Diversity

Extinction Risk in Endemic Marine Fishes

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Developing effective management strategies for conserving species requires identifying the species with the greatest probability of extinction and determining why the probabilities are high. In terrestrial systems, endemic island species have the highest rates of extinctions (Frankham 1998; Whittaker 1998). Endemic species have high probabilities of extinction because they typically have both a small range size and low abundance (Gaston 1998). The tendency of local abundance to increase as a species' geographic range increases has been observed across a wide range of taxa (Brown 1984; Gaston et al. 1997; McKinney 1997). However, this relationship has rarely been tested rigorously for marine assemblages because data are lacking.

We studied this relationship with data for reef fishes. Their taxonomy and distribution is reasonably well known and their life history is typical of most marine species. The majority of reef fishes have a dispersive larval phase, followed by recruitment to, or near, a reef, where juveniles settle, grow, mature, and reproduce with high fecundities (Sale 1980). There are thousands of coral reef fishes, including a large number of endemic species, and they attain their greatest diversity in Indonesian waters, where they form the world's most species-rich vertebrate assemblages (Jones et al. 2002).

If abundance and range size are positively correlated, endemic reef fishes should have low abundance. However, this is not the case. Across a broad range of locations, families, trophic groups, and body sizes, endemic reef fishes are consistently among the most abundant within their taxon or ecological guild (i.e., species using similar resources) in their local assemblages (Table 1) (Fishelson 1977; Allen & Robertson 1996; Allen et al. 1998; Randall 1998; Jones et al. 2002; DeMartini 2004). Endemic reef fishes in some locations (e.g., Chaetodontidae at Lord Howe Island in the Pacific Ocean, Pomacanthidae at Christmas and Cocos islands in the Indian Ocean) are 40–80 times more abundant than co-occurring congenerics with broad geographic ranges (Hobbs et al. 2009; Hobbs et al. 2010). Furthermore, at locations in the Atlantic, Indian, and Pacific oceans, endemic reef fishes can comprise a significant percentage of the total number of individuals in an assemblage (e.g., 31% in Hawaii [DeMartini & Friedlander 2004], 25% in Brazil [Floeter et al. 2006], and 16% in Western Australia [Travers et al. 2010]).

Data on the abundance of widely distributed reef fishes across their entire geographic ranges are generally lacking; however, there are sufficient data for 2 families (butterflyfishes and surgeonfishes) to examine the abundance–range size relation; in neither family is local abundance of species correlated with range size (Jones et al. 2002; Pratchett et al. 2008). Determining the mechanisms by which endemic reef fishes maintain high abundances may be important to ensuring their long-term persistence.

Most endemic reef fishes inhabit waters surrounding isolated islands (Jones et al. 2002), where they may have evolved traits that generally are associated with high local abundance. For example, they may have lost long-distance dispersal abilities while evolving higher recruitment. Strong selection on larvae of species from isolated islands to return to their natal reefs may help maintain consistently high recruitment. In Hawaii, endemic reef fishes appear to have restricted dispersal (Eble et al. 2009) and higher and more consistent recruitment as compared with widespread congeners (DeMartini 2004; DeMartini & Friedlander 2004), which may explain why they maintain high local abundances. Similarly, endemic reef fishes at Lord Howe Island off eastern Australia have greater and more consistent recruitment than closely related species that are not endemic (Crean et al. 2010). However, the evolutionary processes or traits responsible for consistent recruitment and high adult abundance of endemic reef fishes have not been determined (Robertson 2001; Swearer et al. 2002; Crean et al. 2010).

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Table 1. Examples of endemic reef fishes with high abundance.*

Family	*Location*	*Endemic abundance*	n	*Source*
Acanthuridae	Hawaii	2	23	Hourigan & Reese 1987
Blenniidae	Hawaii	1,2	14	Hourigan & Reese 1987
Chaetodontidae	Hawaii	1,2,3	22	Hourigan & Reese 1987
Chaetodontidae	Red Sea	1,2,3,4,7,8,9,11	15	Roberts et al. 1992
Chaetodontidae	Middleton Reef, Australia	1	14	Hobbs & Feary 2007
Chaetodontidae	Lord Howe Island	1	22	Hobbs et al. 2009
Holocentridae	Hawaii	1	16	Hourigan & Reese 1987
Labridae	Hawaii	1,2	41	Hourigan & Reese 1987
Lethrinidae	Western Australia	1	12	Travers et al. 2010
Monocanthidae	Hawaii	1,2	6	Hourigan & Reese 1987
Pomacanthidae	Red Sea	2,3	4	Roberts et al. 1992
Pomacanthidae	Hawaii	1	7	Hourigan & Reese 1987
Pomacanthidae	Christmas Island	1,2	16	Hobbs et al. 2010
Pomacanthidae	Cocos (Keeling) Islands	1,2	9	Hobbs et al. 2010
Pomacentridae	Christmas Island	4	23	J.-P. A. Hobbs et al. unpublished
Scaridae	Hawaii	1,2	7	Hourigan & Reese 1987
Serranidae	Hawaii	1	14	Hourigan & Reese 1987
Tetraodontidae	Hawaii	1	10	Hourigan & Reese 1987

**Abundance presented as rank abundance within a family;* n, *number of species examined per family.*

The observation that endemic reef fishes frequently have high abundance could be influenced by reporting bias. Endemic reef fishes with low abundance are expected to be among the last species to be discovered (Zapata & Robertson 2007) and thus the occurrence of these endemic species may be underestimated. There are some endemic reef fishes with low abundance (Hawkins et al. 2000; Pratchett et al. 2008). However, given the numerous endemic reef fishes with high abundance, a reporting bias would not change the fact that the positive abundance–range size relationship does not apply to reef fishes.

Unlike endemic terrestrial species, endemic reef fishes are not characterized by low abundance, which could be due to extinction filtering. There may be few endemic reef fish with low abundance because such fishes are already extinct (cf. Johnson 1998). Stochastic processes, such as highly variable recruitment, increase extinction risk in small populations (Diamond 1984; McKinney 1997). Reef fishes typically have highly variable recruitment (Doherty 1991); thus, persistence time of endemic reef fishes with low abundance and variable recruitment could be extremely short.

Because reef fishes have distinct larval and adult life-history stages, as do the majority of marine organisms, other marine taxa may also lack a positive correlation between abundance and range size. Compared with terrestrial species, marine species typically have higher fecundities, greater dispersal of offspring, and highly variable offspring survival (Carr et al. 2003). These characteristics greatly increase recruitment variability. Although endemic species in terrestrial systems may persist at low abundances because their life-history traits produce relatively low recruitment variability, the marine endemics most likely to persist are those that can maintain high abundances or evolve traits for consistent recruitment.

The high abundance of marine endemic species may buffer them from intrinsic characteristics that increase the probability of extinction, such as low genetic diversity and demographic stochasticity, and it may also give them greater resilience to anthropogenic stressors (e.g., habitat loss and unsustainable harvest) than terrestrial endemics. However, marine fishes that became extinct in the last 200 years have been species with small ranges (Dulvy et al. 2003). The challenge now is to identify what ecological, biological, or genetic traits increase the probability of extinction in marine endemics. For example, recent habitat loss has resulted in extirpations of reef fishes that are habitat specialists (Munday 2004; Wilson et al. 2006). If specialization is associated with small range size (e.g., Hawkins et al. 2000), then endemic species will have a higher probability of extinction than species that are not endemic. Patterns of abundance in endemic marine fishes illustrate that ecological relationships and theories established in terrestrial systems may not always apply to the marine environment.

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