAA HOTSPOT



Cowman and Bellwood 2013

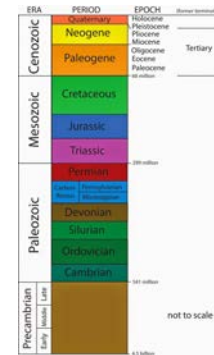
BACKGROUND: THE ORIGIN

Coral reef fishes are a highly diverse group, with an evolutionary history extending back more than 50 Myr.



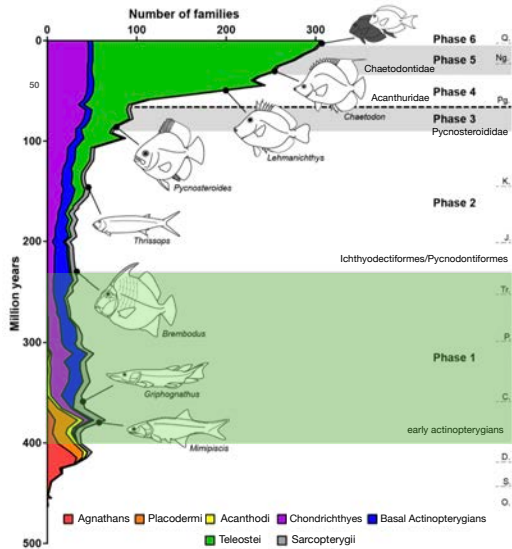
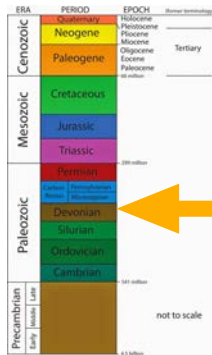
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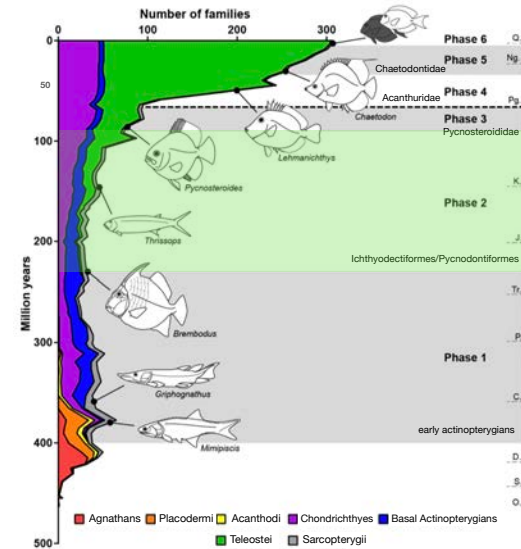
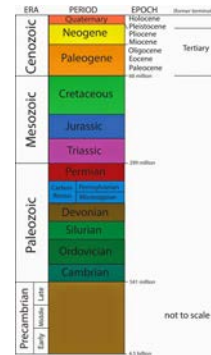
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Bellwood et al. 2015

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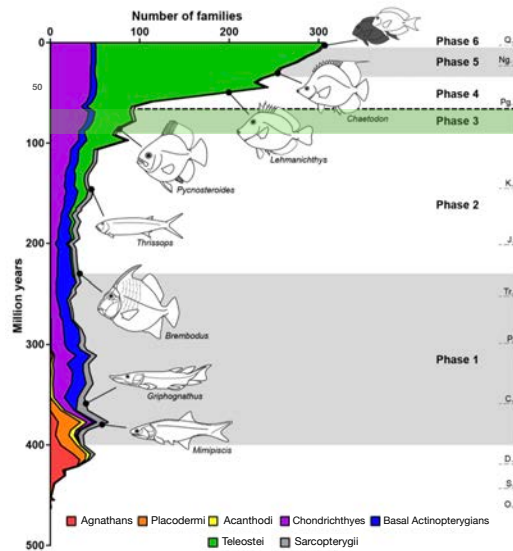
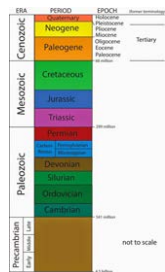
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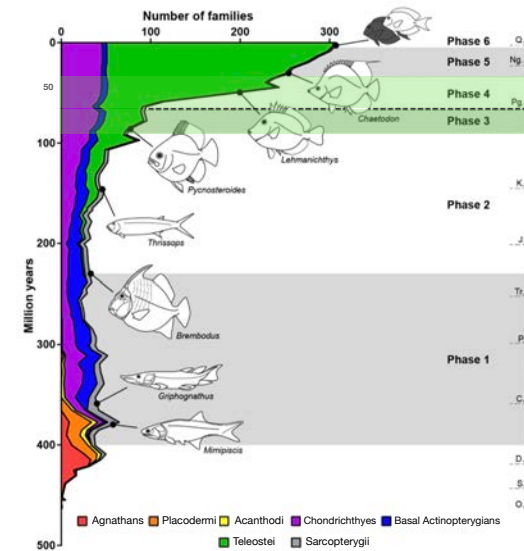
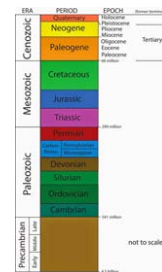
From the fossil record, it appears that **scleractinian**-dominated coral reefs and **modern** coral reef fish families first appeared and then diversified at approximately the same time, in the early **Cenozoic**.



Bellwood et al. 2015

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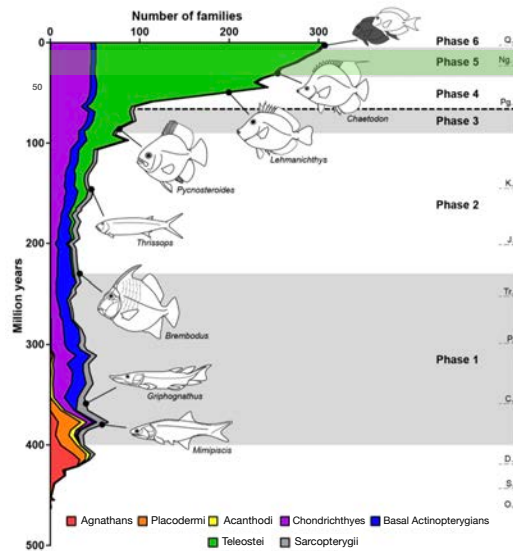
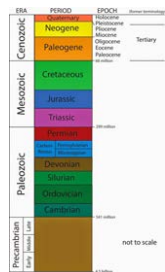
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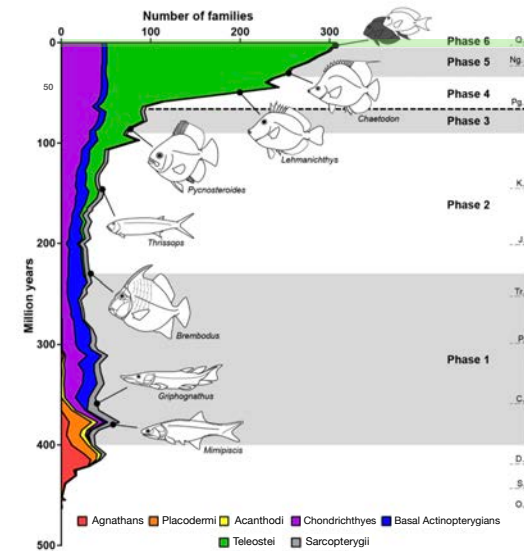
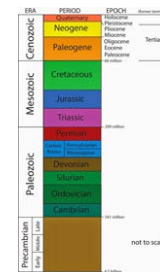
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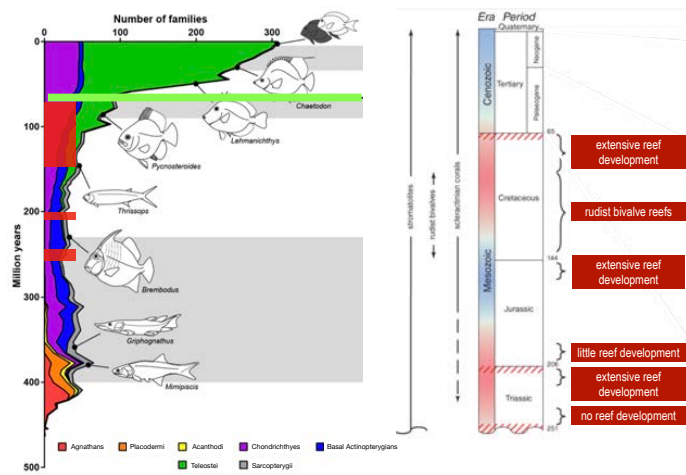
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Bellwood et al. 2015

BACKGROUND: THE ORIGIN



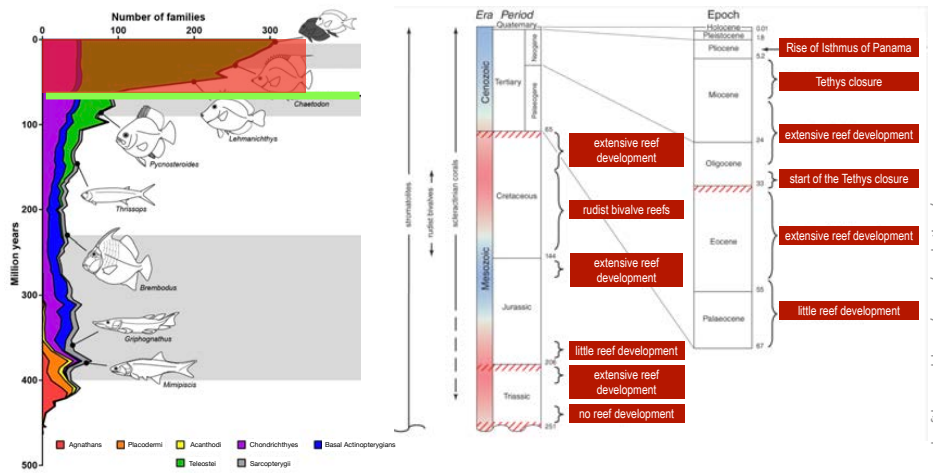
This suggests that the origins of modern coral reefs and their associated fish families may be closely linked.

<http://www.coralsoftheworld.org/page/evolution/>

RUDIST BIVALVE REEFS



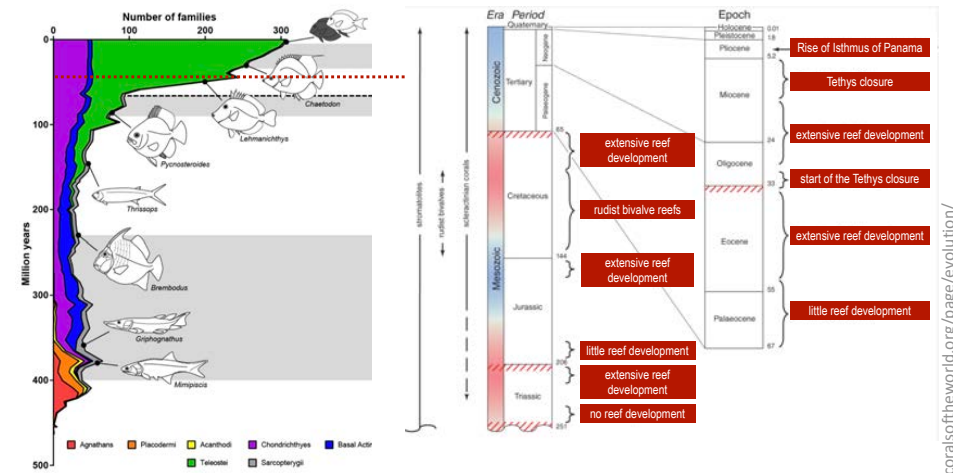
BACKGROUND: THE ORIGIN



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QUESTIONS

1 What are the temporal origins of trophic modes on coral reef fish?

2 What roles have coral reefs played through time?

3 How has historical biogeography shaped coral reef diversity?

TROPHIC EVOLUTION

1 What are the temporal origins of trophic modes on coral reef fish?
Of the 5000 fish species on coral reefs, corals dominate the diet of just 41 species

TROPHIC EVOLUTION

LABRIDAE

1

What are the temporal origins of trophic modes on coral reef fish?

Patterns of trophic evolution?

600 spp, 80 genera

Diverse specialized feeding modes

Moderate fossil record

Little info on origins of novel feeding modes



TROPHIC EVOLUTION

1

What are the temporal origins of trophic modes on coral reefs?

Patterns of trophic evolution?

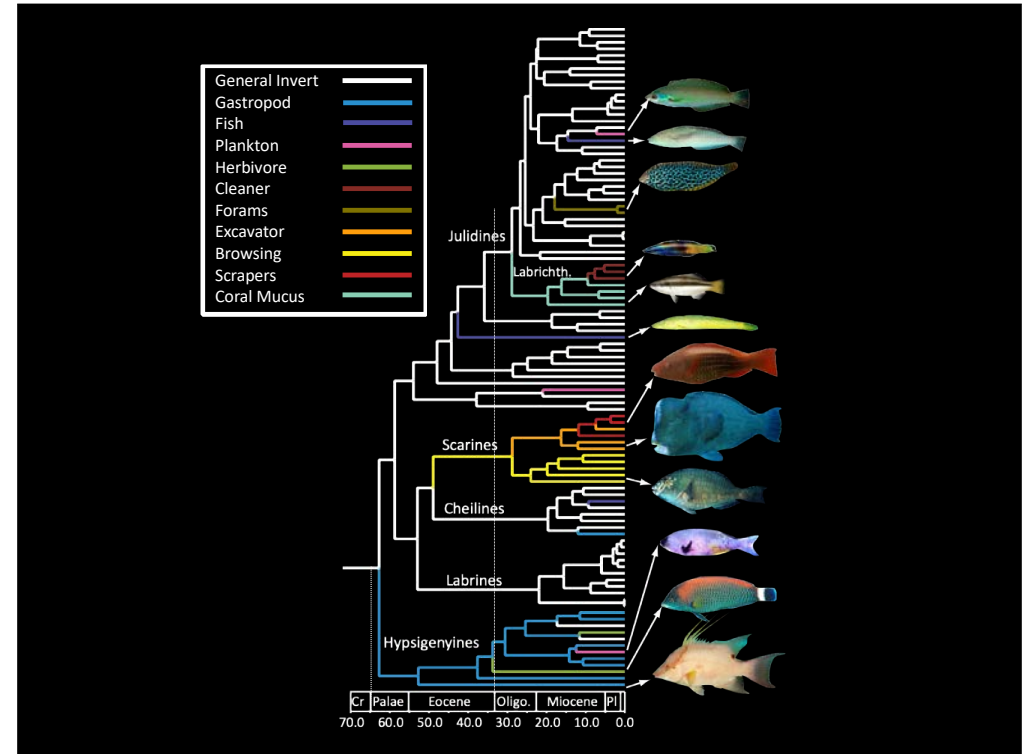
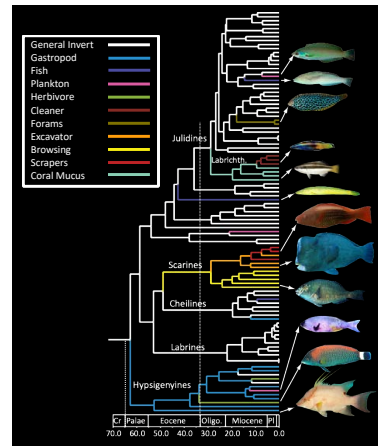


Modest fossil record for the Labridae from the Eocene.

TROPHIC EVOLUTION

LABRIDAE

1 What are the temporal origins of trophic modes on coral reefs?
Patterns of trophic evolution?



TROPHIC EVOLUTION

CHAETODONTIDAE

1

What are the temporal origins of trophic modes on coral reef fish?

Origins of corallivory in the Chaetodontidae

130 spp, 10 genera
63% of all corallivores
Little info on origins of corallivory
Effect of coral feeding of speciation



TROPHIC EVOLUTION

1

What are the temporal origins of trophic modes on coral reef fish?

Origins of corallivory in the Chaetodontidae

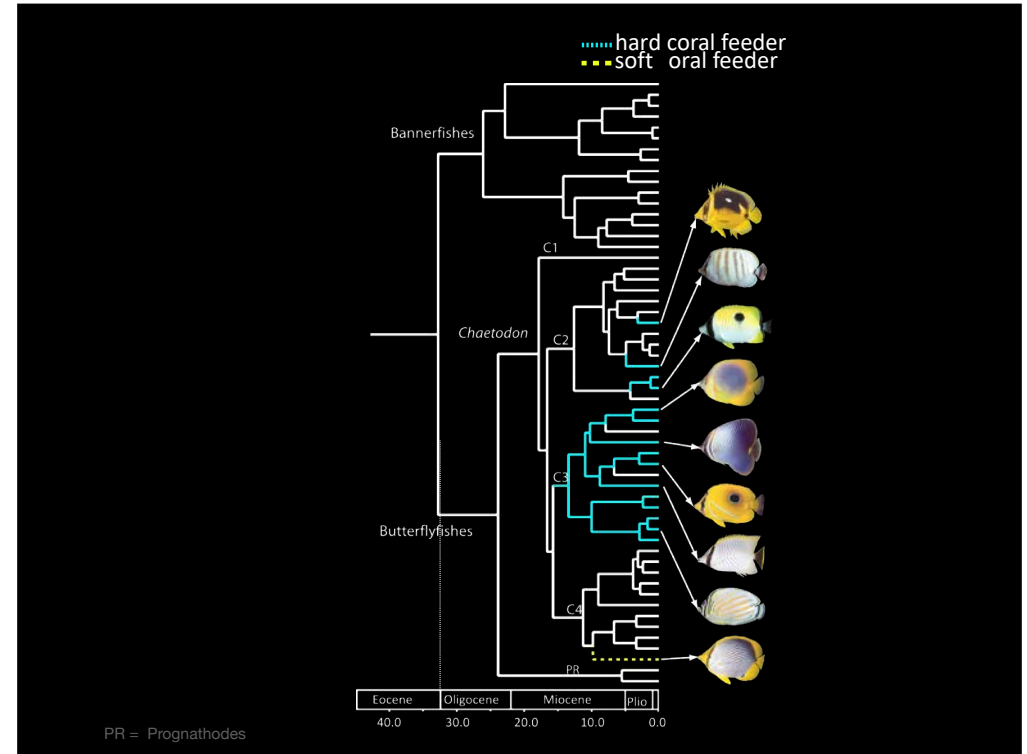
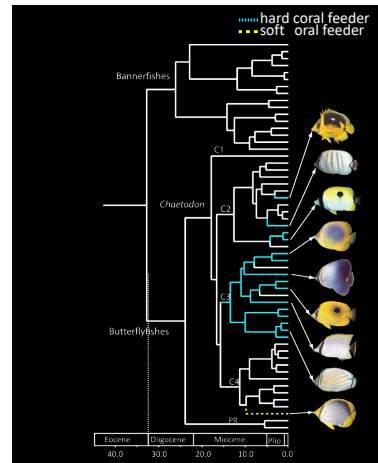


The oldest reliable fossil evidence for the Chaetodontidae is of Miocene age (Carnevale, 2006).

TROPHIC EVOLUTION

CHAETODONTIDAE

1 What are the temporal origins of trophic modes on coral reef fish?
Origins of corallivory in the Chaetodontidae



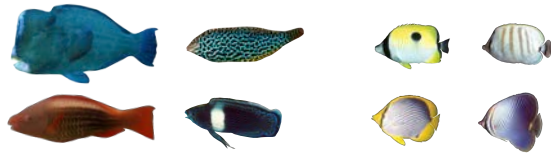
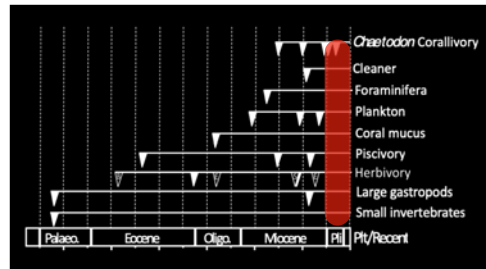
TROPHIC EVOLUTION

LABRIDAE/CHAETODONTIDAE

1

What are the temporal origins of trophic modes on coral reef fish?

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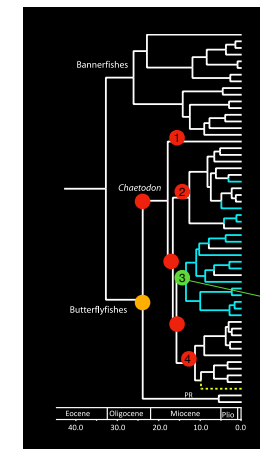
TROPHIC EVOLUTION

CHAETODONTIDAE

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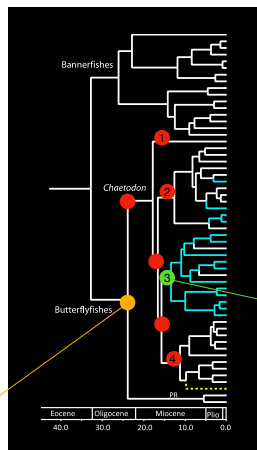
most corallivores

Not more diverse than expected

TROPHIC EVOLUTION

CHAETODONTIDAE

1 What are the temporal origins of trophic modes on coral reef fish?
Origins of corallivory in the Chaetodontidae



Move onto coral reefs underpins cladogenesis in *Chaetodon*

Significantly more diverse than expected

most corallivores

Not more diverse than expected

TROPHIC EVOLUTION: CONCLUSIONS

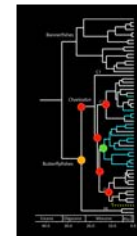
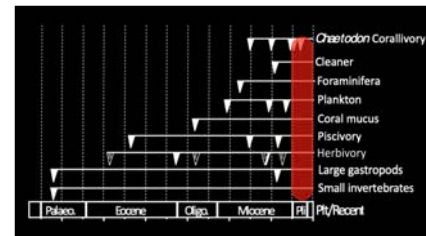
1 Conclusion:
What are the temporal origins of trophic modes on coral reef fish?

LABRIDAE

Multiple origins
Escalation of novelty
Miocene
~7.5 MY in place

CHAETODONTIDAE

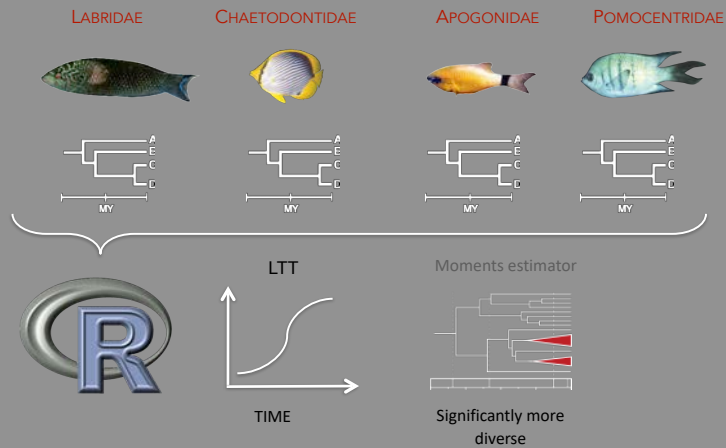
Multiple independent origins (5)
Miocene
Significantly diverse *Chaetodon*
Move onto coral reefs underpinned diversification



CORAL REEFS AS DRIVERS OF CLADOGENESIS

2

What roles have coral reefs played through time?



CORAL REEFS AS DRIVERS OF CLADOGENESIS

2

What roles have coral reefs played through time?

Temporal concordance in reef fish origins?

Does reef use increase diversification?

% Reef vs Rate of Diversification (reefs as drivers)

% Reef vs Extinction (reefs as refuge)

CORAL REEFS AS DRIVERS OF CLADOGENESIS

2

What roles have coral reefs played through time?

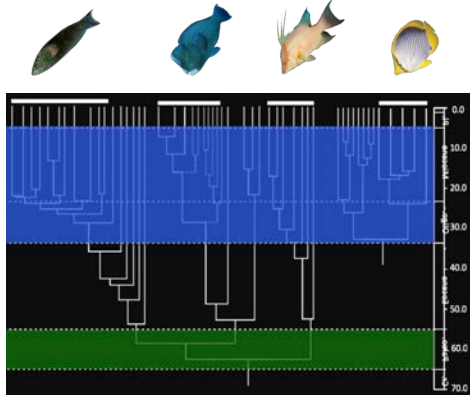
Rate of Diversification



Expanding reefs



K/T boundary



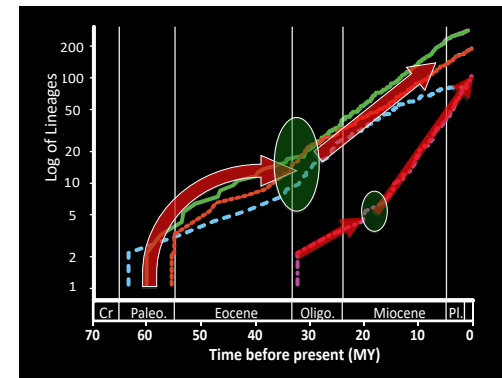
CORAL REEFS AS DRIVERS OF CLADOGENESIS

2

What roles have coral reefs played through time?

Extinction

[LTT]



LINEAGES THROUGH TIME

2

What roles have coral reefs played through time?

- Congruent patterns
- Expanding coral reef habitat
 - ✓ Supporting high diversification
 - ✓ Refuge from high extinction

LINEAGES THROUGH TIME

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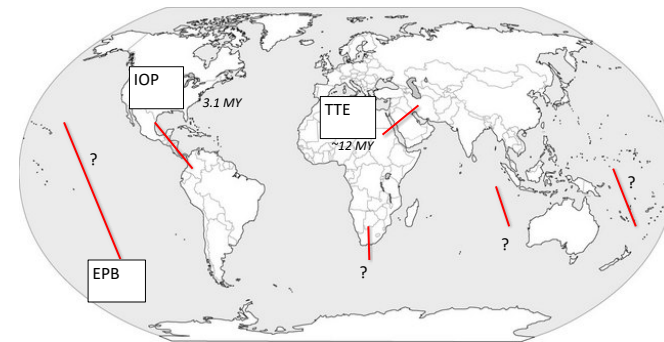
Speculation? There is much more data than what I am showing!

HOW HAS HISTORICAL BIOGEOGRAPHY SHAPED CORAL REEF DIVERSITY?

3

HOW HAS HISTORICAL BIOGEOGRAPHY SHAPED CORAL REEF DIVERSITY?

3



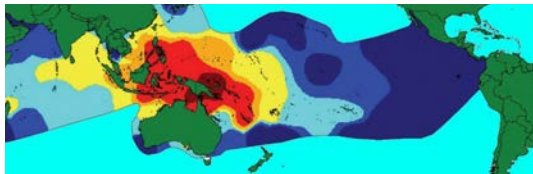
Barriers divide marine realms

HOW HAS HISTORICAL BIOGEOGRAPHY SHAPED CORAL REEF DIVERSITY?

3



Global distribution
Widespread Indo-Pacific
Endemics



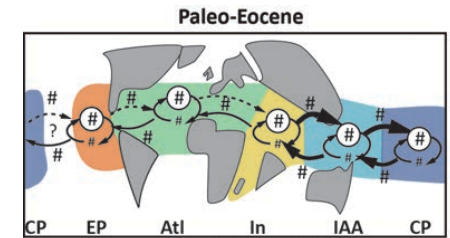
HOW HAS HISTORICAL BIOGEOGRAPHY SHAPED CORAL REEF DIVERSITY?

3



5 biogeography regions

1. East Pacific (EP)
2. Atlantic (Atl.)
3. Indian Ocean (In)
4. Indo-Australian Archipelago (IAA)
5. Central Pacific (CP)

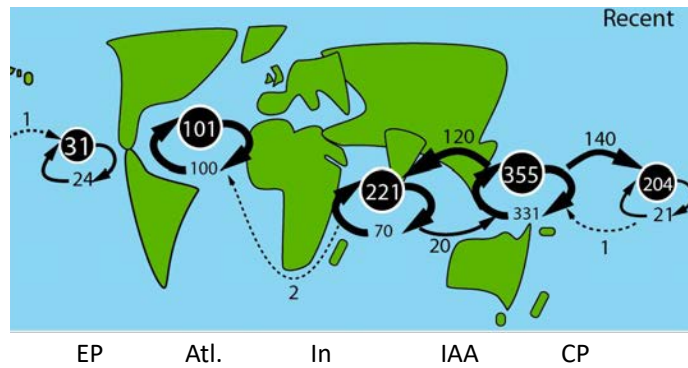


METHODS: ANCESTRAL RANGE RECONSTRUCTION

HOW HAS HISTORICAL BIOGEOGRAPHY SHAPED CORAL REEF DIVERSITY?

3

Extant Lineages



Richness
Origination
Dispersal



HOW HAS HISTORICAL BIOGEOGRAPHY SHAPED CORAL REEF DIVERSITY?

3

Conclusions

Patterns of Origination and dispersal

East Pacific & Atlantic ⇒ Isolated and Independent

IAA ⇒ Accumulation, Survival, Origin, Expansion

Indian Ocean & Central Pacific ⇒ Recipient/evolutionary sink

Vicariance and Barriers ⇒ Hard barriers are temporally diffuse
⇒ Soft barriers are temporally concordant

HOW HAS HISTORICAL BIOGEOGRAPHY SHAPED CORAL REEF DIVERSITY?

Conclusions

3

Trophic Evolution:

Miocene Important for novel feeding modes

Biogeography & coral reef diversity

Drivers of cladogenesis (Miocene)
Refuge during high extinction

Role of Coral Reef:

IAA – Centre of Accumulation, Survival, Origin & Expansion