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BIRD ASSEMBLAGES IN THE THALE NOI NON-HUNTING AREA, SOUTHERN THAILAND

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Abstract: Bird assemblages in the Thale Noi protected area of southern Thailand were investigated using data concerning 23 common resident species routinely reported every month from January 2004 to December 2007 at seven wetland locations. These common resident species were selected using three requirements: (1) they are defined in Lekagul and Round (2005), (2) they were seen in each of the four years, and (3) they had median incidence rate per day greater than zero. The aim of this study was to classify groups of species with respect to incidence rates by season and location. Using factor analysis to find groups of species with common incidence patterns, we isolated five groups of birds that correlated with respect to their habitats and availability of food. The first group (seven species) was found in habitats predominantly providing continuous flooding and aquatic plants. The second group (six species) was found in terrestrial habitats containing various food supplies, especially grain and insects. The third group (six species) was found in habitats connecting from shallow fresh water to suburban environments and typically providing insect food sources both in water and on land. The fourth group (two species) was found in similar habitats to that of the second group, but related to fruit trees. The fifth group (two species) was found in lowland habitats with dense undergrowth providing different food types including insects, seeds and fruit, particularly figs. The classification reflects bird behaviours rather than bird taxonomies.

KEYWORDS: resident birds, Thale Noi non-hunting area, wetland, factor analysis

Introduction

Understanding species assemblages in habitat areas gives ecologists insight on how to effectively manage threatened areas. Bird assemblages are particularly important because they are commonly used as indicators of ecological conditions (O'Connell *et al.*, 2000; Davidar *et al.*, 2001; Schrag *et al.*, 2009).

The Thale Noi non-hunting area is an important site for birds, covering 457 km^2 in southern Thailand, part of which was declared as a Ramsar site, the first in Thailand, in 1998. The area has been used by numerous migratory and resident birds as breeding sites and feeding grounds (Chumrieng & Kongthong, 2005; Kaewdee *et al.*, 2002). In addition, the area has a high diversity of wetland habitat comprising a freshwater lake, marshes, seasonally-flooded grassland and rice fields, swamp forest, and plantations.

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Bird assemblage is related to habitat characteristics and also has been used as an indicator of ecological health (O'Connell *et al.*, 2000; Graham & Blake, 2001, Bryce *et al.*, 2002; Mason & Macdonald, 2005). Several statistical methods have been used to investigate relationships between habitat attributes and bird assemblages, including generalised additive models (Kangas *et al.*, 2010) and principal components analysis (Murkin *et al.*, 1997), as well as the Bird Community Index (O'Connell *et al.*, 2007). Major differences between these methods are based on data scale and study purposes. Data quality is a key issue affecting the reliability of methods. For example, Kangas *et al*. (2010) studied the relative importance of recreation as well as environmental variables on bird communities in protected areas in Finland using generalised additive models. Data containing bird counts and habitat variables were used for analysis. Murkin *et al*. (1997) used

monthly aerial photographs and Geographic Information System (GIS) techniques to characterise habitats, and weekly avian censuses for determining the response of blackbirds, waterfowl, and American Coots to changes in habitat structure using principal components analysis. O'Connell *et al*. (2007) used data from the North American Breeding Bird Survey (BBS) to assess ecological conditions.

The Thale Noi non-hunting area has not been previously studied with respect to relationships between bird assemblages and habitat features. The aim was to identify groups of resident birds characterising behaviours of the birds that reflected habitats and food by using factor analysis (Lattin *et al.*, 2003). Understanding the habitat characteristics associated with bird assemblages is an essential approach towards sustainable management of protected areas for the benefit of wildlife.

Materials and Methods

Bird data

The bird data were provided by the responsible agency of the Thale Noi non-hunting area, from the National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resources and Environment, Thailand. Data were monthly counts collected by the officials in seven stations over the four years 2004-2007, using a framework developed by academics working in the agency. Numbers of resident species were counted on a specified day in each month by taking observations within circles of 100-meter radius around each point, along transect lines, using a point count method with binoculars. The observation periods began simultaneously at each site, from 8 am to noon and from 1 pm to 4 pm.

Study area

The Thale Noi non-hunting area covers parts of Phatthalung, Nakhon Si Thamarat and Songkhla provinces of southern Thailand. Seven locations (Figure 1) were selected for collecting the bird counts, comprising Khuan Kreng (1), Khuan Nang Whean (2), Khuan Thale Mong (3), Klong Yuan (4), Khuan Khi Sian (5), Ban Pran (6), and Laem Din (7). The two major habitats in the Thale Noi non-hunting area are wetlands and agricultural plots. Wetland habitat includes swamp forest and a freshwater lake, whereas agricultural practices consist of paddy fields, rubber plantations and mixed orchards.

Data management

The 'resident' categories for bird species were defined using three criteria: (a) resident species status as categorised according to Lekagul and Round (2005), (b) the species was seen in the Thale Noi non-hunting area in each year of the data collection period, and (c) they had median incidence rate per day greater than zero. Using these criteria, the bird species used thus contained 23 common resident birds among the 117 species observed. The study periods were defined as January-March, April-June, July-September, and October-December, giving 16 quarterly periods over four years, called 'seasons' for this study. Numbers of birds sighted in a day (7 hours) were converted to daily incidence rates. The incidence rates were thus classified by 4 seasons, 7 sites, and 4 years, giving an outcome data array with 23 columns corresponding to the bird species and $4 \times 4 \times 7 = 112$ rows corresponding to occasions observed.

The incidence rates have very skewed distributions with large proportions of zero values. Since outcomes with skewed distribution complicate statistical analysis, the daily incidence rates were transformed by adding 1 before taking natural logarithms. This method is a common practice since these transformed rates are finite and remain zero when the incidence rate is zero (Clarke & Warwick, 1994).

Statistical analysis

In preliminary analysis, box plots were used to display incidence rates of each species. These graphs indicate the degree of dispersion and skewness in the data, and identify outliers (Tukey, 1977). The common names of the species are presented on the vertical axis. The horizontal axis shows incidence rates (Figure 2).

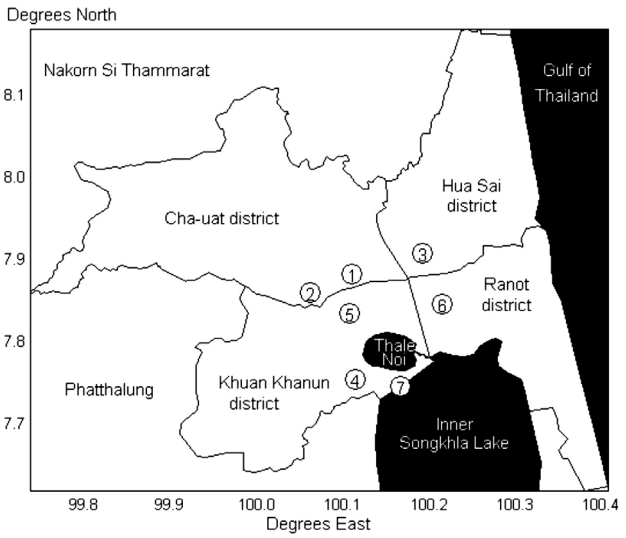

Figure 1: The Thale Noi Non-hunting area with study areas and sampling sites: 1- 7. Thale Noi is the single lake in the study area and is surrounded by the 7 sampling sites: 1-3 are located in Nakhon Si Thammarat,: 4-5, and 7 are located in Phatthalung and 6 is located in Songkhla, southern Thailand. Sites 1, 3, and 5 are mainly swamp forest. Site 2, 4, and 6 are mainly rice fields. Site 7 is mostly seasonally-flooded grassland.

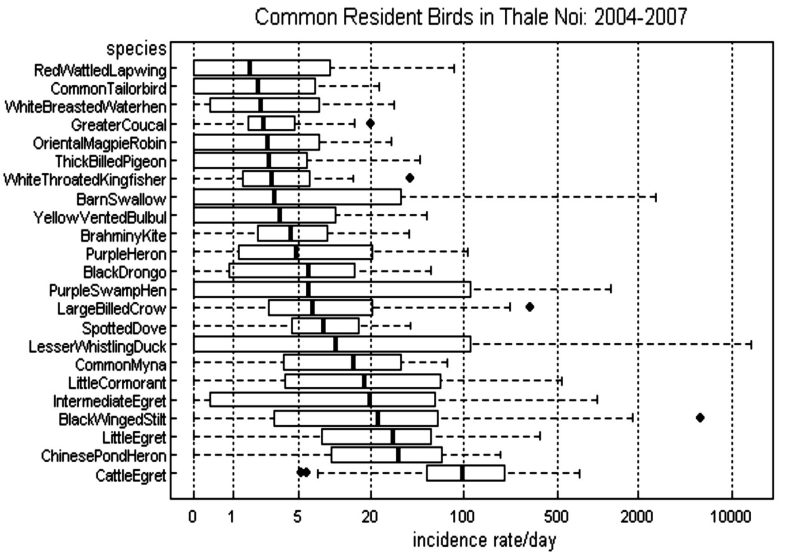

Figure 2: Box plots showing distributions of incidence rates of the 23 resident bird species, ordered by median incidence rates. Horizontal bars cover 50% of each distribution between the lower and upper quartiles. Black vertical stripes show median incidence rates. Black dots show outliers.

The factor analysis (Lattin *et al*., 2003) used is essentially the same as that conventionally used in ecological studies (Sampantarak *et al.*, 2011). Sampantarak used factor analysis on nine environmental variables (organic carbon, total nitrogen, sediment pH, water depth, water pH, salinity, etc.) to form three factors. The three factors were then used as predictor variables in a multivariate multiple-regression model. The aim of the factor analysis in the study was to allocate the 23 bird species into a smaller number of interpretable groups that tended to appear on

the same occasions. The incidence rates of the 23 species thus comprise the variables of interest. Each variable has 112 observations corresponding to combinations of season, year and site. The initial step is the determination of the matrix of correlation coefficients between these 23 variables. The second step is the estimation of factors (groups of species) from the correlation matrix. Ideally each factor (which must contain at least two species to contribute to the factor analysis) contains species that have large correlations with each other and small correlations with species in other groups. To achieve this, species that are not correlated with any other species are said to have high "uniquenesses" and are conventionally omitted from the factor analysis. The factors comprise weighted linear combinations of the species and may be rotated to maximise the weights within each group and minimise the weights outside each group. The resulting weights are called "loadings". Species are assigned to factors based on their loadings. "Promax" rotation was used in preference to "varimax", which requires the rotations to be orthogonal (Browne, 2001).

Results and Discussion

Box plots (Figure 2) showed that the Cattle Egret was seen at every location in every season. The rapid expansion of the Cattle Egret's range is due to its relationship with humans and their domesticated animals. It was typically found in fields and dry grassy habitats, reflecting its dietary reliance on terrestrial insects rather than aquatic prey (McKilligan, 1984). The Lesser Whistling-Duck was seen with the highest numbers, with maximum above 10,000 individuals per day, but this species and eight others were not seen on at least 25% of the quarterly periods. These results are consistent with findings of Chumrieng and Kongthong (2005). Flooded conditions provide ideal foraging zones for a large number of waterfowls (Nguyen *et al*., 2009). This condition resulted in a number of wetland birds increasing their numbers both during and after the flood, especially ducks (Shimada *et al.*, 2000). The majority of the study areas were inundated, particularly in January-March. Birds were seen in large numbers during that season.

The factor analysis gave five groups of species comprising 7, 6, 6, 2 and 2 species, respectively (Table 1). Component species of the first group were the Purple Swamphen (*Porphyrio porphyrio*), Little Cormorant (*Phalacrocorax niger*), Lesser Whistling-Duck (*Dendrocygna javanica*), Intermediate Egret (*Egretta intermedia*), Red-wattled Lapwing (*Vanellus indicus*), Brahminy Kite (*Haliastur indus*), and Chinese Pond-Heron (*Ardeola bacchus*). They prefer mainly wetland habitat including fresh water, marsh and shallow water providing aquatic plants to feed and hide, particularly the Purple Swamphen and Lesser Whistling-Duck. The diet of these two species consists predominantly of plant matter including shoots, leaves, roots, stems, flowers and seeds. Others feed mainly on small fish. The first group thus identified a habitat with attributes predominantly providing continuous flood and aquatic plants.

Components of the second group were the Spotted Dove (*Streptopelia chinensis*), Greater Coucal (*Centropus sinensis*), Cattle Egret (*Bubulcus ibis*), White-throated Kingfisher (*Halcyon smyrnensis*), Large-billed Crow (*Corvus macrorhynchos*), and Black Drongo (*Dicrurus macrocercus*). These species are mostly land birds preferring terrestrial habitat and feeding on a variety of food on the ground. The Greater Coucal and Spotted Dove are usually found walking on the ground while foraging. The Cattle Egret forages on the land, especially with cattle. The diet of the Black Drongo in agriculture land includes a variety of insects (Asokan *et al.*, 2010). Vegetation is an important factor in relation to Black Drongo density (Asokan, Ali & R. Manikannan, 2009). The second group was thus identified with terrestrial habitat containing various food supplies, especially grain and insects.

Component species of the third group were the Common Myna (*Acridotheres tristis*), Little Egret (*Egretta garzetta*), Black-winged Stilt (*Himantopus himantopus*), Common Tailorbird (*Orthotomus sutorius*), Barn Swallow (*Hirundo*

Table 1: Results of the factor analysis listing the rotated factor-loading matrix for the five-factor solution.

Common Name	F1	F2	F3	F4	F5	Uniquenesses
Purple Swamphen	**1.10**	-0.15	-0.21			0.076
Little Cormorant	**0.88**	0.18	-0.13	-0.12		0.131
Lesser Whistling-Duck	**0.70**	-0.19	0.31			0.273
Brahminy Kite	**0.64**	0.38	-0.16	-0.11	-0.26	0.402
Red-wattled Lapwing	**0.63**	-0.11	0.29	0.36		0.307
Intermediate Egret	**0.61**		0.40	-0.15	-0.44	0.063
Chinese Pond-Heron	**0.34**	0.16			0.25	0.685
Spotted Dove	-0.14	**0.83**	0.23		-0.32	0.324
White-throated	-0.29	**0.76**	0.10		-0.38	0.456
Greater Coucal	0.15	**0.68**		-0.13		0.443
Large-billed Crow		**0.66**		0.11	0.31	0.311
Cattle Egret		**0.64**	0.15		0.18	0.431
Black Drongo	0.32	**0.39**	-0.15	0.13		0.635
Common Myna	-0.43	0.13	**0.88**	0.24	0.22	0.264
Little Egret	-0.12	0.27	**0.73**	-0.23	0.28	0.355
Black-winged Stilt	0.16		**0.60**		0.23	0.472
Common Tailorbird		-0.11	**0.51**	0.12	-0.16	0.713
Purple Heron	0.48		**0.51**	0.17		0.220
Barn Swallow	0.28	0.10	**0.42**			0.588
Yellow-vented Bulbul			0.15	**0.92**		0.192
Oriental Magpie Robin		0.25		**0.62**		0.529
White-breasted	-0.15	-0.11	0.30	-0.23	**0.63**	0.615
Thick-billed Green				0.18	**0.47**	0.685

Note: The 5 common factors are F1, F2, F3, F4 and F5. Loadings less than 0.1 in magnitude are not shown in the results. Highlighted values correspond to the maximum factor loading for each species.

Uniquenesses for each species are values close to 1, providing evidence that they cannot be associated with any other species. For this analysis, no uniqueness exceeded 0.75 so all species were included in the factor model.

rustica) and Purple Heron (*Ardea purpurea*). These birds prefer a wide range of habitats from saltwater to freshwater, and woodland to human habitats. The Common Myna thrives in urban and suburban environments. The Little Egret and Black-winged Stilt feed on aquatic insects whereas the Common Tailorbird and Barn Swallow actively forage on insects, with the latter preferring Diptera including flies and mosquitoes (Møller, 2001). Connecting habitat from shallow fresh water to suburban environment providing food sources, mainly insects both in water and land habitat, thus identified the third group.

The fourth group contained the Yellow-vented Bulbul (*Pycnonotus goiavier*) and the Oriental Magpie-Robin (*Copsychus saularis*). These species are found from open woodland to human habitat and are fond of fruits. The birds in both the second and fourth factors are all land birds, but differ in their diets and foraging behaviours. So the fourth group was thus identified with fruit trees.

The White-breasted Waterhen (*Amaurornis phoenicurus*) and Thick-billed Pigeon (*Treron curvirostra*) comprised the fifth group. The White-breasted Waterhen is found in freshwater

marshes and dense undergrowth and forages on the ground. It feeds mainly on seeds, insects and small fish. The habitat of the Thick-billed Pigeon in Peninsular Malaysia is lowland forest, and pigeons of the genus *Treron* are fig-eating specialists (Lambert, 1989). So the fifth group was thus identified with lowland habitat with dense undergrowth providing different food types including insects, seeds and fruit, particularly figs.

Applying exploratory factor analysis to bird data provided groups of bird species. The birds in the same group had similar behaviours, and these behaviours were related to habitats and food sources. Many studies have found that vegetation variables and habitats correlate with bird species richness and diversity (Thinh, 2006, Waltert *et al.*, 2005). Furthermore, food-supply can affect bird diversity, abundance, breeding ecology and flocking behaviour (Sodhi, 2002). Bird species using similar proportions of microhabitats forage in different proportions of vertical strata. This niche segregation enables these species to coexist in the same habitat (Kwok, 2009). For example, The White-breasted Waterhen and Thick-billed Pigeon were allocated to the same group, and they coexist with vertical strata.

The Thale Noi non-hunting area is mostly wetland ranging from a freshwater lake, marshes and swamp forest to seasonally-flooded areas. The important determinants of bird assemblages are thus habitats predominantly providing continuous flood and aquatic plants. These habitats contain niches of wetland birds. High water-bird biodiversity requires natural flooding and drying disturbance on lowland rivers (Kingsford *et al.*, 2004) and diversity of habitat establishes wider bird distribution. Therefore, sustainability of wetland management is an essential approach to provide alternative habitats for water birds. It is also helpful to retain the entire wetland ecosystem. The Thale Noi non-hunting area should do likewise to protect wetland habitat for bird species.

In conclusion, factor analysis can be effectively applied to ecological data in order to classify groups of birds that reflect their behaviours rather than their taxonomies. For this study, it revealed habitat attributes and food types associated with the occurrence of groups of resident birds.

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