**Introduction**

Competitive interactions are widely considered to be dominant in governing the ecological and evolutionary dynamics of biodiversity on earth. Extensive empirical evidence demonstrates that competitive interactions govern the use of resources by species in communities (e.g., Lotka-Volterra, Tilman 1982; Diamond and Case 1986), the mechanism of natural selection (e.g., Darwin 1859; Simpson 1953), character displacement and adaptive radiation (Brown and Wilson 1956; Schluter 2000a,b; Losos 2009). Competition has accordingly occupied a central place in ecology and evolutionary biology for over a century.

In evolutionary biology, competition has been widely invoked to explain patterns of species richness across time and space in a macroevolutionary framework (see review in Rabosky 2013). Competition among species and clades for finite resources (e.g., “ecological limits”) is thought to impose carrying capacities on species diversity, and thus diversity-dependent diversification (Rabosky 2013). Compelling evidence exists that supports the view that diversity-dependent processes operate to regulate patterns of biodiversity at local, regional, and continental scales. This includes (1) lack of a correlation between clade age and species richness correlation (Ricklefs and Renner 1994; Rabosky 2012; Rabosky et al. 2012); (2) evidence from the fossil record of stable patterns of diversity through time at local ((Knoll 1986; Wing and DiMichele 1995; DiMichele et al. 2004; Cleal et al. 2012) and global scales (Spekoski 1978, 1984; Alroy 2010a,b; Smith et al. 2012; but see Benton and Emerson 2007; Friedman and Sallan 2012; Lloyd and Friedman 2012); (3) and, most controversially, some evidence from the branching patterns of molecular phylogenies (see discussion and references in Rabosky 2013).

Substantial evidence for diversity-dependence indicates that such processes and patterns are likely real in many cases, but substantial evidence questioning the primacy of diversity-dependence exists as well. Not all studies examining diversity through time find support for this view in molecular phylogenies, with some studies arguing that such data are consistent with or mask continuously increasing (Morlon et al. 2010; Manceau et al. 2015) or declining diversity trajectories (Quental and Marshall 2010; Morlon et al. 2011). Furthermore, molecular phylogenetic studies apparently consistent with density-dependence might alternately reflect a pattern of some clades undergoing increases in diversity and others decreases at any given point in time (Pyron and Burbrink 2012; Rabosky et al. 2012). The same is true for the fossil record, where there is substantial disagreement over whether patterns of standing diversity through time are consistent with ecological limits; certainly, over deep time, global patterns of diversity (e.g., Sepkoski 1978, 1984) are variously described as consistent with nonequilibrial fluctuations in diversity or a “stepped logistic” increase (see review in Harmon and Harrison 2015). It is possible that some of these examples simply represent exceptional cases—such as the subset of clades that have recently diversified into new adaptive zones (Simpson 1953; Rabosky and Hurlbert 2015). Furthermore, the boundary between the sets of conditions under which competition promotes diversity (e.g., through character displacement, or the ecological theory of adaptive radiation; Lack 1947; Simpson 1953; Brown and Wilson 1956; Schluter 200a,b) and constrains diversity (e.g., clade competition, ecological limits over macroevolutionary timescales; Simpson 1953; Jablonski 2008; Rabosky and Glor 2010; Pires et al. 2015) are not well-understood (Hembry et al. 2014; but see Bailey et al. 2013).

More importantly, in our view, the investigation of whether macroevolutionary patterns are consistent with density-dependence and/or ecological limits on diversity have overlooked the fact that not all ecological interactions among species are competitive. Antagonistic interactions—particularly predator-prey—have attracted substantial attention from paleobiologists, some of whom have emphasized the difficulty of distinguishing the effects of competition from those of predation (Dietl and Kelly 2002; Stanley 2008)—and in some evolutionary radiations, the two are likely intermixed. Integrating mutualism into this macroevolutionary framework has been more challenging for evolutionary biology, although a number of authors have argued that novel mutualisms provide novel resources to interacting clades, thus providing ecological opportunity and spurring diversification (Lengyel et al. 2009; Gómez and Verdú 2012; Litsios et al. 2012; Joy 2013). It is certainly conceivable that competition trumps all other interactions, both because of global resource limitation and because mutualistic and antagonistic interactions often contain a component of interspecific competition within trophic levels for prey or mutualistic partners (Ehrlich and Raven 1964; Schluter 2000; Armbruster and Muchhala 2007). However, it is also possible that the effects of competition on diversity dynamics are substantially modulated by other ecological interactions, such as mutualism and predation.

Here, we introduce a simple model of competitive interactions in a natural community can, and through extensions to mutualistic and antagonistic predator-prey interactions, can generate easily interpretable predictions as to the effects of different types of interactions on mecroevolutionary diversity dynamics. In some cases, these predicted dynamics differ between competition and other types of ecological interactions, suggesting that mixed empirical evidence for diversity-dependence and ecological limits on diversity over evolutionary time may be due in part to the effects of antagonism and mutualism on diversity.