Marine & Environmental Sciences Faculty Articles   Department of Marine and Environmental Sciences

11-21-2014

Comment on "Chemically Mediated Behavior of Recruiting Corals and Fishes: A Tipping Point That May Limit Reef Recovery"

Andrew H. Baird
James Cook University - Townsville, Australia

Vivian R. Cumbo
James Cook University - Townsville, Australia

Joana Figueiredo
Nova Southeastern University, <<span class="elink">jfigueiredo@nova.edu

Saki Harii
University of the Ryukyus - Japan

Tom Hata
Stanford University

See next page for additional authors

Authors

Joshua S. Madin
Macquarie University - Sydney, Australia

1 **Comment on "Chemically mediated behavior of recruiting corals and fishes: A tipping**

2 **point that may limit reef recovery"**

3

4 Baird AH[1*], Cumbo VR[1], Figueiredo J[2], Harii S[3], Hata T[4], Madin JS[5]

5

6 [1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville,

7 Queensland, 4811, Australia

8 [2]Oceanographic Center, Nova Southeastern University, 8000 N Ocean Drive, Dania Beach,

9 FL 33004, USA

10 [3]Sesoko Tropical Biosphere Marine Station, University of the Ryukyus, Okinawa, Japan

11 [4]Hopkins Marine Station, Stanford University, Pacific Grove, CA 93950, USA

12 [5]Department of Biological Sciences, Macquarie University, NSW 2109, Australia

13 *corresponding author andrew.baird@jcu.edu.au

14

15 **Abstract**

16 Dixson *et al.*[1] report that coral larvae navigate towards chemical cues associated with healthy

17 reefs and avoid cues from degraded reefs. However, the swimming capabilities of coral

18 larvae and well-established patterns of recruitment and reef hydrodynamics indicate that coral

19 larvae will not be able to use these cues to recruit to healthy reefs.

20

21 **Main Text**

22 Dixson *et al.* (*1*) present a series of experiments suggesting that coral larvae can distinguish

23 between chemical cues associated with healthy and degraded reefs, and subsequently imply

24 that coral larvae will use these cues to navigate to healthy reefs. However, many of their

25 results are contrary to our current understanding of coral larval swimming capabilities and

26 well-established patterns of recruitment in the field. In addition, the flow structure in their

27 flume is likely to be more dynamic than suggested, making choice experiments with coral

28 larval difficult to interpret.

29   In a first set of flume experiments, larvae of three species of *Acropora* overwhelming

30 preferred to spend time in water collected from areas of reefs protected from fishing when

31 compared to water collected from areas lacking protection. However, coral larvae are very

32 slow swimmers and based on previously published work are unlikely to be able to maintain

33 their position in the flume for the 5 min duration of the experiment. The reported flow speed

34 of 4.2 mms^{-1} is greater than the mean of all average swimming speeds reported to date, even

35 when larvae are assisted by gravity (i.e., swimming downwards; Fig. 1). The maximum

36 horizontal swimming speed recorded for a coral larva is 3.45 mms^{-1} (Table 1), which is well

37 below the minimum speed required to maintain position in the flume, let alone navigate

38 between the two water bodies. The remarkable consistency of larval behavior in the flume

39 (Fig. 1A; Dixson *et al*.) is highly unusual and suggests that a physical rather than behavioral

40 mechanism is operating. Indeed, the flow structure in their flume is likely to be much more

41 complicated than they describe due to the presence of a barrier initially separating the two

42 water sources and the barrier's abrupt end at the beginning of the test section. It is highly

43 unlikely that visual inspection of a dye plume would sufficiently characterize flow conditions

44 experienced by such small larvae in this flume. Well established techniques such as particle

45 image velocimetry, laser-Doppler velocimetry or planar laser-induced fluorescence (*2*) should

46 have been used to verify that flow biases do not exist at the scale relevant to coral larvae.

47   The spatial pattern in the recruitment of corals to settlement tiles are also highly

48 unusual for a reef system that has a high number of reefs in close proximity, such as Dixson

49 *et al.* sites in Fiji. Their results imply a strong positive correlation between adult coral cover

50 and recruitment to settlement tiles. Indeed, not a single recruit was found on tiles placed in

the non-protected reef areas where coral cover was uniformly low. In contrast, in a two year

study of 33 reefs spanning the length of Great Barrier Reef there was no correlation between

adult abundance and coral recruitment to settlement tiles (*3*). Furthermore, only one of the

132 sites (4 sites per reef and 8 tiles per site) had no recruits (*3*). The lack of an effect of algal

clearance on juvenile recruitment to the substratum is also anomalous. In contrast, artificial

exclusion of herbivores reduces rates of coral juvenile recruitment 3-fold, presumably due to

dramatic increases in abundance of seaweeds in herbivore exclusion plots (*4*).

Even if coral larvae can distinguish between chemical cues associated with healthy

and degraded reefs it is highly unlikely they will be able to use this information to navigate

against ubiquitous tidal and other currents to preferred reefs for recruitment. Currents

connecting reefs rarely fall below 100 mms^{-1} (*5*), which is almost two-orders of magnitude

greater than typical coral larval swimming speeds (Table 1; Fig. 1). All existing measures

indicate that coral larvae are very slow swimmers and therefore will behave as passive

particles relative to inter-reef hydrodynamic regimes (*6*). Perfuming degraded reefs, as

suggested by Dixson *et al*., will not enhance recovery rather it will distract from the difficult

task of reducing fishing effort and improving water quality.

68 **References**

69 1. D. L. Dixson, D. Abrego, M. E. Hay, Chemically mediated behavior of recruiting
70 corals and fishes: A tipping point that may limit reef recovery. *Science* **345**, 892-897
71 (2014).
72 2. M. A. R. Koehl, Mini review: Hydrodynamics of larval settlement into fouling
73 communities. *Biofouling* **23**, 357-368 (2007).
74 3. T. P. Hughes, A. H. Baird, E. A. Dinsdale, N. A. Moltschaniwskyj, M. S. Pratchett, J.
75 E. Tanner, B. L. Willis, Supply-side ecology works both ways: The link between
76 benthic adults, fecundity, and larval recruits. *Ecology* **81**, 2241-2249 (2000).
77 4. T. P. Hughes, M. J. Rodrigues, D. R. Bellwood, D. Ceccarelli, O. Hoegh-Guldberg, L.
78 McCook, N. Moltschaniwskyj, M. S. Pratchett, R. S. Steneck, B. Willis, Phase shifts,
79 herbivory, and the resilience of coral reefs to climate change. *Curr. Biol.* **17**, 360-365
80 (2007).
81 5. R. Brinkman, E. Wolanski, E. Deleersnijder, F. McAllister, W. Skirving, Oceanic
82 inflow from the Coral Sea into the Great Barrier Reef. *Estuar. Coast Shelf Sci.* **54**,
83 655-668 (2002).
84 6. E. Wolanski, M. J. Kingsford, Oceanographic and behavioural assumptions in models
85 of the fate of coral and coral reef fish larvae. *J. Roy. Soc. Interface* **11**, 20140209
86 (2014).
87 7. N. Abe, Post-larval development of the coral *Fungia actiniformis* var. *palawensis*
88 Doderlein. *Palao Trop. Biol. Sta. Stud.* **1**, 73-93 (1937).
89 8. S. Harii, H. Kayanne, H. Takigawa, T. Hayashibara, M. Yamamoto, Larval
90 survivorship, competency periods and settlement of two brooding corals, *Heliopora*
91 *coerulea* and *Pocillopora damicornis*. *Mar. Biol.* **141**, 39-46 (2002).
92 9. J. Harrigan, Ph. D., University of Hawaii, Honolulu (1972).
93 10. S. Motoda, Observation of Period of Extrusion of Planula of *Goniastrea aspera*
94 (Verrill.). *Kagaku Nanyo* **1**, 5-7 (1939).
95 11. D. F. Gleason, B. S. Danilowicz, C. J. Nolan, Reef waters stimulate substratum
96 exploration in planulae from brooding Caribbean corals. *Coral Reefs* **28**, 549-554
97 (2009).
98 12. K. Atoda, The larva and postlarval development of the reef-building corals IV
99 *Galaxea aspera* (Quelch). *J. Morphol.* **89**, 17-36 (1951).
100 13. K. Atoda, The larva and postlarval development of some reef-building corals I.
101 *Pocillopora damicornis cespitosa* (Dana). *Sci Rep Tohoku Uni 4th series (Biol)* **18**,
102 24-47 (1947).
103 14. K. Atoda, The larva and postlarval devlopment of the reef-building corals III.
104 *Acropora brueggemanni* (Brook). *J. Morphol* **89**, 1-16 (1951).
105 15. K. Atoda, The larva and post-larval development of some reef-building corals V.
106 *Seriatopora hystrix* (Dana). *Sci Rep Tohoku Uni 4th series (Biol)* **19**, 33-39 (1951).

107

108

Table 1. Swimming speeds in mms^{-1} for hermatypic scleractinian coral larvae. n = number of larvae; SE = standard error; a = mean calculated as average of maximum and minimum value; b = mean calculated from larvae aged 2 to 7 days old.

Species	Swim direction	Min	Max	Mean	SE	n	Larvae length (mm)	Reference
Heliogungia actinoformis	horizontal	1.15	1.90	1.57	0.09	8	0.50	(*7*)
Pocillopora damicornis[a]	horizontal	1.67	1.88	1.78	na	na	1.00	(*8*)
Pocillopora damicornis[b]	horizontal	0.08	3.09	2.01	0.07	82	1.18	(*9*)
Coelastrea aspera[a]	horizontal	2.00	3.45	2.73	na	na	0.47	(*10*)
Heliogungia actinoformis	up	0.90	2.65	1.66	0.09	18	0.50	(*7*)
Agaricia teunifolia	up	1.04	3.16	2.10	0.20	28	na	(*11*)
Galaxea horrescens	up	1.32	3.33	2.41	0.15	20	2.30	(*12*)
Pocillopora damicornis	up	1.61	4.50	2.79	0.11	30	2.00	(*13*)
Porties asteroides	up	1.26	4.34	2.80	0.20	59	0.75	(*11*)
Isopora bruggemanni	up	1.10	4.55	2.86	0.24	20	2.50	(*14*)
Seriatopora hystrix	up	na	na	3.33	na	na	1.50	(*15*)
Heliogungia actinoformis	down	1.97	3.80	2.76	0.17	9	0.50	(*7*)
Isopora bruggemanni	down	2.56	5.56	3.55	0.18	20	2.50	(*14*)
Agaricia teunifolia	down	2.01	5.19	3.60	0.30	28	na	(*11*)
Galaxea horrescens	down	3.03	5.21	3.86	0.13	20	2.30	(*12*)
Porties asteroides	down	2.76	5.84	4.30	0.30	59	0.75	(*11*)
Seriatopora hystrix	down	na	na	4.44	na	na	1.50	(*15*)
Pocillopora damicornis	down	3.68	6.49	4.79	0.13	30	2.00	(*13*)

115   **Figure 1.** Coral larvae are notoriously slow swimmers. The minimum swimming speed

116   required to hold position in the experimental flume used by Dixson *et al.* (4.2 mms^{-1}, red star)

117   is more than twice the mean horizontal swimming speed of larvae in other studies. Mean

118   swimming speeds were taken from 14 studies representing over 450 speed measurements (for

119   references see Table 1. The raw data is available at coraltraits.org). An ANCOVA for log-

120   transformed speed data against larvae size and swimming direction found only a significant

121   effect of direction (after dropping size: $F_{2,15} = 13.72$, $p < 0.001$), where gravity-assisted

122   swimming (downward) was significantly faster than other swimming directions (letters a and

123   b denote significant differences at $a = 0.05$, post-hoc Tukey's test).

124

125