CHAPTER 1

Introduction

1.1 Background and rationale

This thesis is concerned with applying appropriate statistical methods for describing the abundance of resident birds with respect to species, season and site using data collected from the Thale Noi non-hunting area of approximately 450 square kilometers in Southern Thailand over the period 2004-2007. Since the science of counting species of fauna and flora centers around the concept of biodiversity, a basic question is “what is more important to count: the number of species or the number of individuals”. Dawkins (2005, p. 484), in response to a claim that the Australian Great Barrier Reef housed one-third of the world’s sea creatures, asked “but what is being counted?” Stork (2007) began an article on the world of insects by quoting a remark by May (1986) “to a first approximation, all multicellular species on Earth are insects”. Since the diversity of species is one of the most interesting features of our planet, knowing the number of species on Earth is still one of the most basic questions in science (Mora et al. 2011).

Methods for estimating the global number of species have been developed within different studies. Each method is based on different assumptions. For example, May (1988) estimated 10 to 50 million species of animals based on body size frequency distributions, and extrapolated from the frequency of large to small species. Grassle and Maciolek (1992) estimated the world’s deep seafloor based on species-area relationships and extrapolated from the number of species in deep-sea samples. He thus estimated that the world's deep seafloor could contain up to 10 million species. In addition, Mora et al. (2011) recently presented a higher taxon approach to estimate the global number of species. The number of higher taxa was strongly correlated with taxonomic rank and this pattern allowed the extrapolation of the global number of species for any kingdom of life. This method relied on extrapolation of patterns from relatively small areas to estimate the number of species in other locations. In this way, Mora et al. arrived at a global total of 8.7 million eukaryotic species on land.

Moreover, to give a better idea of how many species, May (1988) pointed to various factors affecting diversity and approximation. These factors included the structure of food webs, pattern in relative abundance of species, the pattern of the number of species or number of individuals in different categories of physical size, and general observations about trends in the commonness or rarity of organisms. In addition, Stork (2007) also mentioned that the scale of sampling was needed to answer to questions, such as how many species there are and how they are distributed. In summary, documenting how communities of organisms and their interactions change along ecological gradients is fundamentally more important than counting species. At the end of his discussion, Stork concluded with the question: "how much nearer are we to a model or group of models that predict and explain the distribution of biodiversity on a global or even a regional scale?"

The message from these studies is that explanations for terrestrial biodiversity are based on the number of species that can be accommodated within various factors affecting diversity. Despite this rationale it is natural to perceive the diversity of life through other aspects such as abundance, distribution and assemblages. So to answer such question "is it more important to count the number of species or the number of individuals", we need to specify what aspect of diversity is to be focused on. Moreover, both the number of species and number of individuals can be considered as responding factors in studies, and particularly, the number of individuals need to be qualified by terms such as area and time and thus converted to density and incidence, respectively.

All of these studies provide valuable perspectives for our study on bird abundance. Understanding the nature of species and data depends on appropriate methods for explanation of species abundance. The attempt to apply appropriate statistical methods for species abundance is the aim of this study. Categorized resident birds have both flock and individual occurrences and there are different body sizes for different species. Some species are both migratory and resident birds in the same place. Bird species were counted with respect to both the number of species and the number of individuals seen within a day (7 hours). The numbers of individuals seen were thus converted to daily incidence rates: individuals per day (7-hours).

With quality of data as presented above, both graphical and statistical methods were applied for this study on resident birds. Since ecological data are often discrete counts –the number of species or individuals in a sampling area and they do not meet the assumptions of parametric statistical tests: they are not normally distributed, the variances are not homogeneous. Transforming the data is needed to satisfy statistical assumptions (Osborne 2002). Transformations are possible in many ways based on the kind of variables. In this case, to modify data with regression model, logtransformed incidence rates are needed to satisfy statistical assumptions. We added a constant 1 to all counts before taking logarithms. This method was usually applied to ecological data and these transformed rates were also finite and remain zeros when the incidence rates were zeros (Clark and Warwick 1994). Graphical methods were used to analyse the distributional pattern of incidence rates with species, site and season. Next, to find groups of species with common incidence patterns, factor analysis was used to classify groups of resident birds with respect to incidence rates by season and site. Finally, to answer to the question as "how can bird abundance be measured", we used the log-linear model.

This chapter also presents a summarized literature review on bird as indicator species and statistical issues.

1.2 Review of literature

Birds as indicator species

Birds are often considered to be good indicators of ecological conditions (see, for example, Taylor 1990, O'Connell et al. 2000, Davidar et al. 2001, Bryce et al. 2002, Chambers 2008 and Schrag et al. 2009). In the United Kingdom, composite bird indices are one of 20 'framework' indicators used to measure progress towards a government goal of achieving sustainable development by 2020 (Chambers 2008). In addition, the U.S. Forest Service was required by internal policy to selected monitor 'management indicator species' within national forest in assessing the condition of their respective habitats (Taylor 1990). It selected a group of birds. Moreover bird communities and assemblages had been developed to be an index of biotic integrity in ecological condition (see, for example, O'Connell et al. 2000, 2007, Graham and

Blake 2001, Bryce et al. 2002, and Mason and Macdonald 2005). Mistry et al. (2008) explored the potential of using birds as indicators of ecosystem change in the wetland system of the North Rupununi Guyana where local communities rely heavily on wetland resources for their subsistence activities. Their results implied that birds are potentially good indicators of overall vegetation composition and structure supporting food webs to the bird trophic level. Smith et al. (2001) examined the relative use of different forest stages by resident and migrant birds during the nonbreeding season in successional forest of the Yucatan peninsula, Maxico. They found that all stages of successional forest had highly similar bird assemblage and did not differ in bird abundance or diversity. Both migrant and resident birds occurred across the successional forest. The majority of habitat specialists were resident birds restricted to late-succession forest, and they typically participated in mixed-species flocks and attained their greatest densities in oldest forest habitat. In addition, Roberge and Angelstam (2006) suggested that indicator species approach may be useful for resident birds of deciduous forests in hemiboreal Europe, emphasizing that it should constitute one of many complementary tools for conservation management.

Statistical methods for species abundance, distribution and assemblages

Statistical methods for prediction of species abundance have recently been recognized as significant approaches for understanding factors determining the abundance. So in turn, they can be indirectly helpful for species conservation particularly in threatened areas. However lack of ecological knowledge is a limiting factor in the application of statistical modelling in ecology and conservation planning. Three components are needed for statistical modelling; an ecological model concerning the ecological theory used or assumed, a data model concerning data type and data collection, and a statistical model concerning the statistical methods and theory applied. The combination of ecological knowledge and statistical skill is important for selecting statistical methods (Austin 2002, 2007).

Various forms of regression analysis were used for predicting species abundance. Generalized linear modelling (GLM) approach has been recognized in ecology as having great advantages for dealing with a larger class of distribution for the response variable (Guisan et al. 2002). Of the GLM techniques, logistic regression is frequently used for modelling species abundance using presence-absence data (see, for example, Austin 2002, Rushton 2004. The Poisson model is the basic GLM for count data and is usually used as a starting analysis, but overdispersion commonly occurs in the analysis of abundance data when using Poisson distribution. Thus a negative binomial or quasi-Possion model is considered to handle an overdispersion. When there are many zeroes in abundance data, particularly in ecological data, zero-inflated models with extension of Poisson or negative binomial model are required for fitting zero-inflated count distribution (Guisan et al.2002; Greene 2008; Warton 2005).

Based on an extensive study of ecological data, Warton (2005) found that the negative binomial model provided the best fit for count distributions without zero-inflation, and a Gaussian model based on transformed abundance fitted data surprisingly well. It is common in biological and environmental science applications to transform counts by adding 1 before taking logarithms (Clark and Warwick 1994).

Bird assemblage is related to habitat characteristics and also has been used as an indicator of ecological health (O'Connell et al.2000, Graham and Blake 2001, Bryce et al. 2002, Mason and Macdonald 2005). Several statistical methods have been used to investigate relationships between habitat attributes and bird assemblages, including generalized 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 generalized 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 characterize 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.

1.3 Objectives for studies

These studies investigated appropriate methods to explain and predict bird abundance in the Thale Noi non-hunting area, Southern Thailand. Both graphical and statistical methods were applied for this study, and the outcome was number of birds sighted per day (7-hour). Graphical methods were used to examine bird distribution associated between these species-specific incidence rates and site and season. Next factor analysis was used to find groups of species with common incidence patterns. Finally, regression method was used to measure abundance of resident bird.

1.4 Background information for study area

The Thale Noi non-hunting area covers parts of Phatthalung, Nakhon Si Thamarat and Songkhla provinces of Southern Thailand covering 457 km^2, part of which was declared in 1998 as a Ramsar site, namely Khuan Khi Sian, the first in Thailand. Thale Noi non-hunting area has a high diversity of wetland habitat used by numerous resident and migratory birds (Chumrieng and Kongthong 2005), the majority being 60 species of resident birds. Khuan Khi Sian is a breeding site of five species of waterbirds, consisting of *Phalacrocorax niger*, *Ardea purpurea*, *Bubulcus ibis*, *Egretta garzetta* and *Nycticorax nycticorax*. This area also serves as a night roosting site for a rare migratory species, *Threskiornis melanocephalus* from April to July (Kaewdee et al. 2002). 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, and agricultural plots consist of paddy fields, rubber plantations and mixed orchards.

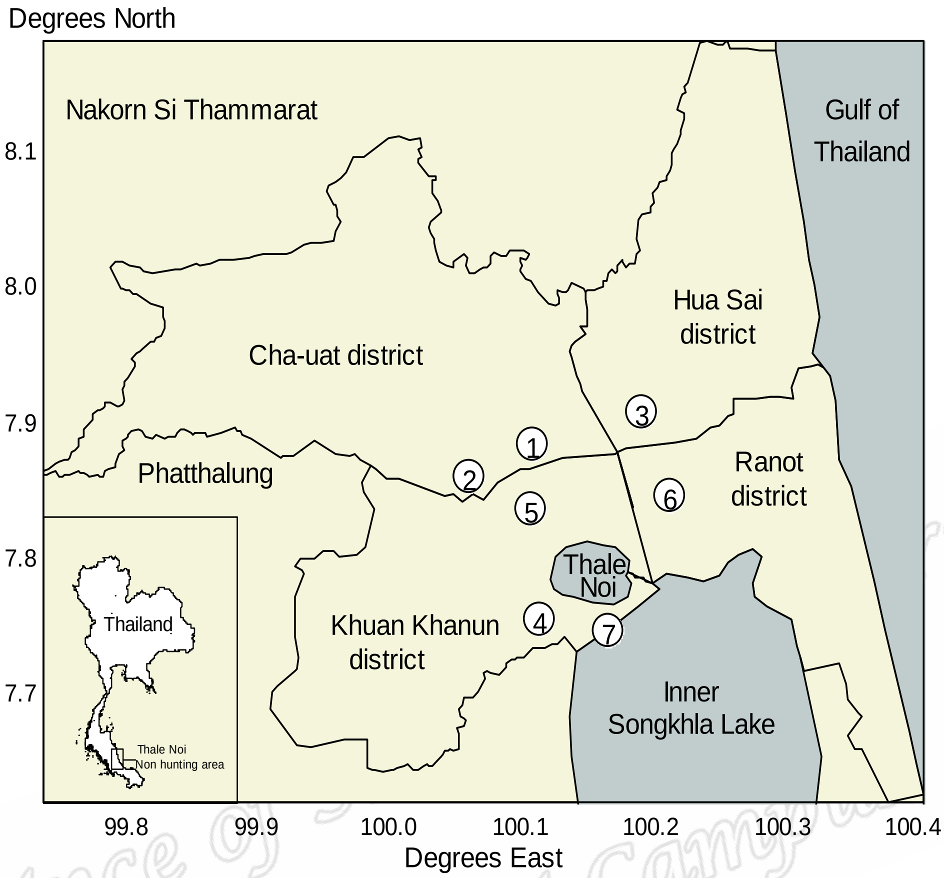

Figure 1.1 Study sites in the Thale Noi non-hunting area, Southern Thailand: Khuan Kreng (1), Khuan Nang Whean (2), Khuan Thale Mong (3), Klong Yuan (4), Khuan Khi Sian (5), Ban Pran (6) and Laem Din (7)

1.5 Road map of the present study

This thesis contains four chapters. The introductory chapter explains rationale, relevant literature and also study area. Chapter 2 provides a description of methodology including data management and an overview of the statistical methods for data analysis. Chapter 3 shows outcomes of studies and chapter 4 concludes the main findings and discusses the implications of the studies. Suggestions for further research are also given in this chapter.