A bird community index using life history guilds of breeding birds in Taiwan

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Abstract.

As humans continue to expand our range, biodiversity is suffering. In order to preserve biodiversity, it becomes necessary to set aside land for preservation. In Taiwan, there is currently a corridor of preserved landscapes that are restricted to the mountainous regions. What about the other landscapes? The Bird Community Index (BCI) uses birds as ecological indicators in order to determine the ability of a landscape to support sensitive native species. Using data from the 2012 Breeding Bird Survey, I compiled a list of all of the breeding birds in Taiwan and their compositional, functional and structural life history traits. Those traits resulted in 12 response guilds and a BCI that can be used in future research to determine the ability of various landscapes to support specialist and native species of Taiwan. This information can then be used for future conservation decisions.

Key words: bird community index; ecological indicator; endemic species; diversity; landscape function; life history guild; Taiwan Breeding Bird Survey.

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Introduction

As human population and demand for natural resources continues to grow, native biodiversity pays the price. In their most recent report on global biodiversity, World Wildlife Fund conservationists estimated that populations of thousands of vertebrate species had decreased by approximately 50% during 1970–2010 (WWF 2014). Although most of these species remain common, loss of abundance on such grand scales demands vigilance to stave off extinctions and, where possible, reverse such trends. Ecological indicators are analytical tools that provide such vigilance by prescribing specific means to compile and compare data on topics such as species' abundance and distribution, resource consumption by humans, vital health rates for humans, atmospheric carbon dioxide, etc.

Often, the locations of critically rare species provide the backdrop for conservation action that results in protected areas such as national parks. Parks can differ widely in the efficacy of conservation within their borders, but they can at least illustrate areas of high potential to support significant biodiversity. There is wide disparity among countries in terms of how much land is set aside for conservation (Hoekstra et al. 2010). Lost in those calculations, however, is advice on conservation and management of lands outside the national parks. Ecological indicators that span the entire gradient of anthropogenic disturbance can be used to assess the condition of entire landscapes, whether pristine wilderness or urban metropolis.

The Bird Community Index (O'Connell, et al. 1998) is one indicator that is specifically designed to reveal the ability of a landscape to support its native species that are sensitive to anthropogenic disturbance, whether those individual species are rare or not. Bird community data can inform reliable ecological indicators because bird populations react predictably to environmental changes, sampling techniques are relatively easy to apply, and there are often well-trained groups of volunteers willing to conduct surveys for long-term monitoring programs (O'Connell, et al. 1998). Multiple species in samples ensure that comparative groups within a community provide opportunities for building indicators that respond to habitat gains and losses. The BCI is predicated on life history guilds and the interpretation of each guild as specialist (sensitive to human disturbances) or generalist (able to persist despite human presence). Each guild is given a numerical value based on the presumed vulnerability of the trait shared by all members of the guild, for example, ground nesters are more sensitive to disturbance than tree nesters (O'Connell, et al. 1998). O'Connell et al. (2000) tested and demonstrated vulnerability of 32 life history guilds, and reported that landscapes in which the potential natural vegetation characterizes the matrix are best able to support vulnerable traits, such as ground-nesting.

The island nation of Taiwan provides a wonderful example of a conservation opportunity that could benefit from development of a BCI. Taiwan is a subtropical, 36,000 km^2 -island off the east coast of China, and it supports both high species richness of birds and unusually high endemism with 15 unique species and many more unique subspecies breeding on the island (Lei, et al. 2007). The island of Taiwan has nationally protected lands covering about 20% of the land area (Hoekstra et al. 2010). Most of these protected lands are along the mountainous region that runs along the central and east side of the island (Fig 1). Most of the western lowlands have a long history of supporting agricultural land uses; many areas have been abandoned as farmland as people have in recent decades moved to rapidly expanding urban centers for jobs in the manufacture of electronics (ITC 2002).

It is the broadleaved evergreen and bamboo forests of the central and eastern mountains that support most of the endemic species in Taiwan. Even where species richness might be relatively low, these forests are obvious conservation priorities due to their high rates of endemism (Jump, et al. 2011). These mountain forests have been recognized, both nationally and internationally, as hotspots of biodiversity, and much of the region is protected in a series of parks. That leaves open the question, however, of how the rest of the island can be categorized and compared. Are there working (or retired) landscapes in Taiwan that also support important biodiversity, and where are they? How much of the rapidly changing land on Taiwan is comprised of functioning landscapes? How do these areas compare to the endemism hotspots in Taiwan's existing parks?

Fortunately, efforts to monitor native biodiversity have grown in Taiwan in recent years, and these provide the source data to address these questions. Notably, the Taiwan Breeding Bird Survey has been collecting species abundance data in Taiwan since 2009 (Ko, et al. 2014), and these data can be used to both create and populate a BCI for Taiwan (O'Connell, et al. 2007). To make a new Taiwan BCI, we need only to compile data on life history traits for breeding birds, because breeding bird data are freely provided. My objective in this research was to build a new Taiwan BCI for application to the existing Taiwan Breeding Bird Survey.

Methods

The Taiwan Breeding Bird Survey from 2012 lists 240 species from over 300 plots all over the country of Taiwan (Ko, et al. 2014). To build the BCI, I first compiled life history information for all of these breeding birds in a Microsoft Excel file. Structural, functional, and compositional life history traits of each species were determined using multiple different sources. I relied on Wilman et al. (2014) to assign species to guilds related to trophic level, foraging substrate, and primary foraging behavior. The most frequent diet and foraging strategy was considered primary and recorded. If there was an even split, for example, a species was listed as 50% frugivorous and 50% insectivorous, I listed the species in both guilds. The primary source for other life history attributes was the *Handbook of the Birds of the World* (HBW; del Hoyo et al. 2016). The HBW provided information such as distribution, migratory behavior, general habitat affinity, nesting substrate, etc. The literature review allowed me to begin with 37 different life history guilds, of which I categorized 20 as structural, 7 as functional, and 10 as compositional.

With 240 species assigned to 37 guilds, I next removed all species detected in the 2012 Taiwan Breeding Bird Survey that do not actually nest on Taiwan. For example, there are species (e.g., Pacific Golden-Plover, *Pluvialis fulva*) detected in the survey that were long distance migrants merely stopping over in Taiwan on their way to breeding ranges farther north (del Hoyo et al. 2016). This step reduced the number of species from 240 to 173. Next I removed species that are not reliably detected by the typical roadside surveys used by the Taiwan Breeding Bird Survey. These surveys are designed to detected singing males on their breeding territories in spring. The surveyed sites detect some species incidentally, but not reliably. This group includes raptors, wading birds, secretive wetland birds, and other species that do not typically sing or call from breeding territories. The species potentially detected by the survey methods include the Galliformes (pheasants and allies), Columbiformes (doves), Cuculiformes (cuckoos), Piciformes (woodpeckers), and Passeriformes (perching birds). Including species from just these five orders reduced the pool of species to 137.

Each reduction in species under consideration reduced the number of potential guilds in the BCI. For example, removing the raptors (Accipitriformes) also reduced to zero the number of birds in the sample in the “carnivore” guild. With few exceptions, I eliminated from consideration all guilds with fewer than 10 species. This exercise reduced the number of potential guilds from 37 to 22. To determine the number of guilds to be included in the BCI, I examined each of the 22 candidate guilds in terms of the number of species in the guild and whether it was likely to provide unique or redundant information. For example, of the 137 breeding birds in the five orders listed above, 129 are annual residents and 8 migrate to Taiwan to breed but winter elsewhere. Given the great disparity in number between the size of the two guilds, one is useful to examine and the other is not: It is likely that most of the species at any site will be annual residents because almost all species in the sample are annual residents. The interesting thing would be to examine sites in terms of the migrant breeders they support: Many sites will have 0 migrants, so the lack of migrants is not particularly informative. Some will have at least one migrant species, and some sites might support 50% or more of the potential migratory species. Sites in the latter category would be unusual in that they would provide breeding conditions suitable for a group of species that undergoes an arduous migratory journey twice per year, and are somewhat less likely to withstand prolonged human disturbances.

With a final selection of guilds to include, I set *a priori* categories of representation for each guild: 0% of species in the guild, 1–25%, 26–50%, and > 51% of the species in an individual guild at a site. I ranked these occurrence categories as 1–4, with larger numeric ranks indicating greater sensitivity to human disturbances. Thus, for every site, every category of guild would receive a rank from 1–4. Because some guilds are specialist and some generalists, it is not always the case that the highest representation of a guild is assigned the highest rank. For example, if a site supported more than 50% of the possible exotic species in Taiwan, the site would receive a low rank of 1 for the “exotic species” guild. As mentioned above, a site supporting more than 50% of the possible migrants species would be assigned the highest rank of 4 for the “migratory” guild.

The Taiwan BCI, built from these 1–4 rankings for guilds, is simply the sum of ranks divided by the total number of guilds included:

$$\text{BCI Score} = \sum \text{ranks } \frac{(\text{structural} + \text{functional} + \text{compositional})}{4}\, i^{-1}$$

where i = the total number of guilds ranked

Results

The Taiwan BCI (Table 1) was built from 12 guilds: ground nesters, tree canopy nesters, grassland species, urban species, ground foragers, tree canopy foragers, seed-eaters (gramnivores), frugivores, breeding migrants, introduced species now naturalized on Taiwan, endemic species, and species listed as either Vulnerable or Near Threatened according to the IUCN (2016). The 12 guilds meant that sums of all guild ranks were divided by 12. This resulted in a range of normalized BCI scores from a minimum of 0.25 to a maximum possible BCI score of 1.00.

Discussion

Compiling the life history information for 173 breeding species in Taiwan (Appendix) is an important advance in our knowledge of life histories for the island nation. Until I completed this task, there was no one repository for life history information of these species. Thus, simply organizing the data and building the Excel workbook will provide the opportunity to advance conservation by other researchers working in Taiwan.

Development of a new BCI for Taiwan was hampered by missing life history data on multiple species. A few of the species were missing some crucial information that we used to determine guild status, such as the Plain Flowerpecker (*Dicaeum minullum*). The only information that we know about this species is its foraging strategies. The bird does forage in the upper canopy on fruit (Wilman et al. 2014), so while we do not know any other information about the species, it can be assumed that the bird is sensitive to human disturbances that harm the upper canopy, such as logging. These birds were treated on a case by case basis, with some being used in the appropriate guild for the known information and some unused due to lack of enough applicable data.

A more broadly applicable limitation, single-broodedness could not be included in the Taiwan BCI despite its strong correlation with functioning landscapes in O'Connell et al. (2000). Data from this guild are important when considering the resilience of species, as species that produce multiple broods a season are given more chances to reproduce successfully (Burley 1980). Unfortunately, single-broodedness could not be included in the Taiwan BCI because basic reproductive life history has not been studied for the majority of species in the country. In the future, it would be beneficial to perform more field research and revisit the current guild for inclusion in a revised BCI.

Despite some key limitations, this research has resulted in a landscape function hypothesis that can be tested through analysis of real-world data. With site-specific information from the individual sampling locations in the Taiwan Breeding Bird Survey, we could code landscapes across the entire range of the samples to indicate landscape function from high to low. This could highlight new areas to target as priorities for conservation reserves. As the

Breeding Bird Survey continues in Taiwan, periodic analysis with the Taiwan BCI could be used to illustrate loss or gain of function over time.

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Figure 1. Map of Taiwan illustrating high topographic relief and forested matrix in the east and widespread agricultural and urban development in the west. (ESRI)

Table 1. Ranks for proportional representation of select life history guilds and calculation of the Taiwan Bird Community Index.

		Rank for Percent of Species from Guild in Sample			
Guild Category	**Guild**	0%	1–25%	26–50%	51–100%
Structural	Ground nester	1	2	3	4
	Canopy nester	1	2	3	4
	Grassland associated	1	2	3	4
	Urban associated	4	3	2	1
	Ground forager	1	2	3	4
	Canopy forager	1	2	3	4
Functional	Gramnivore	4	3	2	1
	Frugivore	1	2	3	4
	Migrant	1	2	3	4
Compositional	Introduced	4	3	2	1
	Endemic	1	2	3	4
	IUCN – NT/VU	1	2	3	4

Variable 1 = $\sum$ structural guild ranks/4 [range 1.50–6.00]

Variable 2 = $\sum$ functional guild ranks/4 [range 0.75–3.00]

Variable 3 = $\sum$ compositional guild ranks/4 [range 0.75–3.00]

BCI Score = $\sum$ (V1–V3)/12 [range 0.25–1.00]