



Original research article

Species turnover in tropical montane forest avifauna links to climatic correlates



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ABSTRACT

We examined avifauna richness and composition in Taiwan's tropical montane forests, and compared to historical records dated 22 years ago. A richness attrition of 44 species caused a discrepancy of 30.2%, and an estimated yearly turnover of 2.2%. More resident species that were narrower or lower in elevation distribution, insectivores/omnivores, small to medium-sized, forest/open-field dwelling, and canopy/ground foragers, vanished; whereas piscivores, carnivores, riparian- and shrub-dwellers, ground and mid-layer foragers, and migrants suffered by higher proportions. Occurrence frequencies of persistent species remained constant but varied among ecological groups, indicating an increased homogeneity for smaller-sized insectivores/omnivores dwelling in the forest canopy, shrub, or understory. While the overall annual temperature slightly increased, a relatively stable mean temperature was replaced by an ascending trend from the mid-1990s until 2002, followed by a cooling down. Mean maximum temperatures increased but minimums decreased gradually over years, resulting in increasing temperature differences up to over 16 °C. This accompanied an increase of extreme typhoons affecting Taiwan or directly striking these montane forests during the last decade. These results, given no direct human disturbances were noted, suggest a link between the species turnover and recent climate change, and convey warning signs of conservation concerns for tropical montane assemblages.

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1. Introduction

Climate change has been progressing rapidly across many regions around the world (Loarie et al., 2009; IPCC, 2013). This trend likely will last over the following decades, and inevitably threaten global biodiversity (Enquist, 2002; Williams et al., 2003; Rosenzweig et al., 2008). For birds, for instance, climate change may directly interfere, often in intricate ways, with their metabolic energetics, reproduction, dispersal, migration, and thus affect distribution, abundance, and survival of species, as well as regional diversity (Root, 1988; Crick, 2004; Visser et al., 2006; Devictor et al., 2008; Knudsen et al., 2011). In addition to weather patterns, climate change may also cause habitat loss, enhance species invasion and disease spreads, and result in further population declines or species extinctions (Pimm et al., 2006; Şekercioğlu et al., 2008; Mac Nally et al., 2009).

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Species richness along elevation gradients to a certain extent often mirrors that along latitudinal gradients, whereas a greater proportion of studies reported diversity peaks in the mid-elevation range (i.e., hump-shaped distributions; [Rahbek, 1995, 2005](#)). Conventional notions suggest that communities of higher species richness may retain better biotic resistance ([Elton, 1958](#)), thus should remain relatively stable longer (e.g., [France and Duffy, 2006](#)), but not necessarily for individual species ([Tilman et al., 2006](#)). Organisms may respond to climatic change by latitudinal or vertical range shifts ([Parmesan, 2006](#)), particularly those highly mobile taxa such as birds ([Thomas and Lennon, 1999](#); but see [Devictor et al., 2008](#) and [Forero-Medina et al., 2011](#)), and thus may alter species richness or reform local assemblage compositions.

Temperature in the tropics is generally more stable; endotherms like birds should have narrower thermal regimes and may be sensitive to temperature deviations ([McCain, 2009](#)). The climate change effects presumably will be greater for tropical species ([Laurance et al., 2011](#); [Şekercioğlu et al., 2012](#)). Those factors contributing to higher diversity and endemism of tropical montane assemblages, such as geographical isolation, constrained distribution, and/or limited dispersal ([Lomolino, 2001](#); [Jetz et al., 2004](#)), may subject the species to prevailing climate change or even vulnerable to extinctions ([Şekercioğlu et al., 2008](#); [La Sorte and Jetz, 2010](#)), and merit greater concerns. Yet, studies of climate change effects on tropical montane birds are relatively few (e.g., [Pounds et al., 1999](#); [Forero-Medina et al., 2011](#); [Anderson et al., 2013](#) and [Freeman and Freeman, 2014](#)), and data not sufficiently adequate (see [Parmesan, 2006](#); [Colwell et al., 2008](#); [Chen et al., 2011](#); [Laurance et al., 2011](#) and [Şekercioğlu et al., 2012](#)).

Taiwan sits on the border of the Eurasia Plate, the Philippine Mobile Belt, and the Okinawa Plate, and right in the center of the East Asian–Australasian migration flyway ([Straw et al., 2006](#)). The Tropic of Cancer passes by its lower one third and characterizing a typical tropical-subtropical weather, while its mountainous topography (over 280 summits above 3000 m with the highest peak, Jade Mountain, at 3952 m) has helped shaping heterogeneous habitats. These features collectively contribute to high species richness and endemism, including birds. The extant avifauna comprises of more than 500 species, 47.2% of the all-year residents are endemic species or subspecies, and many genera, such as *Arborophila*, *Heterophasia*, *Liochichla*, *Myophonus*, and *Urocissa*, consist of only single species ([Severinghaus et al., 2012](#)). Yet, avian assemblages in the majority of montane areas in Taiwan remain less studied ([Lee et al., 2004](#); [Ding et al., 2005](#)), so do their relationships with the potential effects of climatic change correlates.

Our study examined the species richness and composition of avian assemblages in a tropical mid-elevation montane forest in southern Taiwan, their differences from those of a historical survey, and the correlates with climate change. We tested the hypothesis that climate change will affect species richness of bird assemblages in tropical montane forests with increasing climatic variations, and cause temporary discrepancies in bird compositions. Specifically, we predicted that species of broader elevation range will be less affected, while resident species with limited dispersal, more specific habitat or resource demands ([Hewson and Noble, 2009](#)), and migrants of high energy needs ([Both et al., 2006](#); [Jones and Cresswell, 2010](#)) will be affected more severely.

2. Methods

2.1. Study area

Field works took place in Shanping–Nanfengshan in the Liouguei Experimental Forest (LEF; 120° 41'E, 22° 58'N, 9882 ha in area, 250–2600 m in elevation), Kaohsiung, southern Taiwan. The study sites were within a preserved forestry area (Taiwan Forestry Research Institute, TFRI) where implementing an ecosystem-approach to management, thus have been largely free from human disturbances such as habitat fragmentation or alteration since the late 1980s ([King et al., 1990](#); [Lin et al., 2013](#)). Small plantations and cultivation had altered the composition and structure of most lowland forests below 500 m, but over 84% of the land above 500 m in this area comprises of primary/secondary intact forests dominated by Fagaceae and Lauraceae. Conifer patches mixed with hardwoods constitute the rest landscape, comprising Formosan Alder *Alnus formosana*, Formosan Ash *Fraxinus griffithii*, Formosan Michelia *Michelia formosana*, Luanta Fir *Cunninghamia konishii*, Taiwan Fir *Taiwania cryptomerioides*, Taiwan Red Cypress *Chamaecyparis formosensis*, Taiwan Zelkova *Zelkova serrata*, and Stout Camphor Tree *Cinnamomum kanehirae* (TFRI data). An annual rainfall over 3510 mm and temperatures ranging from about 24.5 °C in August to 16.7 °C in January characterize its typical climate ([Lu et al., 2010](#)).

2.2. Bird assemblage

Historical records of mid-elevation avifauna in this area came from [King et al. \(1990\)](#) that conducted monthly surveys from March 1987 to February 1988, roughly 12 days per month, over five transect lines along elevations of 500 m up to around 1500 m as accessible. It covered a land area of about 200 ha, enclosing major forest types such as the primary and secondary forests and plantations, and documented 116 species of birds from 38 families, including 92 residents and 24 migrants, with 12 endemics and 31 species in conservation concerns. We conducted our surveys from March 2009 to February 2010 following the same transect lines but with following minor modifications. We divided the most elevationally meandering transect line into two routes and thus categorized the study area to elevation ranges of 500–1000 m and 1000–1500 m, with three transects in each section, respectively. Depending on the topography, vegetation physiognomies, and accessibility, a transect line ranged 900–2250 m in length (mean: 1425 ± 215 m). Any two adjacent transects were at least 200 m horizontally and 100 m vertically apart, or nearly so. We used the point transects method that is more suitable for our

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