POPULATION STUDY OF WATERBIRDS AND THE ASSESSMENT OF THE SUITABILITY OF KHUAN KHI SIAN, THALE NOI NON-HUNTING AREA, AS A RAMSAR SITE

Miss Watcharaporn Kaewdee

A Thesis Submitted in Partial Fulfillment of the Requirements
for the degree of Master of Science in Environmental Science
Inter-department of Environmental Science
Graduate School
Chulalongkorn University
Academic Year 1999

ISBN 974-333-768-7

การศึกษาประชากรของนกน้ำและการประเมินความเหมาะสมของควนขี้เสียน เขตห้ามล่าสัตว์ป่าทะเลน้อย ในการจัดตั้งเป็นพื้นที่ชุ่มน้ำแรมซาร์

นางสาววัชราภรณ์ แก้วดี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาวิทยาศาสตร์สภาวะแวดล้อม สหสาขาวิชาวิทยาศาสตร์สภาวะแวดล้อม
บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2542

ISBN 974-333-768-7

POPULATION STUDY OF WATERBIRDS AND THE ASSESSMENT OF THE SUITABILITY OF KHUAN KHI SIAN, THALE NOI NON-HUNTING AREA, AS A RAMSAR SITE

Miss Watcharaporn Kaewdee

A Thesis Submitted in Partial Fulfillment of the Requirements
for the degree of Master of Science in Environmental Science
Inter-department of Environmental Science
Graduate School
Chulalongkorn University
Academic Year 1999

ISBN 974-333-768-7

Thesis Title	Population Study of Waterbirds and the Suitability of Khuan Khi Sian, Thale Noi Non-hunting Area, as a Ramsar Site
By	Miss Watcharaporn Kaewdee
Department	Inter-department of Environmental Science
Thesis Advisor	Assistant Professor Kumthorn Thirakhupt, Ph.D.
Thesis Co-advisor	Schwann Tunhikorn, Ph.D.

Accepted by the Graduate School, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master 's Degree

..... Dean of Graduate School
(Professor Suchada Kiranandana, Ph.D.)

THESIS COMMITTEE

..... Chairman
(Assistant Professor Pipat Patanaponpaiboon, Ph.D.)

..... Thesis Advisor
(Assistant Professor Kumthorn Thirakhupt, Ph.D.)

..... Thesis Co-advisor
(Schwann Tunhikorn, Ph.D.)

..... Member
(Jarujin Nabhitabhata)

วัชราภรณ์ แก้วดี : การศึกษาประชากรของนกน้ำและการประเมินความเหมาะสมของควนขี้เสียน เขตห้ามล่าสัตว์ป่าทะเลน้อย ในการจัดตั้งเป็นพื้นที่ชุ่มน้ำแรมซาร์ (POPULATION STUDY OF WATERBIRDS AND THE ASSESSMENT OF THE SUITABILITY OF KHUAN KHI SIAN, THALE NOI NON-HUNTING AREA, AS A RAMSAR SITE) อาจารย์ที่ปรึกษา : ผศ.ดร.กำธร ธีรคุปต์, อาจารย์ที่ปรึกษาร่วม : ดร.ชวาล ทัฬหิกรณ์, 96 หน้า. ISBN 974-333-768-7

การศึกษาประชากรและช่วงฤดูกาลสืบพันธุ์ของนกน้ำที่บริเวณป่าเสม็ดควนขี้เสียน เขตห้ามล่าสัตว์ป่าทะเลน้อย กระทำโดยการนับจำนวนและบันทึกพฤติกรรมการสืบพันธุ์ของนกน้ำทุกเดือน ตั้งแต่เดือนเมษายน พ.ศ.2541 ถึงเดือนมีนาคม พ.ศ.2542 จากการศึกษาพบนกในป่าเสม็ดควนขี้เสียนและบริเวณใกล้เคียงจำนวน 46 ชนิด จำแนกได้เป็น 3 กลุ่ม ได้แก่ นกประจำถิ่น 30 ชนิด นกอพยพ 8 ชนิด และนกที่เป็นทั้งนกประจำถิ่นและนกอพยพ 8 ชนิด ซึ่งเป็นนกน้ำ 18 ชนิด มี 5 ชนิดที่ใช้ป่าเสม็ดเพื่อการสืบพันธุ์โดยสร้างรังอยู่รวมเป็นกลุ่มเดียวกัน ได้แก่ นกกาน้ำเล็ก *Phalacrocorax niger* นกกระสาแดง *Ardea purpurea* นกยางควาย *Bubulcus ibis* นกยางเปีย *Egretta garzetta* และนกแขวก *Nycticorax nycticorax* ทั้งนี้มีเพียงนกกาน้ำเล็ก *Phalacrocorax niger* และนกกระสาแดง *Ardea purpurea* เท่านั้นที่ใช้พื้นที่นี้เพื่อการสืบพันธุ์ตลอดทั้งปี และพบนกหายากในประเทศไทยเกาะนอนที่ป่าเสม็ดนี้ 1 ชนิดคือ นกกุลา *Threskiornis melanocephalus* ประชากรนกน้ำในป่าเสม็ดมีการเปลี่ยนแปลงขึ้นลงอย่างมากในรอบหนึ่งปี โดยมีประชากรเฉลี่ยมากที่สุด 13,867-20,217 ตัว ในเดือนพฤษภาคม และพบกิจกรรมการสืบพันธุ์ของนกน้ำมากที่สุดในเดือนพฤษภาคมและเดือนมิถุนายน เมื่อพิจารณาความสัมพันธ์ระหว่างจำนวนนกกับปัจจัยแวดล้อม (อุณหภูมิ ความชื้นสัมพัทธ์ และปริมาณน้ำฝน) พบนกน้ำ 3 ชนิดที่มีความสัมพันธ์กับปัจจัยดังกล่าว ได้แก่ นกยางควาย *Bubulcus ibis* นกแขวก *Nycticorax nycticorax* และนกกุลา *Threskiornis melanocephalus* จากผลการศึกษาประชากรนกน้ำในครั้งนี้อาจจะสรุปได้ว่าพื้นที่ควนขี้เสียนมีความเหมาะสมกับการเป็นพื้นที่ชุ่มน้ำแรมซาร์ภายใต้เกณฑ์การจำแนกพื้นที่ชุ่มน้ำที่มีความสำคัญระดับนานาชาติ ข้อ 1-6

สหสาขาวิชาวิทยาศาสตร์สภาวะแวดล้อม ลายมือชื่อนิสิต .....

สาขาวิชา วิทยาศาสตร์สภาวะแวดล้อม ลายมือชื่ออาจารย์ที่ปรึกษา .....

ปีการศึกษา 2542 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม .....

39716160213: MAJOR ENVIRONMENTAL SCIENCE
KEY WORD: WATERBIRDS/RAMSAR SITE/POPULATION STUDY/THALE NOI
WATCHARAPORN KAEWDEE: POPULATION STUDY OF WATERBIRDS AND THE ASSESSMENT OF THE SUITABILITY OF KHUAN KHI SIAN, THALE NOI NON-HUNTING AREA, AS A RAMSAR SITE. THESIS ADVISOR: ASSIST. PROF. KUMTHORN THIRAKHUPT, Ph.D., THESIS CO-ADVISOR: SCHWANN TUNHIKORN, Ph.D., 96 pp. ISBN 974-333-768-7

This study investigated the population density and the breeding period of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian, Thale Noi Non-hunting Area from April 1998 to March 1999. The number of these waterbirds was counted monthly and their breeding activities were also observed. A total of 46 species of birds was recorded, the species of which could be classified into 30 species of residents, 8 species of migrants and 8 species of partial migrants. Of 46 species, 18 species were waterbirds, but only 5 species used *Melaleuca* swamp forest as a breeding site, i.e. *Phalacrocorax niger*, *Ardea purpurea*, *Bubulcus ibis*, *Egretta garzetta* and *Nycticorax nycticorax*. This breeding colony also served as a roosting site for *Threskiornis melanocephalus*, a rare species of Thailand. The population density of waterbirds in the breeding colony fluctuated greatly throughout the year. The peak of waterbirds was in May when the number of individuals ranged from 13,867-20,217. The breeding activities also peaked in this month and in June. Of all the waterbirds, only *Phalacrocorax niger* and *Ardea purpurea* used this breeding colony throughout the year. It was found that *Bubulcus ibis*, *Nycticorax nycticorax* and *Threskiornis melanocephalus* showed the correlation between the number of individuals and environmental factors. From this study it might be concluded that Khuan Khi Sian is suitable to be a Ramsar site because it meets the criteria 1-6 of the criteria for identifying wetlands of international importance.

สหสาขา ENVIRONMENTAL SCIENCE ลายมือชื่อนิสิต Watcharaporn Kaewdee

สาขาวิชา ENVIRONMENTAL SCIENCE ลายมือชื่ออาจารย์ที่ปรึกษา K. Thirakhupt

ปีการศึกษา 1999 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม

Acknowledgements

Firstly, my thanks go to Assistant Professor Dr. Kumthorn Thirakhupt, my thesis advisor, for his care, supports, encouragement, patience, invaluable advice and many useful things throughout my study in Inter-department of Environmental Science. I am also grateful to my thesis co-advisor, Dr. Schwann Tunhikorn, for his invaluable guidances and suggestions.

I wish to express my grateful thank to Assistant Professor Dr. Pipat Patanaponphiboon, chairman of thesis committee, and Mr. Jarujin Nabhitabhata as the member of thesis committee for their suggestions. I am also grateful to Ajarn Dr. Art-Ong Pradatsundarasar and Mr.Manop Lauprasert for their invaluable guidance and suggestions.

At Thale Noi, I would like to thank Mr. Narit Khumnurak, the superintendent of Thale Noi Non-hunting Area during my data-collection. I am also grateful to Mr. Nakin Kaewboonsong for his hospitality and help. I wish to thank Mr. Wirat Muanjai, who drove me to the observation tower and give me the hospitality during the study period. I also would like to thank other personnel of Thale Noi Non-hunting Area and in particular to personnel of Khuan Khi Sian Protection Unit for their friendship.

I am indebted to Miss Anamai na-udom, the sister-like person, for her care, encouragements and helping hand in many ways, especially statistical analysis. I am also very grateful to Mr. Supat Posayawattanakul and Miss Nongpal Chancharoen for their useful advice and polishing my English writing.

I would like to thank my friends and colleagues, who assisted in the data-collection phases of this study: Miss Orasa Chaiyapong, Miss Wanna Youngchareon, Miss Rujra Wongplutong, Miss Waleerat Meekul, Miss Khuannat Sabuyjai, Miss Mayuree Pattarachaiyakhupt, Miss Pawinee Patanakorn, Mr. Tarntong Leawsiriwatanakul and Mr. Somrit Somchai. I also thank Mr. Theera Wacharapranee, who lend me a telescope and helped in the data-collection. Thanks also extended to Miss Nopparat Kataitong for her help in some statistical analysis and data-collection. Special thanks to all members of the Thai Turtle Laboratory at Chulalongkorn University for their useful suggestions and assistance in many ways.

I am thankful to the Graduate School of Chulalongkorn University who provides me the partial fund for the data-collection. I would like to express my grateful thank to the committee members and staff of Biodiversity Research and Training Program (BRT) for their supports.

Finally, I would like to express my special thanks to my family for their love and supports.

This work was supported by the TRF/BIOTEC Special Program for Biodiversity Research and Training grant BRT 541086

Contents

Contents (Cont.)

Contents (Cont.)

Page

List of tables

List of tables (cont.)

List of figures

List of figures (cont.)

Figure Page

Chapter 1

Introduction

1.1 Origin and rationale

Thale Noi Non-hunting Area is one of the forty wetlands that have been considered by the International Union for the Conservation of Nature and Natural Resources (IUCN) as the wetland of international importance in Asia. The area has high diversity of freshwater habitats for resident and migratory birds. Thailand has joined the Ramsar Convention as its 110th Contracting Party. Recently, Khuan Khi Sian, an area of 493.6 ha (3,085 rai) north of Thale Noi lake in Thale Noi Non-hunting Area has been listed as the first Ramsar site of Thailand since September 1998. The *Melaleuca* swamp forest at Khuan Khi Sian is one of the two large bird-breeding colonies in Thale Noi Non-hunting Area. Due to the lack of information on the population and breeding of waterbirds in this area, the more thorough study is required for determining the suitability of the area. In addition, the use of wetland resources by waterbirds is two of the eight criteria to identify wetland of international importance, the results of this study would be helpful for the assessment of the suitability of Khuan Khi Sian as a Ramsar site, and for the conservation of waterbirds in Thale Noi Non-hunting Area in the future.

1.2 Objectives

1. To study species composition, population density and population fluctuation of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian, Thale Noi Non-hunting Area, Phattalung Province.
2. To study the breeding period of waterbirds in the breeding colony at Khuan Khi Sian.
3. To assess the suitability of Khuan Khi Sian as a Ramsar site.

1.3 Scope of the study

1. The study of the waterbird diversity and their populations were conducted only at the breeding colony of waterbirds in *Melaleuca* swamp forest of Khuan Khi Sian, Thale Noi Non-hunting Area.
2. The study lasted for one year from April 1998 to March 1999.
3. Specific criteria based on waterbirds were only a consideration for the assessment of the suitability of Khuan Khi Sian as a Ramsar site.

1.4 Anticipated benefits

1. The study will provide basic information on waterbird populations in the breeding colony at Khuan Khi Sian.
2. The results from the study can be used for the assessment of Khuan Khi Sian whether or not it is suitable to be a Ramsar site and for the ecotourism management in the future.

Chapter 2

Literature review

2.1 The Ramsar Convention on Wetland

The Convention on Wetland, signed on 2 February 1971 in Ramsar, Iran, is an intergovernmental treaty which provides the framework for national action and international cooperation for conservation and wise use of wetland and their natural resources. The official name of the treaty is "The Convention on Wetlands of International Importance especially as Waterfowl Habitat". The original purpose of the convention emphasizes on the conservation and wise use of wetlands primarily to provide habitat for waterbirds. At present, its scope covers all of wetland conservation and wise use, recognizing wetland as ecosystems that are extremely important for biodiversity conservation and the well being of human communities. There are presently 119 Contracting Parties to the Convention with 1,023 wetland sites, totaling 74.9 million ha designated for inclusion in the Ramsar list of wetlands of international importance (Ramsar Convention Bureau, 2000a).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) serves as a depositary for the Convention, but its administration has been entrusted to a secretariat known as the "Ramsar Bureau", which is housed in the headquarters of IUCN (The World Conservation Union) in Gland, Switzerland, under the authority of the Standing Committee of the Convention and the Conference of the Parties. Besides, the Convention works closely with four non-government organizations, including Bird Life International (formerly ICBP- the International Council for Bird Preservation), IUCN, Wetland International (formerly IWRB-the International Waterfowl and

Wetlands Research Bureau) and the World Wide Fund for Nature (WWF) (Ramsar Convention Bureau, 2000a).

Each contracting party has to agree to designate at least one site for inclusion in the Ramsar list and promote its conservation, including its wise use when country joined the convention. It has to establish nature reserves in wetland area, expecting to promote training in the fields of wetland resource. Moreover, it has to agree to consult with other contracting parties about implementation of the convention. Contracting parties may designate additional wetlands for the Ramsar list or extend its boundaries anytime (Ramsar Convention Bureau, 2000a).

2.2 Criteria for identifying wetlands of international importance

Wetlands should be selected for the list of international importance on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology. In the first instance, wetlands of international importance to waterfowl at any reason should be included (Ramsar Convention Bureau, 2000a).

Group A of the Criteria.

(Sites containing representative, rare or unique wetland types)

Criterion 1: A wetland should be considered internationally important if it contains representative, rare, or unique example of natural or near-natural wetland type found within the appropriate biogeographic region.

Group B of the Criteria.

(Sites of international importance for conserving biological diversity)

Criteria based on species and ecological communities.

Criterion 2: A wetland should be considered international importance if it supports vulnerable, endangered, critically endangered species or threatened ecological communities.

Criterion 3: A wetland should be considered international importance if it supports populations of plant and/or animal species important for maintaining the biological diversity of particular biogeographic region.

Criterion 4: A wetland should be considered international importance if it supports plants and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Specific criteria based on waterbirds

Criterion 5: A wetland should be considered international importance if it regularly supports 20,000 or more waterbirds.

Criterion 6: A wetland should be considered international importance if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbirds.

Specific criteria based on fish

Criterion 7: A wetland should be considered international importance if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

Criterion 8: A wetland should be considered international importance if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

2.3 Wetlands

Wetlands are areas where water is the primary factor controlling the environment and associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water. According to the Ramsar Convention, wetlands are defined as:

"areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Article 1.1)

In addition, The Convention (Article 2.1) provides that wetlands "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies or marine water deeper than six meters at low tide lying within the wetlands". As a result of this provisions, the coverage of the Convention extends to a wide variety of habitat types, including rivers and lakes, coastal lagoons, mangroves, peatlands and even coral reefs. Moreover, it extends to include human-made wetlands such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage farms, and canals (Ramsar Convention Bureau, 2000a).

Wetlands occur in every country, from the tundra to the tropics. (How much of the earth's surface is presently composed of wetlands is not known exactly) The World Conservation Monitoring Center (WCMC) suggests an estimate of about 570 million ha (5.7million km^2) of wetland in the world. It is

roughly 6% of the earth's land surface, of which 2% is lakes, 30% bogs, 26% fens, 20% swamps, and 15% floodplains. Nevertheless, the conference of the parties to the Convention on Wetlands in 1999 indicated that the minimum of wetland area was estimated at between 748 and 778 million ha. The minimum of global wetland area could be increased to a total of 999 to 4,462 million ha when other resources of information were taken into account (Ramsar Convention Bureau, 2000b).

2.3.1 Wetland classification

Wetland classification frequency refers to their fertility, which is in turn a reflection of their nutrient content. This ranges from the poorest, ultra-oligotrophic and oligotrophic waters which are clear and highly oxygenated, through mesotrophic, eutrophic and hypertrophic waters, the latter being characterized by high levels of nutrients, low levels of oxygen and high algae levels. Eutrophic waters support few higher plants or animals (Ramsar Convention Bureau, 2000b).

According to the recommendation 4.7 of the Ramsar Convention, several broad wetland types can be identified. There are as follows (Davis (ed.), 1994):

- lacustrine (wetlands associated with lakes)
- riverine (wetlands along rivers and steams)
- palustrine (marshes, swamps and bogs)
- marine (coastal wetlands, including rocky shores and coral reefs)
- estuarine (including deltas, tidal marshes and mangroves)
- artificial water bodies (fishponds, reservoirs and artificial lakes)

"The Cowardin classification", is mandated in regulatory situations in the United States. It is the most widely used worldwide. It involves five systems delimited in most case by uplands on the shallow side and by prescribed water depth (2 meters), source of salinity (coastal or inland), and vegetation patterns in the deeper portion. The five systems are as follows:

1) marine (shallow coast saltwater)
2) estuarine (brackish coastal water)
3) lacustrine (relatively shallow, open, freshwater lakes or their sparely vegetation margins)
4) palustrine (marshy fresh or inland saline waters or more dense shoreward vegetated margins of large water bodies)
5) riverine (used in this system to mean those wetlands found only within the river channel, as opposed to river-formed wetlands) (Weller, 1999)

2.3.2 Status of wetlands in Thailand

The total of 340 wetlands was listed by IUCN as the wetlands of international importance in Asia, of which 42 of these are in Thailand. The distribution map of wetlands in Thailand is shown in figure 2.1. Wetland areas of Thailand are estimated to cover 2.5 million ha, provided an approximation of 4.9 % of the total area (The Prince of Songkla University, 1999). Wetland classification of Thailand was modified from the Asian Wetland Bureau (AWB), IUCN, Lower Mekong Basin and US Department of Interior classification after the meeting on 29 April and 13 June 1994 (Chandrachai, 1994). Although it resembles to wetland classification of Lower Mekong basin, it has more details and approaches. Wetland classification of Thailand is divided into 2 classes:

1) Fresh water, including riverine (river, river bank/beach/bars and river floodplain), lacustrine (lake and pond), and palustrine (permanent and seasonal palustrine).
2) Salt water, including marine/coastal (subtidal, intertidal, and nontidal), estuarine (subtidal, intertidal, and nontidal), coastal lagoon and inland salt lake. The complete classification is given in appendix A (Chandrachai, 1998). Figure 2.1 shows the distribution of wetlands of international importance in Thailand.

2.4 General description of Thale Noi Non-hunting Area

Thale Noi Non-hunting Area is one of the forty wetlands of Thailand that were listed by IUCN as the wetland of international importance in Asia (Scott, (ed.). 1989). It is situated on the extreme northern end of Songkhla lake, southern Thailand at the latitude 7° 45' to 8° 00' N and the longitude 100° 05' to 100° 15' E. Its 457 km^2 (285,625 rai) area takes in parts of three provinces: Khuan Khanoon District, Phattalung Province, Ranod District, Songkhla Province and Hua Sai and Cha-aud District, Nakhon Si Thammarat Province (Thai Engineering Consultants Co, Ltd., 1999). Figure 2.2 shows map of Thale Noi Non-hunting area and the location of Khuan Khi Sian.

Thale Noi Non-hunting Area consists of Thale Noi lake (28 km^2), marsh, paddy fields, canals, grasslands, rubber plantations, reed beds, tropical evergreen forest and *Melaleuca* swamp forest. Most of the areas are state owned with three of the national conservation forests: Khlong Yuan, Hua Pa Khieo and Pa Ban Nai Lum-Kum Pae-Phru Khuan Khreng, and open to public and communal use, whereas, the surrounding areas are mainly private-owned. Various parts of the area are presently used for fishing, cattle grazing, and cultivation of rice, rubber, orchard, and "Krajood" (*Lepironia articulata*), a sedge cultivated for the local handicraft industry. Thale Noi Non-hunting

Area is a home to 37 villages containing more than 5,000 families. Weaving of Krajood sedge into mats is a major industry. Tourism is important in some localities, over 200,000 foreign and local visitors come to Thale Noi every year (Ramsar Convention Bureau, 1998, August).

Parr (1994) studied a socio-economic and tourism assessment at Thale Noi Non-hunting Area, from June to September 1994. He reported that activities undertaken by villagers in utilizing the natural resources were diverse. A total of 1,218 households from 37 villages surveyed, were involved in fishing activity and 1,016 families planted Krajood sedge. At least 2,678 people from 1,981 households were involved in weaving of Krajood sedge into mats and handicrafts. There were 282 families raised a total of 4,444 buffaloes. In 1992, 589 families owned rubber plantations, while 4,357 families cultivated rice. All money generated from boat excursions, the handicrafts industry and restaurants were direct into the local economy. Also, he suggested Thale Noi area should remain a non-hunting area, and should not be upgraded to national park.

Khuan Khi Sian is situated approximately 5 km north of Thale Noi lake within Thale Noi Non-hunting Area. It covers an area of 496.3 ha (3,085 rai), including *Melaleuca* swamp forest, grasslands, reed beds and wet meadows. The *Melaleuca* forest of Khuan Khi Sian is one of the two large bird-breeding colonies in Thale Noi Non-hunting Area. Another breeding colony is Khuan Thale Maung situated northeast of Thale Noi Lake. Thailand has joined the Ramsar Convention as its 110th Contracting Party and Khuan Khi Sian has been enforced as the first Ramsar site of Thailand since 13 September 1998 (Ramsar Convention Bureau, 1998, August and Scott (ed.), 1989).

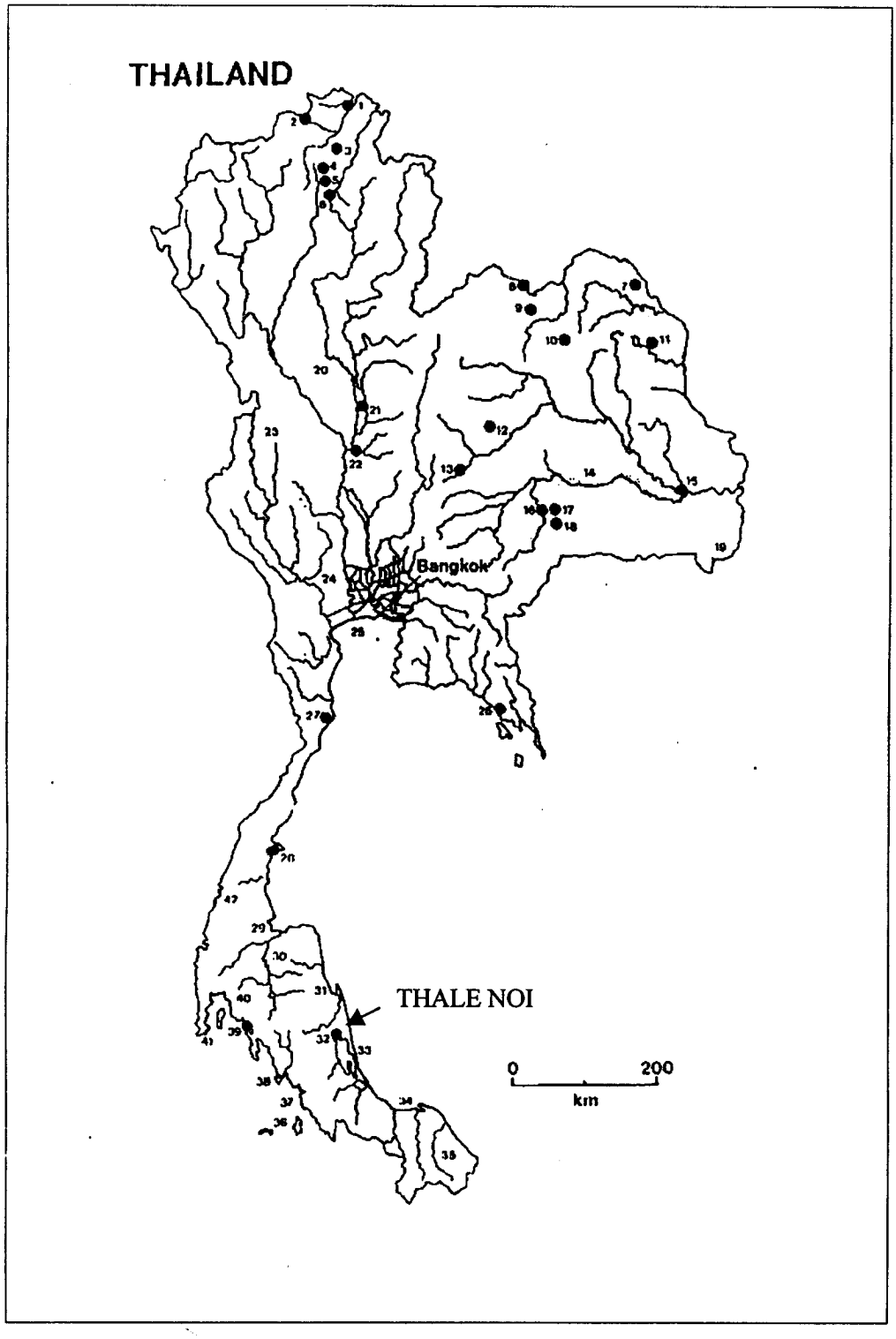


Figure 2.1 Distribution of wetlands of international importance in Thailand (Scott, 1989)

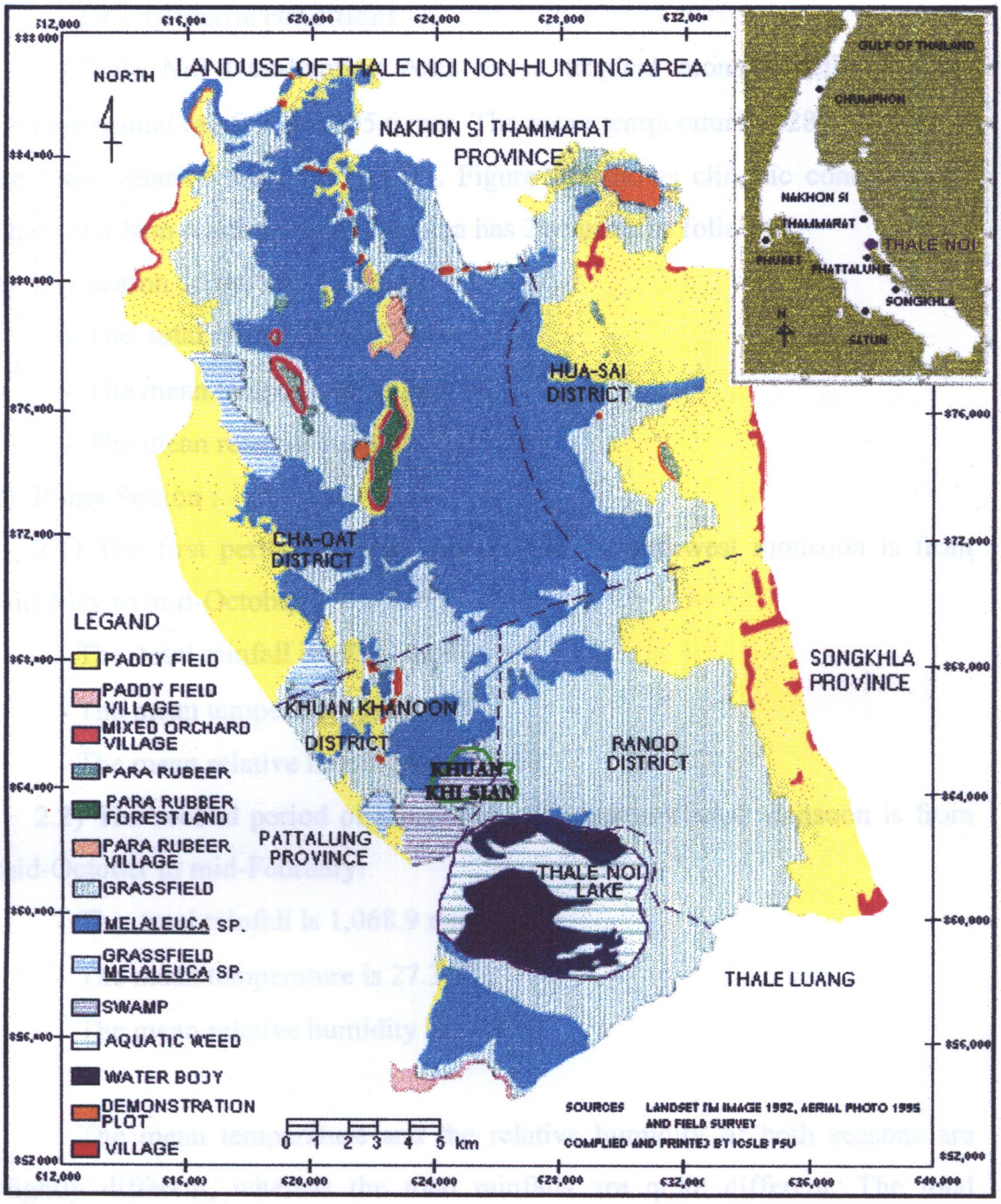


Figure 2.2 Map of Thale Noi Non-hunting Area and the location of Khuan Khi Sian (Modified from Thai Engineering Consultants Co, Ltd., 1999 and Thailand Institute of Scientific and Technological Research,1982)

2.4.1 Climatic conditions

Thale Noi Non-hunting Area has a tropical monsoon climate. The average annual rainfall is 1,805.6 mm. The mean temperature is 28.1 °C, whilst the mean relative humidity is 77%. Figure 2.3 shows climatic conditions of Thale Noi Non-hunting Area. The area has 2 seasons as follows:

1) Dry season : from mid-February to mid-May
   - The total rainfall is 253.2 mm
   - The mean temperature is 28.7 °C
   - The mean relative humidity is 75.3 %
2) Rainy Season :

2.1) The first period of rainy season during southwest monsoon is from mid-May to mid-October:

- The total rainfall is 483.6 mm
- The mean temperature is 28.5 °C
- The mean relative humidity is 76.3 %

2.2) The second period of rainy season during northeast monsoon is from mid-October to mid-February:

- The total rainfall is 1,068.9 mm
- The mean temperature is 27.3 °C
- The mean relative humidity is 78.8 %

The mean temperature and the relative humidity of both seasons are slightly different, whereas the total rainfalls are quite different. The total rainfall data were recorded at Khuan Khanoon District, Phattalung Province, about 17 km from Thale Noi Non-hunting Area. The annual relative humidity and the temperature data were recorded at Songkhla Province, about 80 km from Thale Noi Non-hunting Area (Climatology Department, Meteorological Department, 1999a, 1999b and Local Climate Division, Meteorological Department, n.d.).

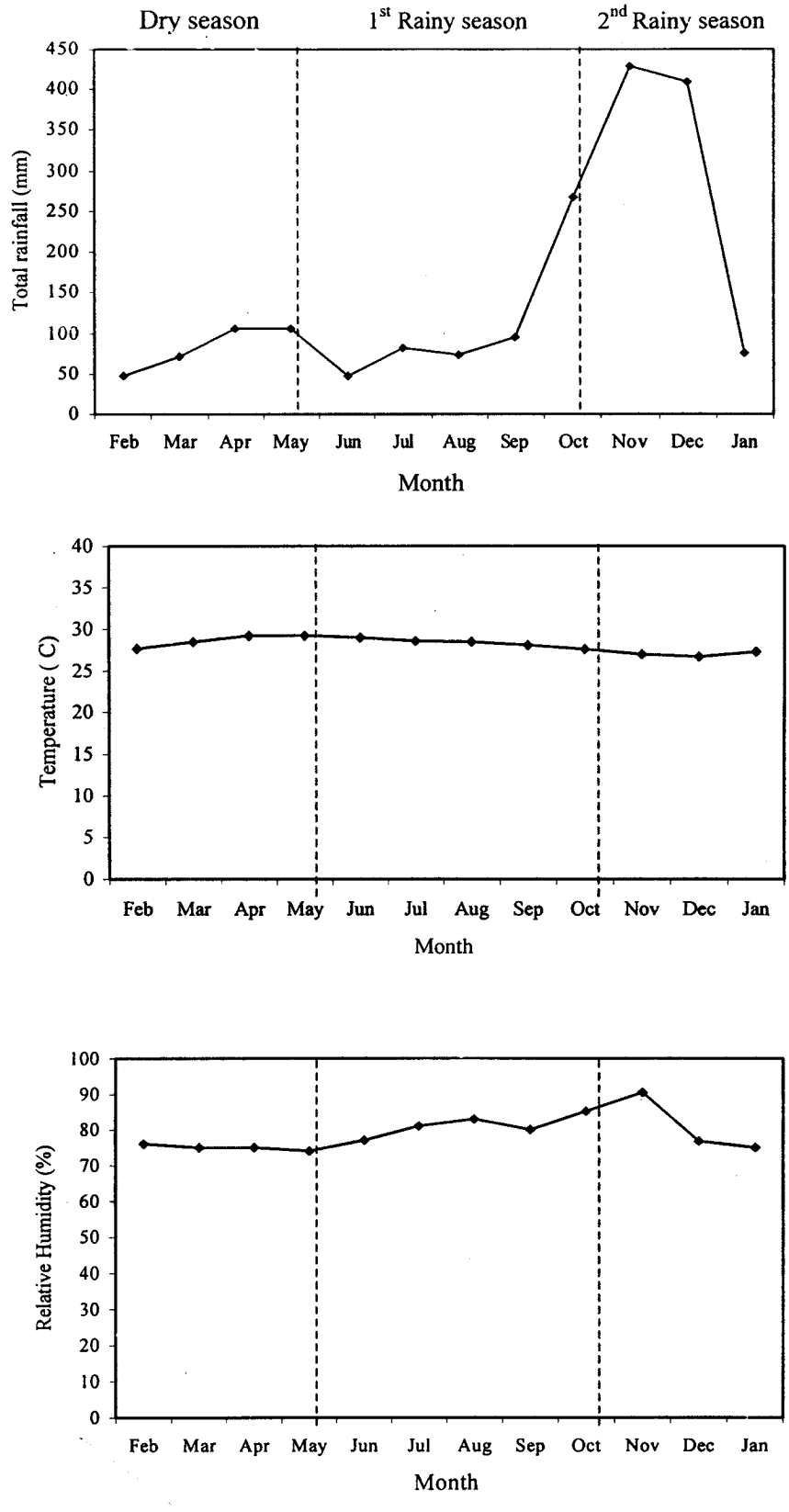


Figure 2.3 Climatic conditions of Thale Noi Non-hunting Area
(Climatology Division, Meteorological Department, 1999a, 1999b)

2.5 Waterbirds

Waterbirds are known as birds that frequently use shallow water or water's edge (Weller, 1999). There are 327 waterbird species, resident as well as migrant occurring in Asia. Some of these species breed in one part of their range and move to another part during the non-breeding period. They exploit a range of different parts of a wetland, or microhabitats. Each of these microhabitats supports a variety of different food sources. The richness of each wetland for waterbirds depends on the diversity of microhabitats and food sources availability. A number of waterbirds in which wetland can support depend on its size and, most importantly, its biological productivity. The groups of waterbirds in Asia are given in appendix B (Sonobe and Usui(eds), 1993).

According to Weller (1999), some birds are less dedicated to water, their morphological characteristics show adaptation to wet areas. Thus, they may be defined as wetland birds. Major groups of birds that regularly use wetlands are given in appendix C.

As the words "especially as waterfowl habitat" in the title of the Ramsar Convention, the particular group of waterfowl indicating wetland's values and diversity are included in the followings:

1) Loons or divers (Gaviidae)
2) Grebes (Podicipedidae)
3) Cormorants (Phalacrocoracidae)
4) Pelicans (Pelicanidae)
5) Herons, bitterns, storks, ibises and spoonbills (Ciconiiformes)
6) Swans, geese and ducks (wildfowl) (Anatidae)
7) Wetland related raptors (Accipitriformes and Falconiformes)

8) Cranes (Gruidae)

9) Shorebirds or waders (Charadriidae) and

10) Terns (Sternidae)

Waterfowl is grouped into the Order Anseriformes, comprising of 3 families: Anhimidae (Screamers), Anseranatidae (Magpie Goose), and Anatidae (ducks, geese, and swans) (Baldassarre and Bolen, 1994).

2.5.1 Waterbirds of Thale Noi Non-hunting Area

Storer (1977) studied the occurrence, seasonal and distribution of waterfowl at Thale Noi Non-hunting Area, from 13 October 1975 to 30 March 1976. A total of 30 species was recorded, of these 9 species were found in *Melaleuca* forest. *Phalacrocorax niger* inhabited all habitats in the study area including the usually barren open water sections, sometimes resting in large flocks of over 100 individuals. It was usually the last species to fly at dusk. *Egretta* spp. and *Bubulcus ibis* were present throughout the study period and found in all habitats shallow enough to wade. The population of *Ardea purpurea* appeared to decrease during November to December. However, the breeding colony location of this bird was not revealed. In addition, the observation concerning man's effect onto waterfowl at the area was also conducted.

Angkapreechases (1980) studied species diversity and bird populations at Thale Noi and Kukut of Songkla Lake from December 1980 to July 1981. The total of 155 species found at Thale Noi was more than that at Kukut, whereas the number of birds was less than that of Kukut. The bird populations of Thale Noi were likely to be more constant because they were less affected by salinity from the sea. Moreover, *Leptoptilos javanicus*, *Mycteria leucocephalus* and *Threskiornis melanocephalus* were only found at Thale Noi.

A similar study by the same author, studied the bird populations in Thale Noi Non-hunting Area, from December 1978 to October 1980 (Angkapreechases (1985)). A total of 149 species was reported, of which 116 species were residents and 33 were seasonal migrants. Most birds were found in swamp forest habitat. The maximum number of bird species was recorded in December, while the minimum number was recorded in July. The highest bird population was observed in April, whereas the lowest was recorded in October. The species diversity and population density varied greatly depending on bird species and some certain environmental factors. Temperature and seasonal variation strongly affected migratory birds, whereas the amount of rainfall, the water level and salinity affected the number of resident birds.

Thailand Institute of Scientific and Technological Research (TISTR) (1982) conducted an ecological study of waterbirds in Kukut and Thale Noi Non-hunting Area, Songkhla Lake. A total of 187 species was recorded, 187 species were found in Thale Noi and 143 species in Kukut. The maximum number of birds was recorded between December and March in both areas, whereas the minimum recorded between June and October. Ten dominant species at Thale Noi were *Tachybaptus ruficollis*, *Phalacrocorax niger*, *Bubulcus ibis*, *Mesophoyx intermedia*, *Ardea purpurea*, *Dendrocygna javanica*, *Nettapus coromandelianus*, *Gallinula chloropus*, *Porphyrio porphyrio*, and *Hydrophasianus chirurgus*.

Kanchanasaka, Tong-aree and La-ong (1986) investigated breeding and food habitats of some birds at Thale Noi Non-hunting Area, from October 1985 to September 1986, and reported that five out of seven species nested in *Melaleuca* forest were waterbirds. Four species nested in grassland and one species nested in floating plant habitat. The breeding period of *Ardea purpurea* started from the end of December to the beginning of July. The old nests of

Ardea purpurea were used by *Bubulcus ibis*. These birds normally fed on aquatic animals, fish, frogs, snakes, roots, stems and seeds.

2.5.2 Species of waterbirds that nested in the breeding colony at Khuan Khi Sian

Little Cormorant *Phalacrocorax niger*

Phalacrocorax niger is found more or less everywhere, in marshy inland area and on the coast. Of the three species of cormorants in Thailand, this species is the most widely spread, although not the most common. Its nests in colonies in trees often close to egrets and herons. The nest is a massy construction of branches piled up in the fork of a tree. It breeds in the central plain and disperses after the breeding season (Eve and Guigue, 1996).

Siriwanichkul (1981) studied food habits and breeding biology of *Phalacrocorax niger* at Khanon Tai Temple, Bang Pa-in District, Ayutthaya Province, from September 1980 to October 1981, and reported that this bird only fed on fish. The breeding period was between June and October. This bird nested colonially on the tree standing near water. The clutch was 2-6 eggs, incubation period ranged from 22 to 26 days and mortality rate of the young was 56.59 %.

Purple Heron *Ardea purpurea*

Ardea purpurea distributes from Africa and Madagascar through Eurasia into Southeast Asia and Sulawesi. It nests in the temperate zone and winters in the tropics, but it has both sedentary and migratory populations. In addition, the birds ringed in Siberia have been recovered in Korea, Thailand, and Malaya (McClure, 1998).

Cattle Egret *Bubulcus ibis*

Bubulcus ibis is common in most part of the world except Arctic and Antarctic. Both migratory and non-migratory populations occur depending upon the latitude, at which it nests. *Bubulcus ibis* ringed in Taiwan have been recorded in the Philippines and northeast of Taiwan (McClure, 1998). The northern subspecies, *Bubulcus ibis coromandus*, is migratory, whilst the southern individuals are sedentary although prone to wandering. Their routes and wintering grounds are unclear. *Bubulcus ibis* ringed in Japan have been recovered in the Philippines. The Taiwanese individuals have been recovered in Japan, the Philippines, Borneo and the Carolines. Non-breeding records in the Malay Peninsula, Sumatra, New Guinea and the Carolines, the Marianas and New Caledonia, reflects extensive wandering and perhaps migration (Hancock and Kushlan, 1984).

Bubulcus ibis, less aquatic than other herons, particularly appreciates the presence of cattle, capturing insects and other small animals disturbed by the movement of the cattle in the grass. Its close association helps the *Bubulcus ibis* greatly in searching for food. During migration in winter, it is possible to see *Bubulcus ibis* throughout the countryside, but the breeding grounds are restricted to the central region. It breeds in mixed colonies with large waders, building a nest of branches in the trees. During this period, its head, back and breast become reddish brown. This color appears progressively from mid-February (Eve and Guigue, 1996).

Silarangsi (1984) studied ecology of *Bubulcus ibis* at Sa Khaew Sub-district, Muang Suphanburi District, Suphanburi Province, from July 1983 to September 1984, and reported that the main diets of this bird were insects and spiders. The breeding period occurred once a year between February and July. It nested colonially on the large tree. The clutch size consisted of 2-5 eggs and

incubation period ranged from 20 to 26 days. Mortality rate of the young was 20.20 %.

Little Egret *Egretta garzetta*

Egretta garzetta, ranging over most of Africa, Eurasia (except far north) and Australia, has both migratory and non-migratory populations. However, the migrant form appears to be a minority in the northern populations, which is mainly a winter visitor in Nakhon Sawan Province of Thailand. There may be some connections of this bird between Asia and Australia according to a recovery recorded of *Egretta garzetta* ringed in Australia. In addition, Japanese individuals have been recovered in China and the Philippines, while Taiwanese individuals have been recovered in the Philippines (McClure, 1998). *Egretta garzetta* breeds sporadically in Africa, the less arid parts of Middle East, India and its islands, and Southeast Asia. In Japan, 80% of breeding population remain throughout the year (Hancock and Kushlan, 1984).

The *Egretta garzetta* nests in colonies, mainly in the central region, often in the company of the other species. The nest is a light structure of branches in the trees. After breeding, the birds fly off south and to the peninsula. In winter, migrants augment their numbers (Eve and Guigue, 1996).

Chaisiripan (1983) studied ecology, biology and behavior of *Egretta garzetta* at Wat Tan-en Non-hunting Area, Bang Pahan District, Ayutthaya Province, from June 1981 to May 1982. The study found that main diet of this bird was fish and the breeding period occurred twice a year; the first period was between June and September and the second was between December and February. The clutch size consisted of 2-5 eggs, and incubation was 20-27 days. Mortality rate of the young was 16.47 %.

Black-crowned Night Heron ***Nycticorax nycticorax***

Nycticorax nycticorax is a nocturnal which found worldwide and breeds in mono-specific or mixed species heronries at all latitudes from the equator to the north and the south of temperate zones. *Nycticorax nycticorax* ringed in Taiwan have been recorded in the Philippines while Japanese individuals have been reported in the Philippines and Taiwan. Besides, it is also protected in many countries and hunted as games in others (McClure, 1998).

Jaiyawat (1982) studied food habits and breeding biology of *Nycticorax nycticorax* at Wat Tan-en Non-hunting Area, Bang Pahan District, Ayutthaya Province, from July 1980 to July 1981, and reported that fish was the main diet of this bird. The breeding period was between June and March. Colonial nests were on the tree standing near water. The clutch consisted of 1-4 eggs and incubation was about 21 days.

Chapter 3

Methodology

3.1 Study area

Khuan Khi Sian is located at latitude 7° 49' to 7° 51' N and longitude 100° 07' to 100° 09' E. It is situated approximately 5 km north of Thale Noi lake in Thale Noi Non-hunting Area. This area has been enforced as the first Ramsar site of Thailand since 13 September 1998. Its area of 496.3 hectares (3,085 rai) is under the jurisdiction of the Khuan Khi Sian Protection Unit of Thale Noi Non-hunting Area, consisting of *Melaleuca* swamp forest, grass lands, reed beds and wet meadows. The study area, as the breeding colony, is situated about 350 m from the office of Khuan Khi Sian Protection Unit. It is one of the two large breeding colonies in Thale Noi Non-hunting Area. The other is situated at Khuan Thale Maung. Map of Thale Noi Non-hunting area and the location of Khuan Khi Sian are shown in figure 2.2.

The *Melaleuca* forest of Khuan Khi Sian is considered to be a secondary forest because most of the original trees were damaged by fire and replaced by the new trees. At present, most of them are approximately 10-15 m high.

The study area is flooded almost year round. In April, the water level is not high and gradually decreases afterwards. The area is absolutely dry from July to September. The study area is flooded again in October, then the water level gradually increases in November and slightly decreases toward March.

3.2 The study of species composition, population density and population fluctuation of waterbirds :

3.2.1 Census was operated by point count method with telescope (15-45x45), binocular (8x40) and naked eyes on the observation tower, situated approximately 300 m from the breeding colony. The breeding colony of waterbirds and the observation tower at Khuan Khi Sian are shown in figure 3.1 and 3.2.

3.2.2 The study was conducted 3 days a month from April 1998 to March 1999.

3.2.3 In each observation day, identifying and counting were performed every two hours from dawn till dusk and the total number of each waterbird species was recorded.

3.2.4 The maximum total number of each species in each observation day was used to calculate for mean and standard deviation.

3.2.5 The temperature and the relative humidity were recorded every two hours at the observation tower. The total rainfall data was taken from the station 50002 of the Meteorological Department at Khuan Khanoon District, about 17 km from the study site.

3.3 The study of the breeding period of waterbirds :

Breeding activities such as nesting, egg lying, hatching, etc were observed every month in the study area.

3.4 The assessment of the suitability of Khuan Khi Sian as a Ramsar site was considered by using the specific criteria based on waterbirds

Figure 3.1 The breeding colony of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian, 18 May 1998 (Aerial photograph)

Figure 3.2 The observation tower in *Melaleuca* swamp forest at Khuan Khi Sian, 17 April 1998

3.5 Data Analysis

3.5.1 Species richness, diversity index, dominant index and similarity index were used to determine diversity of birds in the study area at different time. Their formulas are as follows:

- Species richness = the number of species in the community
- Diversity index (Shannon-Weiner index)

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

where

H' = Index of species diversity (nits per individual)

S = Number of species

pi = Proportion of species i in the community

- Dominant index

$$C = \sum_{i=1}^{s} pi^2$$

where

C = Index of dominance

pi = Proportion of species i in the community

- Similarity index (Sorensen's similarity index)

$$S = \frac{2a}{2a+b+c}$$

where

S = Sorensen's similarity coefficient

a = Number of species in sample A and sample B (joint occurrence)

b = Number of species in sample A but not in sample B

c = Number of species in sample B but not in sample A

3.5.2. The maximum number of each waterbird was calculated for mean and standard deviation (n=3). Means were compared by using analysis of variance (ANOVA), and Duncan's multiple range test was used at $p \leq 0.05$ to classify homogeneous subsets of the means.

3.5.3. The correlation between the population diversity and each environmental factor (temperature, relative humidity and total rainfall) was determined by Pearson's correlation at $p \leq 0.05$.

3.5.4. Stepwise multiple regression analysis was used to determine the relationship between the number of waterbirds and environmental factors.

3.5.5. General calculations were performed by Microsoft Excel version 7.0 for Windows 95. Statistical analysis was performed using SPSS version 7.0 for Windows.

Chapter 4

Results and Discussion

4.1 Species richness of birds at Khuan Khi Sian from April 1998 to March 1999

A total of 46 species of birds from 21 families was found in *Melaleuca* swamp forest and nearby area at Khuan Khi Sian, Thale Noi Non-hunting Area, from April 1998 to March 1999. There were 18 species of waterbirds and 28 species of non-waterbirds such as fruit-eating and insect-eating birds, including the species that lived along *Melaleuca* swamp forest edge and the nearby meadows. It was found that 30 species were resident birds, 8 species were migratory birds and 8 species were classified as partial migrants (Table 4.1).

Seven species were found throughout the year, comprising *Phalacrocorax niger*, *Ardea purpurea*, *Bubulcus ibis*, *Egretta garzetta*, *Nycticorax nycticorax*, *Centropus sinensis* and *Haliastur indus*. A total of 5 species nested colonially in *Melaleuca* swamp forest, comprising *Phalacrocorax niger*, *Ardea purpurea*, *Bubulcus ibis*, *Egretta garzetta* and *Nycticorax nycticorax*. Four species, *Elanus caeruleus*, *Milvus migrans*, *Haliastur indus* and *Tyto alba* were birds of prey. Among these, only *Tyto alba* was classified as a nocturnal bird of prey. Besides, there were other two species of predators at the breeding colony. One was *Corvus macrorhynchos*, which was seen to feed on other waterbirds' eggs and also acts as a scavenger, another was *Nycticorax nycticorax*. According to Hancock and Kushlan (1984) *Nycticorax nycticorax* often takes the young of other colonial-nesting waterbirds by going through the colony.

Most birds found in this area are in the list of the Wild Animal Preservation and Protection Act (WARPA) (Royal Forest Department, 1992) except *Lanius cristatus*, *Hirundo rustica* and *Acridotheres fuscus*. Besides, a rare species in Thailand, *Threskiornis melanocephalus*, listed in 1996 IUCN red list of threatened animals as a near-threatened species (IUCN, 1996), also found in the area. Three species, *Bubulcus ibis*, *Casmerodius albus* and *Egretta garzetta* are listed in Appendix III of checklist of CITES species: checklist of fauna (World Conservation Monitoring Centre, 1998), whereas *Elanus caeruleus* and *Haliastur indus* are listed in Appendix II. Furthermore, four species are listed in the report of the meeting on the status of Thailand biological resources by Office of Environmental Policy and Planing (OEPP) (1996b) i.e. *Threskiornis melanocephalus*, *Ardea purpurea*, and *Milvus migrans* as endangered species and *Haliastur indus* as a near-threatened species.

Species richness of birds differed monthly from 12 to 25 species. The peak was recorded in November, January and February, due to the arrival of migratory species, while the lowest was observed in May and June.

As a matter of fact that most previous studies were conducted in the entire area of Thale Noi Non-hunting Area, therefore species richness of birds from the present study could not compare with them. However, this study has revealed some additional species, which were not recorded previously. For example, *Nycticorax nycticorax* was not recorded in the studies by Storer (1977) and Thailand Institute of Scientific and Technological Research (TISTR) (1982). Ten species were not recorded in the report studied by Angkapreechases (1980), of which the list were *Nycticorax nycticorax*, *Milvus migrans*, *Geopelia striata*, *Merops leschenaulti*, *Merops philippinus*, *Dinopium javanense*, *Cypsiurus balasiensis*, *Apus affinis*, *Hirundo rustica* and

Acrocephalus bistrigiceps. Three species - *Nycticorax nycticorax*, *Acrocephalus bistrigiceps* and *Dinopium javanense* -were not reported either (Angkapreechases, 1985). Moreover, four species were not listed in the Mahidol database (Mahidol University, 1994), comprising *Circus melanoleucos*, *Merops leschenaulti*, *Lanius cristatus* and *Apus affinis*.

The differences in species richness are probably due to the different of time and methodologies used in each study. It was found that most of these birds were partial migrants i.e. *Milvus migrans*, *Merops leschenaulti*, *Merops philippinus*, *Apus affinis*, *Hirundo rustica* and *Acrocephalus bistrigiceps*. Since *Nycticorax nycticorax* was not recorded in the reports of Storer (1977), TIRSTR (1982) and Angkapreechases (1980 and 1985), it is possible that this species may immigrate into Thale Noi Area and was a new record of this place since 1985.

In comparison with the data of Thai Engineering Consultants Co, Ltd. (TEC) (1998a and 1999), species found in this study were greater than the report prepared by TEC which studied birds in the same area. The TEC's report revealed 10 species which were not recorded in April, i.e *Nycticorax nycticorax*, *Threskiornis melanocephalus*, *Haliastur indus*, *Geopelia striata*, *Centropus sinensis*, *Centropus bengalensis*, *Apus affinis*, *Corvus macrorhynchos*, *Acrocephalus orientalis* and *Nectarinia jugularis*. However, two species listed in TEC's report- *Ardeola bacchus* and *Mesophoyx intermedia* - were not observed in this study. Thirteen species were not found in TEC's study between August and September, comprising *Ardeola bacchus*, *Egretta garzetta*, *Dupeter flavicollis*, *Treron vernans*, *Centropus sinensis*, *Tyto alba*, *Halcyon smyrnensis*, *Dinopium javanense*, *Cypsiurus balasiensis*, *Apus affinis*, *Lanius cristatus*, *Nectarinia jugularis* and *Dicaeum cruentatum*. Moreover, the following species recorded by TEC (1998) were not found in this study, i.e.

Ixobrychus sinensis, *Gallinula chloropus*, *Porphyrio porphyrio*, *Streptopelia chinensis* and *Apus affinis*.

In conclusion, the number of bird species found in this study was greater than in TEC's report. It may be because this study was conducted at the tower throughout the daytime, whereas the strip transect in the motor boat and the point count at the tower operated by TEC was conducted only a few hours in the late afternoon. As a result, the present study had more opportunities to observe more species of birds than TEC's survey, especially a nocturnal bird such as *Nycticorax nycticorax* and a rare species, *Threskiornis melanocephalus* that use *Melaleuca* swamp forest for roosting. Moreover, most of the birds are likely to be fled away, unnoticed, due to the loud noise from the motor boat.

As note by Sonobe and Usui (eds.) (1993), migratory period as form August to March and non-migratory period is from April to July. However, the present study found that the monthly numbers of species in each period were not quite different. For example, in migratory period, there were 23, 25 and 25 species in November, December and January, respectively. However, the species found in each month of the same period may not be exactly the same as indicated by similarity indices. The highest similarity index was 0.923 between April and May (table 4.2). The second highest value of similarity indices was 0.833 between May and June. These high values could be explained by the fact that April, May and June were the same period of non-migration. On the other hand, in the different period, the lowest value of 0.410 was recorded between April and November.

Table 4.1 Species richness of birds at Khuan Khi Sian from April 1998 to March 1999

Birds	Seasonal status	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
Family Dendrocygnidae													
เป็ดแดง *Dendrocygna javanica*	P					✓	✓	✓	✓	✓	✓	✓	✓
Family Picidae													
นกหัวขวานสามนิ้วหลังสีทอง *Dinopium javanense*	R						✓						
Family Halcyonidae													
นกกระเต็นอกขาว *Halcyon smyrnensis*	R			✓	✓	✓	✓	✓	✓	✓	✓		✓
Family Meropidae													
นกจาบคาหัวเขียว *Merops philippinus*	P							✓					
นกจาบคาหัวสีส้ม *Merops leschenaulti*	R							✓					
Family Cuculidae													
นกบั้งรอกใหญ่ *Phaenicophaeus tristis*	R				✓								
นกกระปูดใหญ่ *Centropus sinensis*	R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
นกกระปูดเล็ก *Centropus bengalensis*	R	✓	✓	✓	✓	✓	✓	✓			✓		
Family Apodidae													
นกแอ่นตาล *Cypsiurus balasiensis*	R						✓						
นกแอ่นบ้าน *Apus affinis*	R	✓				✓	✓						
Family Tytonidae													
นกแสก *Tyto alba*	R					✓							
Family Columbidae													
นกเขาใหญ่ *Streptopelia chinensis*	R							✓	✓	✓	✓	✓	✓

Table 4.1 Species richness of birds at Khuan Khi Sian from April 1998 to March 1999 (cont.)

Birds	Seasonal status	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
นกเขาเล็ก *Geopelia striata*	R	✓											
นกเปล้าคอสีม่วง *Treron vernans*	R				✓	✓	✓	✓	✓				
Family Rallidae													
นกกวัก *Amaurornis phoenicurus*	R			✓		✓			✓	✓	✓	✓	✓
นกอีโก้ง *Porphyrio porphyrio*	R								✓		✓	✓	✓
นกอีล้ำ *Gallinula chloropus*	R								✓	✓		✓	
Family Jacanidae													
นกพริก *Metopodius indicus*	R								✓	✓			
Family Charadriidae													
นกตีนเทียน *Himantopus himantopus*	P												✓
Family Accipitridae													
เหยี่ยวขาว *Elanus caeruleus*	R				✓			✓	✓	✓		✓	
เหยี่ยวดำ *Milvus migrans*	P							✓	✓		✓	✓	
เหยี่ยวแดง *Haliastur indus*	R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
เหยี่ยวด่างดำขาว *Circus melanoleucos*	M										✓	✓	
Family Phalacrocoracidae													
นกกาน้ำเล็ก *Phalacrocorax niger*	R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Family Ardeidae													
นกยางเปีย *Egretta garzetta*	R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
นกกระสาแดง *Ardea purpurea*	R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 4.1 Species richness of birds at Khuan Khi Sian from April 1998 to March 1999 (cont.)

Birds	Seasonal status	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
นกยางโทนใหญ่ *Casmerodius albus*	P										✓	✓	
นกยางโทนน้อย *Mesophoyx intermedia*	M										✓	✓	✓
นกยางควาย *Bubulcus ibis*	R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
นกยางกรอกพันธุ์จีน *Ardeola bacchus*	M						✓		✓	✓	✓		✓
นกแขวก *Nycticorax nycticorax*	R	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
นกยางไฟหัวดำ *Ixobrycus sinensis*	P								✓	✓	✓	✓	✓
นกยางไฟธรรมดา *Ixobrycus cinnamomeus*	R									✓		✓	
นกยางดำ *Dupeter flavicollis*	M						✓						✓
Family Threskiornidae นกกุลา *Threskiornis melanocephalus*	M	✓	✓	✓	✓								
Family Laniidae นกอีเสือสีน้ำตาล *Lanius cristatus*	M						✓	✓		✓	✓	✓	
Family Corvidae อีกา *Corvus macrorhynchos*	R	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
นกแซงแซวหางปลา *Dicrurus macrocercus*	P							✓	✓		✓		✓
Family Sturnidae นกเอี้ยงควาย *Acridotheres fuscus*	R							✓	✓	✓	✓	✓	✓
Family Hirundidae นกนางแอ่นบ้าน *Hirundo rustica*	P								✓				

Table 4.1 Species richness of birds at Khuan Khi Sian from April 1998 to March 1999 (cont.)

Birds	Seasonal status	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
Family Pycnonotidae													
นกปรอดหน้านวล *Pycnonotus goiavier*	R							✓	✓			✓	
Family Sylviidae													
นกพงคิ้วดำ *Acrocephalus bistrigiceps*	M									✓			
นกพงใหญ่พันธุ์ญี่ปุ่น *Acrocephalus orientalis*	M	✓	✓	✓						✓	✓	✓	✓
นกกระจิบคอดำ *Orthotomus atrogularis*	R								✓		✓		
นกกินปลีอกเหลือง *Nectarinia jugularis*	R	✓	✓			✓				✓			
นกสีชมพูสวน *Dicaeum cruentatum*	R					✓						✓	
Number of species	R = 30 M = 8 P = 8	14	12	12	14	17	17	21	25	23	25	25	21

Remarks:

R : Resident (a species which is present throughout the year and breeds or presumes to breed in Thailand)

M : Migrant (a species which migrates every year from the northern countries to Thailand or the other southern countries during the northern winter from August to November and return northward in March, April and May)

P : Partial migrant (a species is classified as resident and migrant because different populations show different seasonal status)

* The Scientific nomenclature followed Khobkhet (1999)

Table 4.2 Similarity indices of birds at Khuan Khi Sian from April 1998 to March 1999

Month	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99
Apr-98	1.000											
May-98	0.923**	1.000										
Jun-98	0.769	0.833	1.000									
Jul-98	0.714	0.769	0.769	1.000								
Aug-98	0.710	0.690	0.610	0.710	1.000							
Sep-98	0.581	0.552	0.621	0.645	0.706	1.000						
Oct-98	0.514	0.545	0.545	0.686	0.632	0.632	1.000					
Nov-98	0.410*	0.432	0.486	0.564	0.571	0.524	0.739	1.000				
Dec-98	0.540	0.571	0.571	0.541	0.600	0.550	0.636	0.750	1.000			
Jan-99	0.526	0.541	0.595	0.513	0.571	0.571	0.698	0.760	0.708	1.000		
Feb-99	0.461	0.486	0.486	0.426	0.524	0.429	0.652	0.720	0.750	0.800	1.000	
Mar-99	0.514	0.545	0.606	0.514	0.579	0.579	0.619	0.739	0.727	0.826	0.698	1.000

** highest similarity index

* lowest similarity index

4.2 Species richness, diversity indices, dominant indices and similarity indices of waterbirds

During the study period, six species of waterbirds were observed in *Melaleuca* swamp forest at Khuan Khi Sian. Among these waterbirds, five species nested colonially in *Melaleuca* swamp forest i.e. *Phalacrocorax niger*, *Ardea purpurea*, *Bubulcus ibis*, *Egretta garzetta* and *Nycticorax nycticorax*, while *Threskiornis melanocephalus* used *Melaleuca* swamp forest as the roosting site. Only *Phalacrocorax niger* and *Ardea purpurea* were found in the study area throughout the year. Waterbirds that nested colonially in *Melaleuca* swamp forest of Khuan Khi Sian are shown in figure 4.1.

Species richness of waterbirds differed monthly from 2 to 6 species. The highest species richness was in April, May, June and July. The lowest species richness was in September when only 2 species, *Phalacrocorax niger* and *Ardea purpurea* were observed in the breeding colony. It is assumed that other waterbirds gathered in various wet areas, such as, paddy fields, Thale Noi lake and wet meadows for most of the time in this month.

The diversity indices were proportional to the dominance indices. The former was greatest in March and lowest in October with the value of 1.369 and 0.500, respectively. The latter was in the opposite order. Table 4.3 shows species richness, diversity indices, dominant indices of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999.

The number of waterbird species was slightly different throughout the year as indicated by high value of similarity indices (Table 4.4). The highest values were 1.000 between April and May, April and June, May and June, May and July, December and January, December and February, December and March, January and February, January and March, and February and March. The lowest values were 0.500 between September and April, September and May, and September and June. The indices of waterbirds in September were low due to the decrease of the number of bird species. Moreover, four species, *Bubulcus ibis, Egretta garzetta*, *Nycticorax nycticorax* and *Threskiornis melanocephalus*, left the breeding colony temporarily in this month. All of them except, *Threskiornis melanocephalus*, seemed to gather in the wet areas.

Phalacrocorax niger

Ardea purpurea

Nycticorax nycticorax

Bubulcus ibis

Egretta garzetta

Figure 4.1 Waterbirds that nested colonially in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Table 4.3 Species richness, diversity indices and dominant indices of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Birds	Mean total number of waterbirds											
	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99
Phalacrocorax niger	2,687	3,473	2,333	2,532	1,112	53	779	1,430	2,235	2,034	1,771	1,704
Ardea purpurea	81	183	372	198	158	36	10	371	315	615	455	694
Bubulcus ibis	2,580	13,342	9,054	3,971	628	0	0	0	1,675	3,195	1,237	1,260
Egretta garzetta	277	42	28	18	35	0	34	1,002	281	671	115	264
Nycticorax nycticorax	132	26	11	1	7	0	95	1,118	1,156	445	317	337
Threskiornis melanocephalus	23	11	2	1	0	0	0	0	0	0	0	0
Total (individuals)	5,779	17,077	11,800	6,721	1,940	90	919	3,921	5,662	6,960	3,895	4,258
Species richness (species)	6	6	6	6	5	2	4	4	5	5	5	5
Species diversity index (nits per individual)	1.030	0.596	0.655	0.801	0.981	0.675	0.553	1.297	1.361	1.333	1.282	1.369
Dominant index	0.418	0.652	0.629	0.492	0.440	0.518	0.731	0.298	0.291	0.317	0.329	0.284

Table 4.4 Similarity indices of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

	Apr-98	May-98	Jun-98	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99
Apr-98												
Mar-98	1.000**											
Jun-98	1.000**	1.000**										
Jul-98	1.000**	1.000**	1.000**									
Aug-98	0.909	0.909	0.909	0.909								
Sep-98	0.500*	0.500*	0.500*	0.500*	0.571							
Oct-98	0.800	0.800	0.800	0.800	0.889	0.667						
Nov-98	0.800	0.800	0.800	0.800	0.889	0.667	1.000**					
Dec-98	0.909	0.909	0.909	0.909	1.000**	0.571	0.889	0.889				
Jan-99	0.909	0.909	0.909	0.909	1.000**	0.571	0.889	0.889	1.000**			
Feb-99	0.909	0.909	0.909	0.909	1.000**	0.571	0.889	0.889	1.000**	1.000**		
Mar-99	0.909	0.909	0.909	0.909	1.000**	0.571	0.889	0.889	1.000**	1.000**	1.000**	

** highest value of similarity index (Complete similarity)

* lowest value of similarity index

4.3 The population density of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian

The population density of each waterbird species fluctuated throughout the year and coincided with the breeding period of each species. The population density of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999 is shown in table 4.5.

The mean numbers of all waterbirds in each month fluctuated greatly throughout the year, which the maximum number was 17,077±3,140 individuals in May, and the minimum was 90±38 individuals in September. The average of means for all waterbirds was 5,752±4,731 individuals per month. In May, the mean numbers increased dramatically to the highest value, which was significantly different from other months. After that, they decreased steeply to the lowest point in September, then increased gradually to the second high value in January. Nevertheless, there was no significant difference in means among August, September and October. Later, mean numbers decreased in February and increased slightly in March. Figure 4.2 shows that mean numbers of all waterbirds which have two peaks. The first peak was recorded in May and the second peak was in January.

Table 4.5 Density of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Month	Means±SD						
	Phalacrocorax niger	*Ardea purpurea*	*Bubulcus ibis*	*Egretta garzetta*	*Nycticorax nycticorax*	*Threskiornis melanocephalus*	All waterbirds
Apr-98	2687^{gB}±114	81^{abA}±8	2580^{bcdB}±575	277^{bA}±96	132^{abA}±23	23^{cA}±5	5779^{cdC}±617
May-98	3473^{hB}±337	183^{bA}±24	13342^{fB}±3452	42^{aA}±18	26^{aA}±12	11^{bA}±3	17077^{fB}±3140
Jun-98	2333^{efgB}±483	372^{cdA}±87	9054^{eB}±1647	28^{aA}±16	11^{aA}±7	2^{aA}±3	11800^{eB}±2179
Jul-98	2532^{fgB}±173	198^{bA}±34	3971^{dB}±561	18^{aA}±7	1^{aA}±1	1^{aA}±1	6721^{dB}±646
Aug-98	1112^{bcB}±324	158^{bA}±13	628^{abB}±192	35^{aA}±15	7^{aA}±6	0^{aA}	1940^{abB}±441
Sep-98	53^{aB}±33	36^{aAB}±11	0^{aA}	0^{aA}	0^{aA}	0^{aA}	90^{aC}±38
Oct- 98	779^{bB}±314	10^{aA}±12	0^{aA}	34^{aA}±24	95^{abA}±94	0^{aA}	919^{aB}±425
Nov-98	1430^{cdD}±323	371^{cdB}±42	0^{aA}	1002^{dC}±321	1118^{dCD}±66	0^{aA}	3921^{bcE}±198
Dec-98	2235^{efgC}±421	315^{cAB}±95	1675^{abcC}±906	281^{bAB}±75	1156^{dBC}±352	0^{aA}	5662^{cdD}±1211
Jan-99	2034^{defB}±391	615^{eA}±22	3195^{cdB}±934	671^{cA}±183	445^{cA}±152	0^{aA}	6961^{dB}±695
Feb-99	1771^{deC}±302	455^{dAB}±159	1237^{abcBC}±748	115^{abA}±44	317^{bcAB}±78	0^{aA}	3895^{bcD}±1121
Mar-99	1704^{cdeC}±571	694^{eAB}±82	1260^{abcBC}±476	264^{bA}±162	337^{bcA}±214	0^{aA}	4258^{bcD}±812
number per month	1845±921	291±220	3079±4103	231±310	304±418	3±7	5752±4731

* Significant differences ($p<0.05$) between months are indicated by differences in superscript letter in the same column (normal letter) or in the same row (capital letter)

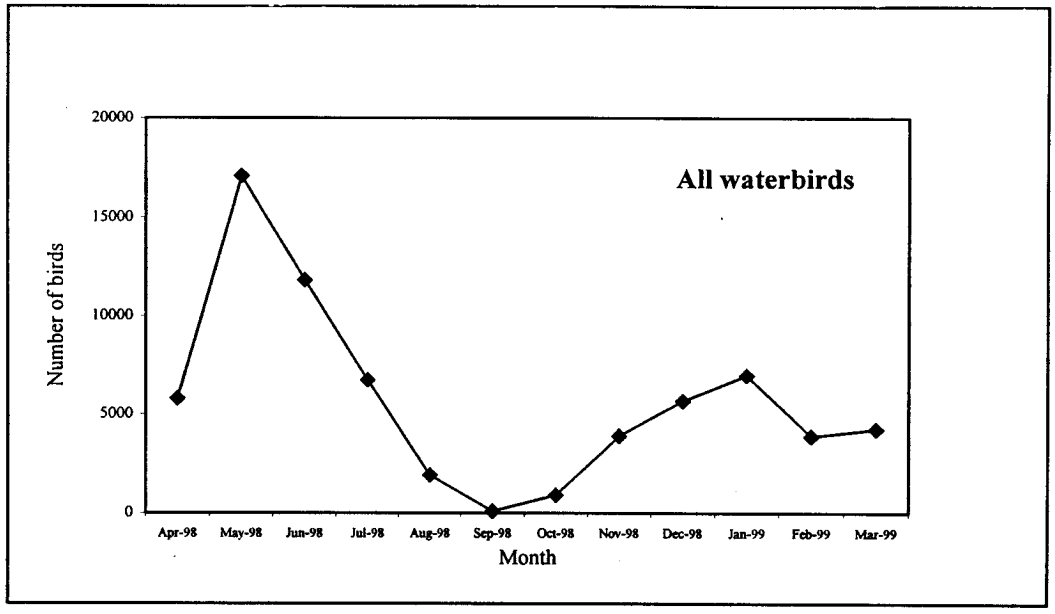


Figure 4.2 Population fluctuation of all waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Little Cormorant *Phalacrocorax niger*

The population density of *Phalacrocorax niger* fluctuated greatly throughout the year. The maximum of means, which was significantly different from data collected in other months, was 3,473±337 individuals in May, whereas the minimum was 53±33 individuals in September. There was also a significant difference in means between September and other months. After the decrease in September, the population density of this species increased to the second peak in December and decreased slightly until March. The results showed that *Phalacrocorax niger* had 2 peaks of population density; the higher peak was in the first period of rainy season from May to July and another was in the second period of rainy season from October to February.

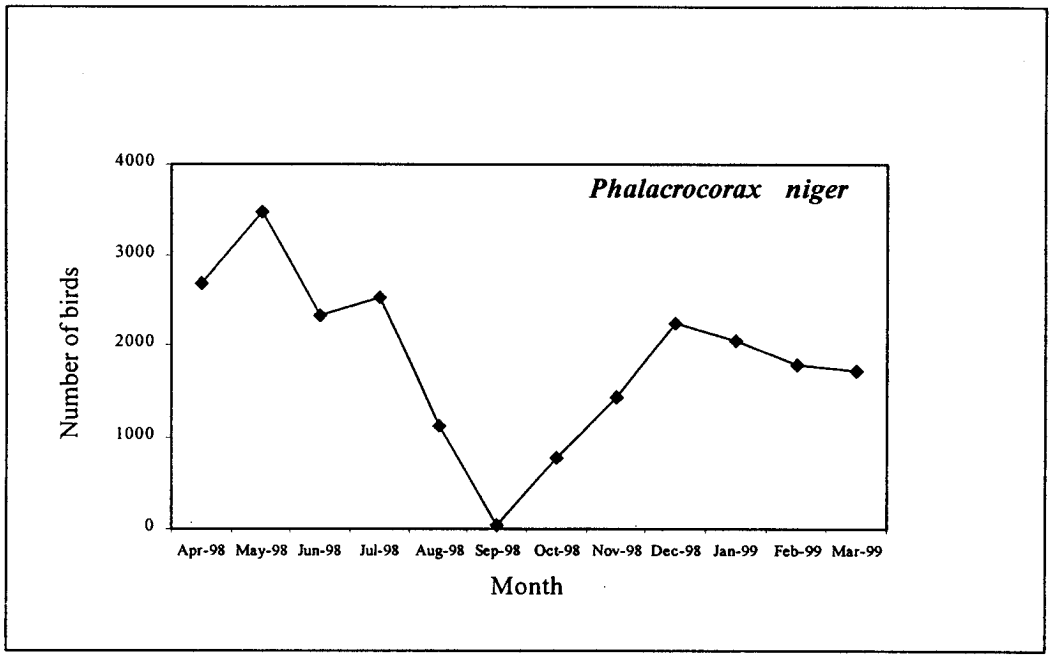


Figure 4.3 Population fluctuation of *Phalacrocorax niger* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Purple Heron *Ardea purpurea*

In comparison with *Phalacrocorax niger*, monthly mean numbers of *Ardea purpurea* did not change greatly throughout the year. The maximum number was 694±82 individuals in March, whilst the minimum was 10±12 individuals in October. The average of means for this bird was 291±220 individuals per month. The result in figure 4.4 showed that the means increased to the first peak in June then gradually decreased to the lowest value in October. The highest peak was recorded in March after a slight fluctuation from December to February. Significant differences in means were found except between September and October and between January and March.

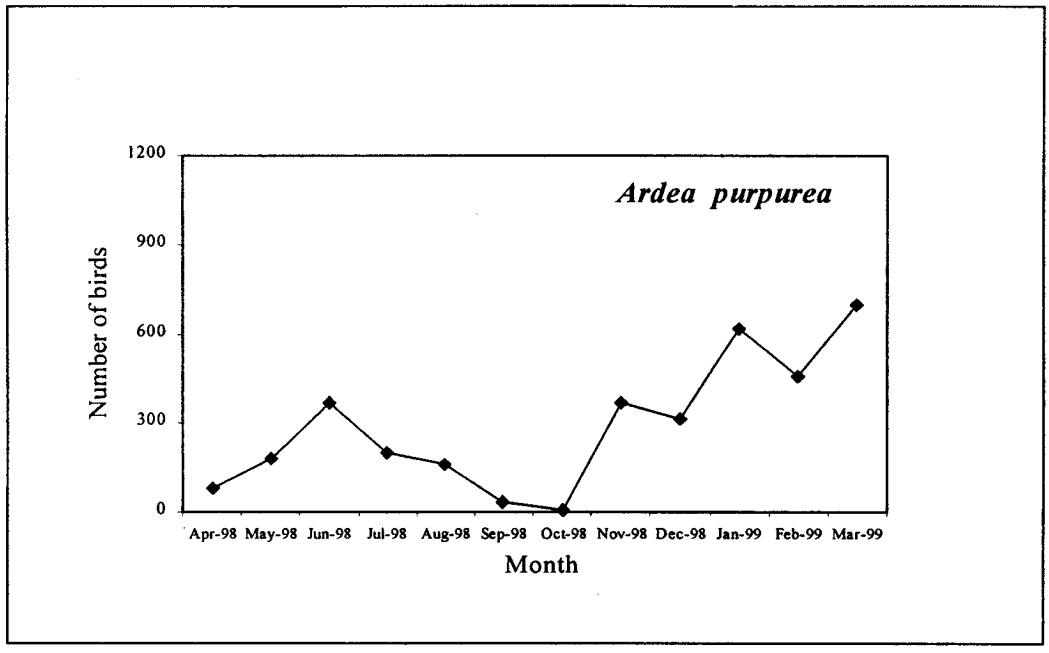


Figure 4.4 Population fluctuation of *Ardea purpurea* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

***Bubulcus ibis* Cattle Egret**

The monthly mean numbers of *Bubulcus ibis* fluctuated in a wide range pattern from 0 to 13,342±3,452 individuals, which the maximum number was recorded in May. The minimum number of 628±192 individuals was in August. The average of means was 3,079±4,103 individuals per month. The population density increased steeply from April to the highest peak in May then decreased dramatically to zero from September to November when none of this bird was found. The second peak was in January followed by a slight decrease in February and March.

As shown in figure 4.5, the higher peak was observed in the first period of rainy season from May to July. During this time the population carried on its breeding activities. In the second period of rainy season, a considerable number of *Bubulcus ibis* returned to the breeding area at dusk in

January but their breeding activities were not found. It is likely that they prepare to occupy nesting sites.

Little Egret *Egretta garzetta*

The number of *Egretta garzetta* from May to October was not high and did not show significant difference (Figure 4.6). The maximum value, which was significantly different from other months, was 1,002±321 individuals in November, whereas the minimum was 18±7 individuals in July. None of this bird was found in September. The average number per month of *Egretta garzetta* was 231±310 individuals. After the absence from the study area in September, this bird was seen again and its number fluctuated moderately from December to March.

From the data obtained, it indicated that the number of *Egretta garzetta* was low during the first period of rainy season from May to October, even though some of its breeding activities could be observed. It is probably that some factors are not suitable for this bird to complete its breeding activities. For example, a large number of *Bubulcus ibis* may compete with *Egretta garzetta* for the nesting site, thereby limiting the population of *Egretta garzetta* during its breeding period from April to September. However, the mean numbers of this species were high at the second breeding activities from October to January when *Bubulcus ibis* did not nest during these months.

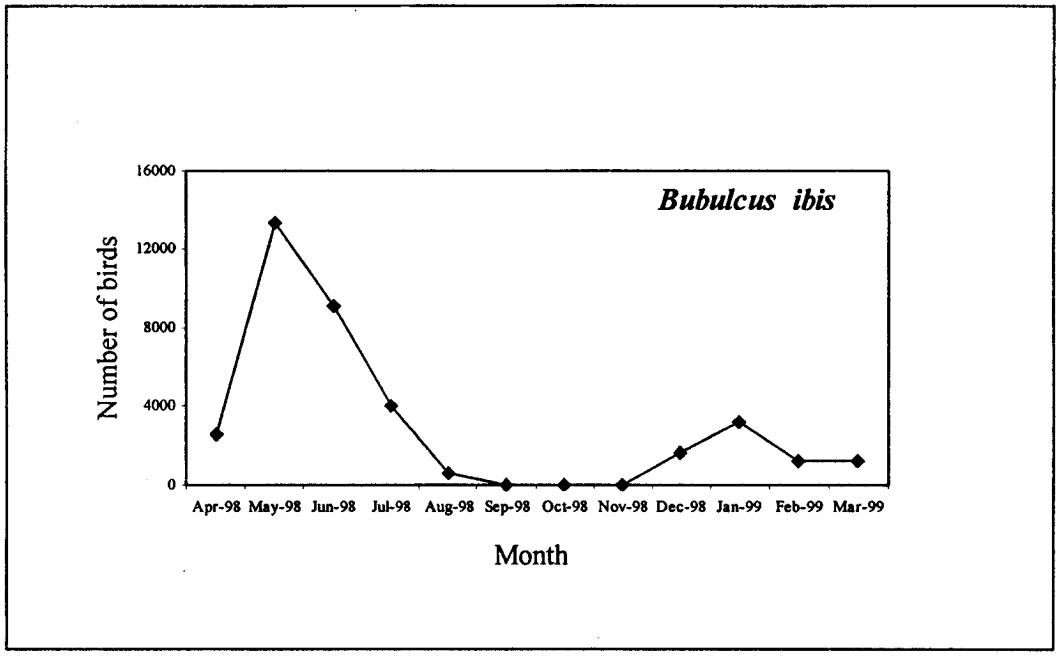


Figure 4.5 Population fluctuation of *Bubulcus ibis* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

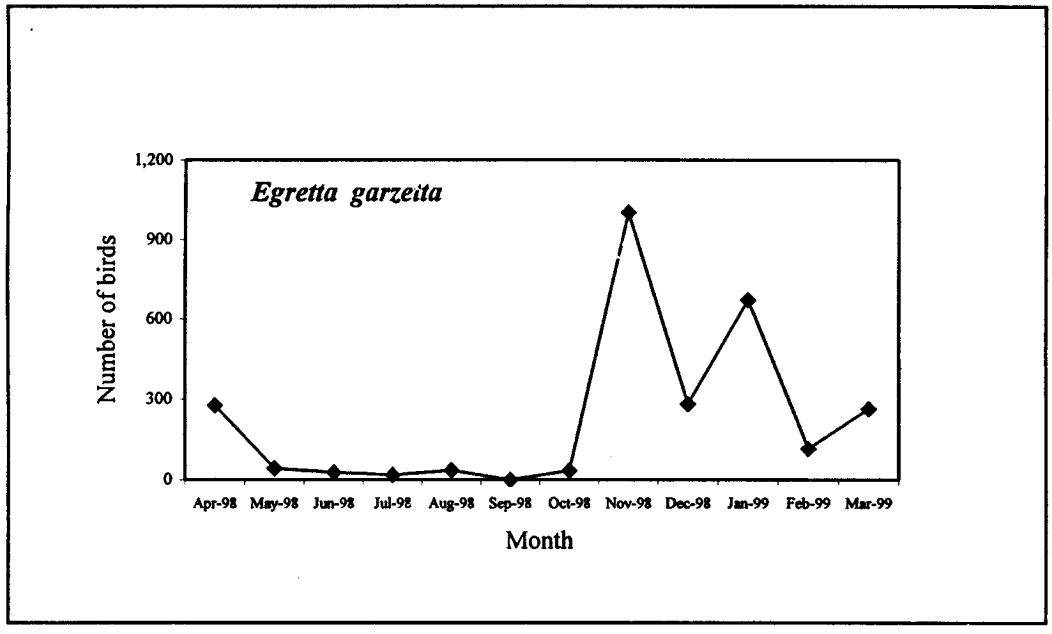


Figure 4.6 Population fluctuation of *Egretta garzetta* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Black-crowed Night Heron ***Nycticorax nycticorax***

The population density of *Nycticorax nycticorax* was low in the first period of rainy season from April to October (Figure 4.7). The average number of *Nycticorax nycticorax* was 304±418 individuals per month, which the maximum was 1,156±325 individuals in December, whereas the minimum was 1±1 individual in July. None of this bird was found in September. Population density was low from April to October and did not reveal a significant difference among these months. The population density of this species peaked in November and December. Then the reduction of almost half of its original number was recorded.

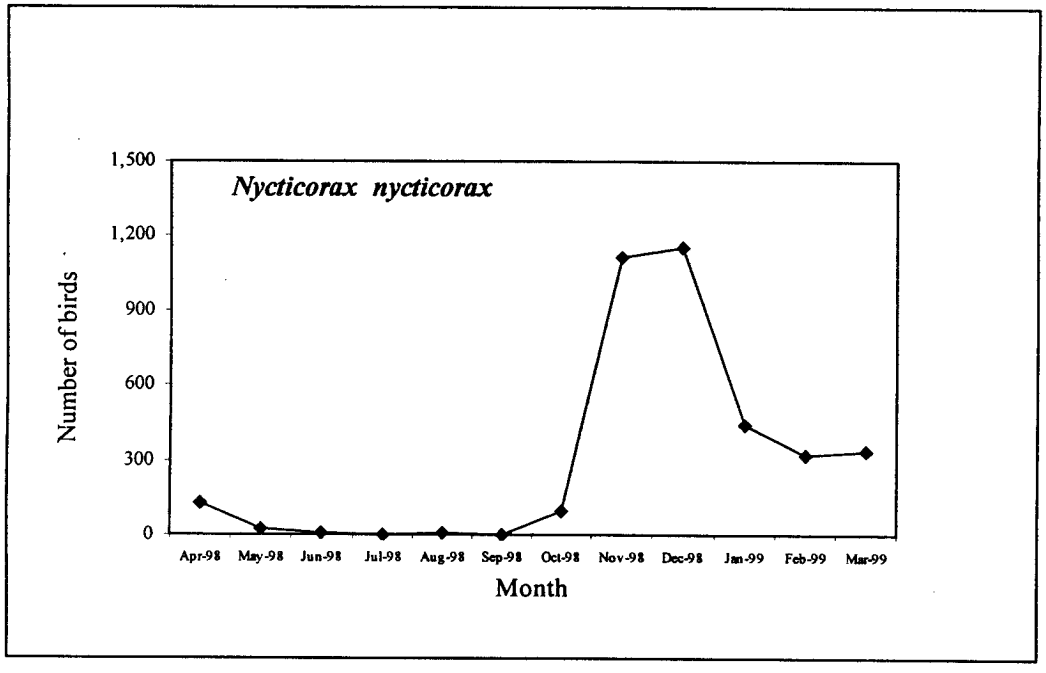


Figure 4.7 Population fluctuation of *Nycticorax nycticorax* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

***Threskiornis melanocephalus* Black-headed Ibis**

From the data obtained, population of *Threskiornis melanocephalus* tended to decrease significantly over time and after July it disappeared from Khuan Khi Sian area. An average of means was 3±7 individuals per month, which the maximum was 23±5 individuals in April. Figure 4.8 shows Population fluctuation of *Threskiornis melanocephalus* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999.

Threskiornis melanocephalus, did not nest in Khuan Khi Sian breeding colony, however it flew into the area for roosting after dusk from April to July. It left the colony for feeding before dawn, thus none of this bird was found in the study area during daytime. According to the observation by Thale Noi Non-hunting Area personnel (personal comm.), this species traveled to feed during daytime in wetland areas at Ban Pran and Khuan Thale Maung, which located in the north and the northeast of Thale Noi lake.

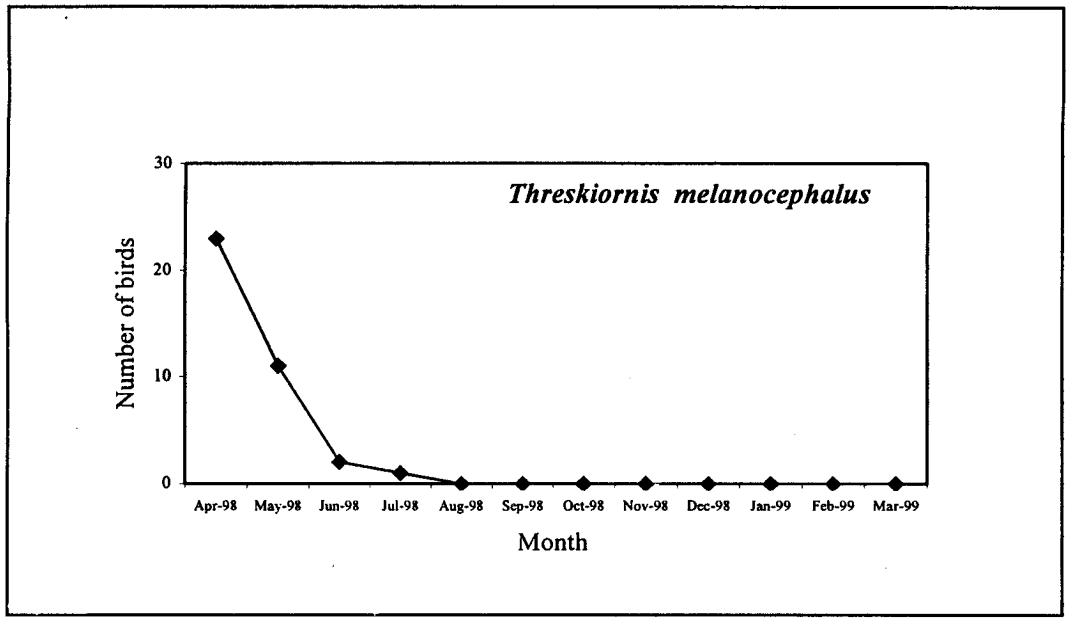


Figure 4.8 Population fluctuation of *Threskiornis melanocephalus* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

It can be concluded from this study that the mean numbers of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian peaked in breeding period relating to the peak of breeding activities. The population density was low in a non-breeding period when most of young birds completely fledged and left the breeding colony temporarily for feeding with their parents in some wet areas. Population fluctuation of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999 is shown in figure 4.9.

4.4 The breeding period of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian

Breeding activities were observed monthly during the study period. It was found that five species of waterbirds nested colonially in *Melaleuca* swamp forest, comprising, *Phalacrocorax niger*, *Ardea purpurea*, *Bubulcus ibis*, *Egretta garzetta* and *Nycticorax nycticorax* (Figure 4.1). Among these waterbirds, only *Phalacrocorax niger* and *Ardea purpurea* used this *Melaleuca* swamp forest for breeding and roosting throughout the year.

Kanchanasaka, Tong-aree and La-ong (1986) reported that three out of seven species of birds that nested in *Melaleuca* forest at Thale Noi Non-hunting Area were waterbirds, namely *Mycteria leucocephalus*, *Ardea purpurea* and *Bubulcus ibis*. Among these, only *Mycteria leucocephalus* was not found in the present study. Three species, *Phalacrocorax niger*, *Egretta garzetta* and *Nycticorax nycticorax* nested at Khuan Khi Sian but not recorded in the previous study by Kanchanasaka, Tong-aree and La-ong (1986). *Ardea purpurea* and *Bubulcus ibis* were observed in both studies. Although *Mycteria leucocephalus* were not found in this study, a few *Mycteria leucocephalus* foraged in some wet areas in Thale Noi Non-hunting Area during the study period, according to the observation by Thale Noi Non-hunting Area personnel (personal comm.).

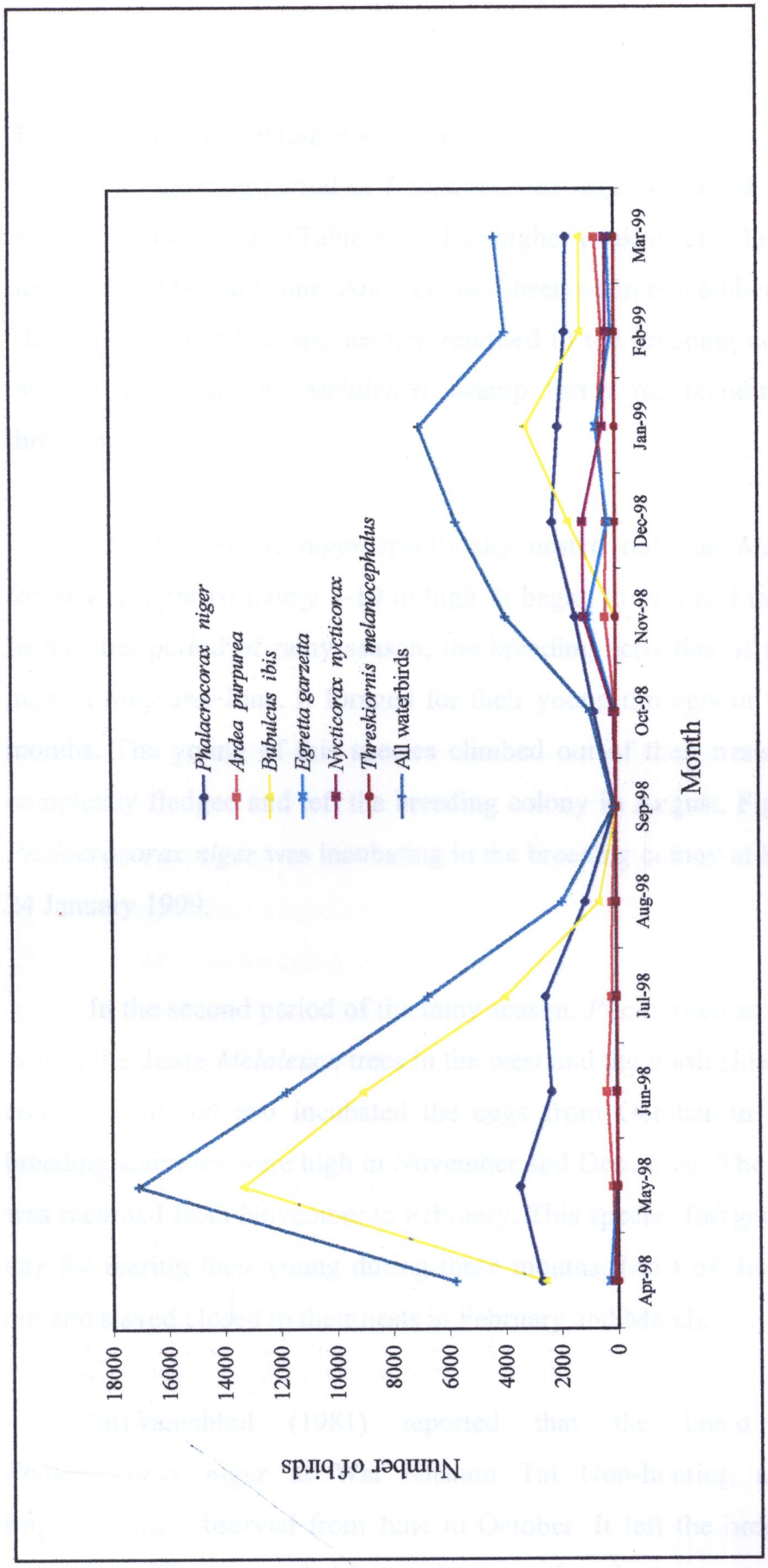


Figure 4.9 Population fluctuation of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Little Cormorant *Phalacrocorax niger*

The breeding period of *Phalacrocorax niger* occurred from October to August has two peaks (Table 4.6). The higher peak of breeding activities was observed in May and June. Another was observed in November and December. This bird was the first species that returned to the breeding colony in the late evening and used the *Melaleuca* swamp forest for breeding and roosting throughout the year.

Phalacrocorax niger specifically nested only on *Melaleuca* swamp forest with approximately 5-10 m high. It began to nest and lay eggs in April. In the first period of rainy season, the breeding activities of this species was high in May and June. It foraged for their young throughout the day in these months. The young of this species climbed out of their nests after May and completely fledged and left the breeding colony in August. Figure 4.10 shows *Phalacrocorax niger* was incubating in the breeding colony at Khuan Khi Sian, 24 January 1999.

In the second period of the rainy season, *Phalacrocorax niger* moved to nest in the dense *Melaleuca* trees in the west and the north side of the breeding colony. It nested and incubated the eggs from October to December. The breeding activities were high in November and December. The hatching period was recorded from November to February. This species foraged throughout the day for rearing their young during these months. Most of the young climbed out and stayed closed to their nests in February and March.

Siriwanichkul (1981) reported that the breeding period of *Phalacrocorax niger* at Wat Khanon Tai Non-hunting area, Ayutthaya Province, was observed from June to October. It left the breeding colony in December. The nest of this species was found on some native trees in

descending order from *Ficus* sp., *Nauclea orientalis*, *Samanea saman*, *Altingia excelsa* to *Mallotus philippinensis* at 15- 20 m high. In contrast, the breeding period of *Phalacrocorax niger* at Khuan Khi Sian occurred all year round from October to September with two peaks of breeding activities.

As can be seen, the breeding period of *Phalacrocorax niger* at Khuan Khi Sian differed from that at Wat Khanon Tai. It may be because the environmental factors influenced the limitation of breeding period of this bird at Wat Khanon Tai. It is likely that Khuan Khi Sian has 2 periods of the rainy season and also contains various habitats and foods which are available for waterbirds most of the year, whereas the site at Wat Khanon Tai is located at the central plain which has longer drought period. These differences may contribute to the different findings between these 2 studies.

***Ardea purpurea* Purple Heron**

The breeding period of *Ardea purpurea* was from November to October. This bird had high breeding activities twice a year. The higher peak of breeding activities was recorded in January and February and the other peak was observed in June and July. Table 4.7 shows the breeding period of *Ardea purpurea* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999.

Most of this bird nested on the canopy of *Melaleuca* trees at the range of 10-15 m high. It sometimes nested in dense *Phragmites* reed beds. The young of *Ardea purpurea* and incubating adults were found in the breeding colony in April when some of this species nested, and they laid eggs from April to June. It foraged through the daytime between June and July during the incubation and hatching period. The breeding activities were also high at this time. The young were found outside their nests in August. A few of them were

observed in the breeding area in daytime when they completely fledged in October. None of *Ardea purpurea* was found in the breeding colony during daytime in this month. Figure 4.11 shows nestling of *Ardea purpurea* were in their nest in the breeding colony at Khuan Khi Sian, 24 January 1999.

Later, *Ardea purpurea*'s nests were seen at the breeding colony again from November to February. This species foraged throughout the daytime from December to February. Breeding activities peaked in January and February. Most of the young climbed out of their nest and spent most of their time in adjacent trees in February. Fledglings and incubating adults were observed in March.

Kanchanasaka, Tong-aree and La-ong (1986) mentioned that two breeding groups of *Ardea purpurea* were found near the Khuan Khi Sian Protection Unit and *Melaleuca* swamp forest of Khuan Khi Sian was the only breeding colony of *Ardea purpurea* in Thale Noi Non-hunting Area. The breeding period of this species was from December to July. The peak of nesting activities was observed from February to April. The breeding period of *Ardea purpurea* of the present study was from November to October. High breeding activities were observed twice a year in January and February and in June and July. However, the finding in both studies is not quite different. It may be because they observed in the same breeding area.

According to the survey of Thale Noi Non-hunting Area personnel, there was another mixed-species colony at Khuan Thale Maung which situated in the northeast of Thale Noi lake (personal comm.). However, none of *Ardea purpurea*'s nest was found in the breeding colony of this area in November when *Ardea purpurea* at Khuan Khi Sian was nesting.

In Thailand, there are only two breeding colonies of *Ardea purpurea*. One is in Sam Roy Yod national park and another is in Thale Noi Non-hunting area (Gray, Piprell and Graham, 1991). According to Parr (1994), Thale Noi Non-hunting area is the largest breeding colony of *Ardea purpurea* in southern Thailand. Therefore, it is clearly shown that the breeding colony of Khuan Khi Sian is a very important breeding area for supporting the population of *Ardea purpurea* in Thailand.

Cattle Egret *Bubulcus ibis*

The breeding period of *Bubulcus ibis* at Khuan Khi Sian occurred once a year from February to August. The peak of breeding activities was observed in May and June. Most of their nests were hidden in dense *Phragmites* reed beds, however some were found in the *Melaleuca* trees, at approximately 3-5 m. Its nest was observed at lower level than those of *Ardea purpurea* and *Phalacrocorax niger*. Table 4.8 shows the breeding period of *Bubulcus ibis* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999.

Most of *Bubulcus ibis* were incubating and rearing their young when the study was conducted in April. All of them have changed their plumage and coloration in this month. *Bubulcus ibis* foraged to rear its young throughout the daytime in April and May. Most of the young were seen outside their nests and spent most of their time in nearby trees in July. They completely fledged in August. None of *Bubulcus ibis* was observed in the breeding area from September to November. It appears that *Bubulcus ibis* temporarily left the breeding colony. Figure 4.12 illustrates *Bubulcus ibis* incubating its eggs in the breeding colony at Khuan Khi Sian on 22 March 1999.

In the second period of rainy season, none of *Bubulcus ibis* was observed during daytime in December and January, but some were seen after

dusk. In addition, *Bubulcus ibis* with distinct plumage, was observed again in January. It is likely that they prepare to occupy their nesting sites in February. Most of them foraged throughout the daytime period in March.

Kanchanasaka, Tong-aree and La-ong (1986) reported that the breeding period of *Bubulcus ibis* in *Melaleuca* forest at Thale Noi Non-hunting Area was from May to June. From the present study, it was found that the breeding period of *Bubulcus ibis* at Khuan Khi Sian was from February to August longer than the study mentioned above. It is probably that the breeding factors such as food and the nesting site during this study were more suitable to their breeding activities rather than in the previous one.

Silarangsi (1984) stated that *Bubulcus ibis* at Muang District, Suphanburi Province bred once a year from February to July. Their nesting activities peaked in April and May. The nests of this species were observed in the large trees, at approximately 4-15 m high. The present study showed similar result of the breeding period of this species with the study by Silarangsi (1984), which observed in the terrestrial habitat of the central plain. This species does not specify the type or the height of trees for nesting.

Occasionally, *Bubulcus ibis* occurs throughout the countryside but their breeding grounds are restricted to the central region of Thailand (Eve and Giurgue, 1996). However, Parr (1994) claimed that Khuan Khi Sian might be the only place where the breeding colony of *Bubulcus ibis* occurred in the South of Thailand.

Figure 4.10 *Phalacrocorax niger* incubating its eggs in the breeding colony at Khuan Khi Sian, 24 January 1999

Table 4.6 The breeding period of *Phalacrocorax niger* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Apr 98	May 98	June 98	July 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
N,E, I	N,E, I,H	N,E, I,H, F_1	I,H, F_1	F_1, F_2	F_2	N,E, I	N,E, I,H	N,E, I,H, F_1	I,H, F_1	H,F_1, F_2	F_1, F_2

Remarks:

N : Nesting period

E : Egg-laying period

I : Incubation period

H : Hatching period (hatchling and nestling)

F_1 : Fledging period (stage1: the young of the bird climbed out from the nest and spent most of its time outside)

F_2 : Fledging period (stage2: the young of the bird completely fledged)

* The colored letter indicates high breeding activities; the red letter indicates the highest peak

Figure 4.11 Nestlings of *Ardea purpurea* in their nest in the breeding colony at Khuan Khi Sian, 22 March 1999

Table 4.7 The breeding period of *Ardea purpurea* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Apr 98	May 98	June 98	July 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
F_2,N ,E,I	N,E, I,H	N,E, I,H, F_1	N,E, I,H, F_1,F_2	H,F_1 ,F_2	F_1, F_2	F_2	N,E, I	N,E, I, H	N,E, I,H, F_1	N,E, I,H, F_1,F_2	H,F_1, F_2

Remarks:

N : Nesting period

E : Egg-laying period

I : Incubation period

H : Hatching period (hatchling and nestling)

F_1 : Fledging period (stage1: the young of the bird climbed out from the nest and spent most of its time outside)

F_2 : Fledging period (stage2: the young of the bird completely fledged)

* The colored letter indicates high breeding activities; the red letter indicates the highest peak

Figure 4.12 *Bubulcus ibis* incubating its eggs in the breeding colony at Khuan Khi Sian, 22 March 1999

Table 4.8 The breeding period of *Bubulcus ibis* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Apr 98	May 98	June 98	July 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
N,E, I,H, F_1	N,E, I,H, F_1,F_2	N,I, H,F_1 ,F_2	F_1, F_2	F_2						N,E, I	N,E, I,H

Remarks:

N : Nesting period

E : Egg-laying period

I : Incubation period

H : Hatching period (hatchling and nestling)

F_1 : Fledging period (stage1: the young of the bird climbed out from the nest and spent most of its time outside)

F_2 : Fledging period (stage2: the young of the bird completely fledged)

* The colored letter indicates high breeding activities; the red letter indicates the highest peak

Little Egret *Egretta garzetta*

The breeding period of *Egretta garzetta* at Khuan Khi Sian was from December to August. The higher peak of breeding activities was recorded in May and June and another was observed in December and January. The breeding period of *Egretta garzetta* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999 is shown in table 4.9.

This bird occupied the same habitat as *Bubulcus ibis*. Most of *Egretta garzetta*'s nests were found in *Melaleuca* trees. In the first period of rainy season, the nesting and incubation activities of *Egretta garzetta* were in April and May. The chicks hatched, and some of young climbed out from the nest after April. The young completely fledged from June to August. None of them was found at the breeding colony throughout daytime in September. From September to November, they temporarily left the breeding colony during daytime. Figure 4.13 shows nestlings of *Egretta garzetta* were in their nest in the breeding colony at Khuan Khi Sian on 24 January 1999.

Egretta garzetta's nest was observed again in December. This bird foraged throughout the day in January. The young were observed outside their nests in February. These young were the same size as their parents but they could not feed by themselves during this time. Most of them fledged out of the breeding colony in March.

A similar study by Chaisiripan (1983) reported that *Egretta garzetta* at Wat Tan-en Non-hunting area, Ayutthaya, bred twice a year. The first breeding period was from June to September and the second was December till March. The differences in the breeding period between the present study and the previous one may due to the fact that the breeding areas are absolutely different, terrestrial habitat at Wat Tan-en and wetland at Khuan Khi Sian.

Figure 4.13 Nestlings of *Egretta garzetta* in their nest in the breeding colony at Khuan Khi Sian, 22 March 1999

Table 4.9 The breeding period of *Egretta garzetta* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Apr 98	May 98	June 98	July 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
N,E, I	N,E, I,H, F_1	H,F_1 ,F_2	F_1, F_2	F2				N,E, I	N,E, I,H, F_1	H, F_1	F_1, F_2

Remarks:

N : Nesting period

E : Egg-laying period

I : Incubation period

H : Hatching period (hatchling and nestling)

F_1 : Fledging period (stage1: the young of the bird climbed out from the nest and spent most of its time outside)

F_2 : Fledging period (stage2: the young of the bird completely fledged)

* The colored letter indicates high breeding activities; the red letter indicates the highest peak

Black-crowed Night Heron ***Nycticorax nycticorax***

The breeding period of *Nycticorax nycticorax* at Khuan Khi Sian occurred once a year from October to June. The peak of breeding activities was observed from October to December (Table 4.10). However, *Nycticorax nycticorax*'s nest was hardly seen from the observation tower. It is possible that the nest may located lower than 3 m on the *Melaleuca* trees or in dense *Phragmites* reed beds. Therefore, most of the data obtained were based on other breeding activities.

In the first period of rainy season, the breeding adults and the young of *Nycticorax nycticorax* were observed in the breeding colony during 0600 to 1000 am from April to June. None of *Nycticorax nycticorax* was found in the breeding colony throughout daytime from July to August. Figure 4.14 shows the nestling of *Nycticorax nycticorax* in its nest in the breeding colony at Khuan Khi Sain, 24 January 1999.

In November, the breeding adults were observed in the breeding colony during the daytime. They foraged throughout the daytime in December and January. The higher peak of breeding activity was observed from October to January. Some juveniles were found in the study area during the daytime in February but not found in March. However, they left the breeding colony with adults after dusk in March.

The breeding period of *Nycticorax nycticorax* at Wat Tan-en Non-hunting Area, Ayutthaya Province, started from June to March (Jaiyawat, 1982). The breeding period of this species at Khuan Khi Sian is slightly different from the previous study by Jaiyawat (1982). The differences in habitat types may not influence the breeding period of this bird.

Figure 4.14 The nestling of *Nycticorax nycticorax* in its nest in the breeding colony at Khuan Khi Sian, 24 January 1999

Table 4.10 The breeding period of *Nycticorax nycticorax* in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Apr 98	May 98	June 98	July 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
F_1, F_2	F_1, F_2	F_2				N,E, I	N,E, I,H	N,E, I,H, F_1	N,E, I,H, F_1	I,H, F_1,F_2	I,H, F_1,F_2

Remarks:

N : Nesting period

E : Egg-laying period

I : Incubation period

H : Hatching period (hatchling and nestling)

F_1 : Fledging period (stage1: the young of the bird climbed out from the nest and spent most of its time outside)

F_2 : Fledging period (stage2: the young of the bird completely fledged)

* The colored letter indicates high breeding activities; the red letter indicates the highest peak

It can be concluded from this study that the breeding colony in *Melaleuca* swamp forest at Khuan Khi Sian was used throughout the year for breeding and roosting by at least 5 waterbird species. The breeding activities of *Phalacrocorax niger*, *Ardea purpurea* and *Egretta garzetta* were recorded twice a year, while *Bubulcus ibis* and *nycticorax nycticorax* was observed once a year. Table 4.11 shows the breeding periods of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999.

According to the report by TEC (1999), fish and other aquatic faunas were abundant at Khuan Khi Sian and Thale Noi area in the second period of rainy season. The breeding activities of waterbirds also began in this period.

In the first period of rainy season, *Phalacrocorax niger* and *Ardea purpurea* started nesting and egg laying in April, whilst *Bubulcus* ibis and *Egretta garzetta* were incubating and rearing their young. Some juveniles of *Ardea purpurea* and breeding adults of *Nycticorax nycticorax* were also observed in the breeding colony in this month. The young of waterbirds completely fledged and left their nests in August. Almost all of waterbirds left the breeding colony temporarily in September, and none of them was observed in the breeding colony during daytime, except *Phalacrocorax niger* and *Ardea purpurea* which returned to the breeding colony for roosting. It is possible that the parents may take their young to forage outside the study area.

Four species nested in the second period of rainy season, consisting of *Phalacrocorax niger*, *Ardea purpurea*, *Egretta garzetta* and *Nycticorax nycticorax*. The nests of all waterbirds were found in the same breeding colony but their nests were separated by the height of *Melaleuca* trees. Only *Phalacrocorax niger* was specific to M*elaleuca* trees, whereas other species nested in both *Melaleuca* trees and *Phragmites* reed beds. *Phalacrocorax niger*

nested in *Melaleuca* trees at the height of 5-10 m, whereas *Ardea purpurea* nested on the canopy of *Melaleuca* trees or over 10 m elevation, however this bird sometimes nested in *Phragmites* reed beds. Most of *Bubulcus ibis* nested in *Phragmites* reed beds, but separated from *Ardea purpurea*'s nest. *Bubulcus ibis* also nested in *Melaleuca* trees, approximately 3-5 m above the ground. *Egretta garzetta* nested in the same habitat as *Bubulcus ibis* and occasionally nested in the same area as *Phalacrocorax niger*. It was difficult to observe *Nycticorax nycticorax*'s nest from the observation tower. This bird is probably nested in *Melaleuca* trees, lower than 3 m high, and in dense *Phragmites* reed beds.

Due to the damage of *Melaleuca* trees resulted from overnesting of waterbirds, the position of waterbirds' nests in the *Melaleuca* swamp forest was shifted over time. For example, waterbirds' nests scattered over the breeding colony in April when the *Melaleuca* trees were found in the entire breeding area. In October, waterbirds seemed to nest in the *Melaleuca* trees in the west and the north sides of the breeding area or nearby *Phragmites* reed beds when the *Melaleuca* trees in the east side of this area were deteriorated. Damaged *Melaleuca* trees could flourish again when waterbirds shift their nests to new dense *Melaleuca* trees. It is likely that waterbirds will soon come back to nest in the newly recovered area.

Table 4.11 The Breeding period of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sain from April 1998 to March 1999

Birds	Breeding periods											
	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99
Phalacrocorax niger	N,E,I	N,E, I,H	N,E,I, H,F_1	I, H,F_1	F_1,F_2	F_2	N,E,I	N,E, I,H	N,E,I, H, F_1	I,H,F_1	H,F_1, F_2	F_1,F_2
Ardea purpurea	F_2,N, E,I	N,E, I,H	N,E, I,H, F_1	N,E,I, H,F_1, F_2	H,F_1, F_2	F_1,F_2	F_2	N,E,I	N, E, I, H	N,E,I, H,F_1	N,E,I, H,F_1, F_2	H,F_1, F_2
Bubulcus ibis	N,E,I, H,F_1	N,E,I, H,F_1, F_2	N,I,H. F_1,F_2	F_1,F_2	F_2						N,E,I	N,E, I,H
Egretta garzetta	N,E,I	N,E,I, H,F_1	H,F_1, F_2	F_1,F_2	F_2				N,E,I	N,E,I H,F_1	H, F_1	F_1,F_2
Nycticorax nycticorax	F_1, F_2	F_1,F_2	F_2				N,E,I	N,E, I,H	N,E,I, H,F_1	N,E,I, H, F_1	I,H,F_1, F_2	I,H, F_1,F_2

Remarks:

N : Nesting period

E : Egg-laying period

I : Incubation period

H : Hatching period (hatchling and nestling)

F_1 : Fledging period (stage1: the young of waterbirds climbed out from the nest and spent most of its time outside)

F_2 : Fledging period (stage2: the young of the waterbirds completely fledged)

* The colored letter indicates high breeding activities; the red latter indicates the highest peak

4.5 The relationship between environmental factors and the number of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian

Table 4.12 shows the correlation between environmental factors and the number of waterbirds at Khuan Khi Sian from April 1998 to March 1999. The number of *Bubulcus ibis* showed negative correlation to the total rainfall, while the number of *Nycticorax nycticorax* and *Threskiornis melanocephalus* showed negative and positive correlation to the mean temperature, respectively.

Regarding the multiple linear regression, R^2 between the number of *Bubulcus ibis* and the total rainfall was low as well as R^2 between the number of *Nycticorax nycticorax* and the mean temperature. Moreover, the mean absolute errors (MAE) were also high compared with the real data from the observation. Thus, linear regression models between the number of these birds and environmental factors were not fit. R^2, MAE, equations and the regression models of them were shown in appendix D. In contrast, R^2 between the number of *Threskiornis melanocephalus* and the environmental variables was quite high and MAE was low. The equation of the number of *Threskiornis melanocephalus* and the environmental variables is as follows:

The number of *Threskiornis melanocephalus*

= -102.584+1.351(mean temp.)
+0.871(mean relative humid.)
-0.028(total rainfall)

where

R^2 of the mean temperature	=	0.347
R^2 of the mean relative humidity	=	0.713
R^2 of the total rainfall	=	0.876
Mean Absolute Error (MAE)	=	1.8405 individuals

Table 4.12 Pearson's correlation coefficient relating environmental data and the number of waterbirds in *Melaleuca* swamp forest at Khuan Khi Sian from April 1998 to March 1999

Parameters	*Phalacrocorax niger*	*Ardea purpurea*	*Bubulcus ibis*	*Egretta garzetta*	*Nycticorax nycticorax*	*Threskiornis melanocephalus*	All water-birds	Temp.	Relative humid.	Total rainfall
Phalacrocorax niger	1.000									
Ardea purpurea	0.123	1.000								
Bubulcus ibis	0.467	0.231	1.000							
Egretta garzetta	0.012	0.482	-0.178	1.000						
Nycticorax nycticorax	0.013	0.403	-0.250	0.750**	1.000					
Threskiornis melanocephalus	0.555	-0.388	0.097	-0.072	-0.247	1.000				
All waterbirds	0.771**	0.088	0.719**	-0.131	-0.177	0.130	1.000			
Tempurature	0.569	-0.275	0.385	-0.356	-0.598*	0.589*	0.569	1.000		
Relative humidity	0.139	-0.257	-0.449	0.167	0.213	0.483	-0.030	-0.252	1.000	
Total rainfall	-0.409	0.128	-0.592*	0.355	0.566	-0.527	-0.422	-0.753**	0.366	1.000

** Correlation is significant at P≤ 0.01 (2-tailed)

* Correlation is significant at P≤ 0.05 (2-tailed)

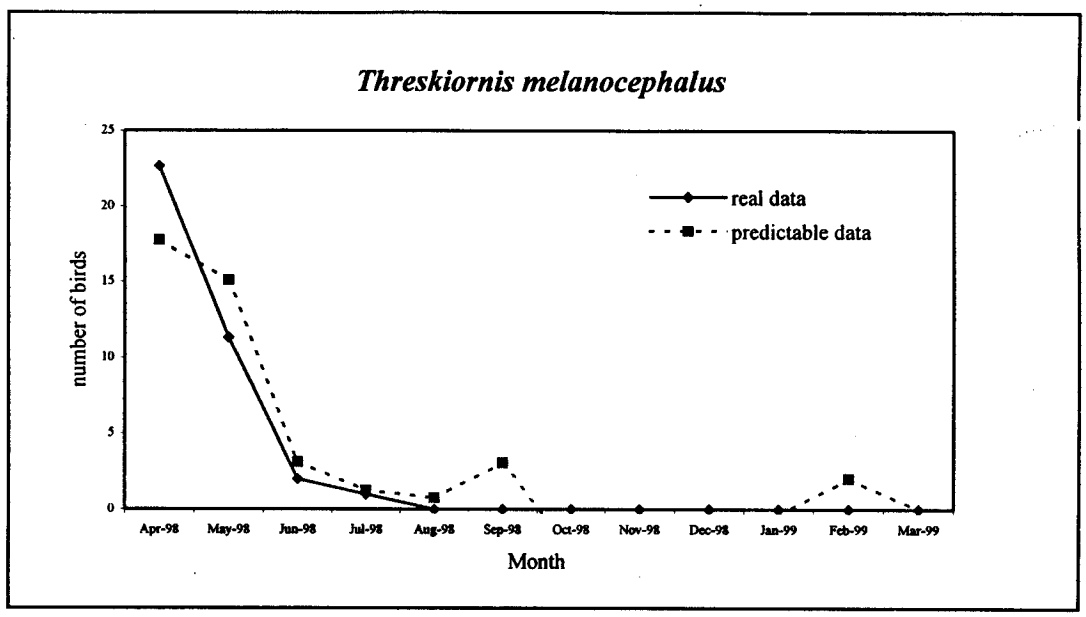


Figure 4.15 The regression model among the number of *T. melanocephalus* and environmental factors ($p \leq 0.05$)

For *Phalacrocorax niger*, *Ardea purpurea* and *Egretta garzetta*, the population numbers were not significantly correlated to the environmental variables. Therefore, the regression models cannot be drawn.

4.6 The assessment of the suitability of Khuan Khi Sian as a Ramsar Site

1) According to the criterion 5 of the criteria for identifying wetlands of international importance (specific criteria based on waterbirds), the Ramsar site should regularly supports 20,000 or more waterbirds. Considering the number of waterbirds within one-year duration, it is likely that Khuan Khi Sian area can support at lease 20,000 waterbirds a year. However, the one year study period may not be sufficient and long term study should be conducted in order to determine the sustainability of the area.

2) Khuan Khi Sian seems to meet criterion 6 of the criteria for identifying wetlands of international importance (specific criteria based on waterbirds) as follows:

-It supports one of the two populations of *Ardea purpurea* that nest in Thailand.

-It supports a population of *Bubulcus ibis* that nests in southern region of Thailand.

-It supports substantial numbers of *Threskiornis melanocephalus* which is a rare species of Thailand.

3) Khuan Khi Sian meets other criteria of the criteria for identifying wetlands of international importance as follows:

-It contains a *Melaleuca* forest, which is a rare forest type in Thailand (criterion 1).

-It supports a near-threatened species, *Threskiornis melanocephalus* (criterion 2).

-It supports a population of *Bubulcus ibis* that nests in southern region of Thailand (criterion 3).

- It supports one of the two populations of *Ardea purpurea* that nest in Thailand (criterion 3).

-It is a breeding colony of at least 5 species of waterbirds (criterion 4).

Chapter 5

Conclusions and Recommendations

5.1 Conclusions

1) A total of 46 species of birds was found in *Melaleuca* swamp forest and nearby area of Khuan Khi Sian, comprising 18 species of waterbirds and 28 species of non-waterbirds. Of these 46 species, 30 species were residents, whereas 8 species were migrants, and 8 species were partial migrants.

2) Species found in migratory period (August-March) were more than that observed in non-migratory period (April-July). Similarity indices within the same period, either migratory or non-migratory period, were high. Similarity indices between the different period were low.

3) Five resident waterbirds nested colonially in the breeding colony at Khuan Khi Sian, whereas a rare migratory species in Thailand used this area for roosting.

4) The highest value of diversity indices of waterbirds was in March, whereas the lowest value was in October. Most similarity indices of waterbirds were high throughout the year.

5) The population density of all waterbirds fluctuated greatly throughout the year. In May when the peak of breeding activities was recorded, the number ranged from 13,867-20,217individuals. The number ranging from 52-118 individuals was recorded as the lowest density in September.

6) The population density of *Phalacrocorax niger* and *Bubulcus ibis* fluctuated greatly throughout the year.

7) The number of *Ardea purpurea*, in comparison to other waterbirds, did not change greatly throughout the year.

8) The numbers of *Egretta garzetta* and *Nycticorax nycticorax* were not high and did not show significant difference in means among months in the first period of the rainy season.

9) The population of *Threskiornis melanocephalus* disappeared from Khuan Khi Sian from August to March.

10) The breeding activities of waterbirds occurred all year round but peaked in May and June.

11) *Phalacrocorax niger* and *Ardea purpurea* used the breeding colony throughout the year.

12) The breeding period of *Phalacrocorax niger*, *Ardea purpurea* and *Egretta garzetta* occurred twice a year, compare to *Bubulcus ibis* and *Nycticorax nycticorax* that occurred once a year.

13) The number of *Threskiornis melanocephalus* showed positive correlation with the mean temperature.

14) From the data obtained, Khuan Khi Sian appears to meet criteria 1-6 of the criteria for identifying wetlands of international importance. However, monitoring of waterbird populations should be conducted regularly in order to determine the sustainability of the area.

5.2 Recommendations

1) Although the result of this study provides more information about waterbird population in the breeding colony at Khuan Khi Sian, it requires more long-term study for the better conclusion. Further studies should focus on the breeding ecology and the habitat utilization by each species of waterbirds.

2) Khuan Khi Sian boundary should be expanded in order to increase the potential of the area for supporting 20,000 or more waterbirds. Moreover, other animals can take an advantage of the larger area for safety breeding and foraging.

3) The food resource should be improved and located near the breeding colony in order to reduce the foraging distance of waterbirds. It is essential to build up the storage of water near this area such as pond for food reserve during drought period. In addition, this water reserve will be benefit when a fire breaks out near the breeding colony.

4) The *Melaleuca* forest in the breeding colony should be maintained, improved and revived annually such as planting the new *Melaleuca* trees to substitute ones that damaged or died by overnesting. Native wetland plants such as *Alstonia spathulata*, which *Mycteria leucocephalus* use to nest, should be planted so that they will provide the breeding site to other waterbirds, particularly *Mycteria leucocephalus*.

5) Training programs in wildlife management for the persons of Khuan Khi Sian Protection Unit should be organized regularly. The strictly protection should be stipulated during the high peak of breeding activities as well as during the drought period when a fire may take place.

6) Definite protective boundaries of the breeding colony should be proclaimed in order to prevent this area from disturbance resulted from fishing and animal grazing.

7) Promote public awareness on the importance of the breeding colony.

References

Angkapreechases, P. 1980. Population dynamics of birds at Thale Noi Non-hunting Area, **Wildlife Journal of Thailand**. pp.146-168. Bangkok: Kasetsart University. (In Thai)

Angkapreechases, P.1985. **Population dynamics of birds at Thale Noi Non-hunting Area**. Master's thesis, Department Environmental Science, Graduated School, Kasetsart University. (In Thai)

Baldassarre, G. A. and Bolen, E.G. 1994. **Waterfowl ecology and management.** USA: John Wiley & Sons.

Chaisiriphan, S.1983. **Ecology, biology and behavior of Little Egret *Egretta garzetta***. Master's thesis, Department of Zoology, Graduated School, Kasetsart University. (In Thai)

Chandrachai, W. 1994. Wetland classification of Thailand. In Ramsar Center Japan (ed.), **Public awareness of biodiversity in wetland in Asia.** pp.109-110. Bangkok: Dharmasarn.

Chandrachai, W. 1998. Wetland in the lower Mekong Basin. In Office of Environmental Policy and Planning (OEPP)(ed.), **Workshop on wetland's management in Thailand.** pp. 28-33. Bangkok: Integrated Promotion Technology. (In Thai)

Davis, T. J. (ed). 1994. **The Ramsar Convention manual: A guide to the conservation on wetland of international importance especially as waterfowl habitat**. UK: Orchard & Ind.

Erftermeijer, L.A. P. 1998. Wetland management in South-East Asia. In OEPP (ed.), **Workshop on wetland's management in Thailand**. pp.10-16. Bangkok: Integrated Promotion Technology.

Eve, R. and Guigue, A-M. 1996. **Birds of Thailand**. Bangkok: BookSiam, a division of Distri-Thai.

Gray, D., Piprell, C. and Graham, M. 1991. **National parks of Thailand.** Bangkok: Thai Wattana Panich.

Gill, F.B. 1990. **Ornithology**. New York: W.H. Freeman.

Hancock, J. and Kushlan, J. 1984. **The heron handbook.** New York: Harper& Low.

IUCN. 1996. **1996 IUCN red list of threatened animals.** Switzerland: IUCN.

Jaiyawat, K. 1982. **Food habits and breeding biology of Night Heron *Nycticorax nycticorax.*** Master's thesis, Department of Forestry Biology, Graduated School, Kasetsart University. (In Thai)

Kanchanasaka, B, Tong-aree, S. and La-ong, S. 1986. Reproductive biology and food habits of some birds in Thale Noi Non-hunting Area, **Wildlife Journal of Thailand,** pp. 8-1 - 8-36. Bangkok: Kasetsart University. (In Thai)

Khobkhet, O. 1998a. **Birds in Thailand volume 1.** Bangkok: Bangkok (1984). (In Thai)

Khobkhet, O. 1998b. **Birds of Bung Borapet.** Bangkok: Integrated Promotion Technology. (In Thai)

Khobkhet, O. 1999. **Birds in Thailand volume 2.** Bangkok: Bangkok (1984). (In Thai)

Khobkhet, O. (n.d.). **Synopsis of order and family of birds in Thailand.** Bangkok : (n.p.). (Unpublished Manuscript, in Thai)

Kreb, J.C. 1989. **Ecology methodology**. New York: R.R. Donelley & Son company.

Lekagul, B. and Round, P.D. 1991. **A guide to the birds of Thailand.** Bangkok: Darnsutha Press.

Mahidol University. 1994. **Species expected/confirmed form Thale Noi [Computer database]**. Bangkok: Center for conservation Biology Mahidol University.

McClure, E.1998. **The migratory birds of Asia**. Bangkok:White Lotus.

Meteorological Department, Climatology Division . 1999a. **The mean temperature and annual relative humidity data of Songkhla Province from 1979 to 1999 [Printout from computer database]**. Bangkok: Data processing sub-division, Climatology Division, Meteorological Department, Ministry of Transport and Communications.

Meteorological Department, Climatology Division. 1999b. **The total rainfall data of Khuan Khanoon District, Phattalung Province from 1979 to 1999 [Printout from computer database]**. Bangkok: Data processing sub-division, Climatology Division, Meteorological Department, Ministry of Transport and Communications.

Meteorological Department, Local Climate Division. (n.d.). **The season of Thailand**. Bangkok: Local Climate Division, Meteorological Department, Ministry of Transport and Communications. (Mimeographed, in Thai)

Mitsch, W. J., Mitsch, R. H. and Turner, R.E. 1994. Wetlands of the Old and New Worlds: ecology and management. In Mitsch, W.J. (ed.), **Global wetlands:Old world and new**. pp.3-12. USA: John Wiley & Sons.

Office of Environmental Policy and Planning. 1996a. **Understanding of the Ramsar Convention**. Bangkok: (n.p.). (Mimeographed, in Thai)

Office of Environmental Policy and Planning. 1996b. **The report of the meeting on the status of Thailand biological resources**. Bangkok: Intrigated Promotion Technology. (In Thai)

Office of Environmental Policy and Planning. 1997. **The report of the meeting on the status of wetlands of Thailand**. Bangkok: Intrigated Promotion Technology. (In Thai)

Office of Environmental Policy and Planning. 1998. **The report of the meeting on the status of wetlands of Thailand**. Bangkok: Intrigated Promotion Technology. (In Thai)

Office of Environmental Policy and Planning. (n.d.). **Ramsar Convention.** Bangkok: (n.p). (Mimeographed, in Thai)

Office of Environmental Policy and Planning. 2000. **Wetland 2000.** Bangkok: (n.p.). (Unpublished Manuscript, in Thai)

Parr, J.W. K.1994. **A socio-economic and tourism assessment at Thale Noi Non-hunting Area.** Bangkok: The Bird Conservation Society of Thailand in cooperation with the Royal Forest Department.

Perrrins, M.C., Lebreton, J-D. and Hirons ,G.J.M. (eds.). 1991. **Bird population studies relevant to conservation and management.** New York: Oxford University Press.

Pookpakdi, T. 1994. **Wetlands in Thailand.** Bangkok: OEPP. (Mimeographed, in Thai)

Puegsawan, N. 2000. Wetlands of international importance. **Proceedings of preparing wetlands for the next millennium: Wetland 2000,** Bangkok, 2-3 February 2000. (Unpublished Manuscript, in Thai)

Ramsar Convention Bureau. 1998, August. Four new contracting parties welcomed. **Convention on Wetlands.** 28:1-2.

Ramsar Convention Bureau. 2000a. **The Ramsar info pack.** Switzerland: Ramsar Convention Bureau. Available from http://ramsar.org/index_cbd.htm. INTERNET.

Ramsar Convention Bureau. 2000b. **Wetlands and biodiversity.** Switzerland:Ramsar Convention Bureau. Available from http://ramsar.org/about_biodiversity.htm. INTERNET.

Royal Forest Department. 1978. **The preserved and protected wildlife.** Bangkok: Agsornsiam Press. (In Thai)

Royal Forest Department. 1997. **Thale Noi Non-hunting Area.** Bangkok: Wildlife Conservation Division, Royal Forest Department (RFD). (In Thai)

Royal Forest Department. 1992. **The list of the Wild Animal Preservation and Protection Act (WARPA)**. Bangkok : RFD. (In Thai)

Round, P. D. 1988. **Resident forest birds in Thailand:Their status and conservation**. UK: S-Print, Cambridge.

Sampantharak, W. 2000. The implementation followed Ramsar Convention on wetland for the year 2000. **Proceedings of preparing wetlands for the next millennium: wetland 2000**, pp.1-9. Bangkok, 2-3 February 2000. (Unpublished Manuscript, in Thai)

Scott, D. A (ed.). 1989. **A directory of Asian wetlands**. U.K: Page Bros (Norwich).

Silarangsri, K.1984. **Ecology of Cattle Egret *Bubulcus ibis***. Master's thesis, Department of Forest Biology, Graduated School, Kasetsart University. (In Thai)

Siriwanichkul, A. 1981. **Food habits and biology of Little Cormorant *Phalacrocorax niger***. Master's thesis Department of Zoology, Graduated School, Kasetsart University. (In Thai)

Smith, R. L. 1996. **Ecology and field biology**. 5th ed. New York: Harpercollins.

Storer, P.J. 1977. A Study of the waterfowl at Thale Noi waterfowl Reserve Area. **National History Bulletin of the Siam Society**. 26:317-338.

Sutherland, W. J.1996. **Ecological census techniques a handbook**. Great Britain: The Bath Press.

Sonobe, K. and Usui, S. (eds.). 1993. **A field guide to the waterbirds of Asia**. Tokyo: Sanyo Printing.

Thai Engineering Consultants Co, Ltd. 1998a. **The conservation and protection of the important wetland namely Thale Noi Non-hunting Area, Phattalung Province: Appendix**. Submitted to the Official of Environment al Policy and Planning. Bangkok. (In Thai)

Thai Engineering Consultants Co, Ltd. 1998b. **The conservation and protection of the important wetland namely Thale Noi Non-hunting Area, Phattalung Province: Managing plan for the important wetland of Thale Noi Non-hunting Area.** Submitted to OEPP. Bangkok: (n.p.). (In Thai)

Thai Engineering Consultants Co, Ltd. 1999. **The conservation and protection of the important wetland namely Thale Noi Non-huntiong Area, Phattalung Province: Main report.** Submitted to OEPP. Bangkok: (n.p.).

Thailand Institute of Scientific and Technological Research. 1981. **Ecological studies for conservation of shore birds in Songkla Lake volume 1.** Submitted to the Office of the National Environmental Board Thailand (NEB). Bangkok: Thailand Institute of Scientific and Technological Research (TISTR) Press.

Thailand Institute of Scientific and Technological Research. 1982. **Ecological studies for conservation of shore birds in Songkla Lake volume 2.** Submitted to NEB. Bangkok: TISTR. Press.

Tunhikorn, S. 1994. Management of Biodiversity of Wetland in Thailand. In Ramsar Center Japan (ed.), **Public awareness of biodiversity in wetland in Asia.** pp.96-98. Bangkok: Dharmasarn.

The Prince of Songkla University. 1999. List and status of wetlands in southern Thailand. In OEEP (ed.), **Proceedings of status of wetlands of Thailand**: pp.1-10. Bangkok, 2-3 February 1999. (Unpublished Manuscript, in Thai)

Tyne, J.V. and Berger, A.J. 1976. **Fundamentals of ornithology.** 2nd ed. USA: John Weiley&Sons.

Weller, M.W. 1999. **Wetland birds: Habitat resources and conservation Implication.** U.K: Cambridge University Press.

World Conservation Monitoring Centre. 1998. **Checklist of CITES species: Checklist of fauna**. UK: Unwin Brothers, Martins Printing Group, Old working, Surrey.

Appendix A

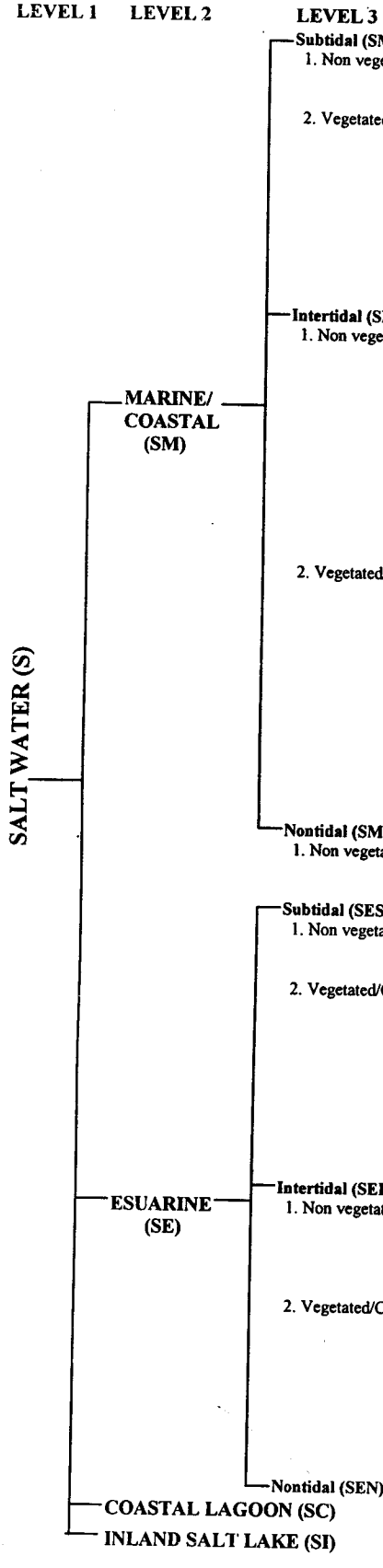
The wetland classification of Thailand

WETLANDS CLASSIFICATION OF THAILAND (1994)

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	Code
FRESH WATER (F)	RIVERINE (FR)	River (FRR)		
		1. Perennial River (FRR1)	- Natural	
			a. Pool (Pool in Perennial River)	FRR1a
			b. Channel (Channel in Perennial River)	FRR1b
			- Artificial (m)	
			b. Channel (Perennial Canal)	FRR1bm
			- Natural	
			c. Rapid (Perennial Rapid)	FRR1c
			d. Waterfall (Perennial Waterfall)	FRR1d
		2. Seasonal River (FRR2)	- Natural	
			a. Pool (Pool Seasonal River)	FRR2a
			b. Channel (Channel Seasonal River)	FRR2b
			- Artificial (m)	
			b. Channel (Seasonal Canal)	FRR2bm
			- Natural	
			c. Rapid (Seasonal Rapid)	FRR2c
			d. Waterfall (Seasonal Waterfall)	FRR2d
		River Bank/Beach/Bars (FRB)		
		River Floodplain (FRF)		
		1. Floodplain Grassland	- Natural	
			a. Grassland (Floodplain Grassland)	FRF1a
			- Artificial (m)	
			a. Rice (Floodplain Wet Rice)	FRF1am
			b. Other Crops (Floodplain Other Crops)	FRF1bm
		2. Floodplain Trees/Shrubs	- Natural	
			a. Trees/Shrubs (Seasonally Flooded – Trees/Shrubs)	FRF2a
			- Artificial (m)	
			a. Plantation/Orchards (Seasonally Flooded – Plantation/Orchards)	FRF2am
		3.Seasonal Floodplain Lake		FRF3
		4. Seasonal Floodplain Pond		FRF4
		5. Seasonal Backswamp/Marsh	- Natural	
			a. Seasonal Backswamp/Marsh	FRF5a
			- Artificial (m)	
			a. Rice (Wet in Seasonal)	FRF5am
			b. Other Crops (Other Crops in Seasonal)	FRF5bm
	LACUSTRINE (FL)	Lake (> 8 ha) (FLL)		
		1. Permanent	- Natural	
			a. Permanent Freshwater Lake	FLL1a
			- Artificial (m)	
			a. Permanent Freshwater Lake	FLL1am
		2. Seasonal	- Natural	
			a. Seasonal Freshwater Lake	FLL2a
			- Artificial (m)	
			a. Seasonal Freshwater Lake	FLL2am
		Pond (> 8 ha) (FLP)		
		1. Permanent	- Natural	
			a. Permanent Freshwater Pond	FLP1a
			- Artificial (m)	
			a. Freshwater Aquaculture Pond	FLP1am
			b. Sewage Treatment Pond	FLP1bm
			c. Farm Pond	FLP1cm
			d. Freshwater Cooling Pond	FLP1dm
			e. Borrow Pit, Excavation	FLP1em
			f. Other Permanent Freshwater Pond	FLP1fm
		2. Seasonal	- Natural	
			a. Permanent Freshwater Pond	FLP2a
	PALUSTRINE (FP)	Permanent Palustrine (EPP)		
		- Permanent Flooded/Wet	- Natural	
			a. Grasses (Permanent Flooded Grassland)	FPPa
			b. Sedges (Permanent Freshwater Marsh)	FPPb
			c. Trees/Shrubs (Permanent Swamp)	FPPc
		Seasonal Palustrine (FPS)		
		- Seasonal Flooded/Wet	- Natural	
			a. Grasses (Seasonal Flooded Grassland)	FPSa
			- Artificial (m)	
			a. Grasses (Seasonal Flooded Plantation)	FPSam
			- Natural	
			b. Sedges (Seasonal Flooded Plantation)	FPSb
			c. Trees/Shrubs (Seasonal Flooded Swamp)	FPSc
			- Artificial (m)	
			c. Trees/Shrubs (Seasonal Flooded Plantation)	FPScm

Conclusion of Wetlands Classification at Maruay Hotel, Bangkok, June 13, 1994

WETLANDS CLASSIFICATION OF THAILAND (1994) (cont.)



LEVEL 3	LEVEL 4	Code
Subtidal (SMS)		
1. Non vegetated (SMS1)	- Natural	
	a. Rock Bottom	SMS1a
	b. Unconsolidated Bottom	SMS1b
2. Vegetated/Coral (SMS2)	- Natural	
	a. Coral (Marine Subtidal Coral)	SMS2a
	- Artificial (m)	
	a. Coral (Marine Subtidal Coral Farm)	SMS2am
	- Natural	
	b. Seagrass (Marine Subtidal Seagrass)	SMS2b
	c. Seaweed (Marine Subtidal Seaweed)	SMS2c
	- Artificial (m)	
	c. Seaweed (Marine Subtidal Seaweed Farm)	SMS2cm
	d. Maricalture (Marine Subtidal Mariculture)	SMS2dm
Intertidal (SMI)		
1. Non vegetated (SMI1)	- Natural	
	a. Beach (Coastal Beach)	SMI1a
	- Artificial (m)	
	a. Salt Work (Coastal Salt Work)	SMI1am
	- Natural	
	b. Mudflat (Coastal Mudflat)	SMI1b
	- Artificial (m)	
	b. Culture (Coastal Culture)	SMI1bm
	- Natural	
	d. Saltflat (Coastal Saltflat)	SMI1d
	c. Cliff (Coastal Cliff)	SMI1c
	e. Tide Pool (Coastal Tide Pool)	SMI1e
2. Vegetated/Coral (SMI2)	- Natural	
	a. Coral (Marine Intertidal Coral)	SMI2a
	- Artificial (m)	
	a. Coral (Marine Intertidal Coral Farm)	SMI2am
	- Natural	
	b. Seagrass (Marine Intertidal Seagrass)	SMI2b
	c. Seaweed (Marine Intertidal Seaweed)	SMI2c
	- Artificial (m)	
	c. Seaweed (Marine Intertidal Seaweed Farm)	SMI2cm
	- Natural	
	d. Trees/Shrubs (Coastal Mangrove)	SMI2d
	- Artificial (m)	
	d. Trees/Shrubs (Coastal Mangrove - Plantation)	SMI2dm
Nontidal (SMN)		
1. Non vegetated (SMN1)	- Artificial (m)	
	a. Maricalture (Nontidal Maricalture)	SMN1am
	b. Salt Work (Nontidal Salt Work)	SMN1bm
Subtidal (SES)		
1. Non vegetated (SES1)	- Natural	
	a. Rock Bottom	SES1a
	b. Unconsolidated Bottom	SES1b
2. Vegetated/Coral (SES2)	- Natural	
	a. Coral (Estuarine Subtidal Coral)	SES2a
	- Artificial (m)	
	a. Coral (Estuarine Subtidal Coral Farm)	SES2am
	- Natural	
	b. Seagrass (Estuarine Subtidal Seagrass)	SES2b
	c. Seaweed (Estuarine Subtidal Seaweed)	SES2c
	- Artificial (m)	
	c. Seaweed (Estuarine Subtidal Seaweed Farm)	SES2cm
	d. Mariculture (Estuarine Subtidal Mariculture)	SES2dm
Intertidal (SEI)		
1. Non vegetated (SEI1)	- Natural	
	a. Beach (Estuarine Beach)	SEI1a
	b. Mudflat (Estuarine Mudflat)	SEI1b
	c. Cliff (Estuarine Cliff)	SEI1c
	d. Salt Flat (Estuarine Salt Flat)	SEI1d
2. Vegetated/Coral (SEI2)	- Natural	
	a. Coral (Estuarine Intertidal Coral)	SEI2a
	- Artificial (m)	
	a. Coral (Estuarine Intertidal Coral Farm)	SEI2am
	- Natural	
	b. Seagrass (Estuarine Intertidal Seagrass)	SEI2b
	c. Seaweed (Estuarine Intertidal Seaweed)	SEI2c
	d. Trees/Shrub (Estuarine Mangrove - Swamp)	SEI2d
	e. Fords (Estuarine Saltmarsh)	SEI2e
Nontidal (SEN)		
COASTAL LAGOON (SC)	Coastal Saline/Brackist Lagoon	
INLAND SALT LAKE (SI)		

Appendix B

The waterbird groups in Asia

The waterbird groups in Asia (Sonobe and Usui (eds), 1993)

1. Grebes (Podicipedidae)
2. Pelicans (Pilicanidae)
3. Cormorants (Phalacrocoracidae)
4. Darters (Anhingidae)
5. Flamingos (Phoenicopteridae)
6. Herons and bitterns (Ardeidae)
7. Storks (Ciconiidae)
8. Ibises and spoonbills (Threskiornithidae)
9. Ducks, geese and swans (Anatidae)
10. Cranes (Gruidae)
11. Rail and coots (Rallidae)
12. Finfoots (Heliornitidae)
13. Jacanas (Jacanidae)
14. Painted snipe(Rostratulidae)
15. Crab plover (Dromadidae)
16. Oystercatchers (Haematopodidae)
17. Ibis Bill (Ibidorhychidae)
18. Still and avocet (Recurvirostridae)
19. Stone-curlews (Burhinidae)
20. Pratincoles (Glareolidae)
21. Plovers (Charadriidae)
22. Sandpipers (Scolopacidae)
23. Gulls and terns (Laridae)
24. Skimmer (Rynchopidae)

Appendix C

Major groups of birds that use wetlands

Major taxonomic orders and families or other lower taxa of birds that regularly use wetlands, with general breeding distribution. Examples are given where only a few species of the group are obligate or regular users[a]

No. species[b]	General breeding distribution
Gaviiformes[c]	
Divers (or loss) (Gaviidae) 5	Arctic and north temperate
Podicipediformes[c]	
Grebes (Podicipedidae) 21	Worldwide
Pelecaniformes[c]	
Frigatebirds (Fregatidae) 4-5	Tropical oceanic
Cormorants (Phalacrocoracidae) 38	
Cormorants (Phalacrocoracinae)	Worldwide but strongly tropical
Shags (Leucocorboninae)	Mostly high latitude and cold waters
Anhinga and darters (Anhingidae) 4	Circumtropical
Pelicans (Pelecanidae) 7-8	Worldwide tropical and temperate
Anseriformes[c]	
Screamers (Anhimidae) 3	South America
Magpie Goose (Anseranatidae) 1	Australia
Ducks, geese and swans (Anatidae) 151-154	Worldwide
Whistling Ducks 8	Circumtropical and warm temperate
White-backed Duck 1	Africa
Geese 16	Arctic and cold temperate; 1 Australia
Swans 8	Arctic and cold temperate; 1 South America, 1 Australia
Freckled Duck 1	Australia
Spur-winged Goose 1	Africa
Shelducks, sheldgeese, and allies 17-19	Eurasia, Africa, Australia, South America
Steamer-ducks 4	Patagonia (3 of 4 are flightless coastal species)
Dabbling and Wood Ducks 51	Worldwide
Bay Ducks or Pochards 17	Worldwide
Seaducks 20	Arctic and northern cold temperate; 1 extinct Auckland Island Merganser
Stifftail Ducks 9	Worldwide in temperate and tropical regions
Phoenicopteriformes[c]	
Flamingos (Phoenicopteridae) 4-5	Circumtropical
Ciconiiformes[c]	
Herons, egrets, and bitterns (Ardeidae) 65	Worldwide
Whalehead or Shoebill Stork (Balaenicipitidae) 1	Africa
Hammerkop or Hammerhead Stork (Scopidae) 1	Africa
Ibises and spoonbills (Threskiornithidae) 34	Tropical and warm temperate
Storks (Ciconiidae) 19	Temperate and tropics
Falconiformes	
Kites, eagles, harriers, hawk (Accipitridae) 239	Worldwide
Osprey[c] 1	Worldwide along coasts, and large rivers and lakes
Harriers[c] 17	Worldwide
Kites, e.g., Snail, Slender-billed, Brahminy, Swallow-tailed	Mostly tropical and warm temperate
Hawks, e.g., Red-shouldered, Black-collared, Common Black-Hawk	Americas (only)
Eagles, e.g., Bald Eagle, Steller's Sea-eagle, African Fishing Eagle	Mostly Northern Hemisphere
Falcons and Caracaras (Falconidae) 63	
Peregrin Falcon	Worldwide
Chimango Caracara	South America

(cont.)

No. species[b]	General breeding distribution
Gruiformes[c]	
Rails, crakes, gallinules and coots (Rallidae) 142	Worldwide
Finfoots or sungrebs (Heliornithidae) 3	South America, India, and Africa
Sunbittern (Eurypygidae) 1	South and Central America
Cranes (Gruidae) 14-15	All continents except South America and Antarctica
Limpkin (Aramidae) 1	South and Central America
Charadriiformes[c]	
Jacanas (Jacanidae) 8	Central and South America, Africa, Asia, and Australia
Painted-snipe (Rostratulidae) 2	South America, Africa, Asia, and Australia
Sandpipers, phalaropes, and snipes (Scolopacidae)	
Sandpipers, snipe, woodcock (Scolopacinae) 85	Worldwide
Phaloropes (Phalaropinae) 3	Northern hemisphere
Thick-knees (Burhinidae), e.g., Water Thick-knee, Beach Stone-Curlew 9	Worldwide except North America
Oystercatchers (Haematopodidae) 10-11	Worldwide
Stilts and avocets (Recurvirostridae) 10	Worldwide
Crab-plover (Dromadidae) 1	East Africa coast
Coursers and pratincoles (Glareolidae) 17	Europe, Asia
Plovers and lapwings (Charadriidae) 63-66	Worldwide
Lapwings (Vanellinae)	
Plovers (Charadrinae)	
Skimmers (Rynchopidae) 3	Americas, Africa, India, and Southeast Asia
Gulls and terns (Laridae)	Worldwide
Skuas and jaegers (Stercorariidae) 7-8	High latitudes, coastal
Gulls (Larinae) 50	Worldwide
Terns (Sterninae) 44	Worldwide
Cuculiformes	
Mangrove and Swamp (or Pheasant) Coucal 2	Tropical and warm temperate
Hoatzin 1	South America
Strigiformes	
Barn owl (Tytonidae) 17	Worldwide
African Grass Owl	Only wetland barn owl
Typical owls (Strigidae) 161	Worldwide
Fishing-Owls	Africa and Asia
Barred Owl	North America
Short-eared Owl	Worldwide apart from Africa (where replaced by African Marsh Owl)
Coraciiformes	
Kingfishers[c] (Alcedinidae) 87-94	Worldwide in tropical and temperate
Piciformes	
Ivory-billed Woodpecker 1 (presumed extinct)	Southern USA and Cuba
Passeriformes (opportunistic wetland use; examples given)	
Tyrant Flycatchers (Tyrannidae): Willow, Alder, Kiskadees, Many-colored Rush-Tyrant, Water-Tyrant, White-headed Marsh-Tyrant	
Ovenbirds (Furnariidae): Wren-like Rushbird, Reedhaunters, Streamcreeper	
Australian warblers (Acanthizidae): Fairy Warbler, Mangrove Warbler	Australia
Crows (Corvidae): Fish Crow, Northwestern Crow	
Vireos (Vireonidae): White-eyed, Mangrove	
Dipper[c] (Cinclidae) 5	Worldwide
Thrushes (Turdidae): Veery, Swainson's Thrush	

(cont.)

No. species[b]	General breeding distribution
Old World Flycatchers (Muscicapidae): Swamp Alseonax Or Flycatcher	Africa
Starlings (Sturnidae): Slender-billed Starling	
Babblers (Muscicapidae): Marsh, Chestnut-capped	
Wrens (Troglodytidae): Sedge, Marsh	North America
Titmice (Paridae): Marsh Tit	Europe
Swallows (Hirundinidae): Tree and Mangrove Swallows (many nest near and feed and roost over water)	Worldwide
Old World Warblers (Sylviidae): Arctic, Reed, Marsh, Swamp, Aquatic, Sedge, Paddyfield, Carruther's, Cisticola, Little Rush Warbler	Eurasian, Africa, Australia
Pipits and wagtails (Motacillidae)	
Pipits, e.g., American, Water, Rock	Northern Hemisphere; South Georgia (Antarctic)
Wagtails, e.g., Yellow, Grey, Mountain	Eurasia
Cape Wagtail	Africa (only)
Bush-Shrikes (Malaconotidae), e.g., Marsh Tchagra, Papyrus Gonelek	Africa (only)
Old World Weavers (Plocidae), e.g., Red Bishop, Fan-tailed Widowbird, Marsh Widowbird	Africa (only)
Seedeaters (Fringillidae), e.g., Papyrus Canary	Africa (only)
Sparrows (Emberizidae), e.g., Swamp, Seaside, Nelson's Sharp-tailed, Le Conte's	North America (only)
New World Warblers (Parulidae), e.g., Prothonotary, Bachman's (extinct?), Swainson's, Yellow (incl. Mangrove), Hooded, Yellow-throated, C. Yellowthroat, Waterthrushes	North America (only)
New World blackbirds (Icteridae), e.g., Red-winged, Tricolored, Yellow-headed, Scarlet-headed, Yellow-winged, Brown-and-Yellow Marshbird, Brewer's, Boat-tailed and Great-tailed Grackles	Americas (only)

Notes:

[a] Gill (1995) was used as a basis for taxonomic ordering except for loons.

[b] Number of species varies because of various interpretations in group treatments.

[c] A majority of species in the group are obligate wetland users.

Appendix D

The regression data

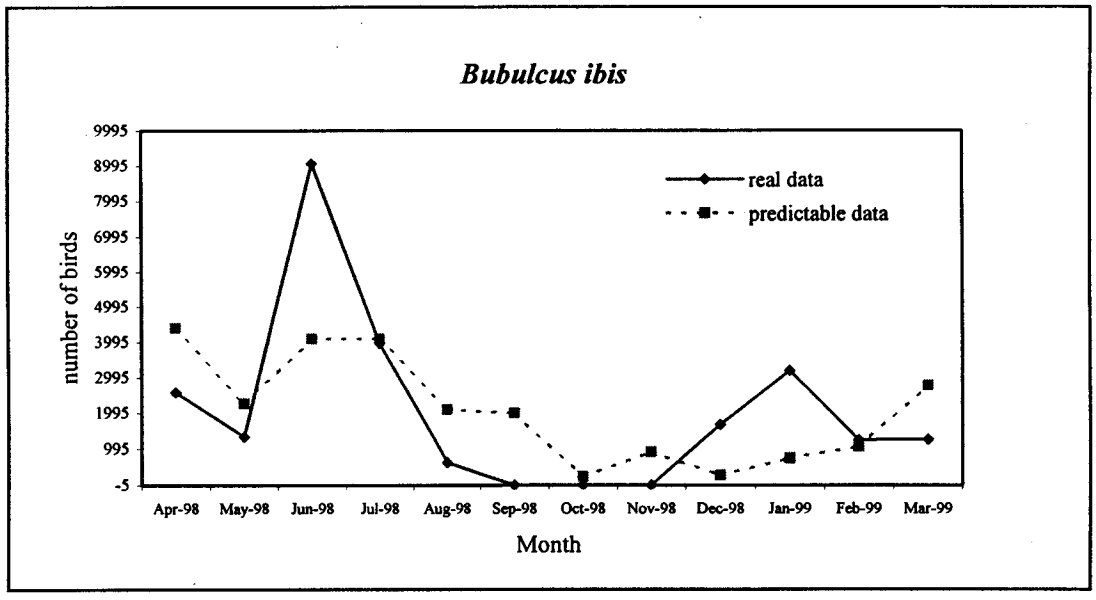


Figure D-1 The regression model among the number of *Bubulcus ibis* and the total rainfall ($p \leq 0.05$)

The number of *Bubulcus ibis*

= 4396.427-12.135 (total rainfall)

where

R^2 = 0.351

Mean Absolute Error (MAE) = 1497.73 individuals

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.5E+07	1	2.5E+07	5.403	.042[b]
	Residual	4.6E+07	10	4602299		
	Total	7.1E+07	11			
2	Regression	2.5E+07	1	2.5E+07	5.403	.042[b]
	Residual	4.6E+07	10	4602299		
	Total	7.1E+07	11			

a. Dependent Variable: CATT.E

b. Independent Variables: (Constant), TOT.RAIN

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4396.427	1173.836		3.745	.004
	TOT.RAIN	-12.135	5.221	-.592	-2.324	.042
2	(Constant)	4396.427	1173.836		3.745	.004
	TOT.RAIN	-12.135	5.221	-.592	-2.324	.042

a. Dependent Variable: CATT.E

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	TOT.RAIN[c]	.	.592	.351	.286	2145.30
2	TOT.RAIN[c,d]	.	.592	.351	.286	2145.30

a. Dependent Variable: CATT.E

b. Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

c. Independent Variables: (Constant), TOT.RAIN

d. Probability of F-to-enter = .050 limits reached.

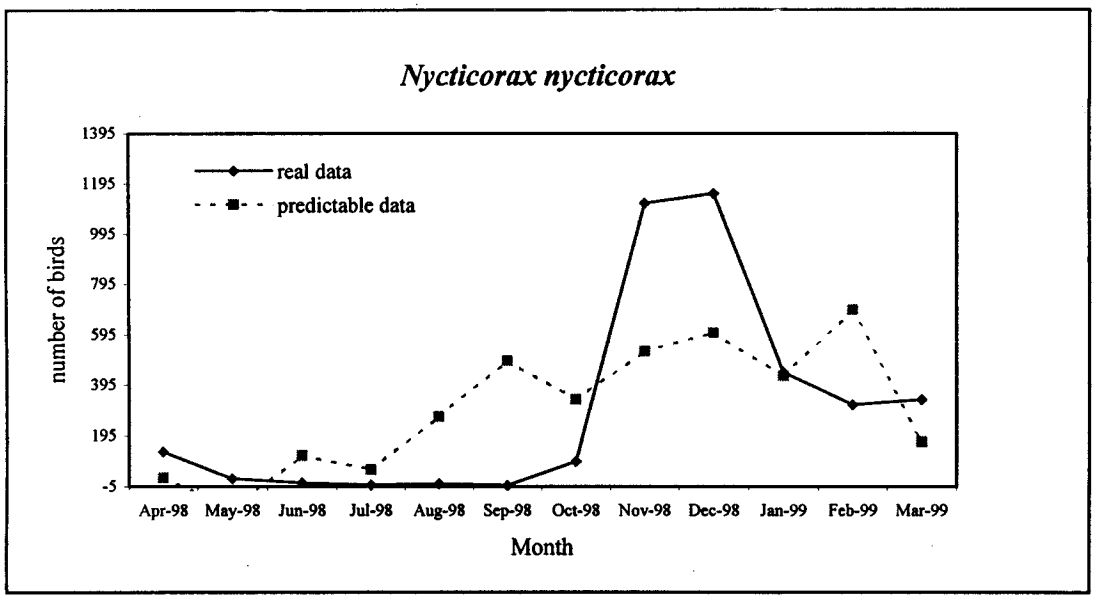


Figure D-2 The regression model among the number of *Nycticrorax nycticorax* and the mean temperature ($p \leq 0.05$)

The number of *Nycticorax nycticorax*

= 3699.412-120.577 (mean temp.)

where

R^2 = 0.358

Mean Absolute Error (MAE) = 256.5 individuals

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	686946	1	686946	5.573	.040[b]
	Residual	1232629	10	123263		
	Total	1919575	11			
2	Regression	686946	1	686946	5.573	.040[b]
	Residual	1232629	10	123263		
	Total	1919575	11			

a. Dependent Variable: NIGH.H

b. Independent Variables: (Constant), AV.TEMP

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3699.412	1441.965		2.566	.028
	AV.TEMP	-120.577	51.076	-.598	-2.361	.040
2	(Constant)	3699.412	1441.965		2.566	.028
	AV.TEMP	-120.577	51.076	-.598	-2.361	.040

a. Dependent Variable: NIGH.H

Model Summary[a,b]

Model	Variables Entered	Variables Removed	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	AV.TEMP[c]	.	.598	.358	.294	351.0881
2	AV.TEMP[c]	.	.598	.358	.294	351.0881

a. Dependent Variable: NIGH.H

b. Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

c. Independent Variables: (Constant), AV.TEMP

d. Probability of F-to-enter = .050 limits reached.

BIOGRAPHY

Miss Watcharaporn Kaewdee was born on October 3, 1974 at Prachinburi Province. She received a Bachelor degree of Education (Science Education) from Faculty of Education, Chulalongkorn University 1996. She furthered her education at the Inter-department of Environmental Science, Chulalongkorn University in 1996.