"Birding high": Ornithological studies in the canopy

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An understanding of the structure and organization of the canopy avifauna is critical to having a complete picture of tropical-forest bird communities (Naka 2004). Most ornithological observations and studies, however, have been carried out from the ground. Such studies have obvious disadvantages when the habitat is structurally complex, as with tall mature canopies.

Birds that inhabit the canopies include important functional groups such as seed dispersers, pollinators, and predators (Howe 1977, Nadkarni and Matelson 1989, Blake and Loiselle 2000, Holbrook and Smith 2000). The last three decades have seen many advances in canopy access techniques, which have enabled scientists' safe access to the canopy of rainforests around the world (Lowman & Wittman 1996, Sutton 2001). Avian studies have also greatly benefitted from these techniques (Munn & Loiselle 1995, Winkler & Preleuthner 2001).

A brief review

The earliest attempts to study birds in the canopy used mist netting in the Amazon. Canopy towers were used to conduct censuses in the Brazilian Amazon at Manaus by Lovejoy (1975) and in Panama (Greenberg 1981). Abundance and seasonality of migrants in the canopy of the lowland rainforests of Costa Rica was investigated by Loiselle (1987, 1988).

The use of portable canopy platforms to observe foraging behavior of birds (Nadkarni 1988, Nadkarni and Matelson 1989) greatly improved our understanding of the ecology and behavior of canopy birds in Costa Rica. Similarly, Cohn-Haft *et al*. (1997) and Naka (2004) demonstrated how canopy surveys using canopy towers showed that the canopy avifauna of Manaus was mostly composed of typical canopy bird species.

Since the establishment of canopy crane sites in the early 1990's in tropical and temperate forests, many ornithological studies have taken advantage of these facilities. The Surumoni crane at Venezuela has been a host to many such studies; especially on frugivore bird assemblages, their foraging behavior and vertical stratification of the neotropical bird community (Walther 2000, Nemeth *et al*. 2001, Walther 2002 a, b, Schaefer *et al*. 2003). Other insights came from the Wind River Canopy Crane Research Facility in Oregon (Shaw and Flick 1999, Shaw *et al.* 2002). Van Beal *et al*. (2003) studied the effect of birds on herbivory in the Neotropical forest canopy in Panama using the canopy crane. In a similar study by Kalka *et al.* (2008), effects on herbivory by bird and bat predation were examined.

Pros and cons of canopy sampling

Although access to the canopies for ornithological studies has provided valuable data in regard to the structure and function of avian assemblages (Walther 2003, Anderson 2009), an obvious disadvantage of crane-based sampling has been the small sample size. Cranes allow flexible and continuous access to a large area with minimal effect on birds. They also facilitate deployment of canopy nets in places inaccessible for ground-operated canopy nets. But the n=1 forest stand focus limits the utility of bird ecology studies using cranes.

Platforms or canopy towers can provide a localized permanent access solution to the canopy and facilitate observation, but they provide a biased impression as they do not provide the opportunity of actively pursuing birds in the canopy (Walther 2003). It is important to consider the high spatio-temporal variability of food resources in the canopy (Leigh *et al.* 1996), which could influence the number of species and individual birds available to the observer.

In our study in the Western ghats of India, we have worked around these problems by installing eighteen canopy platforms in an area of about 12 sq km. These platforms are spread across a habitat mosaic of primary, selection-felled, and clear-felled regenerating forests and provide continuous repeated access to the canopy. To circumvent the problem of independence of observations, we have used short intervals of sampling to track individual birds that can be distinguished by differences in plumage and location in the forest, which avoids double counting (Vivek and Ganesh 2011).

Development activities and global change scenarios have increased the need for conservation of biologically important sites. We must use canopy-based estimates of species richness and abundance of bird species, which can be more accurately estimated without bias and will help to prioritize the conservation potential of sites. Canopy-based censuses are necessary to monitor long-term changes in composition of the avian assemblage following fragmentation and forest disturbance such as logging.

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