



9-1-2013

A Pre-Zygotic Barrier to Hybridization in Two Con-Generic Species of Scleractinian Corals

Andrew H. Baird
James Cook University


Vivian R. Cumbo
James Cook University

Joana Figueiredo
James Cook University, jfigueiredo@nova.edu

Saki Harii
University of the Ryukyus - Japan

Find out more information about [Nova Southeastern University](#) and the [Oceanographic Center](#).

Follow this and additional works at: http://nsuworks.nova.edu/occ_facarticles

 Part of the [Marine Biology Commons](#), and the [Oceanography and Atmospheric Sciences and Meteorology Commons](#)

NSUWorks Citation

Andrew H. Baird, Vivian R. Cumbo, Joana Figueiredo, and Saki Harii. 2013. A Pre-Zygotic Barrier to Hybridization in Two Con-Generic Species of Scleractinian Corals .F1000Research , (193) : 1 -5. http://nsuworks.nova.edu/occ_facarticles/422.

This Article is brought to you for free and open access by the Department of Marine and Environmental Sciences at NSUWorks. It has been accepted for inclusion in Oceanography Faculty Articles by an authorized administrator of NSUWorks. For more information, please contact nsuworks@nova.edu.



OBSERVATION ARTICLE

A pre-zygotic barrier to hybridization in two con-generic species of scleractinian corals [v1; ref status: indexed, <http://f1000r.es/1uz>]

Andrew H. Baird¹, Vivian R. Cumbo¹, Joana Figueiredo¹, Saki Harii²

¹Australian Research Council, Centre of Excellence for Coral Reefs Studies, James Cook University, Townsville, Australia

²Sesoko Station, Tropical Biosphere Research Center, University of the Ryukyus, Okinawa, Japan

v1 First published: 20 Sep 2013, 2:193 (doi: [10.12688/f1000research.2-193.v1](https://doi.org/10.12688/f1000research.2-193.v1))
 Latest published: 01 Nov 2013, 2:193 (doi: [10.12688/f1000research.2-193.v2](https://doi.org/10.12688/f1000research.2-193.v2))

Abstract

Hybridization is often cited as a potential source of evolutionary novelty in the order *Scleractinia*. While hybrid embryos can be produced *in vitro*, it has been difficult to identify adult hybrids in the wild. Here, we tested the potential for hybridization between two closely related species in the family Fungiidae. We mixed approximately 5000 eggs of *Ctenactis echinata* with sperm from *Ctenactis crass*. No hybrid embryos were produced. This observation adds to a growing body of evidence for pre-zygotic barriers to hybridization in corals and challenges the claim that hybridization is a major source of evolutionary novelty in the order.

Open Peer Review

Referee Status:

	Invited Referees	
	1	2
version 2 published 01 Nov 2013	report	
version 1 published 20 Sep 2013	report	report

- 1 **Yossi Loya**, Tel Aviv University Israel
- 2 **Bernie Degnan**, University of Queensland Australia

Discuss this article

Comments (0)

Corresponding author: Andrew H. Baird (andrew.baird@jcu.edu.au)

How to cite this article: Baird AH, Cumbo VR, Figueiredo J and Harii S. **A pre-zygotic barrier to hybridization in two con-generic species of scleractinian corals [v1; ref status: indexed, <http://f1000r.es/1uz>]** *F1000Research* 2013, 2:193 (doi: [10.12688/f1000research.2-193.v1](https://doi.org/10.12688/f1000research.2-193.v1))

Copyright: © 2013 Baird AH *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution Licence](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Data associated with the article are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver](#) (CC0 1.0 Public domain dedication).

Grant information: Funding was provided by the Australian Research Council Centre of Excellence for Coral Reef Studies COE561432 (AHB), a Queensland Smart Futures Fellowship (JF) and a Sesoko Tropical Biosphere Research Station Travel Award 2013 (VRC). *The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

Competing interests: No competing interests were disclosed.

First published: 20 Sep 2013, 2:193 (doi: [10.12688/f1000research.2-193.v1](https://doi.org/10.12688/f1000research.2-193.v1))

First indexed: 24 Oct 2013, 2:193 (doi: [10.12688/f1000research.2-193.v1](https://doi.org/10.12688/f1000research.2-193.v1))

Observation

Hybridization is a controversial topic in coral reef ecology^{1,2}. While small numbers of hybrid embryos can be produced in a few species *in vitro*³, the evidence for hybrids in the field is often equivocal because the genetic techniques used for corals cannot distinguish between hybridization and incomplete lineage sorting⁴. In fact, only one of the over 1300 species in the order is generally accepted to be unequivocally of hybrid origin: *Acropora prolifera*^{1,5}. Nonetheless, hybridization is often invoked as a source of evolutionary novelty in the order *Scleractinia*^{6,7}.

Here, we report an incidental observation on the potential for hybridization between two closely related scleractinian corals species in the family Fungiidae, *Ctenactis echinata* and *Ctenactis crassa*. These species are sympatric, often dominating large multi-specific assemblages of fungiid corals throughout the central Indo-Pacific⁸. Colonies of these species are superficially very similar (Figure 1A and B) but can readily be distinguished by the shape of the costal dentitions⁹. Both species are gonochoric, that is each colony is either male or female, and reproduce by broadcast spawning, releasing gametes into the water column for fertilization⁸ (Figure 1C and D). At our study site on Sesoko Island (26°38'13.00"N; 127°51'56.24"E), Okinawa, Japan, spawning occurs following the full moons from July to August⁸. Furthermore, both species release gametes at the same time⁸ and consequently there is the potential for hybridization. In the days before the predicted date of spawning in July 2013, we collected four colonies of *C. echinata* and six colonies of *C. crassa*, to produce larvae for other experiments.

While the species are relatively easy to identify, determining the sex of each individual prior to spawning is impossible without destructive sampling to expose the gametes. Consequently, we placed each individual in a separate 20 L bucket containing sea water in the open air at approximately 20:00 h in order to sex each individual once gametes had been released. On the night of 27 July between 22:30 and 23:30 h three *C. echinata* and five *C. crassa* spawned revealing that the three spawning *C. echinata* were female, while four *C. crassa* were females and one was a male. The size of the eggs of each species at the time of release was distinct with a range in maximum diameter of 244–266 µm in *C. echinata* and 133–155 µm in *C. crassa*. In contrast to earlier work on *C. echinata*¹⁰, we saw no symbiotic algae in the eggs of either species. We collected approximately 5000 eggs from the three *C. echinata* females and mixed them with sperm from the *C. crassa* male. As a positive control we mixed eggs from the four *C. crassa* females with the *C. crassa* sperm. Approximately 100 eggs were observed under a stereo-dissecting microscope for cleavage, indicating fertilization, every 2 to 6 h over the next 24 h. At no point did we observe cleavage in the cross between species indicating that no hybrid embryos were produced. In contrast, over 90% of *C. crassa* eggs in the positive control were fertilized within 2 h. We conclude that despite synchrony in the time of gamete release between these two closely related sympatric species there appears to be strong pre-zygotic mechanism

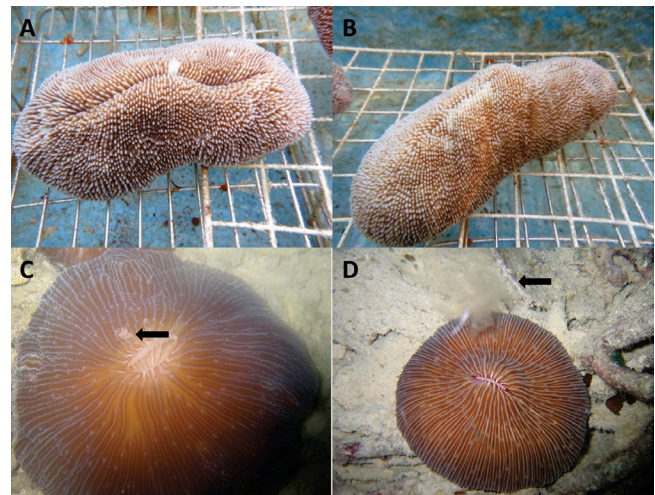


Figure 1. Study species and broadcast spawning in fungiid corals. Live *Ctenactis echinata* (A) and *C. crassa* (B) in aquaria prior to being isolated for spawning. Each colony is approximately 20 cm in length. Coral species in the family Fungiidae, such as these colonies of *Fungia repanda*, are gonochoric broadcast spawners: each individual releases either eggs (C) or sperm (D) into the water column where fertilization takes place (arrows indicate gametes).

to avoid hybridization. While our observations are preliminary and in only one direction (i.e. we did not cross *C. echinata* males with *C. crassa* females) we predict that hybridization between these species is unlikely. This observation adds to a growing body of evidence indicating strong pre-zygotic barriers to hybridization in many scleractinian corals^{11–13}.

Author contributions

AHB, VRC & JF conceived the study and performed the experiment. All authors contributed to writing the manuscript.

Competing interests

No competing interests were disclosed.

Grant information

Funding was provided by the Australian Research Council Centre of Excellence for Coral Reef Studies COE561432 (AHB), a Queensland Smart Futures Fellowship (JF) and a Sesoko Tropical Biosphere Research Station Travel Award 2013 (VRC).

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Acknowledgements

We thank the staff at the Sesoko Tropical Biosphere Research Station, University of the Ryukyus, for their assistance.

References

1. Vollmer SV, Palumbi SR: **Hybridization and the evolution of reef coral diversity.** *Science*. 2002; **296**: 2023–2025.
[PubMed Abstract](#) | [Publisher Full Text](#)
2. Miller DJ, van Oppen MJ: **A 'fair go' for coral hybridization.** *Mol Ecol*. 2003; **12**(4): 805–807.
[PubMed Abstract](#) | [Publisher Full Text](#)
3. Willis BL, Babcock RC, Harrison PL, *et al.*: **Experimental hybridization and breeding incompatibilities within the mating systems of mass spawning reef corals.** *Coral Reefs*. 1997; **16**: S53–S65.
[Publisher Full Text](#)
4. Flot JF, Couloux A, Tillier S: **Haplonebs as a graphical tool for delimiting species: a revival of Doyle's "field for recombination" approach and its application to the coral genus *Pocillopora*.** in Clipperton. *BMC Evol Biol*. 2010; **10**: 372.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
5. Fogarty ND: **Caribbean acroporid coral hybrids are viable across life history stages.** *Marine Ecology Progress Series*. 2012; **446**: 145–159.
[Publisher Full Text](#)
6. Willis BL, van Oppen MJ, Miller DJ, *et al.*: **The role of hybridization in the evolution of reef corals.** *Annual Review of Ecology Evolution and Systematics*. 2006; **37**: 489–517.
[Publisher Full Text](#)
7. Richards ZT, van Oppen MJ, Wallace CC, *et al.*: **Some rare Indo-Pacific coral species are probable hybrids.** *Plos One*. 2008; **3**: e3240.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
8. Loya Y, Heyward A, Sakai K: **Reproductive patterns of fungiid corals in Okinawa, Japan.** *Galaxea*. 2009; **11**: 119–129.
[Publisher Full Text](#)
9. Hoeksema BW: **Systematics and ecology of mushroom corals.** (Scleractinia: Fungiidae) [Ph D] 1989.
10. Combosch DJ: **Preliminary investigations about the hybridization potential in Japanese Fungiidea (Scleractinia).** In: Hidaka M, Sakai K, Harii S, editors; 2007; Proceedings of the 21st Century Centre of Excellence International Summer Programme, University of the Ryukyus, Okinawa, Japan. University of the Ryukyus.
11. Wolstenholme JK: **Temporal reproductive isolation and gametic compatibility are evolutionary mechanisms in the *Acropora humilis* species group (Cnidaria; Scleractinia).** *Marine Biology*. 2004; **144**: 567–582.
[Publisher Full Text](#)
12. Morita M, Nishikawa A, Nakajima A, *et al.*: **Eggs regulate sperm flagellar motility initiation, chemotaxis and inhibition in the coral *Acropora digitifera*, *A. gemmifera* and *A. tenuis*.** *J Exp Biol*. 2006; **209**(Pt 22): 4574–4579.
[PubMed Abstract](#) | [Publisher Full Text](#)
13. Fogarty ND, Lowenberg M, Ojima MN, *et al.*: **Asymmetric conspecific sperm precedence in relation to spawning times in the *Montastraea annularis* species complex (Cnidaria: Scleractinia).** *J Evol Biol*. 2012; **25**(12): 2481–2488.
[PubMed Abstract](#) | [Publisher Full Text](#)

Open Peer Review

Current Referee Status:



Version 1

Referee Report 24 October 2013

doi:10.5256/f1000research.2411.r1878



Bernie Degnan

School of Biological Sciences, University of Queensland, Brisbane, Australia

This Observation Article reports the lack of cross-fertilization between *Ctenactis echinata* and *Ctenactis crassa*, closely related fungiid corals that naturally release gametes at the same time. The authors recognise the limitations of this observation - only small numbers of eggs (100's) were observed and only eggs from *C. echinata* were available to be fertilized (i.e. they did not cross *C. echinata* males with *C. crassa* females) - but rightly point out that this study provides further evidence that hybridization is not as widespread amongst scleractinian corals as often portrayed in the literature. However, the analysis of reciprocal crosses and a larger numbers of eggs is necessary before it can be said with some confidence that these congeners can not hybridize.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.

Author Response (F1000Research Advisory Board Member) 26 Oct 2013

Andrew Baird, School of Marine Biology and Aquaculture, James Cook University, Australia

Dear Bernie,

Thank you for your comments. We would just like to point out that while we only examined 100 eggs every few hours under the microscope, we used approximately 5000 eggs in the fertilization experiment, all of which had broken down after 24 h suggesting none had fertilized. We have added a sentence to the revised text to draw attention to this.

Competing Interests: no competing interests

Referee Report 22 October 2013

doi:10.5256/f1000research.2411.r2160



Yossi Loya

Department of Zoology, Tel Aviv University, Tel Aviv, Israel

- The title is appropriate for the content of the article. The abstract represents a suitable summary of the work. Please correct: *crass* to *crassa*, in the 3rd line of the Abstract.
- Article content: The design, methods and analysis of the results been clearly explained and are appropriate for the topic being studied. Figures 1C and 1D appear to be irrelevant to the article since they show different species. I suggest deleting them. A proper reference to the statement '*spawning occurs following the full moons from July to August*' (reference 8 in the manuscript) is: [Loya Y. & K. Sakai \(2008\). Bidirectional sex change in mushroom corals. *Proc. Roy. Soc. Biol. B* 275: 2335-2343.](#)
- Data and Conclusions: The authors note that they did not cross *C. echinata* males with *C. crassa* females; however they also did not test the positive control of crossing *C. echinata* males with *C. echinata* females (all their experimental *C. echinata* specimen were females). Nevertheless, this does not diminish their prediction that hybridization between these species is unlikely. The paper contributes further information to the controversial topic of potential hybridization and breeding incompatibilities within the mating systems of broadcast spawning reef corals.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.

Author Response (*F1000Research Advisory Board Member*) 26 Oct 2013

Andrew Baird, School of Marine Biology and Aquaculture, James Cook University, Australia

Dear Yossi,

Thank you for your comments. We have corrected the typos you identified, changed the reference as requested and added a sentence to clarify the controls that were used to test for gamete viability. Images 1 C & D are presented as an example of the spawning behavior of fungiids.

Competing Interests: none