An enormous variety of strategies have evolved by which organisms capture the resources necessary for life, and by which organisms avoid being consumed as a resource. These strategies range from organisms that are specialized upon a single resource species to ones that consume a wide range of resources. Similarly, some organisms have evolved elaborate defensive strategies and are consumed by few species while others are vulnerable to a much wider range of predators. The nature of the balance between specialist to generalist consumers and vulnerable to highly defended resources and the determination of the biological processes that have driven this differentiation is a central problem in food web ecology.

Degree distributions, or the distribution of fraction of nodes in a network with a particular number of links, have long played a central role in the description and interpretation of the structure of complex networks (Albert & Barabasi 2002; Amaral et al. 2000; Barabasi & Albert 1999), including food webs, networks of who eats whom in ecosystems (Camacho et al. 2002; Dunne et al. 2002; Montoya & Sole 2002). Food webs are directed networks of links from resource species to consumer species, and so links directed into and away from nodes can be analyzed separately. The distribution of incoming links (the prey distribution) describes the relative abundance of specialist and generalist consumer species while the distribution of outgoing links (the predator distribution) describes the relative abundance of highly defended to more widely consumed resource species. Here, these ecologically important distributions are analyzed along with the more commonly studied undirected degree distribution.

Maximum entropy (Maxent) (Jaynes 1957) degree distributions constrained only by the numbers of species, resources or consumers and links in the food webs provide a less information-rich null model for food web degree distributions than Erdős and Rényi random graph models (Erdős & Rényi 1959). In addition, unlike earlier studies which rely on visual comparison between observed degree distributions and various functional forms, I use a test of goodness of fit based on a likelihood ratio measure of the difference between observed and expected distributions (Sokal & Rohlf 1995). Using a set of 51 food webs with 25 or more trophic species, I show that the undirected degree distributions in 42 (82%) of the food webs, the predator distribution in 30 (59%) of the food webs and the prey distribution in 42 (82%) of the food webs are not significantly different at the 95% confidence level from Maxent distributions. In addition, the prey distributions of niche model (Williams & Martinez 2000) and generalized cascade model (Stouffer et al. 2005) networks closely follow Maxent
distributions but their predator distributions differ greatly from both Maxent distributions and the empirical distributions, particularly at high mean connectivity (links per species). The deviations of the predator distributions in turn drive the undirected degree distributions of the niche and generalized cascade model webs away from the Maxent model’s predictions.

These findings offer a simple null model for the most probable degree distributions in complex food webs that predicts their form in a remarkably high percentage of food webs. The relatively close agreement between the various degree distribution of the 51 empirical food webs and the Maxent model shows that one does not need to consider detailed ecological processes to be able to predict the degree distributions of complex food webs. The agreement between the observed prey distributions and the Maxent model suggests that there is relatively little ecological pressure favouring generalist versus specialist consumption strategies. The somewhat worse fit of the Maxent model to the predator distributions suggests that there is more (though still limited) ecological pressure driving the distribution of the number of predators away from the Maxent distribution. Finally, while an approximately Maxent prey distribution is one of the assumptions that underpins the success of the niche model and its variants, these models describe the predator distributions of complex food webs very poorly, a deficiency that must be addressed in future models.