CHAPTER 4

Discussion and Conclusions

This chapter summarizes the main results of the three studies included in CHAPTER 3. The first section summarizes the overall findings and statistical methods used in the studies. The second section discusses the implications of the study in ecology. Limitations and suggestions are given in the last section.

4.1 Overall findings

Distribution of resident birds

The aim of the first study was to analyse the distributional pattern of incidence rate, with species, site and season as determinant factors. The results showed that site and season were associated with incidence of resident birds. In particular, the continuously flooded grassland habitat was strongly related to incidence of resident species. Additionally, the flooding season led to high abundance of resident species. The six species with high abundance in the January-March season were *Dendrocygna javanica* (Lesser Whistling-Duck), *Himantopus himantopus* (Black-winged Stilt), *Bubulcus ibis* (Cattle Egret), *Nettapus coromandelianus* (Cotton Pygmy-Goose), *Porphyrio porphyrio* (Purple Swamphen) and *Phalacrocorax niger* (Little Cormorant). They all preferred seasonally inundated wetland habitats such as *Melaleuca* swamp forest, rice field and grassland.

For example, the highest incidence rate occurred at Laem Din, which had 9,540 individuals per day. Notably, the Lesser Whistling-Duck contributed around 30 per cent of all bird sightings. The Thale Noi non-hunting area is an important habitat for supporting waterbirds in wetlands, whereas the protected areas have been partly converted to agricultural areas such as oil palm and rubber plantations, particularly in sites Khuan Kreng (1), Khuan Nang Whean (2) and Khuan Thale Mong (3). Schrag et al. (2009) suggested that continued conversion of native ecosystems to annual crops may lead to a decrease in the overall richness of avifauna, because species richness is negatively correlated with agricultural expansion. Furthermore, Nguyen et al. (2009) found that the hydrological condition in the Tram Chim national park exerted a strong influence, sometimes positive and sometimes negative, upon wetland grassland structures including vegetation communities and the fauna, which could support birds by providing roosting, foraging and breeding areas. The Thale Noi non-hunting area has been utilized by both wildlife and human communities. Effective management of this area is required to protect habitats of bird species. For ongoing co-existence any additional human activities that interfere with bird habitats should be avoided.

Bird assemblages

The aim of the second study was to classify groups of species with respect to incidence rates by season and location. The classification reflects bird behaviours rather than bird taxonomies. The results indicated five groups of birds that correlated with respect to their habitats and availability of food. The first group (seven species) were 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 were found in habitats predominantly providing continuous flooding and aquatic plants. The second group (six species) were 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 were found in terrestrial habitats containing various food supplies, especially grain and insects. The third group (six species) were the Common Myna (*Acridotheres tristis*), Little Egret (*Egretta garzetta*), Black-winged Stilt (*Himantopus himantopus*), Common Tailorbird (*Orthotomus sutorius*), Barn Swallow (*Hirundo rustica*) and Purple Heron (*Ardea purpurea*). They were found in habitats connecting shallow fresh water to suburban environments and typically providing insect food sources both in water and on land. The fourth group (two species) were Yellow-vented Bulbul (*Pycnonotus goiavier*) and the Oriental Magpie-Robin (*Copsychus saularis*). These species were found in similar habitats to that of the second group, but related to fruit trees. The fifth group (two species) were the White-breasted Waterhen (*Amaurornis phoenicurus*) and Thick-billed Pigeon (*Treron curvirostra*). They were found in lowland habitats with dense undergrowth providing different food types including insects, seeds and fruit, particularly figs.

The birds in the same group coexist in the same habitat within different ecological functions performed by each species. Ecological roles of bird species include various functions as pollinators, seed dispersers, insectivores, raptors and scavengers (Sekercioglu 2006). Species' presence and abundance are influenced by habitats and available resources. Many studies have found that vegetation variables and habitats correlate with bird species richness and diversity (Catterall et al. 1989; 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 levels 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 (Ma et al. 2010). The Thale Noi non-hunting area should do likewise to protect wetland habitat for bird species.

Measuring Bird Abundance

The aim of the third study was to investigate methods for identifying daily incidence rates for bird species. The log-linear regression model based on aggregated data by species, site, season, and year were well fitted by this simple model of 2576 cells, 528 (20.50 %) zero counts. To modify data in this model, 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 zero when the incidence rate was zero (Clark and Warwick 1994).

The result of the third study showed that the incidence rates of species from the model are mostly higher than those from data (Figure 3.3). This result might be related to transformation function of skewness data. In addition, this probably related to counting species within different pattern of their occurrence especially, the Lesser Whistling-Duck and the Cattle Egret. The results from model refer to population. Our findings revealed that the Cattle Egret was found at the Thale-Noi non-hunting area with the highest incidence rates (394 individuals per day). The nine species with the high incidence rates comprised Cattle Egret (*Bubulcus ibis*), Chinese Pond-Heron (*Ardeola bacchus*), Little Egret (*Egretta garzetta*), Black-winged Stilt (*Himantopus himantopus*) Intermediate Egret (*Egretta intermedia*), Little Cormorant (*Phalacrocorax niger*), Common Myna (*Acridotheres tristis*)Lesser Whistling-Duck (*Dendrocygna javanica*), and Purple Swamphen (*Porphyrio porphyrio*). These most species were found in wetland habitats, particularly seasonally flooded, aquatic plants, *melaleuca* forest and grassland (Kaewdee et al. 2002, Chumrieng and Kongthong 2005, Rittiboon and Karntanut 2011, Rittiboon et al. 2012).

Similarly, the mean from the model are mostly higher than those from data except for site 7 Laem Din shown as Figure 3.4 (left panel). The resident birds were seen with higher numbers in Ban Pran and Laem Din, whereas they were seen with lower numbers in Khuan Kreng and Khuan Nang Whean. The majority of Ban Pran and Laem Din comprise wetland habitats including rice field, *Melaleuca* forest, grassland and inundated areas being important as feeding and breeding sites for bird species (Fasola and Ruiz 1996, Czech and Parsons 2002, Kaewdee 2002, Hamer et al. 2006, Nguyen et al. 2009). It probably influence high abundance of bird species. However, the seasonal effect little relates to occurrence of these birds as Figure 3.4 (right panel).

It shows incidence rates are mostly average occurrence rates. This due to resident bird is a species which is present throughout the year and presumed to breed (Lekagul and Round 2005).

Graphical and Statistical methods used

Data analysis is an important process to obtain results of study and to more understand on such study. Moreover, how this process can provide valuable results, it is based on methods used for analysis. As regards appropriate methods are important for accurate results and useful for further application. Selecting graphical and statistical methods used are based on type of data and purposes of study.

Mosaic plots (Hofmann 2003) and bubble charts are graphical methods used for the first study. Mosaic plots were used to display the associations between overall incidence rates and the site and season factors. These graphics represent values such as counts or incidence rates in a contingency table by rectangular tiles with areas proportional to the values. The advantage of the mosaic plots is that they give clearly present incidence rates associated with the site and season as proportional areas, and provide outstanding presentation. They can assist viewer by facilitating of comparison of three variables simultaneously.

Bubble charts were also used to depict the associations between the species-specific incidence rates and the site and seasonal factors. Bubble charts are structurally identical to mosaic plots, but use circles rather than rectangles. The bubble chart can be compared in terms of their size as well as their relative positions with respect to each axis. The area of the plot depended on the magnitude of a third numeric variable. In this case, the third numeric variable was incidence rates. For bubble charts with

large numbers of data, it is often useful to place a number in the centre of each bubble so that it can be easily located in a corresponding legend. It is otherwise quite complicated to plot a data-proportionate item for the third variable.

The advantage of a bubble chart is that it gives an accurate representation of the third variable. The bubble size has an area that is equal to the square-root of the value of the third variable.

Furthermore, graphical methods highlight how resident bird species abundance is distributed with respect to location and season. They are also useful to understand presentation instantly.

Factor analysis in the second study was used to find groups of species with common incidence patterns. The factor analysis in this 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. 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 maximize the weights within each group and minimize 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).

Factor analysis can be effectively applied to ecological data in order to classify groups of the birds that reflect their behaviours rather than their taxonomies.

In the third study, although a common feature of ecological data is that they typically have many zeros and are not Gaussian distribution, based on converting the numbers of individuals to daily incidence rates; our results revealed that special techniques are necessary to handle zeros. In this case, we reduced the number of zeros by using integrated approaches including ecological and statistical criteria. Moreover, transformations are often used to overcome such problems in ecology (Clark and Warwick 1994). With appropriate transformed outcomes, the log-linear model was found to be a good model for measuring bird abundance. This analysis suggests that a good approach to analysis of such data not only handles zeros but also considers factors affecting approximation. Therefore, with different data, investigating an appropriate method will be the interesting challenge to reasonably predict and explain the distribution of species.

4.2 Implication of the study

Many studies suggested that the overall practice of wetland management requires integrated knowledge related to ecosystem-based approach needed to improve the habitat quality. This study provides knowledge of the bird distribution on Thale Noi non-hunting areas helping officials to understand how such areas can be managed to provide bird habitats especially natural habitats including *melaleuca* forest, grassland and flooded area. It is especially important to know how species guild distributions

are affected by factors such as location and season and by specific wetland characteristics including land use by human communities. The adverse influence of human activities affects loss and degradation of bird habitats. Moreover, our findings revealed that graphical methods could be used as simple methods for display of species distribution. In addition, factor analysis could be applied not only to reduce variables for modelling but also to identify groups of species with common incidence patterns. This method is powerful to indicate relationships within different species appearing on the same occasions. Furthermore simple linear models fitted to log-transformed counts can estimate bird abundance reasonably well. Particular approaches are also needed to handle zeros.

4.3 Limitations and suggestions for further study

A limitation of the studies based on provided data is that the characteristics of environmental variables were not obtained in bird data. In addition, counting birds might not be consistent because of different bird occurrences such as flock, colony and individual. The count data range from small numbers to large numbers of birds. These factors affect data analyses in particular, modelling incidence rates.

Suggestions for further study

However, based on those factors affecting approximation, obtaining appropriate methods for measuring numbers of bird species should be considered for further research. In addition, evaluation of the area after the study period: (2004-2007) is an interesting issue because land use changes have probably caused bird habitat changes. Bird species can be considered as an indicator species to assess ecosystem changes in this protected area. Data thus contain vegetable characteristics and hydrological systems should be for further analyses. Important species including migratory birds

and endangered species should be investigated with the goal of identifying the best areas to be preserved as protected areas or Ramsar sites. This area has been degraded to different degrees because of uncontrolled forest fire and adverse influence of human use. Therefore, it is important to take the recommendation into account. The Thale Noi non-hunting area should also be managed to function as a social-ecological system for a harmonious co-existence of wildlife and human's sustainable livelihood.