Integrative Zoology 2011; 6: 165-167 doi: 10.1111/j.1749-4877.2011.00256.x

EDITORIAL

Frugivory and seed dispersal: integrating patterns, mechanisms and consequences of a key animal–plant interaction

The study of frugivory and seed dispersal is both exciting and challenging because it integrates research from multiple biological disciplines, including zoology, botany, physiology, behavioral ecology, evolution, conservation, and population and community ecology. At the center of these investigations is one of the most important mutualistic relationships hypothesized to organize and maintain diversity in terrestrial ecosystems: the movement of plant seeds by fruit and seed-eating animals (Bascompte & Jordano 2007). Although recent studies on the seed dispersal process have advanced the breadth and depth of our understanding of this keystone interaction, many questions are still unanswered. A clear synthesis and theoretical framework for integrating what we do know also remains elusive. Moreover, the imperative to better understand the movement of organisms in the face of human-induced global changes has sparked an additional need for seed dispersal studies (Wang & Smith 2002; Bullock & Nathan 2008; Nathan *et al*. 2008). It might seem curious that research on seed dispersal commonly leads to the study of animals, but, indeed, the vast majority of woody plants are dispersed by frugivores and granivores (Herrera 2002). This special section of *Integrative Zoology* features eight papers in frugivory and seed dispersal, and it is a sequel to the special section published earlier this year (Campos-Arceiz *et al*. 2011). Here, we present a set of research articles that provide readers with both a taste of the wide spectrum of topics and approaches that this field entails, and a glimpse of the vast challenges involved in integrating and synthesizing the results from such a broad field of study.

A large-scale community perspective is presented by Sankamethawee *et al*. (2011), who examine the structure of bird-plant frugivory networks in an intact tropical forest in Thailand. Comprehensive and detailed community-wide frugivory datasets like this one are challenging to obtain and, therefore, remain rare in the literature. The findings of Sankamethawee and colleagues add to a growing body of evidence pointing to the disproportionate importance that a few abundant generalist species of frugivores have in dispersing the seeds of the majority of the plant species even in a highly diverse tropical forest community.

Also approached at the community level is the paper by Ratiarison and Forget (2011), which examines the factors influencing seed removal of two congeneric primate-dispersed tree species. Their findings underscore that seed removal is highly dependent on population context, with significant influences of the intra-specific and inter-specific fruiting environment and population density. A key finding of Ratiarison and Forget is the presence of a masting fruiting pattern in the two tree species, something rarely documented for fleshy-fruited tropical species outside of Southeast Asia.

At the most basic level, understanding how variability in fruit and seed traits affect frugivore choices and seed dispersal is essential to understanding the coevolutionary forces that shape the mutualism between plants and frugivores. The experimental works of Larrinaga (2011) and Bartlow *et al*. (2011) examine the behavioral responses of birds to variation in fruit color and seed size, respectively. With elegant experiments using artificial fruits, Larrinaga demonstrates that two congeneric bird species can differ in their choices for black and red fruits, pointing to fundamental ways in which similar species in a community can partition resources. In contrast, Bartlow and colleagues use field experiments to

show that Blue Jays often select smaller acorns that could be transported in larger quantities to caches, which, in some circumstances, provides a dispersal advantage for smaller acorns over larger ones. As exemplified by these two studies, the choosy behavior of seed dispersers can be an evolutionary force when: (i) the traits of fruits and seeds in question are heritable, and (ii) when behavioral differences in fruit removal and seed dispersal by vertebrates translate into demographic differences for plants.

The 4 studies presented so far focus on aspects of the frugivory and/or seed dispersal process. However, it is also important to link seed dispersal to its demographic consequences to fully close the seed dispersal loop (Wang & Smith 2002). Three papers in this special issue take a step further and link dispersal by 3 different animal taxa (rodents, cassowaries, and ants) with the early stages of plant recruitment. For example, the paper by Cao *et al*. (2011) shows that small scatter-hoarding rodents can provide effective seed dispersal services and maintain recruitment for a tree species in a community where its primary frugivores have been extirpated. Similarly, the paper by Bradford and Westcott (2011) reports that the large-bodied Australian cassowary plays an important role in seed dispersal and plant recruitment, but not equally for all the plants species on which they feed. Predation rates for seeds in cassowary dung piles depend on seed size and hardness of different plant species. Finally, the piece by Hardesty (2011) reports that primary and secondary dispersal by leafcutter ants can increase seedling emergence 5-fold compared to locations without ants, showing that interactions with invertebrates can also play an important role in the recruitment of plant species.

Together, the papers in this special section examine different ways by which frugivores and other seed dispersers can influence plant reproduction and demography. However, some of the processes encompassed by frugivory and seed dispersal are unexpected, as illustrated by the final paper of this special issue. The piece by Hernández (2011) is a review of the incidental dispersal of seed-inhabiting insects by frugivores. In this phenomenon, insects inhabiting seeds prior to frugivory are shown to survive transit through the guts of frugivores, resulting in dispersal of "viable" insects. More than a curiosity, it is easy to imagine how insect dispersal by frugivores could affect the spread, persistence and gene flow of populations of specialized seed predators.

In the best spirit of the 5th International Congress on Frugivores and Seed Dispersal held in Montpellier, France in 2010, we hope that this special section will continue to fuel integrative research in this exciting and relevant field and, in some small way, contribute to a broader appreciation for the process of seed dispersal.

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