High Mortality in a Surgeonfish Following an Exceptional Settlement Event

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Source: Pacific Science, 67(4):533-538. 2013.
Published By: University of Hawai'i Press
DOI: http://dx.doi.org/10.2984/67.4.4
URL: http://www.bioone.org/doi/full/10.2984/67.4.4

High Mortality in a Surgeonfish following an Exceptional Settlement Event[1]

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Abstract: Marine organisms occasionally settle at exceptional densities, whereby thousands of individuals arrive concurrently. High levels of mortality, which has historically been attributed to predation or competition, often follow this episodic settlement of reef fishes. Here, however, we observed large numbers of newly settled surgeonfish (*Ctenochaetus striatus*) with white lesions lying dead on the sand amongst patch reefs following separate episodic settlement events in 2006 and 2009 in Moorea, French Polynesia. Pathogens have been identified as an important driver of population dynamics in other marine organisms but less so for reef fishes. Our observations suggest that disease outbreaks may play an underappreciated role as a mechanism of mortality following episodic settlement events in reef fishes.

Reef fishes exhibit considerable spatiotemporal variation in recruitment. In rare cases, extraordinarily high levels of settlement (episodic settlement events) have been documented for a number of different families (Kami and Ikehara 1976, Pillai et al. 1983, Cowen 1985, Robertson 1988, Letourneur et al. 1998). High levels of postsettlement mortality often accompany episodic settlement events (e.g., Letourneur et al. 1998, Doherty et al. 2004, Jordan-Garza et al. 2009), which, in reef fishes, is typically attributed to predation (Almany and Webster 2006). For example, in a settlement event of >40,000 unicornfish, *Naso unicornis* (Acanthuridae), Doherty et al. (2004) estimated that approximately 60% of settlers were killed overnight by predators (with dead or injured settlers rarely observed). However, other processes such as the depletion of food resources (Kami and Ikehara 1976) and disease (Landsberg et al. 1995, Ferguson et al. 2000, Panek 2005) also likely contribute to mortality during episodic settlement. The most compelling evidence for alternate mechanisms of postsettlement mortality following episodic settlement is the documented presence of large numbers of newly settled fishes washing up on shores with no obvious evidence of physical damage from predatory encounters: Letourneur et al. (1998) documented thousands of undamaged honeycomb groupers, *Epinephelus merra* (Serranidae), being washed ashore on Réunion Island following a large recruitment event, and a recent study by Jordán-Garza et al. (2009) described up to 40 dead sharpnose pufferfish, *Canthigaster rostrata* (Tetraodontidae), per square meter on the beaches of the Yucatán. One possible explanation for this peculiar phenomenon is epizootic disease, whereby pathogens have high transmission rates in animal populations at high densities. Empirical evidence for disease, however,

[1] Funding provided by The French American Cultural Exchange Program and a Centre national de la recherche scientifique grant to Y. Chancerelle and T. Lison de Loma at CRIOBE. Manuscript accepted 28 October 2012.

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Pacific Science (2013), vol. 67, no. 4:533–538
doi:10.2984/67.4.4

remains elusive; for example, visual examination by Jordán-Garza et al. (2009) gave no obvious indication that *C. rostrata* were diseased. Thus, despite an emerging appreciation of the consequences of disease transmission in population die-offs of marine invertebrates (e.g., sea urchins, abalone, coral, and sea fans [Harvell et al. 1999]), there is little evidence to suggest that epizootic disease plays an important role in mortality of reef fishes.

In February 2006 and 2009, we observed two separate episodic settlement events of the striped bristletooth, *Ctenochaetus striatus* (Acanthuridae), where settlers formed large schools that swarmed throughout the lagoon of Moorea, French Polynesia. High levels of settler mortality followed this episodic settlement within the first week; however, here we hypothesize that an unknown pathogen caused high mortality, which left large numbers of dead and dying fish within the lagoon. We used a biannual 5-yr data set (2004 to 2009) to document two exceptionally high recruitment events of *C. striatus* and concurrent observations of pathogen-associated mass mortality of *C. striatus* to motivate future research.

MATERIALS AND METHODS

Moorea is a small volcanic island (~61 km of coastline) with a barrier reef enclosing a lagoon around most of the island's perimeter (see Galzin and Pointer [1985] for a description). To describe temporal variation in *Ctenochaetus striatus* recruitment we explored a 5-yr data set of fish community counts conducted biannually at 13 locations surrounding Moorea. Sites (26 total) were paired within two main reef habitats: (1) at nearshore fringing reef, and (2) at the backreef near the reef crest. Twice per year (in January–February and July–August), observers conducted three 20 m × 2 m transects to visually estimate the abundance and size of all fishes at each of the sites (see Lison de Loma et al. [2008] for full survey methodology and site map). Acanthurids like *C. striatus* can have specialized larvae that may spend several months in the plankton (Doherty et al. 1995) and settle at large sizes (Doherty et al. 2004, Lecchini and Galzin 2005; this study). We used 10 cm as the maximum size of *C. striatus* recruits, based upon direct in situ observations of *C. striatus* recruits and observed size frequency distributions of *C. striatus* during each sampling period.

RESULTS

Recruit densities of *Ctenochaetus striatus* were more than six times higher in February 2006 and 2009, in both the fringing reef and backreef, relative to the average density of recruits in other sampling periods (~3 recruits/50 m^2), respectively. There were smaller increases in 2009, relative to 2006 (Figure 1), but in both 2006 and 2009 we observed hundreds of apparently diseased fish lying dead or dying on the lagoon floor. Visible symptoms of the apparent infection and poor condition included large white lesions on the body and particularly anterior to the caudal peduncle, decreased swimming ability, and tattered fins (Figure 2). It is interesting that we did not observe predators immediately consuming dead or dying individuals. Predators may have been satiated, or alternatively may have avoided prey due to their poor condition.

DISCUSSION

Episodic settlement events have been documented for a number of families of coral reef fishes; however, our observations suggesting disease as a potential mechanism of post-settlement mortality are particularly unusual. Epizootic disease in marine fish appears to be ephemeral, and reports of obvious disease-associated lesions are relatively uncommon in reef fish populations (although disease incidence has been linked to density in a variety of taxa: Goulson and Cory 1995, Wilcox and Elderd 2003, Bell et al. 2006). A review of epizootic disease in coral reef fishes by Panek (2005) identified host-ectoparasite relationships and bacterial, fungal, and viral pathogens as possible causative agents of disease outbreak. Biotoxic algae (e.g., *Caulerpa*) and toxic dinoflagellates (e.g., *Gambierdiscus* and *Prorocentrum*) have also been cited as the possible etiologic agents of disease in reef fish

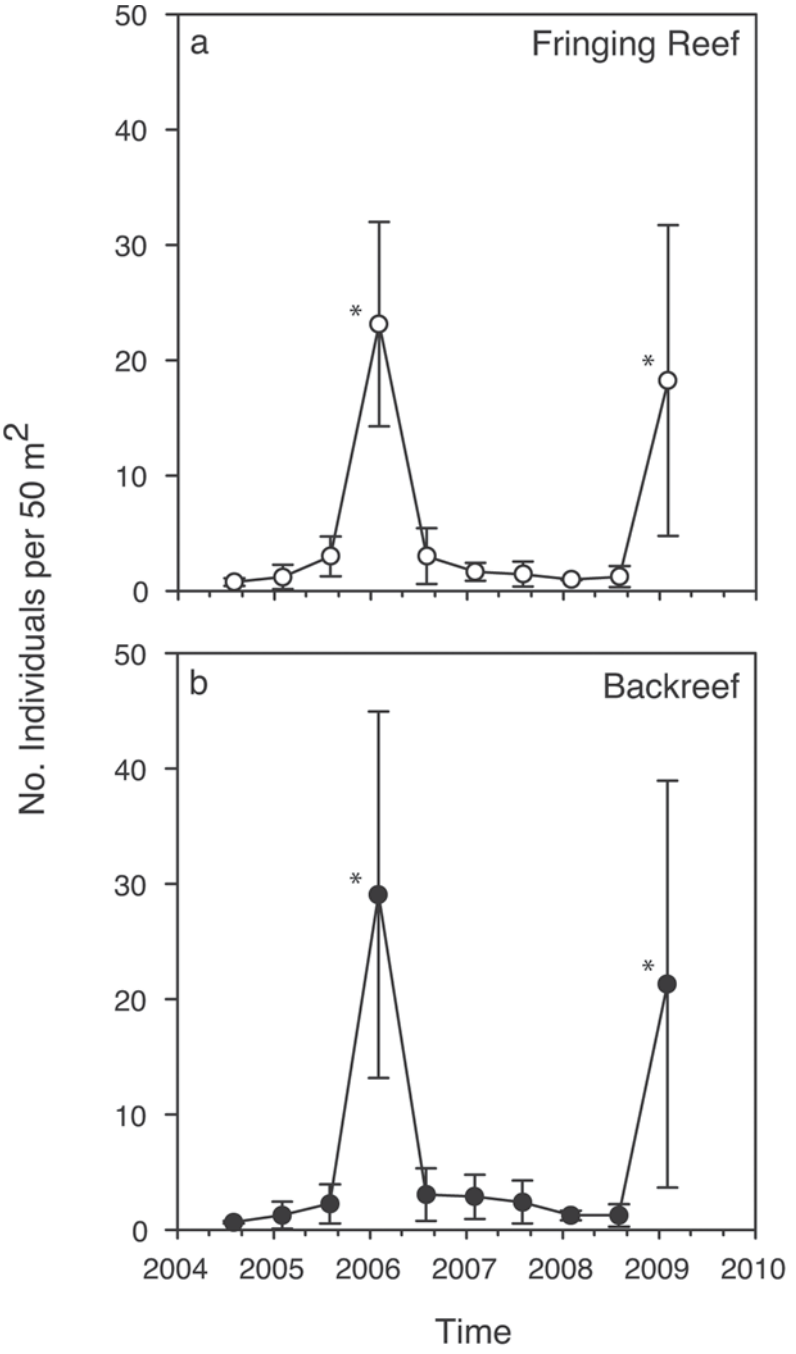

FIGURE 1. Temporal variation in mean (±1 SE) abundance of recently settled *Ctenochaetus striatus* (<10 cm) in (*a*) fringing reef and (*b*) backreef habitats from biannual samples between 2004 to 2009 at 13 survey sites surrounding Moorea, French Polynesia. Points with asterisks represent the two time steps (February 2006 and 2009) when disease was observed.

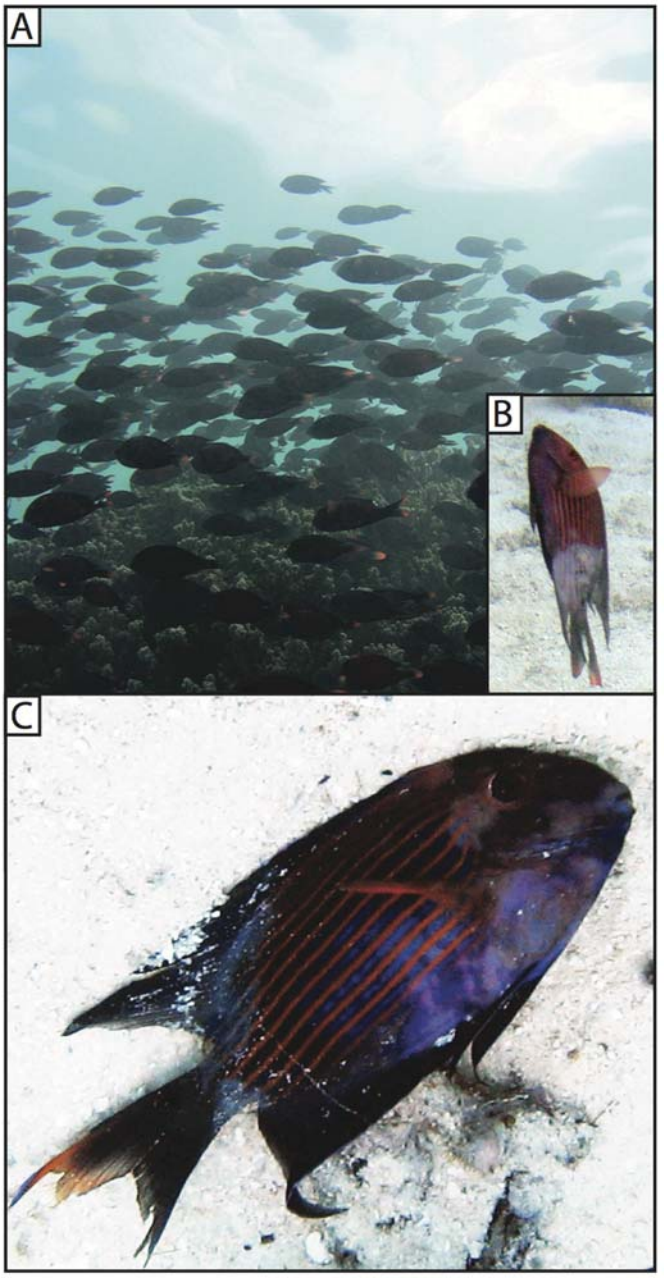

FIGURE 2. (*A*) *Ctenochaetus striatus* settlers swarm over a reef in Moorea during an episodic settlement event. (*B*) Many individuals exhibited white lesions anterior to the caudal peduncle and ventral of the right operculum. (*C*) A large fraction of settlers suffered mortality.

(Panek 2005). It is interesting that both episodic settlement pulses of *Ctenochaetus striatus* were concurrent with increased biomass of the toxic cyanobacteria *Lyngbya majuscula*, which has been implicated in surgeonfish toxicity in Hawai'i (Osborn et al. 2001) and therefore provides an alternative explanation for the observed mass mortality. However, toxic effects of *Lyngbya* on fish are generally not restricted to a single species, and we observed no other evidence of distressed or diseased fish in the lagoon. Unfortunately, the capricious nature of the episodic settlement event left us unable to conduct a more comprehensive investigation to verify the potential occurrence of disease or toxins as drivers of these mass mortality events; consequently, there is no conclusive evidence that either disease or toxins are the principal cause of mortality during these episodic recruitment events. However, from the evidence we present here, namely large numbers of dead and dying fish with visible lesions during major recruitment events, we hypothesize an important role of disease in driving the population structure of this reef fish during episodic settlement events. Future work should determine whether pathogens lead to outbreaks of epizootic disease in this and other reef fishes, and to assess potential population-level effects.

ACKNOWLEDGMENTS

We thank C. Osenberg for helpful comments and the Moorea Marine Protected Area consortium for access to recruitment data.

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