

# **Driving forces influencing the fluctuation of the number of Purple Herons (*Ardea purpurea*) at Bung Khong Long Ramsar Site, Thailand**

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by

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## **Dedication**

This thesis is dedicated to my beloved parents, Mr. Peerasak Kanongdate and Mrs. Kamolrat Kanongdate for their priceless sacrifices that has brought me so far.

## **Acknowledgement**

Firstly, I would like to extend my sincere gratitude to my supervisor, Prof. Dr. rer. nat. habil. Gerhard Wiegleb, who supported me throughout my thesis with his patience and always encourages me to be successful, I am also highly indebted to PD Dr. rer. nat. habil. Udo Bröring, my co-supervisor for his invaluable assistance, particularly for statistical analysis. Throughout this study, I have been blessed to have friendly and nice colleagues at the chair of general ecology and in the university, which provide me with opportunities to expand both my academic and cultural horizon. These good memories would forever remain with me.

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Kamalaporn Kanongdate

## Abstract

The decrease in the maximum number of Purple Herons (*Ardea purpurea*) observed at Bung Khong Long Non-Hunting Area, northeastern Thailand since 2004 has been attributed to the changes in food supply in the lake. The aim of the present research was to investigate the actual food supply in the different periods of two migratory seasons of the bird (October 2009 – April 2010 and October 2010 – April 2011). Scarce food supply was hypothesized to be one of the most important reasons which provoke these birds to leave the lake to other wetlands during the migratory seasons.

Six sampling stations were selected based on the foraging areas of Purple Heron around the lake where the water level did not exceed 1.5 m. The sampling was focused on fish, shrimps, amphibians, and insect larvae, which are the major food sources. Two kinds of equipment were used including fish net bags and fish traps. An investigation of amphibians was carried out during the night using light attack on their eyes. The wet biomass of these food sources was determined and compared with the daily food requirement of Purple Heron in each period of the migratory seasons. The local fishery was also taken into account as a habitat disturbance, and was subsequently analyzed using questionnaires.

The actual food supply of Purple Herons at the foraging areas during the second migratory season decreased from the early to late period. This was in accordance with the reduction in the number of Purple Herons throughout the migratory season. It is shown that the biomass of medium size fish is the highest in every period. It is suggested that the major food source is from this group. Therefore, the reduction in fish biomass has influenced the total food supply of Purple Herons. Even though the bird forages on a wide range of prey types, other food sources showed a low biomass which could not support the maximum number of Purple Heron throughout the migratory season. Moreover, overfishing in the lake was reported and expected to be a major factor influencing the changes in the food supply of Purple Herons in this lake. Ultimately, the number of Purple Herons decreased from six in the early migratory period to two in the late migratory period.

**Key words:** *Ardea purpurea*, Bung Khong Long, Food supply, Freshwater ecosystem, Migratory bird, Overfishing, Purple Heron, Southeast Asia, Thailand

## **Ursachen der Veränderungen in den Individuendichten des Purpurreihers (*Ardea purpurea*) am Bung-Khong-Long-Ramsar Vogelschutzgebiet, Thailand (Kurzfassung)**

In dem im Norden Thailands liegenden Bung-Khong-Long-Ramsar-Vogelschutzgebiet wurde seit 2004 ein Rückgang der Populationsdichte der Purpurreiher (*Ardea purpurea*) festgestellt. Der Rückgang in diesem Gebiet, in dem keine Jagd erfolgt, wurde auf Veränderungen des Nahrungsangebotes im Bung-Khong-Long-See zurückgeführt. Ziel der vorliegenden Arbeit war die Ermittlung des Nahrungsangebotes innerhalb zweier Wanderzyklen der Reiher, denn ein verändertes oder reduziertes Nahrungsangebot gilt als einer der Gründe, warum die Vögel während der Wanderungszeit den Bung-Khong-Long-See verlassen und andere Nahrungshabitate aufsuchen.

Es wurden Proben an sechs verschiedenen am See gelegenen Probestellen (maximale Wassertiefe 1,5 m), die von den Purpurreihern zur Nahrungssuche aufgesucht werden, entnommen. Die Erfassung des Nahrungsangebotes konzentrierte sich auf Fische, Garnelen, Amphibien und Insektenlarven, die die Hauptnahrungsquelle der Vögel bilden. Für den Fang wurden Netze und Fischfallen eingesetzt, Amphibien wurden in der Nacht durch Licht angelockt und untersucht. Die Feuchtbioasse der Fische wurde erfasst und mit dem täglichen Nahrungsbedarf der Purpurreiher innerhalb der Wanderzyklen in Beziehung gesetzt. Darüber hinaus wurde die lokale Fischerei-Praxis als potentieller Störfaktor in den Vogelhabitaten durch Umfragen ermittelt.

Das Nahrungsangebot für die Purpurreiher nahm zum Ende des zweiten Wanderzyklus ab, was mit der abnehmenden Anzahl der Vögel korrespondierte. Es zeigte sich, dass zu jedem Zeitpunkt der Untersuchungen Fische mittlerer Größe die höchste Biomasse aufwiesen. Da diese als präferierte Hauptnahrungsquelle der Vögel dienen, führt der rückläufige Bestand an diesen Fischen zu wesentlichen Veränderungen im Gesamt-Nahrungsangebot. Auch wenn Purpurreiher ein breites Beutespektrum aufweisen, können die übrigen möglichen Ressourcen (Garnelen, Amphibien und Insektenlarven) aufgrund ihrer geringeren Biomassen die Reiher-Populationen während ihrer Überwinterung nicht ausreichend versorgen. Darüber hinaus wurde bei den durchgeführten Umfragen von einer Überfischung des Sees berichtet, was als Hauptgrund für das reduzierte Nahrungsangebot für die Vögel gilt. Demzufolge sank die Anzahl an Purpurreihern innerhalb des betreffenden Wanderzyklus von sechs auf zwei Individuen.

**Stichworte:** Zugvogel, Nahrungsversorgung, Nahrungsangebot, Süßwasser-Ökosystem, Überfischung, Südostasien, Bung-Khong-Long, Thailand, Purpurreiher, *Ardea purpurea*

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## **1 Introduction**

The Purple Heron (*Ardea purpurea* L.) is globally wide spread and has been classified as least concern in the IUCN red list (BirdLife International 2009a; BirdLife International 2010; IUCN 2011). Currently, in Thailand, the status of *Ardea purpurea manilensis* had changed from endangered to vulnerable (Sanguansombat 2005). The bird is reported to be commonly found in suitable habitats across the country as non-breeding visitor (Roson 2002), including the Ramsar site, Bung Khong Long Non-Hunting area. The period that Purple Herons visit the lake in Thailand called migratory season throughout the present study. During winter they migrate from Russia to Thailand and other countries (McClure 1974a) and join the resident in some areas in the north, the northeastern, the central, and the south of Thailand (Robson 2002). There have been several efforts to understand their migratory route, food preference and feeding behavior. Unfortunately, most studies were carried out in breeding grounds, thus information on their ecology and feeding behavior in migratory areas is still lacking or unclear. Particularly, knowledge on *Ardea purpurea manilensis* at Bung Khong Long Ramsar Site is very scarce even though the area is under conservation and serves as wintering rest area for migratory birds. The factors that influence the alteration in the number of these birds after they arrive at Bung Khong Long Lake therefore have been studied.

The only attempt to study the food sources of this bird was carried out by Kanjanasaka et al. (1987) at the breeding area in the south of Thailand. This data base of food type selection at breeding area serves as basic knowledge of the type of preys preferred by Purple Heron in other wetlands including Bung Khong Long Lake. Similar available food sources are expected to be selected by the Purple Herons which are found at Bung Khong Long Lake. It has been observed that the number of Purple Herons decreases from the first to the last month of the same migratory season; it is hypothesized that changes in food supply throughout the migratory season have influenced the fluctuation of the number of the birds. Limited access to food sources due to some factors causes some of the birds to leave Bung Khong Long Lake.

Thus the objectives of this study are:

- (1) To assess the fluctuation of the number of Purple Herons from year 2004 to 2011 at Bung Khong Long Lake during migratory seasons
- (2) To assess the number of Purple Herons from the first to the last month of migratory season of year 2009/10 and 2010/11

- (3) To investigate breeding nests of Purple Heron within the lake environ and cross check data with breeding and migratory period of other groups from other parts of Thailand
- (4) To determine the catch per unit effort (CPUE) of probable food sources including fish, amphibians, shrimps, and insect larvae in the lake during migration time
- (5) To investigate number of fish and amphibians, wet biomass of fish, amphibians, shrimps, and insect larvae during the visiting period of the Purple Herons
- (6) To gather information from local fishermen on daily fish-caught during the migratory season

Other factors such as climate change, loss during migration and loss of habitats at the origins that may also influence the number of Purple Herons are not considered in the present study.

It is hypothesized that:

- (1) The number of Purple Herons during migratory season at Bung Khong Long Lake has decreased even though the status of this bird in Thailand has changed from endangered to vulnerable species
- (2) The Purple Herons at Bung Khong Long Lake is only a migrant group
- (3) If Purple Herons at Bung Khong Long Lake are only migrants, the numbers should remain the same from the time of arrival at the lake until they migrate back to the origins
- (4) Scarce food supply at Bung Khong Long Lake is one of several factors that have influenced on the fluctuation of the number of Purple Herons
- (5) Food supply and general environmental conditions at Bung Khong Long Lake are not suitable for Purple Herons due to anthropogenic influences either intensive local fisheries or reed beds cut

The conception of investigation (Figure 1) focused mainly on the influence of available major food sources on the fluctuation of the number of Purple Herons at Bung Khong Long Lake. Probable food sources include fish, frogs, shrimps and insect larvae. The amount of food supply from these probable food items is linked to the present number of Purple Herons at the lake. The amount of food supply was compared with daily food requirement of Purple Heron. If the total wet biomass of all possible preys was less than the daily food requirement of Purple Heron, it is suggested that the lake has scarce food supply for the birds. Higher biomass than the daily requirement suggests that the lake has enough food supply. Scarce food supply was expected to drive some of the birds away from the lake. High amount of food supply would attract Purple

Hérons, which arrived at the lake at the beginning of migratory season to forage in the lake throughout the migratory season. Declining food supply may drive some birds to other wetlands during early to late migratory period. On the contrary, birds are attracted to forage at Bung Khong Long Lake when there is adequate and constant food supply.

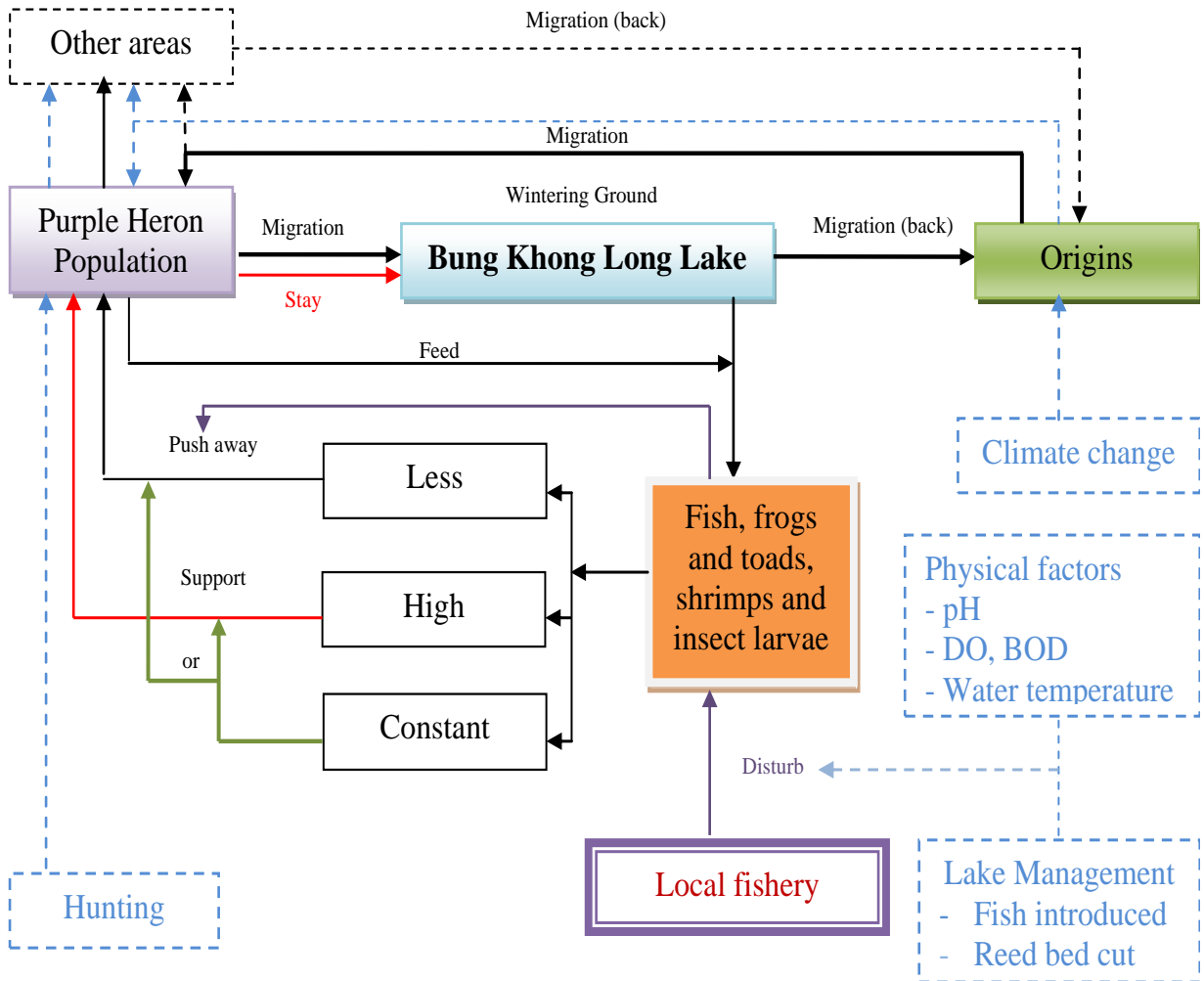


Figure legends

	Other factors which are not investigated in the field
	A driving force
	Influence or relation
	Influence of high amount of food supply to support the bird to stay at the lake
	Influence of constant amount of food supply to attract the bird to stay or to drive the bird fly away from the lake
	Routed
	Additional factor that was hypothesized to have influence in the decline of food stock of Purple Heron
	Probable major food sources of Purple Heron in Bung Khong Long Lake

**Figure 1:** Conceptual framework of the food supply as a driving force influencing fluctuation in the population of Purple Herons at Bung Khong Long Lake

Besides, difficulty of catching preys owing to activities of local fishery may indirectly influence the alteration in the population of Purple Herons during the migratory season. Even though there is enough food available in the lake, it does not mean that Purple Herons are able to meet their daily food requirement. Therefore, local fishery was also taken into account as a driving force likely to influence the food stock for Purple Herons.

The thick-black arrows represent the migratory routes from the origins to Bung Khong Long Lake and from Bung Khong Long Lake back to the origins. The orange box contains probable food sources of Purple Herons in the lake. The influence from the food sources is shown by the thin-black arrows into three possible situations: less food supply, high amount of food supply, and constant food supply. The thin-black arrow from the box of less food supply shows that scarce food may drive Purple Herons move away from the lake to other wetlands. The red arrow from the box of high amount of food supply shows that enough food may attract Purple Herons to spend foraging time at the lake instead of moving to other areas. The green arrows from the box of constant food supply shows that Purple Herons may move away or forage at the lake. Local fishery is an additional factor as shown in the purple box. It may disturb the density of preys in the orange box. Consequently, it drives the bird to move away from the lake due to the difficult access to the food sources. The influence from local fishery is shown by the purple arrows. The dash-blue boxes contain other factors which may influence the fluctuation in the number of Purple Herons at Bung Khong Long Lake. The influence of these factors is linked with the dash-blue arrows. These factors are not investigated in the field.

## **2 Study area: Bung Khong Long Ramsar Site**

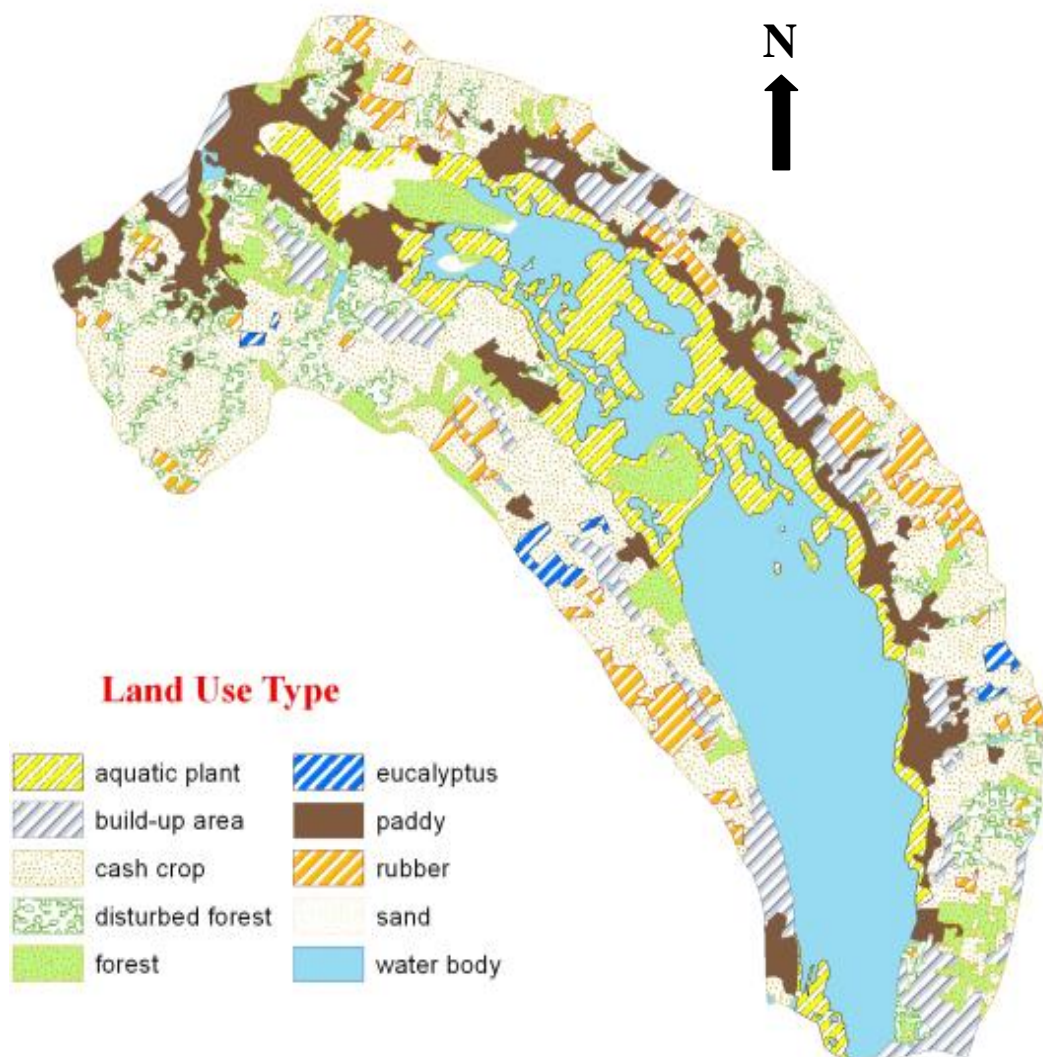
Wetlands International (2007) reported in the “Information Sheet on Ramsar Wetlands (RIS)” that Bung Khong Long Lake is one of the largest freshwater lakes in Northeastern Thailand. It is a permanent natural water reservoir on Thailand’s border with Laos. Bung Khong Long Lake was proclaimed as a wildlife non-hunting area in 1982 by the Royal Forest Department (ONEP 2006). Thereafter in 2001, it was designated as an important international wetland under the Ramsar Convention (Ramsar Secretariat 2007 a; Svasti 2007) with 158 membership (Peck 2008) and just reached 160 members in 2011 (Ramsar Secretariat 2011). Thailand was the convention’s 110<sup>th</sup> contracting party in 1998 and proposed "Kuan Ki Sian of the Thale Noi Non-Hunting Area Wetlands" (493.6 hectares) as the first Wetland of International Importance (Peck 1998; ONEP 2000). Bung Khong Long Lake is the second Ramsar Site. At the present there are 11 Ramsar sites in Thailand (Ramsar Secretariat 2007 b) and as at 2009, there were plans to designate 20 new Ramsar sites (Vidthayanon 2008).

Bung Khong Long Lake qualifies to be classified as a Ramsar site because two species of fish, namely *Betta smaragdina* and *B. splendens* have been classified in Thailand as threatened species in the wild (Wetlands International 2007). The fish *Kryptopterus bicirrhis* and *Clarias batrachus* have also been classified as a nationally vulnerable species (Wetlands International 2007). Moreover, Bung Khong Long Lake also supports nationally endemic fish species such as *Boraras micros*, *Brachygobius* sp., *Clupeichthys aesarnensis*, *Monotretete leiurus* (*Tetraodon leiurus*), *Neodontobutis aurarmus*, and *Rasbora spilocerca* (ONEP 2002; Wetlands International 2007). Nationally endangered avian species include *Ardea cinerea*, *A. purpurea* and *Milvus migrans* whereas *Aythya nyroca* and *Vanellus duvaucelii* have been classified as vulnerable species (Wetlands International 2007). *Aythya nyroca* is also globally recorded as a near threatened species. Other three species of birds, *Haliastur indus*, *Nettapus coromandelianus*, and *Vanellus cinercus* are classified as nationally near threatened species (Wetlands International 2007).

Bung Khong Long Lake is located in northeastern Thailand (17° 18′-17° 58′ N and 103° 59′-104° E; 160-170 m). It covers an area of 22.14 km<sup>2</sup> (approximately 12 km x 2 km). It is a narrow ox-bow lake, which backs up the drainage of streams and rivers, especially Songkram River before flooding into Mekong River. It is a closed system of freshwater lake. Adjacent areas around the lake are rice fields, Para rubber crops and settlements of local inhabitants (Figure 2). Main



products are rice (*Oryza sativa*), para rubber (*Hevea brasiliensis*), and tobacco (*Nicotiana tabacum*). There is a small area of deciduous forest called “Don Sa Wan”, which protrudes into the lake. The Non-Hunting Area Office is located at this part, and serves as the first benchmark point of lake investigation by GPS marking from the north to the south. In the lake, emergent hydrophyte communities are scattering and covering the water surface. The north and south portions of the lake are shallower compared to the middle part. Fishing is the major economic activity carried out around the lake. The Royal Forest Department (2001) reported that local people make profit of about 50-70 baht (1-1.4 Euro) per day per head from fishery. However, some local people also had been employed in commercial production and earned 95 baht (1.9 Euro) per day per head (Settakit Ruam Duai Chuai Kan Co. Ltd 2006). Bung Khong Long area is not famous for tourism because of the limitation on seasonal bird observation.



**Figure 2:** Bung Khong Long land use map (Land Development Department 2000)

Bung Khong Long Lake was selected for this study based on the following reasons:

- (1) It is the first Ramsar site of freshwater ecosystem in Thailand, which is under conservation and monitoring
- (2) It is a close system which is less influenced by other natural conditions such as sea water disturbance and it is far from anthropogenic disturbance such as water contamination from industries
- (3) It is a supporting area of Purple Herons and other migratory birds during their migratory season
- (4) It is a non-hunting area, thus the number of Purple Herons is expected not to be exposed to hunting
- (5) Local fishery is likely one of the causes that impact food supply of Purple Heron during the migratory season

### **Sampling site characteristics**

The six sampling sites are Huai Pong Tao, Don Seo Tai, Don Mor Tong, Ban Chareon Suk, Noan Eee Yord, and Don Sa Wan (abbreviation of each station, see Table 1).

**Table 1:** Acronyms of the name of sampling stations

<b>Station Number</b>	<b>Name</b>	<b>Acronyms</b>
1	Huai Pong Tao	HPT
2	Don Seo Tai	DST
3	Don Mor Tong	DMT
4	Ban Chareon Suk	BCS
5	Noan Eee Yord	NEY
6	Don Sa Wan	DSW

Each site represents the potential feeding ground of Purple Heron around the lake. All sampling stations are shallow areas with water level not over 1.5 m. The difference in characteristics among the stations is described as follows.

#### *First station: Huai Pong Tao*

Huai Pong Tao is a small stream between Lad Taae and Lad Sa Bang. It discharges into Bung Khong Long Lake. About 2,400 m<sup>2</sup> of this area remains unaffected by waterlog conditions during the rainy season. Typical vegetation observed at this area includes *Eleocharis dulcis*, *Imperata*

*cylindrica*, and *Utricularia aurea*. Rambutan orchards and Para rubber plantation owned by local inhabitants encloses the area out of the lake margin at Lad Taae side. Purple Herons are often observed at this area in October and November (Wongkumkaew, personal communication). Figure 3 shows a view of the characteristics of this area. Some parts are covered with emergent hydrophyte communities and reedbeds swamp. Huai Pong Tao area is relatively close to Don Sa Wan, but the morphological characteristic is relatively different.



**Figure 3:** First station, Huai Pong Tao as a combination between Lad Taae and Lad Sa Bang (October 2009)

*Second station: Don Seo Tai*

Don Seo Tai is located in the north of Huai Pong Tao next to Lad Sa Bang in the northern part of the lake. Figure 4 shows the characteristics of the area. The vegetation comprises *Myrtaceae* and *Cyperaceae* (ONEP 2002) and the area is mostly fitted with fish trap fence.



**Figure 4:** Second station, Don Seo Tai

*Third station: Don Mor Tong*

Don Mor Tong (Figure 5) is located at the end of northern part and the shallowest part of the lake. The area is about 1,600 m<sup>2</sup> and mostly covered with *Myrtaceae* plant community (ONEP 2002). Water color during observation time was yellow due to its sediment like mud. Some fish trap fences were set up along the rim of reed swamp similar to Don Seo Tai area. A large rice field is close to this area.



**Figure 5:** Third station, Don Mor Tong

*Fourth station: Ban Chareon Suk*

The name refers to the village in this area, and it is located in the northeastern part of the lake opposite to Don Sa Wan. Figure 6 shows the characteristics of Ban Chareon Suk. The vegetation comprises *Angiopteris evecta*, *Carex baccans*, *Diplazium esculentum*, *Eragrostis tenella*, *Homalomena rostrata*, and *Imperata cylindrica* (ONEP 2002). Besides, there is a large area of *Eleocharis dulcis* and *Utricularia aurea* disperse among lotus swamp. Most areas of emergent hydrophytes are in the form of islands shape. The terrestrial area is cultivated to Para rubber (*Hevea brasiliensis*) plantation, which belong to local inhabitants.



**Figure 6:** Fourth station, Ban Chareon Suk

*Fifth station: Noan Eee Yord*

Noan Eee Yord is located at the end of southern part of the lake. There is a weir with a water gate to control the water level in the lake for agricultural purpose during the dry season. Most of the area is covered with *Eleocharis dulcis*. The area is about 9,600 - 12,800 m<sup>2</sup> (Wongkumkaew, personal communication) and has many shrimp traps. Figure 7 shows the characteristics of Noan Eee Yord area and shrimp traps distribution. About 6,400 m<sup>2</sup> are always submerged during rainy season. Emergent hydrophytes are scattered in the form of several small patches. Birds often observed at this area include Great Egret, Intermediate Egret, Little Egret, Cattle Egret, Chinese Pond Heron, and Purple Heron (Wongkumkaew, personal communication). However, Purple Herons were not observed at this area during the study period in both migratory seasons.



**Figure 7:** Fifth station, Noan Eee Yord

*Sixth station: Don Sa Wan*

Don Sa Wan is located in the western part of the lake. Large emergent hydrophyte communities are found aggregated in large areas. The terrestrial part of Don Sa Wan is an evergreen forest. Figure 8 shows the characteristics of Don Sa Wan area, which comprises three main parts: Som Yai, middle part, and Lad Mai Tai.

- (1) Som Yai, the first part of Don Sa Wan, is about 3,200 - 4,800 m<sup>2</sup>. The vegetation comprises *Eragrostis* sp. and *Stenochlaena palustris* at this area. At this particular area, Purple Herons have been frequently observed compared to Grey Herons (Wongkumkaew, personal communication)
- (2) Middle part of Don Sa Wan area is a concave area which is expected to be a good shelter for the birds to hide or to prey
- (3) Lad Mai Tai is the end part of Don Sa Wan, close to the Don Sa Wan forest, and the vegetation cover mainly comprises *Cyperaceae* (ONEP 2002)

Don Sa Wan area is not only expected to provide the main food for Purple Herons, but also alternative food sources.



**Figure 8:** Sixth station, Don Sa Wan

#### *Don Nong area*

Besides the six sampling stations, Don Nong was observed as an additional area for fly path since Purple Heron has been frequently observed to pass by this area during flight between Ban Chareon Suk and Huai Pong Toa. Other samplings were not taken into account. Figure 9 shows the characteristics of Don Nong area. Emergent hydrophytes cover a large area and comprised *Digitaria* sp, *Imperata cylindrica*, and *Nepenthes mirabilis*. Between April and June, this area has been reported to be around 1,600 m<sup>2</sup> in size, with the largest part usually submerged between July and October. Purple Heron, Pied Harrier, and Eastern Marsh have been observed here (Wongkumkaew, personal communication).



**Figure 9:** Additionally included observed area, Don Nong

### 3 Methodology

The methodology took into account two key aspects: observation in the field and data analysis. Field study was conducted at six sampling sites based on documented observation on areas in the region where Purple Herons have been observed foraging during migratory season. The field investigation focused on food supply and number of Purple Herons. Other birds observed during foraging time of Purple Herons were also recorded. In addition, physical, chemical, and biological parameters of the lake, which comprised water level, water temperature, pH, and percent coverage of emergent hydrophytes, were determined. Information to assess the impact of local fishery on Purple Herons was collected through questionnaires.

Acronyms of periods (Table 2) within the migratory season were used throughout the chapter of methodology, result, and discussion.

**Table 2:** Acronyms of periods within the migratory season of Purple Heron

<b>Periods within the migratory season</b>	<b>Acronyms</b>
Early period (October)	EP
Middle period (January)	MP
Late period (April)	LP

Field investigation was carried out twice with respect to the migratory season of Purple Heron. The first investigation was carried out during the first migratory season, which spanned from October 2009 to April 2010, and the second investigation was in the second migratory season, which is between October 2010 and April 2011. The number of observations made was divided into three periods for each migratory season. Early period (October) represents the time when the birds arrive, middle period (January) when the birds stay, and late period (April) when the birds migrate back to origins. In the first migratory season, the aim was to investigate the number of fish and amphibians as well as their number of species in each migratory period. In the second migratory season, investigation of the parameters was repeated. In addition, data on wet biomass of probable food sources of Purple Heron were obtained. During this season, the observation was done within 20 days for each period. Samples were collected from three of the six stations in a day. Immediately after sampling, fish identification was done at Bung Khong Long Non Hunting area office. Fish identification based on Faculty of Fishery 1999, Kottelat 1990, and Vidthayanon et al. 1997.

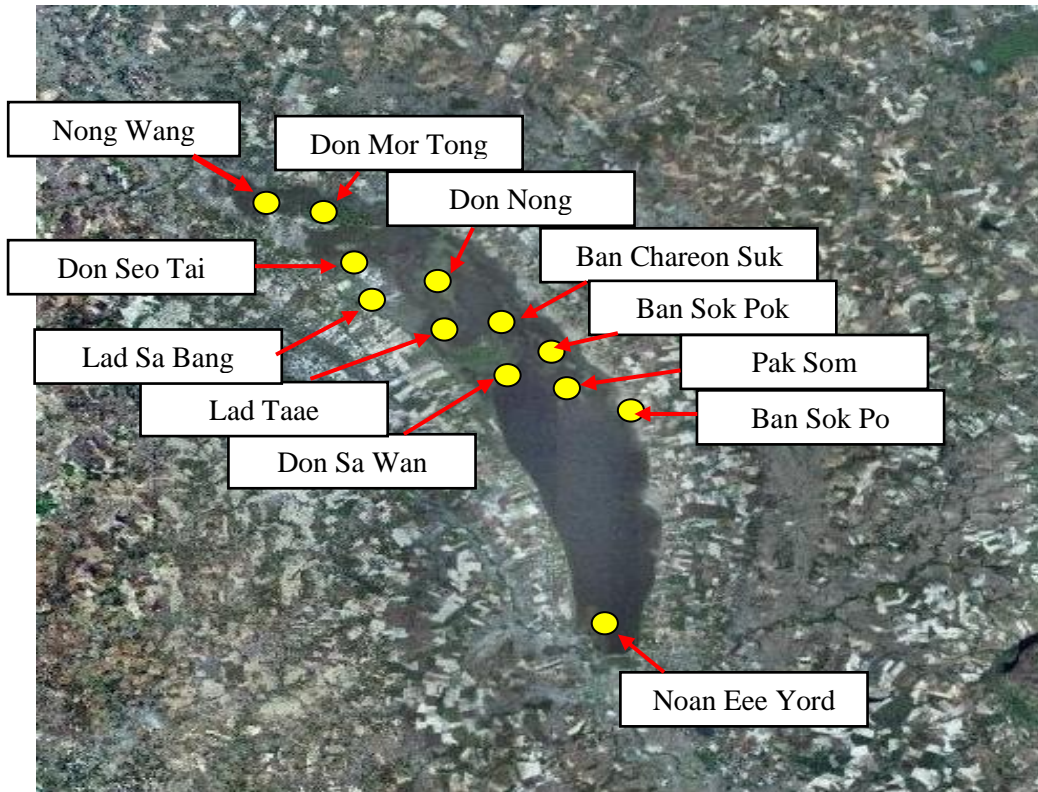
In order to analyze the impact of local fishery on Purple Herons, questionnaires were administered and interviews conducted with the local fishermen in the second migratory season (see Appendix I). The target was fishermen who carry out their fishing activity at the shallow part of feeding areas of Purple Herons. Interviews were assisted by officers from Bung Khong Long Non Hunting Area due to language barriers. The questionnaires focused on the amount of fish caught and frequency of fishing. In addition, the questions covered attitudes of local fishermen on the lake and bird management at Bung Khong Long Lake.

Secondary data were collected on the number of Purple Herons at the lake from 2004 to 2011. The data were obtained from the information office of Bung Khong Long Non-Hunting Area and the Department of National Park Wildlife and Plant Conservation, Thailand.

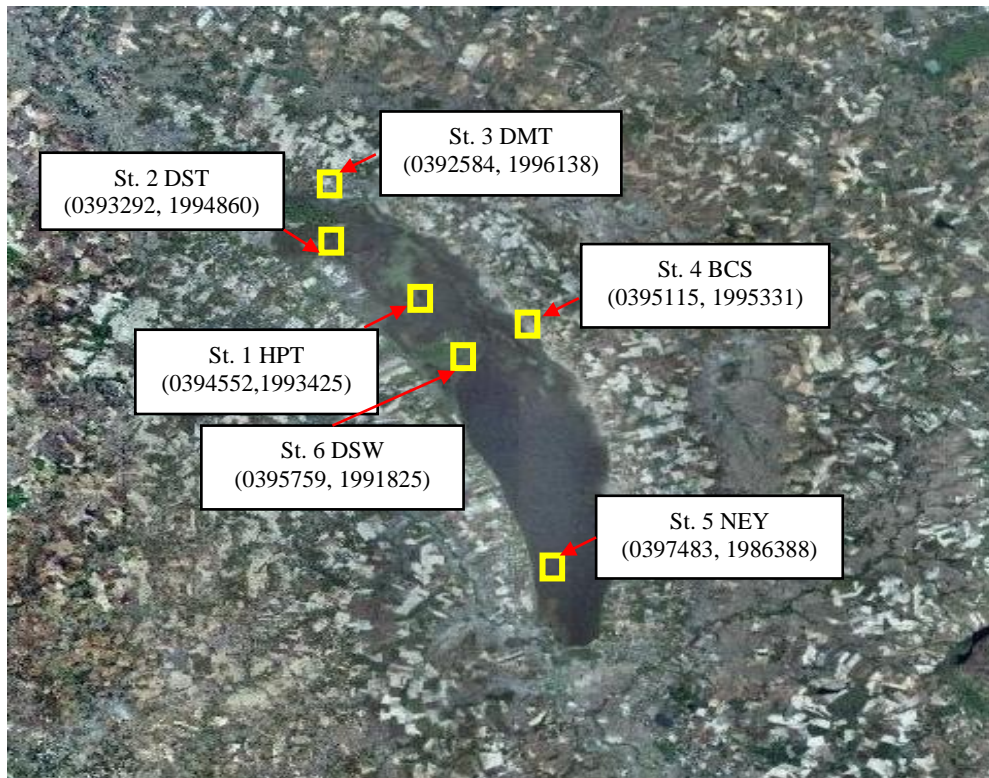
### **3.1 Field survey and pre-sampling**

A pre-survey of the study area was carried out in April 2009. Areas where Purple Herons have been observed at Bung Khong Long Lake were investigated and marked with GPS (GPS 1 Germin, UTM zone 47). Feeding and sheltering areas were marked for 12 sites (Figure 10). These are Don Sa Wan, Lad Taae, Lad Sa Bang, Don Seo Tai, Nong Wang, Don Mor Tong, Don Nong, Ban Chareon Suk, Ban Sok Pok, Pak Som, Ban Sok Po, and Noan Eee Yord. Six sampling sites (Huai Pong Tao, Don Seo Tai, Don Mor Tong, Ban Chareon Suk, Noan Eee Yord, Don Sa Wan) were selected as a representative of the potential feeding areas of Purple Herons (Figure 11). Some expected food sources of Purple Heron including fish and amphibians were randomly investigated in the selected feeding areas, particularly at the rim of the lake in the dense reed beds.



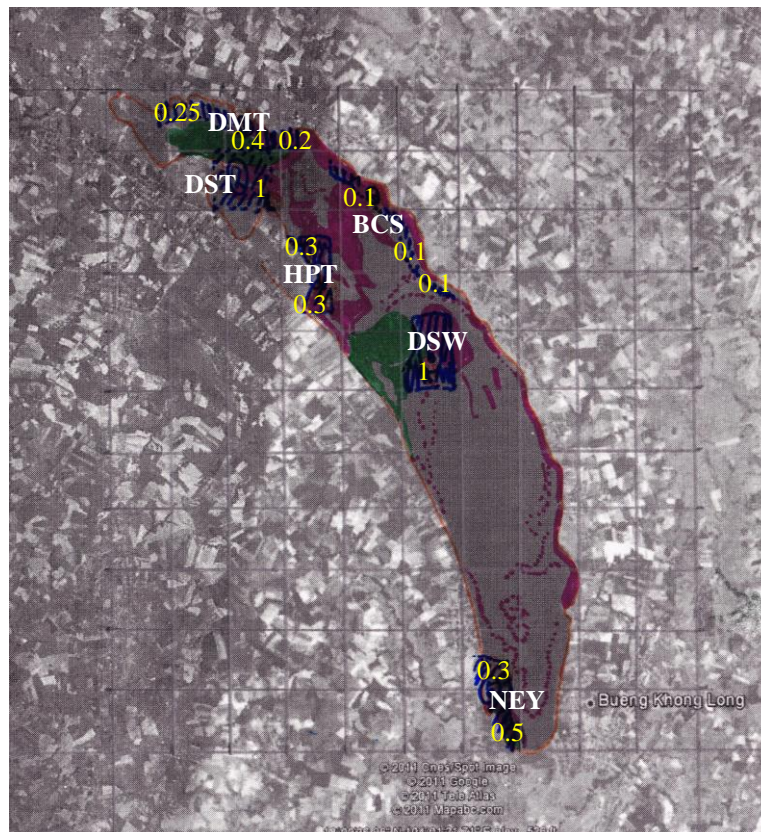


**Figure 10:** Areas where Purple Heron could be found (April 2009) (Source of map: Google earth 2009)



**Figure 11:** Sampling sites: HPT, DST, DMT, BCS, NEY, DSW, marking with GPS UTM 47 (Source of map: Google earth 2009)

An estimation of the potential feeding areas of Purple Herons at Bung Khong Long Lake was calculated with grid measurement. Figure 12 shows how the potential feeding areas of the entire lake environs and each station were estimated by grids. The area covered with one grid was counted as 1. Area covered by half grid was counted as 0.5 and other proportions are depending on the covered area. Total areas of Bung Khong Long Lake were estimated 22.14 km<sup>2</sup> (22,140 m<sup>2</sup>). The potential feeding areas were calculated as a proportion of the total area of Bung Khong Long Lake, and that of each station was calculated as a proportion of the potential feeding areas.



**Figure 12:** Grid measurement of the potential feeding areas of Purple Heron at Bung Khong Long Lake. Green represents forest area, purple: aquatic plants, blue: areas of sampling stations. (Source of map: Google earth 2009)

The total counted grids of Bung Khong Long Lake amount to 23.9 grids whereas the total potential feeding area is 11.5 grids. Thus, the total potential feeding area of Purple Herons at Bung Khong Long Lake constitutes approximately 50 % of the lake area which is about 11.07 km<sup>2</sup> (11,070 m<sup>2</sup>). The estimation of sampling areas is shown in the following list:

Station 1: Huai Pong Tao	= 0.6 grids, thus (11,070 m <sup>2</sup> /11.5) x 0.6	= 577.57 m <sup>2</sup>
Station 2: Don Seo Tai	= 1.0 grids, thus (11,070 m <sup>2</sup> /11.5) x 1	= 962.61 m <sup>2</sup>
Station 3: Don Mor Tong	= 0.85 grids, thus (11,070 m <sup>2</sup> /11.5) x 0.85	= 818.22 m <sup>2</sup>
Station 4: Ban Chareon Suk	= 0.30 grids, thus (11,070 m <sup>2</sup> /11.5) x 0.3	= 288.79 m <sup>2</sup>

Station 5: Noan Eee Yord = 0.80 grids, thus  $(11,070 \text{ m}^2/11.5) \times 0.8 = 770.09 \text{ m}^2$

Station 6: Don Sa Wan = 1.0 grids, thus  $(11,070 \text{ m}^2/11.5) \times 1 = 962.61 \text{ m}^2$

### **3.2 Abiotic and biotic factors**

Abiotic factors in Bung Khong Long Lake were measured three times of each migratory season. Water level, water temperature, and pH are included. The measurement of water level was done by vertically placing a long bamboo stick in the water until it hits the bottom, and the top that is in contact with the water surface was marked, and then removed from the water. After that a meter rule was used to estimate the length of the bamboo immersed in the water, which was representative of the depth of the water. Water temperature (°C) and pH were measured at the same place where the water level was estimated. Thermometer and pH test kid, respectively, were used for the measurement.

Abiotic factors throughout the migratory season were expected not to be different in each period. Therefore, they were measured at each sampling station for each period. They could be a factor influencing changes in number and biomass of fish that are likely to be main food of Purple Heron.

Biotic factors investigated include diversity and structure of vegetation coverage. Plants identifications are based on IPNI (2001) and Smitinan (2001). Percent coverage of plant species was investigated during the second migratory season for three periods. This was done to analyze the role of the vegetation structure as a temporal shelter of Purple Heron throughout the migratory season. The areas investigated have two main characteristics; reed swamp and emergent hydrophyte communities which form a shape-like small island. At both areas, percent coverage of each plant species was estimated within a representative area of approximately 25 m<sup>2</sup>.

Acronyms of size class of emergent hydrophyte community (Table 3) were used throughout the chapter of methodology, result, and discussion.

**Table 3:** Acronyms of the size class of expanded emergent hydrophyte community

<b>Size class</b>	<b>Acronyms</b>
Small (less than 100 m <sup>2</sup> )	S
Medium (100-1,000 m <sup>2</sup> )	M
Large (more than 1,000 m <sup>2</sup> )	L

The area size of emergent hydrophytes was classified into three classes namely small, medium and large. Small size refers to expanded areas less than 100 m<sup>2</sup>; medium size, between 100-1,000 m<sup>2</sup>; large size refers to areas larger than 1,000 m<sup>2</sup>. In addition, the maximum and minimum height of each plant species was measured.

### **3.3 Purple Herons observation**

In both migratory seasons, the number of Purple Herons was obtained from the regular observation of Bung Khong Long Non-Hunting Area and from the Department of National Park Wildlife and Plant Conservation, Thailand. In the second migratory season (October 2010 - April 2011), additional data on the number of Purple Herons was obtained through intensive observation over a period of 20 days from 7.00 a.m. to 6.00 p.m. within each migratory period.

Observation of Purple Herons was commenced at Lad Sa Bang by navigating with a boat to the north and the east of the lake. Pictures of the bird were taken through a binocular (8 x 42) and a digital camera from the closest distance, and the behavior of Purple Heron was also recorded. The main behavior of the bird during foraging including the time spent on the prey was considered. For example, Purple Heron taking the prey into the mouth till swallowing were recorded in situations where it was possible. However, the observation was restricted since it was impossible to follow the birds everywhere. Nevertheless, following the direction of their flight would lead us to know their resting site.

### **3.4 Determination of food supply**

Food sources comprise fish, shrimp, insect larvae, and amphibians. They constitute the main food types that have been reported to be fed on by Purple Herons at breeding areas. It is therefore assumed that the same group of preys would serve as food source for Purple Herons at the wintering area. Particularly, fish remains the main food implying Purple Heron prefers to search for fish first before changing to other food types. Based on this reason, seven fish species, which have been reported as food for Purple Heron at the breeding area in the south of Thailand, deserve attention.

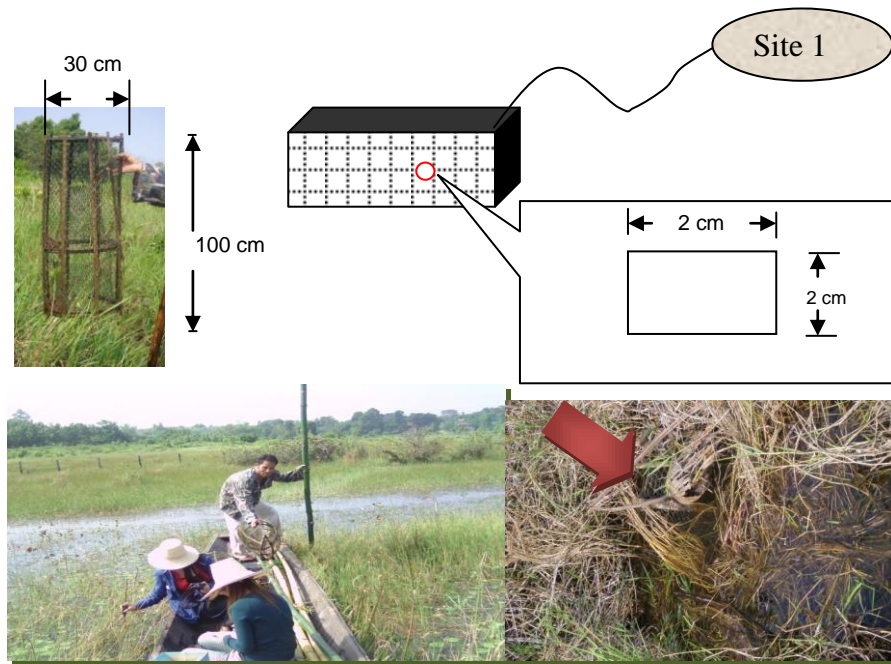
Food investigation was carried out for a period of 10 days for each migratory period in the first migratory season; 7 days for fish, and 3 days for amphibians. Each station was sampled in a day and in the following day traps set were checked for fish caught. Amphibians were investigated at two stations at night. The investigation process was more intensive in the second migratory

season. The observation was carried out in 20 days for each period. Three sampling stations were investigated in a day due to limited time and resources. Therefore, six stations were investigated in two days. However, for the purpose of analysis, each period comprises ten days.

### 3.4.1 Fish investigation

Two fishing gears were used in this study to sample fish. Species identification and counting were done in both migratory seasons. However, measurement of wet biomass was done only in the second migratory season.

Fish trap was used to sample fish that are found mainly dwelling at the bottom of the lake, particularly *Anabas testudineus*, *Channa striata*, *Clarias* sp., *Notopterus notopterus*, and *Xenentodon cancila*, which have been reported as food of Purple Heron in the south of Thailand. Two more other species, *Channa lucius* and *Channa micropeltes* were also considered owing to the same behavior as the above five species. Besides, they are of economic importance to local fishermen. These seven species are likely food preference of Purple Heron. Thus, their number and biomass during the second migratory season were analyzed separately from other species. Two fish traps were placed at the bottom of the lake at each station and covered with aquatic plants (Figure 13). The volume of fish trap is  $0.14 \text{ m}^3$  ( $\pi r^2 \times \text{length} \times \text{number of traps}$ ). The mesh is  $4 \text{ cm}^2$  (Figure 13).



**Figure 13:** Fish trap covered by the dry reed and aquatic plants

The fish net bags (Figure 14) target small pelagic fish or fish which move between surface water and bottom. The fish net bag has a volume of 157 m<sup>3</sup> ( $\pi r^2 \times \text{length} \times \text{distance}$ ). Its size is 1 x 1 m<sup>2</sup>. At each station this gear was drawn along the shore line of about 100 - 200 meters at 30 - 50 cm depth.

$$\begin{aligned} \text{Volume of traps} &= \pi r^2 \times \text{length} \dots\dots\dots (1) \\ &= 3.14 \times 0.15^2 \times 1 \times 2 \text{ m}^3 \\ &= 0.14 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Volume of net bag} &= \pi r^2 \times \text{length} \times \text{distance} \dots\dots\dots (2) \\ &= 3.14 \times 0.5^2 \times 1 \times 200 \text{ m}^3 \\ &= 157 \text{ m}^3 \end{aligned}$$

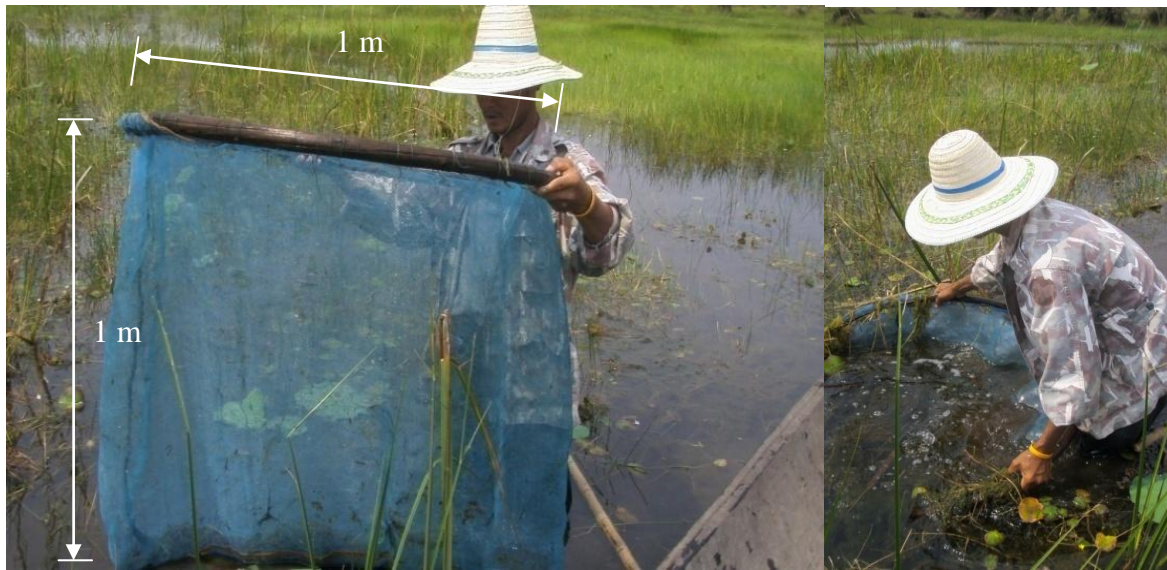
To make the data comparable with other studies that investigated fish per area, the area of traps and the net bag were standardized as follows:

$$\begin{aligned} \text{Area of traps} &= \text{width} \times \text{length} \times \text{number of traps} \dots\dots\dots (3) \\ &= 0.3 \times 1 \times 2 \text{ m}^2 \\ &= 0.6 \text{ m}^2 \end{aligned}$$

Where width is diameter and length is the length of trap.

$$\begin{aligned} \text{Area of net bag} &= \text{Width} \times \text{length} \times \text{distance} \dots\dots\dots (4) \\ &= 0.5 \times 1 \times 200 \text{ m}^2 \\ &= 100 \text{ m}^2 \end{aligned}$$

Where width is the water level at 50 cm, length is the length of net bag, and distance is the distance of drawing a net bag at each station.



**Figure 14:** Fish net bag along the reed beds

Additional fish investigation took place in the Peitz Ponds, Germany. Total fish caught ( $N = 153$ ) comprised Cyprinidae and Perciformes which are similar to the fish found in the Bung Khong Long Lake. These fish were measured as to length and wet weight. The results were used to analyze the opportunity of fish caught by the Purple Heron.

### ***3.4.2 Shrimp and insect larvae investigation***

Additionally, shrimps and insect larvae, which are also noted to be fed on by Purple Herons, were sampled and their fresh biomass was weighed. Their biomass was taken into account during the second migratory season only: biomass seems to be more important than their numbers. They were caught within the fish net bags.

### ***3.4.3 Investigation of amphibians***

Amphibians were assumed to be one of the probable food sources available at Bung Khong Long Lake as much as fish. Therefore, the probability of Purple Heron preying on amphibians may be similar to that of fish. At each station, amphibians, fish, shrimps and insect larvae were sampled from the same sampling area. For the first migratory season, only the number of each species was considered whereas in the second migratory season, both number and wet weight were determined.

Sampling of amphibians was done with the assistance of local experts using light attack on amphibians. Investigation commenced at dusk between 6 and 9 p. m. The area of investigation was about  $25 \text{ m}^2$  (Figure 15).



**Figure 15:** Investigation of amphibians

### **3.5 Influence of local fishery on food supply of Purple Herons**

A questionnaire was developed for the purpose of cross checking activities of local fishery at Bung Khong Long Lake, which is suspected to affect the food supply of Purple Heron. Target groups are local fishermen ( $n = 82$ ) whose fishing activities are concentrated in the shallow areas of the lake overlapping the feeding areas of Purple Herons. Fishermen who fish in the middle of the lake where the water level is more than one meter were excluded. Questions asked were divided into seven categories (Appendix I) as follow:

- (1) General information on age and duration of residence in the study area
- (2) Frequency and tools for fishing
- (3) Fish and shrimps caught by fishermen which are of economic interest
- (4) Fishing areas where expected to have influenced on the feeding behavior of Purple Heron
- (5) Information on bird hunting and migratory birds at the lake area
- (6) Amphibians consumption by local people
- (7) Lake management; higher reed cut or higher removal of aquatic plants from the lake suggests highly disturbed habitat

### **3.6 Secondary data collection**

Data on the number of Purple Herons in Thailand, ecological functions of fish in the lake, and lake management were not investigated in the field. Therefore, data on these aspects were obtained from secondary sources:

- (1) Data on the population of Purple Heron in Thailand from 2004 to 2011 were obtained from the Department of National Park Wildlife and Plant Conservation, Thailand



- (2) Biology, ecology and migratory route of Purple Heron in the world, especially information which is related to South East Asia, are collected. Moreover, Purple Heron management was taken into account
- (3) Fish, particularly species reported to be the food of Purple Herons; behavioral means, condition of living, and reproduction period
- (4) Lake management in Thailand with special reference to Ramsar Convention

### **3.7 Data analysis**

#### ***3.7.1 Physical, chemical, and biological characteristics***

Average value of water level, water temperature and pH revealed differences in each of these parameters for the early, middle and late period of migratory seasons. Vegetation cover at each sampling site was the main biotic feature investigated during the second migratory season and the percent coverage of dominant species of plants was compared among periods and among stations within the same period.

#### ***3.7.2 Number of Purple Herons***

The number of Purple Herons at Bung Khong Long Lake from 2004 to 2011 obtained from the Department of National Park Wildlife and Plant Conservation was averaged for year (between January and December) and migratory season (between October of year “A” and April of year “B”). However, since the record of migratory season in some years started earlier (Knysh and Sypko 1997), an average of their population in each migratory season was not strictly calculated for a particular month (Sep 04 - Apr 05, Sep 05 - Jun 06, Nov 06 - Jun 07, Sep 07 - Apr 08, Oct 08 - Apr 09, Oct 09 - Apr 10, Oct 10 - Apr 11). Moreover, the difference in the maximum number of the birds observed in different migratory years was considered. One-way ANOVA on ranks was used to analyze the average number of Purple Herons among years and migratory seasons when the data are not normally distributed.

Additional observation on the number of Purple Herons in the first migratory season was done by officers at the office of Bung Khong Long Non-Hunting Area. Bird observation was made twice in a month. However, intensive observation was done in each period of the second migratory season. Observation days for each period were 20 days in October 2010, January 2011, and April 2011. However, for November 2010, December 2010, February 2011, and March 2011 the birds

were observed for two days monthly as it was done in the first migratory season. This observation design was because of limited budget and resources.

### **3.7.3 Food supply analysis**

The difference in number of fish and amphibians between the first and the second migratory season was analyzed using one-way ANOVA on ranks for non-parametric data. The number of fish from fish traps and net bags was noted by counting the individuals of each species. The number of amphibians was counted at the investigation areas and local experts assisted to distinguish each species of amphibians. The number of prey types was converted and expressed per m<sup>2</sup>.

The number of fish at each station was standardized per square meter, thus it is comparable between the first and second migratory season. The average number of fish from three periods within each migratory season was used to compare the difference of the same station between the first and second migratory season. One-way ANOVA on ranks was used to analyze the difference in the number of fish among sampling stations within the same migratory periods and migratory seasons. Similarly, it was used to analyze the difference in the number of fish among sampling stations between the first and second migratory season.

Moreover, one-way ANOVA was used to analyze the difference in the number of seven species of fish between the first and second migratory season, when the data were normally distributed.

The difference in the number of amphibians between two species of frogs was analyzed with one-way ANOVA on ranks within the same migratory season.

In the second migratory season, besides counting number of fish and amphibians, biomass of different prey types was determined. The difference of total biomass from all prey types among periods (early, middle, and late) was analyzed using one-way ANOVA on ranks because the data were not normally distributed. However, mean values were used for the estimation of food supply that could support the number of Purple Herons in the early, middle, and late period. The mean values were used instead of medians because the average of biomass of food supply is more realistic to compare with the daily food requirement of Purple Heron. Wet weight (g) was a representative of biomass of preys likely to support the number of Purple Herons during their migratory seasons. The biomass of preys was categorized as follow:

- (1) All food items together
- (2) Fish from traps represent the medium size (5-15 cm)
- (3) Fish from net bags represent the small size (< 5 cm)
- (4) Seven species of fish from both traps and net bags
- (5) Amphibians
- (6) Shrimps
- (7) Insect larvae

Total biomass of the different type of preys (all fish, amphibians, shrimp, and insect larvae) was determined for the different periods. Similarly, the biomass of the seven species of fish collected from the fishing gears used for sampling over the different migratory periods was also determined. Besides, the total biomass of preys was determined for each sampling station. Data obtained were subjected to one-way and two-ways ANOVA.

Biomass of food was compared with the daily average food requirement (200 g/day/individual, Bauer et al. 2005) of Purple Heron. The average daily food supply indicates ability to support the population size of Purple Heron in each period. For example, an average food supply of 600 g per day suggests that about 3 Purple Herons could be supported within that period of migratory season. Additionally, it is an indication of the potential of lake capacity to support Purple Herons around its feeding areas.

#### ***3.7.4 Habitat disturbance***

Habitat disturbance as a result of fishing activity is expected to be a factor making it difficult for Purple Herons to reach its food sources. Therefore, in order to analyze the impact of food supply on Purple Herons through fishing activity, the number of fishermen at each station in a day was taken into account. Particularly, the intensity of fishermen and fishing activities occurring during the feeding time of Purple Heron was assessed. Fishing activity was focused on the group of fishermen who fish every day. It was considered as the main source of disturbance that affects the feeding behavior of Purple Herons.

The biomass of fish caught by fishermen per day was compared with the biomass of fish availability which is assumed to be the food supply for Purple Herons at the feeding areas in the early, middle, and late period.

Other activities of fishery such as the type of boats used by fishermen were also examined because they were hypothesized as a driving force that drives the birds to fly away during foraging time. The frequency of using boats was classified on the basis of the different periods of time in a day. In addition, information on lake and bird management was collected in order to gain insight into the understanding of local fishermen on the current status of Bung Khong Long Ramsar Site.

## 4 Results

### 4.1 Abiotic and biotic characteristics of Bung Khong Long Lake

#### 4.1.1 Physical and chemical characteristics

The average water level from the six stations was highest in the early periods and the lowest in the late periods for both migratory seasons (Table 4). Average water temperature from six stations varied between 21 and 30 °C; the middle period of both migratory seasons was found to have the lowest water temperature (Table 4). The lake water pH, was between 6 and 7 in the first season, and was stable (pH around 6) in the second season. Abiotic parameters at each station are shown in Appendix II.

**Table 4:** Average of water level, water temperature, and pH from six sampling stations within the migratory seasons of Purple Heron

Migratory season	Water level (m)			Water temperature (°C)			pH		
	EP	MP	LP	EP	MP	LP	EP	MP	LP
First season (October 2009-April 2010)	1.13	1.10	0.45	30.0	25.08	28.75	8.0	7.0	6.0
Second season (October 2010-April 2011)	1.20	0.86	0.79	28.47	21.11	28.13	6.0	6.0	6.0

#### 4.1.2 Biological characteristics

The study on diversity and structure of cover plant species at each sampling station were carried out in the second migratory season, and was investigated by means of numbering of species and estimation of percent coverage. The structure refers to the study of life and growth form. The areas investigated were classified as reed swamp area and emergent hydrophyte area. Thirty-one species of plants were observed in the swamp and emergent hydrophyte areas (Table 5). Some species were found in both area types whereas others were observed only at one area type.

**Table 5:** Species of plants observed in the potential feeding areas of Purple Herons in Bung Khong Long Lake in the second migratory season

Species of plants	Reed swamp area	Emergent hydrophytes area	Station Number	Period of migratory season
<i>Actinoscirpus grossus</i>	X		1,2,3,4,5	EP, MP
	X		2,3,4,5	LP
		X	4	EP
		X	3	MP
<i>Balanophora abbreviate</i>	X		4,5	EP, MP
		X	4, 5, 6	EP
		X	1,4, 5, 6	MP, LP
<i>Bambusa bambus</i>	X		5	EP, MP
<i>Barclaya longifolia</i>	X		1	EP, MP
		X	3, 4	EP
		X	1, 4, 5, 6	MP
		X	1, 4	LP
<i>Biophytum sensitivum</i>	X		5	EP, MP
<i>Chromolaena odoratum</i>	X		5	EP, MP
<i>Chrysopogon aciculatus</i>	X		5	EP, MP
	X		3	LP
		X	3	MP
<i>Echinochloa colona</i>	X		1, 3, 4, 5	EP, MP
		X	3, 6	EP
		X	6	MP
<i>Eleocharis dulcis</i>	X		1, 2, 4, 5	EP, LP
	X		1, 2, 3, 4, 5	MP
		X	4, 6	EP
		X	1, 4, 5, 6	MP, LP
<i>Eragrostis diplachnoides</i>		X	3, 6	EP
		X	6	MP
		X	1	LP
<i>Habenaria rhodocheila</i>		X	4, 5	EP
		X	1, 4, 5, 6	MP, LP
<i>Hydrilla verticillata</i>	X		3	EP, MP, LP
<i>Hygroryza aristata</i>	X		2	EP, MP
<i>Imperata cylindrica</i>	X		4	EP
	X		3, 5	MP
	X		3	LP
		X	1, 3, 4, 5, 6	EP, MP
		X	1, 4, 5, 6	LP
<i>Ischaemum barbatum</i>	X		1, 2, 5	EP
	X		4, 5	MP
	X		4	LP
		X	4	EP
		X	4, 5, 6	MP
		X	5, 6	LP
<i>Lasia spinosa</i>		X	1, 3, 4, 6	EP
		X	1, 4, 5, 6	MP
		X	1, 6	LP
<i>Leersia hexandra</i>	X		1, 2, 3, 5	EP, LP
	X		1, 2, 3, 4, 5	MP

Species of plants	Reed swamp area	Emergent hydrophytes area	Station Number	Period of migratory season
			1, 3, 4, 5, 6	EP, MP
		X	1, 4, 5	LP
		X		
<i>Lygodium microphyllum</i>	X		1, 5	EP
	X		5	MP
		X	1	EP
<i>Melastoma saigonensis</i>	X		5	EP
	X		2, 5	MP
	X		2, 3	LP
		X	4, 5	EP
		X	1, 3, 4, 5, 6	MP
		X	1, 4, 5	LP
<i>Nelumbo nucifera</i>	X		1, 2, 3, 4, 5	EP, MP
	X		1	LP
<i>Nepenthes mirabilis</i>	X		1, 4, 5	EP
	X		2, 5	MP
	X		2	LP
		X	1, 4, 5, 6	EP, MP, LP
<i>Nymphaea pubescens</i>	X		1, 2, 4, 5	EP
	X		1, 2	MP
<i>Nymphoides indicum</i>	X		1, 2, 4, 5	EP
	X		1	MP
<i>Ottelia alismoides</i>	X		2, 5	EP
	X		1, 2, 5	MP
	X		5	LP
<i>Saccharum arundinaceum</i>	X		2	EP
	X		1	MP
<i>Sacciolepis indica</i>	X		1, 4, 5	EP
	X		1, 2, 5	MP
	X		1, 5	LP
		X	1, 3, 4, 5, 6	EP
		X	1, 4, 5, 6	MP, LP
<i>Schoenoplectiella mucronata</i>	X		1, 4, 5	EP, MP
	X		4	LP
		X	4, 6	EP
		X	1, 4, 6	MP
		X	1, 6	LP
<i>Scleria ciliaris</i>	X		2	EP
	X		1	MP
<i>Scleria tonkinensis</i>	X		1, 5	EP, MP
	X		4	EP, MP, LP
		X	1, 4, 5, 6	EP, MP, LP
<i>Stenochlaena palustris</i>		X	1, 4, 6	EP
		X	1, 4, 5, 6	MP
		X	1, 4, 5	LP
<i>Utricularia aurea</i>	X		1, 2, 3	MP
	X		3	LP

Percent coverage of each species was determined within an area of approximately 25 m<sup>2</sup>. Table 6 shows the dominant species with the highest percent coverage in the reed swamp and emergent hydrophyte areas. *Echinochloa colona* and *Imperata cylindrica* were dominant species in the reed swamp area. *Echinochloa colona* was found to be dominant in two periods (early and middle) whereas *Imperata cylindrica* was dominant in the late period. Four species of plants were dominant in the early period at emergent hydrophytes area; *Imperata cylindrica*, *Nepenthes mirabilis*, *Schoenoplectiella mucronata*, and *Scleria tonkinensis*. *Imperata cylindrica* was dominant in early and late periods at the medium size of emergent hydrophyte areas. *Schoenoplectiella mucronata* was dominant in early and middle periods at the small size of emergent hydrophyte areas. *Nepenthes mirabilis* and *Schoenoplectiella mucronata* have similar dominance, and were also dominant on the small size area during the early and mid-migratory period. *Scleria tonkinensis* was dominant in every period but on the different size of emergent hydrophyte areas. In the early period, it was dominant on the medium and large size areas. In the middle period, it was dominant on the medium size class and on the large size class in the late period.

**Table 6:** Percent coverage of dominant species of plants in each period in the second migratory season in the reed swamp area and the emergent hydrophyte areas

Species of Plants	Percent coverage (%)			
	Reed swamp area, station name	Emergent hydrophyte areas (Size classes, station name)		
		S	M	L
<b>EP</b>				
<i>Echinochloa colona</i>	40, DMT	-	-	-
<i>Imperata cylindrica</i>	-	-	60, NEY	-
<i>Nepenthes mirabilis</i>	-	70, HPT	-	-
<i>Schoenoplectiella mucronata</i>	-	70, BCS	-	-
<i>Scleria tonkinensis</i>	-	-	60, BCS	40, DSW
<b>MP</b>				
<i>Echinochloa colona</i>	70, HPT	-	-	-
<i>Nepenthes mirabilis</i>	-	70, HPT	-	32, DSW
<i>Schoenoplectiella mucronata</i>	-	70, BCS	-	-
<i>Scleria tonkinensis</i>	-	-	45, BCS	-
<b>LP</b>				
<i>Imperata cylindrica</i>	60, DMT	-	54, BCS	-
<i>Nepenthes mirabilis</i>	-	70, HPT	-	-
<i>Scleria tonkinensis</i>	-	-	-	70, DSW



Table 7 shows percent coverage of plants at each sampling station in the different migratory periods at the reed swamp area. The area includes the five stations. The station Don Sa Wan was excluded. The first six of the most dominant species from a total of 31 species observed includes *Actinoscirpus grossus*, *Echinochloa colona*, *Eleocharis dulcis*, *Imperata cylindrica*, *Leersia hexandra*, and *Nelumbo nucifera*. These species are more abundant than others. *Actinoscirpus grossus* was the dominant species at Don Mor Tong in the early period (30 %), whereas Ban Chareon Suk was dominated with this species in the late period (24 %). *Echinochloa colona* has highest percent coverage at Ban Chareon Suk (70 %) in the middle period, however, it was not found at any of the stations in the late period. *Eleocharis dulcis* was dominant at Don Seo Tai in the early (35 %) and late (32 %) period, but was dominant at Noan Eee Yord in the middle period (35 %). *Imperata cylindrica* was dominant at Noan Eee Yord in the middle period (15 %) and in the late period at Don Mor Tong (60 %). *Leersia hexandra* was the dominant species at Noan Eee Yord (23 %) in the early period. This species was equally dominant (20 %) at three stations (Huai Pong Tao, Don Seo Tai, Noan Eee Yord) in the late period. *Nelumbo nucifera* was dominant at Don Seo Tai in the early and middle period (35 %), but at Huai Pong Tao in the late period (30 %).

**Table 7:** Percent coverage of the first six most dominant species in the reed swamp area

Species of plants	Period	Stations and % coverage				
		HPT	DST	DMT	BCS	NEY
<i>Actinoscirpus grossus</i>	EP	1	1	<b>30</b>	5	3
	MP	3	2	20	7	1
	LP	0	16	20	24	15
<i>Echinochloa colona</i>	EP	25	0	40	33	3
	MP	30	0	50	<b>70</b>	4
	LP	0	0	0	0	0
<i>Eleocharis dulcis</i>	EP	15	<b>35</b>	0	4	15
	MP	10	25	1	7	<b>35</b>
	LP	28	32	0	19	30
<i>Imperata cylindrica</i>	EP	0	0	0	5	10
	MP	0	0	8	0	15
	LP	0	0	<b>60</b>	0	0
<i>Leersia hexandra</i>	EP	4	10	15	0	<b>23</b>
	MP	5	15	6	2	10
	LP	20	20	3	0	20
<i>Nelumbo nucifera</i>	EP	10	<b>35</b>	5	5	1
	MP	10	<b>35</b>	5	4	2
	LP	30	0	0	0	0

Note: The bold numbers refer to the highest percent coverage

Table 8 shows percent coverage of the first four dominant species of plants at each sampling station of the emergent hydrophyte areas in the different migratory periods. At Don Seo Tai emergent hydrophytes during the study period were not found.

**Table 8:** Percent coverage of the first four most dominant species in the emergent hydrophyte community

Species of plants	Size	Period	Station and % coverage				
			HPT	DMT	BCS	NEY	DSW
<i>Imperata cylindrica</i>	S	EP	0	20	50	-	-
		MP	0	25	27	-	-
		LP	0	-	24	-	-
	M	EP	3	-	11	<b>60</b>	-
		MP	10	-	20	20	-
		LP	10	-	<b>54</b>	14	-
	L	EP	-	-	-	-	2
		MP	-	-	-	-	5
		LP	-	-	-	-	10
<i>Nepenthes mirabilis</i>	S	EP	<b>70</b>	0	5	-	-
		MP	<b>70</b>	0	19	-	-
		LP	<b>70</b>	-	-	-	-
	M	EP	-	-	5	6	-
		MP	20	-	15	7	-
		LP	15	-	10	1	-
	L	EP	-	-	-	-	20
		MP	-	-	-	-	<b>32</b>
		LP	-	-	-	-	25
<i>Schoenoplectiella mucronata</i>	S	EP	0	0	<b>70</b>	-	-
		MP	0	0	<b>70</b>	-	-
		LP	0	-	0	-	-
	M	EP	0	-	0	0	-
		MP	2	-	0	0	-
		LP	1	-	0	0	-
	L	EP	-	-	-	-	20
		MP	-	-	-	-	13
		LP	-	-	-	-	20
<i>Scleria tonkinensis</i>	S	EP	20	0	20	-	-
		MP	25	0	24	-	-
		LP	20	-	23	-	-
	M	EP	40	-	<b>60</b>	12	-
		MP	25	-	45	13	-
		LP	25	-	35	10	-
	L	EP	-	-	-	-	40
		MP	-	-	-	-	32
		LP	-	-	-	-	<b>70</b>

Note: The bold numbers refer to the highest percent coverage. Zero means that the species was not present at that area during investigation. Dash (-) means the emergent hydrophytes of that size were not found at the particular time of observation.

On the small size area at Huai Pong Tao, *Nepenthes mirabilis* was the dominant species in every period (70 %). On the medium size area, *Scleria tonkinensis* was dominant at Ban Chareon Suk (60 %) whereas *Imperata cylindrica* was dominant at Noan Eee Yord (60 %) in the early period. *Imperata cylindrica* was also dominant at Ban Chareon Suk on the medium size area (54 %) in

the late period. On the large size area at Don Sa Wan, *Nepenthes mirabilis* was dominant in the middle period (32 %) whereas *Scleria tonkinensis* was dominant in the late period (70 %).

Table 9 shows the growth and life form of the dominant species. Most plants have graminoid form except *Nepenthes mirabilis* which has liana form. Most of these plants have a life form as hemicryptophyte which are different from *Nepenthes mirabilis* and *Echinochloa colona* that have therophyte and *Nelumbo nucifera* that has hydrophyte life form.

**Table 9:** Growth and life form of the dominant species of plants in the reed swamp area and the emergent hydrophyte area

<b>Species of plants</b>	<b>Growth form</b>	<b>Life form</b>
<b>Reed swamp area</b>		
<i>Actinoscirpus grossus</i>	Graminoid	Hemicryptophyte or tuber geophyte
<i>Echinochloa colona</i>	Graminoid	Therophyte
<i>Eleocharis dulcis</i>	Graminoid	Hemicryptophyte or tuber geophyte
<i>Imperata cylindrica</i>	Graminoid	Hemicryptophyte
<i>Leersia hexandra</i>	Graminoid	Hemicryptophyte
<i>Nelumbo nucifera</i>	Graminoid	Hydrophytes
<b>Emergent hydrophytes area</b>		
<i>Imperata cylindrica</i>	Graminoid	Hemicryptophyte
<i>Nepenthes mirabilis</i>	Liana	Therophyte
<i>Schoenoplectiella mucronata</i>	Graminoid	Hemicryptophyte
<i>Scleria tonkinensis</i>	Graminoid	Hemicryptophyte

## 4.2 Purple Heron observations

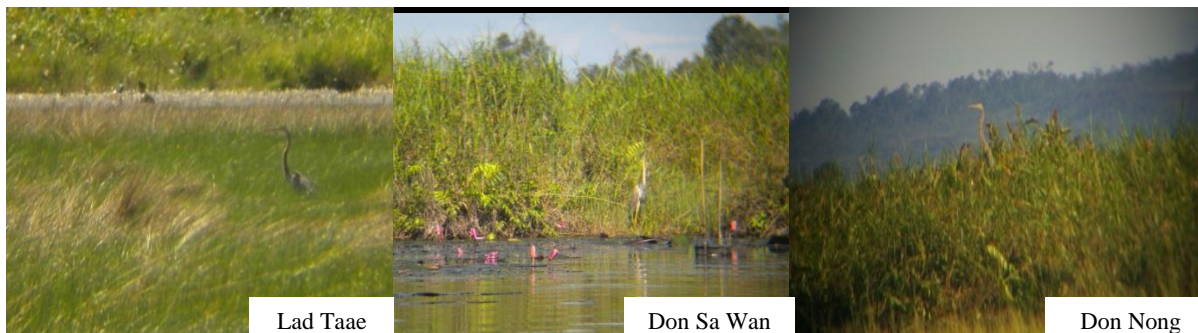
### 4.2.1 General behavior

The most active time for the feeding behavior of Purple Heron during the observation periods was between 7.00 - 10.00 hours and 15.00 - 17.00 hours. Purple Heron began foraging at Lad Sa Bang and frequently ended at Don Sa Wan. It was presumed that Don Sa Wan forest was the resting area during the night because Purple Herons moved to that direction almost every

observation day after 6 p.m. Figure 16 and 17 illustrate Purple Heron at the feeding areas. Sometimes it perched on the top of the trees close to the foraging areas. The characteristics of plant structure at the reed swamp and emergent hydrophyte area indicate a good shelter for Purple Herons during feeding time. The brown color and straight form of plants assist Purple Heron to camouflage (Figure 17).



**Figure 16:** Purple Heron on the tree in October 2010



**Figure 17:** Purple Heron among reeds and emergent hydrophytes in October 2010

Purple Herons have been frequently found at Bung Khong Long Lake at six sampling stations including Don Nong where there is a high density of emergent hydrophyte plants and reeds. Purple Herons have never been reported to have been observed at the middle of the lake, which is an open area and deeper. Purple Herons were found at eight areas in October 2010 within 20 days. The areas are Lad Sa Bang, Lad Taae, Huai Pong Tao, Don Seo Tai, Ban Chareon Suk, Don Nong, Don SaWan (Lad Mai Tai), and Don Mor Tong. The frequency of area visiting of this bird at each area is shown in Table 10. Lad Sa Bang and Don Seo Tai were the most frequently visited (65 %) sites and was not much different from Huai Pong Tao (60 %). This suggests that Lad Sa Bang and Don Seo Tai including Huai Pong Tao are the most attractive areas for Purple

Heron. Lad Taae and Don Sa Wan (Lad Mai Tai) have 50 % of visiting frequency. Don Mor Tong was the less visited (15 %). This suggests that this area is not attractive for the Purple Heron.

**Table 10:** Frequency of visiting feeding areas within 20 days (October 2010)

<b>Feeding Areas</b>	<b>Days</b>
Lad Sa Bang	13
Don Seo Tai	13
Huai Pong Tao	12
Lad Taae	10
Don Sa Wan (Lad Mai Tai)	10
Ban Chareon Suk	5
Don Nong	5
Don Mor Tong	3

Table 10 shows the areas where Purple Heron visits whereas Figure 18 shows the routes followed regularly by the bird during the day. Three patterns of fly pathes were observed:

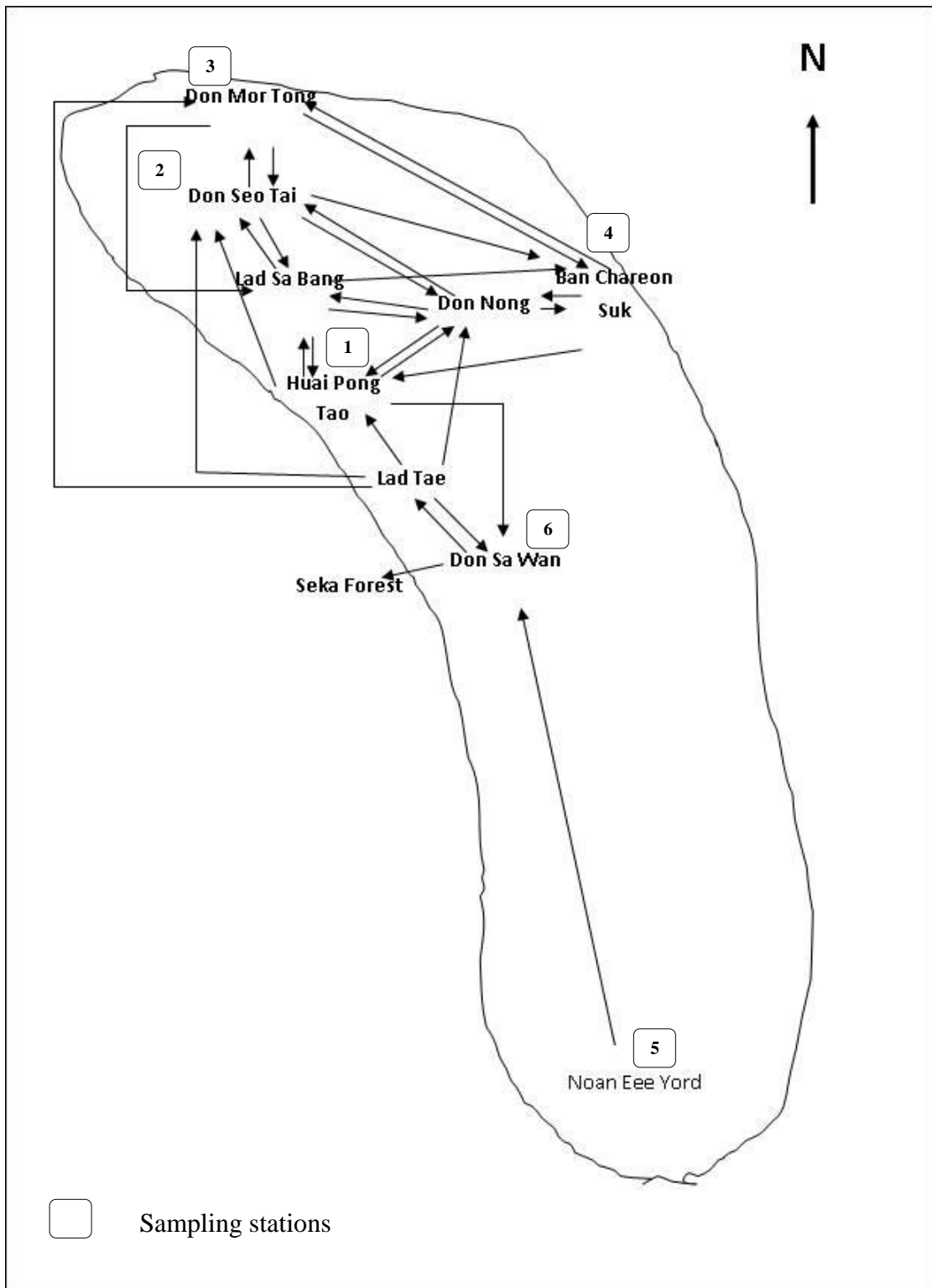
**Pattern 1:** Purple Heron begins at Huai Pong Tao, and then flies to Lad Sa Bang or Don Nong. The direction from Don Nong could be Ban Chareon Suk, Lad Sa Bang or Don Seo Tai. At Don Seo Tai Purple Heron moved further to Don Mor Tong or returned to Lad Sa Bang. Sometimes the bird flies directly from Don Mor Tong or Don Seo Tai to Ban Chareon Suk without stopping over at Don Nong. Purple Heron would fly back from other areas and stop over at Huai Pong Tao before continue to Don Sa Wan.

**Pattern 2:** Purple Heron begins at Don Sa Wan, and then flies over to Lad Taae. From Lad Taae the direction could be towards Don Nong or Huai Pong Tao and then follows pattern 1. When the bird arrives at Don Sa Wan, it would fly into the Seka forest close to Don Sa Wan area.

**Pattern 3:** Purple Heron begins at Lad Taae, excluded sampling station, and may fly longer directly to Don Seo Tai or Don Mor Tong. The backward direction follows the pattern 1.

During observation, Purple Herons were not seen at Noan Eee Yord. However, local people reported that two Purple Herons flew from Noan Eee Yord to Don Sa Wan in the early morning about 7.00 a.m. Thus, it was probable that Purple Herons from Noan Eee Yord would join the

three patterns mentioned above. Based on the feeding route at Bung Khong Long Lake, it is likely that Purple Herons would not fly to a different distant feeding area within the same day.



**Figure 18:** The routes of searching food of Purple Heron in Bung Khong Long Lake (Source: field observation October 2010)

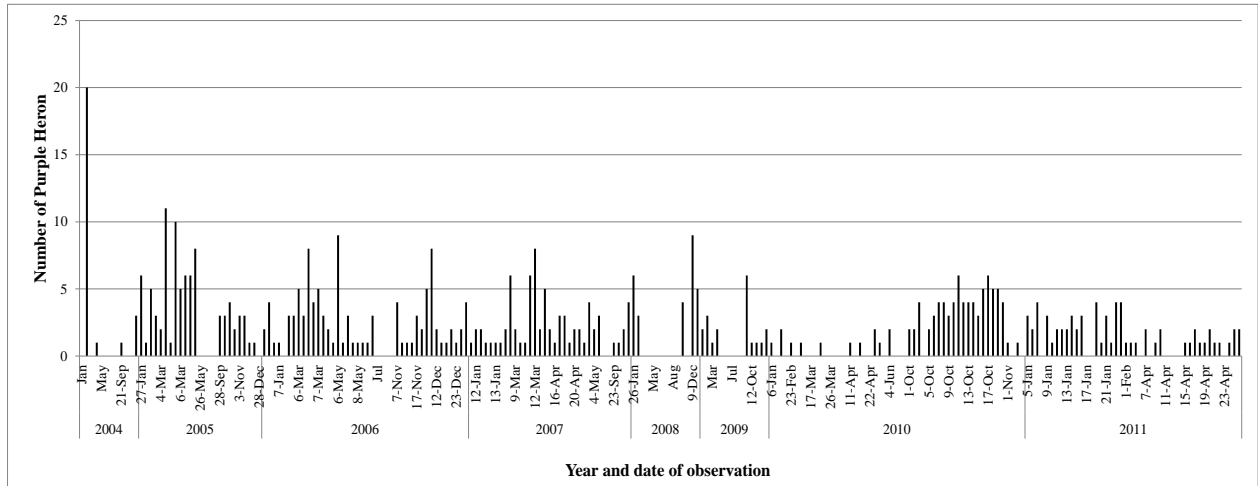
Purple Heron observed at each sampling station was habitually found standing among the dense vegetation of reed swamp or emergent hydrophytes. Most often they were observed as single feeder and stayed far away from each other. On few occasions, two birds were observed feeding at the same station simultaneously, but one of them flew to another station after some time. The birds are sensitive to motor-boats moving closer (from a distance of less than 50 meters) and also to boats without motors used by fishermen. In both situations, Purple Herons fly to other areas in the vicinity and sometimes they perched on trees close to that area. This is a typical behavior of Purple Heron in search of feeding area. They normally spend very long time in the reed swamp area to search for food. There is no definite time pattern for being among the reed, emergent hydrophytes, or to perch on trees. Drizzling was not the problem for feeding, but whenever there was heavy rain and wind, Purple Herons were hardly seen in the reed swamp areas. In the evening, Purple Herons from other areas would join others at one place before moving together in a group to the resting area. They made loud and croak voice “Krak Krak” which seems to be a signal of calling their group.

Whenever Purple Heron stood among the reed to search for food, it would not move to anywhere within five minutes. It reduced the height of its neck to the same level of the vegetation for two minutes making it possible to camouflage. Afterwards, it raised up its neck at the highest level and bended down to water level. If it was unable to find any preys, it moves for about one meter away from latest point and repeat the same procedure. Sometimes it preened its feather and form its neck to be “S” shaped, and remain stable for five minutes and then began to move around again within the vicinity of about one meter. When it sighted a prey, it raised up its neck before bending down very fast to catch that prey. However, it takes about ten minutes between the time of raising up the neck and bending down to catch the prey. It catches a single prey per time.

The catching of preys by Purple Herons was observed for at least three times during field work. Sometimes, it takes about five minutes difference to catch the next prey and in some cases, over an hour. Estimated consuming time from moving the prey into the mouth and swallow from three observations was about five minutes. On the three occasions, the preys caught by Purple Heron were identified as: *Clarias* sp. of size approximately 5 cm and weighs 50 g; *Channa* sp. approximately 13 cm in size, and weighs 90 g; *Clarias* sp. size approximately 5 cm and weighs 50 g.

#### 4.2.2 Number of Purple Herons at Bung Khong Long Ramsar Site

Data on the number of Purple Herons at Bung Khong Long Lake, which were obtained from the Department of National Park Wildlife and Plant Conservation, Thailand, covered 2004 to 2011. Figure 19 shows the fluctuation of Purple Herons at Bung Khong Long Lake within this interim of time. The maximum number of Purple Herons counted within this period was 20, which was recorded in February 2004. The minimum number was one individual every year.



**Figure 19:** Fluctuation of Purple Herons at Bung Khong Long Lake from 2004 to 2011 according to the number of observations (DNP 2011)

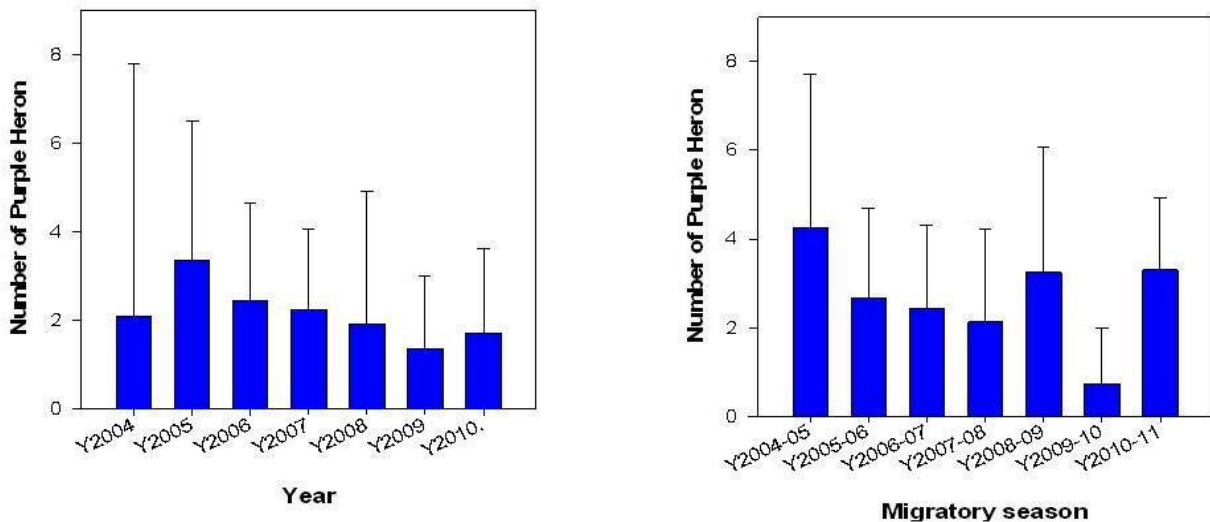
The number has varied between one and ten individuals since 2006. However, the maximum number of birds observed decreased from 20 individuals in 2004 to 6 individuals in 2011 (Table 11).

**Table 11:** Maximum number of Purple Herons observed at Bung Khong Long Lake from the migratory season of the year 2003/04-2010/11

<b>Migratory Year</b>	<b>Maximum number</b>
2003/04	20
2004/05	11
2005/06	9
2006/07	8
2007/08	6
2008/09	9
2009/10	6
2010/11	6



The number of observation days in each year (Figure 19) is different depending on the yearly policy of the bird monitoring program. Therefore, the fluctuation of number of the birds does not show a clearer trend of decreasing or increasing in a year or during a migratory season. For this reason, an average of the observed number of Purple Herons in a year and during the migratory seasons was analyzed. Figure 20 shows the average number of Purple Herons in a year from January to December and the average in the migratory season, normally from October to April. Nevertheless, the duration of migratory season depends on the onset of months that the birds were observed at Bung Khong Long Lake. Most often, it begins in October and ends in April. However, in some years it begins early September and ends early February. Therefore, the average number of Purple Herons during the migratory season considered the beginning month of year “A” to the month that the bird leaves the lake of year “B” (Figure 20). Nevertheless, average duration of migratory season of Purple Herons at Bung Khong Long Lake is about six months.



**Figure 20:** Number of Purple Herons in year (left) and migratory season (right) (2004-2011)

Kruskal-Wallis one-way ANOVA on ranks showed that the number of Purple Herons was significantly different among years ( $p = 0.006$ ) and among the migratory seasons ( $p < 0.001$ ).

In addition, the field investigation showed similar results; the number of the birds in two migratory seasons was less than that of the previous years (Table 12). The maximum number of Purple Herons was six individuals in both the early period of the first and the second migratory seasons. Throughout the migratory seasons the number of Purple Herons decreased to between 1 and 2 in the late period of the first and second migratory season, respectively.

Purple Herons at Bung Khong Long Lake are assumed to be only migrant group since breeding nests were not found around the lake area. Even though the number of Purple Herons showed no significant decrease over the years, within the same migratory season the numbers decreased from early to late period.

**Table 12:** The maximum observed number of Purple Herons in the first and second migratory seasons at Bung Khong Long Lake

<b>Number of Purple Herons in migratory period</b>							
<b>Migratory season</b>	<b>October (EP)</b>	<b>November</b>	<b>December</b>	<b>January (MP)</b>	<b>February</b>	<b>March</b>	<b>April (LP)</b>
<b>Year 2009/10</b>	6	1	2	1	2	1	1
<b>Year 2010/11</b>	6	1	1	4	1	1	2

Even though the maximum number of observed Purple Herons in early period of the first and second migratory seasons was the same, the results were from the different interval observation days: in the first migratory season, the observation days were two in a month. However, in the second migratory season, observation of birds was done for 20 days in the early, middle, and late migratory periods. Similar approach used in the first migratory season was followed for the observation of the birds in other months of the second migratory season.

### **4.3 Food supply of Purple Herons**

#### **4.3.1 Number of fish**

Fish sampled from the six stations represent the potential food supply in the feeding areas of Purple Heron during the migratory season. In the first migratory season 15 species of fish were caught in the early and late period, and 13 species in the middle period. The total number of species caught for all periods in the second migratory season was 39. During the second migratory season, 35, 22 and 27 species of fish were sampled in the early, middle and late period, respectively. The combined total number of fish species for both migratory seasons was 40. Table 13 shows the number of fish for each period in the first and second migratory season per m<sup>2</sup>. *Trichopsis vittata* shows the highest abundance in every period of the first migratory season.

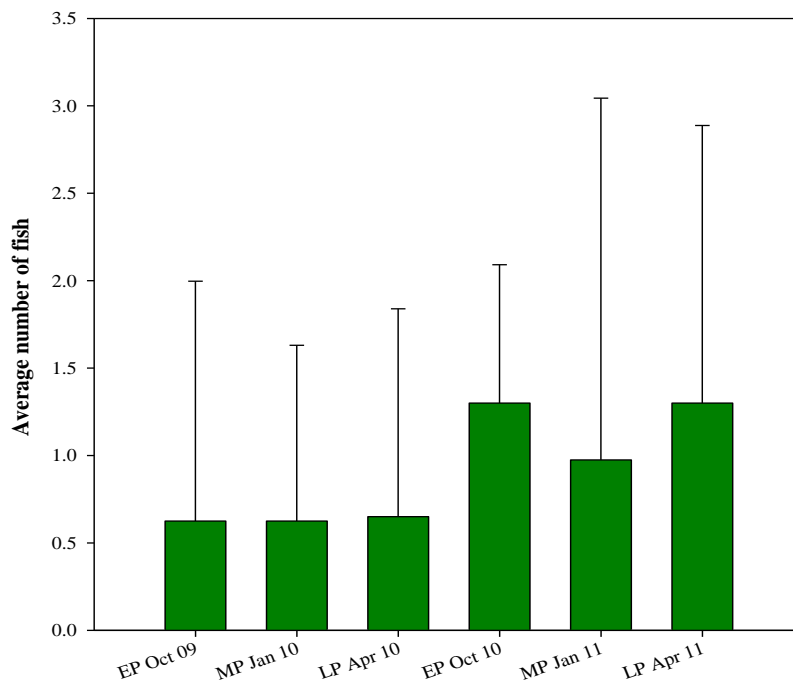
*Channa lucius* has the highest number in the middle period of the second migratory season whereas *Channa micropeltes* and *Nandus oxyrhynchus* are highest in the late period. Other species could be observed in small numbers. Pictures of observed fish in two migratory seasons are shown in Appendix IV.

**Table 13:** Total number of fish from traps and net bags as a compilation from six stations in the first and second migratory season

Species	Number of fish/m <sup>2</sup>					
	Oct-09	Jan-10	Apr-10	Oct-10	Jan-11	Apr-11
<i>Acantopsis choirorhynchus</i>	0	0	0	1	1	1
<i>Anabas testudineus</i>	0.01	0	0	1	2	3
<i>Barbonymus gonionotus</i>	0	0	0	1	0	0
<i>Betta splendens</i>	0.01	0.02	0	0	0	1
<i>Boraras micros</i>	0.04	0.28	0.99	1	1	1
<i>Catopra fasciata</i>	0.22	0	0	3	0	2
<i>Channa lucius</i>	0.02	0	1.67	3	13	2
<i>Channa micropeltes</i>	0	0	0	2	0	7
<i>Channa striata</i>	0	1.7	1.98	3	2	2
<i>Chitala ornata</i>	0	0	0	2	0	0
<i>Clarias batrachus</i>	0	0	0.01	2	1	2
<i>Clarias macrocephalus</i>	0	0	0	2	1	2
<i>Cyclocheilichthys armatus</i>	0	0	0.01	0	0	0
<i>Dangila</i> sp.	0	0	0	2	2	0
<i>Esomus longimanus</i>	0	0	0	1	1	1
<i>Hampala dispa</i>	0	1.67	0	2	0	0
<i>Henicorhynchus siamensis</i>	0	0	0.01	0	1	1
<i>Indostomus spinosus</i>	0.02	0.02	0	1	1	0
<i>Monopterus albus</i>	0	0	0	1	0	1
<i>Monotretete suvattii</i>	0	0	0.04	1	0	1
<i>Nandus oxyrhynchus</i>	0.23	1.68	0.16	1	1	7
<i>Neodontobutis aurarmus</i>	1.05	0.08	0.39	1	1	1
<i>Notopterus notopterus</i>	0	0	0.02	2	1	2
<i>Ompok siluroides</i>	0	0.02	0	2	0	2
<i>(Ompok krattensis)</i>						
<i>Osteochilus vittatus</i>	0	0	0	1	0	0
<i>(Osteochilus hasselti)</i>						
<i>Parambassis siamensis</i>	0	0	0	1	0	0
<i>Puntius partipentazona</i>	0	0	0	1	1	0
<i>Rasbora borapetensis</i>	0.19	0.35	0.19	1	1	1
<i>Rasbora lateristriata</i>	0	0	0	0	1	1
<i>Rasbora daniconius</i>	0	0	0	1	0	0

Species	Number of fish/m <sup>2</sup>					
	Oct-09	Jan-10	Apr-10	Oct-10	Jan-11	Apr-11
<i>(Rasbora palustris)</i>						
<i>Rasbora paviana</i>	0	0	0	1	0	0
<i>Rasbora tornieri</i>	0.01	0	0	0	0	1
<i>Rasbora trilineata</i>	0.15	0.11	0.07	1	1	1
<i>Puntius brevis</i>	0	0	0	2	0	0
<i>(Systemus leiacant)</i>						
<i>Puntius orphoides</i>	0	0	0	2	0	0
<i>(Systemus orphoides)</i>						
<i>Tetraodon abei</i>	0.02	0	0	1	0	1
<i>Trichogaster pectoralis</i>	0	0	0	1	2	2
<i>Trichopodus trichopterus</i>	0.03	0.01	3.34	1	1	3
<i>(Trichogaster trichopterus)</i>						
<i>Trichopsis vittata</i>	8.37	4.13	6.41	2	2	2
<i>Xenentodon cancila</i>	0.02	1	0.03	1	1	1
<b>Total</b>	10.39	11.77	15.3	52	39	52

Kruskal-Wallis one-way ANOVA on ranks shows that the average number of fish per square meter among periods of the first and second migratory season is significantly different ( $p = < 0.001$ ) (Figure 21).



**Figure 21:** Average number of fish per square meter for each period of the first and second migratory season

Table 14 shows the number of fish per square meter and the number of species at the different stations in both migratory seasons. To compare the number of fish between two migratory seasons, the average number of fish from three periods was used. Kruskal-Wallis one-way ANOVA on ranks shows that the average number of fish at each station, on one hand, in the first migratory season is not significantly different from the second migratory season ( $p = 0.224$ ). On the other hand, the numbers among stations within the same period are also not significantly different ( $p = 0.13$ ). The higher number of fish seems to suggest a high amount food available for Purple Herons. However, the higher number of species does not imply higher number of individuals.

**Table 14:** Number of individuals of fish per square meter and number of species at different stations in the first and second migratory season

Migratory period	Number of fish/m <sup>2</sup>					
	HPT	DST	DMT	BCS	NEY	DSW
October 09	3	2	1	4	5	2
January 10	3	1	3	3	1	3
April 10	2	2	1	6	1	1
October 10	6	3	6	3	3	3
January 11	3	3	3	3	1	1
April 11	3	3	3	3	3	3
<b>Average (1<sup>st</sup> period)</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>2</b>	<b>2</b>
<b>Average (2<sup>nd</sup> period)</b>	<b>4</b>	<b>3</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>2</b>
<b>Maximum number of species of fish</b>						
	<b>21</b>	<b>18</b>	<b>22</b>	<b>17</b>	<b>16</b>	<b>13</b>

Table 15 shows the number of individuals of seven species of fish per square meter in the first and second migratory season without considering the different tool approaches (traps and net bags). Holm-Sidak one-way ANOVA test shows that the number of these fish in the second migratory season is significantly higher than the first season ( $F = 4.545$ ,  $p = 0.003$ ).

**Table 15:** Number of individuals of seven species of fish from six stations without separating between trap and net bag per square meter

Species of fish	Number of fish/m <sup>2</sup>					
	1 <sup>st</sup> migratory season			2 <sup>nd</sup> migratory season		
	Oct 09	Jan 10	Apr 10	Oct 10	Jan 11	Apr 11
1. <i>Anabas testudineus</i>	2	0	0	3	2	2
2. <i>Channa lucius</i>	1	2	2	4	3	3
3. <i>Channa micropeltes</i>	0	0	0	3	0	1
4. <i>Channa striata</i>	0	3	3	3	3	3
5. <i>Clarias</i> sp.	0	2	1	3	2	2
6. <i>Notopterus notopterus</i>	0	0	1	3	3	3
7. <i>Xenentodon cancila</i>	1	1	0	1	1	1
<b>Total</b>	<b>4</b>	<b>8</b>	<b>7</b>	<b>20</b>	<b>14</b>	<b>15</b>

Besides the number of individuals, the size of fish was measured. Fish caught from net bags were usually found in small size, not more than ten centimeters. Fish caught from traps were relatively bigger, they were about 10-30 cm. Fish of those seven species varied between 6 and 30 cm. Figure 22 provides an example of *Channa lucius* specimen caught by traps in the first migratory season. On the other hand, the size of other species of fish (e.g. *Trichopsis vittata*: Figure 23) caught by net bags was about four centimeters in average in every period of the first migratory season. The sizes of these fish were not different in the second migratory season.



**Figure 22:** *Channa lucius* in a) early period, 8.89 cm; b) middle period, 20.32 cm; c) late period, 27.94 cm of the first migratory season



**Figure 23:** *Trichopsis vittata* in a) early period; b) middle period; c) late period of the first migratory season

### 4.3.2 Number of amphibians

Two different species of frogs (*Rana erythraea* and *Rana macrodactyla*) were observed in every period of both migratory seasons. In October 2010, in the early period of the second migratory season, another one species of frog (*Hoplobatrachus rugulosus*) was observed but in very small numbers. It was found once at Noan Eee Yord. Therefore, only two species of toads were considered as probable food supply of Purple Herons in this study. Figure 24 shows the size of *Rana erythraea* and *R. macrodactyla*. *Rana erythraea* could be found in different sizes, but often found in mature size which is about 12 cm. On the other hand, *R. macrodactyla* was usually found in small size of about 3 cm.



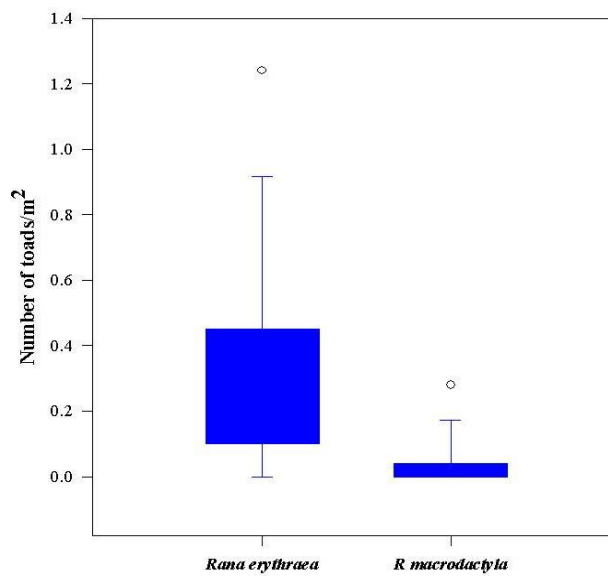
**Figure 24:** Frogs; *Rana erythraea* (left) and *Rana macrodactyla* (right)

Table 16 shows the number of *Rana erythraea* and *R. macrodactyla* per square meter between the first and second migratory season. The number of *R. erythraea* is the highest in the late period in both migratory seasons. Its number is also higher than *R. macrodactyla* in every period in both migratory seasons.

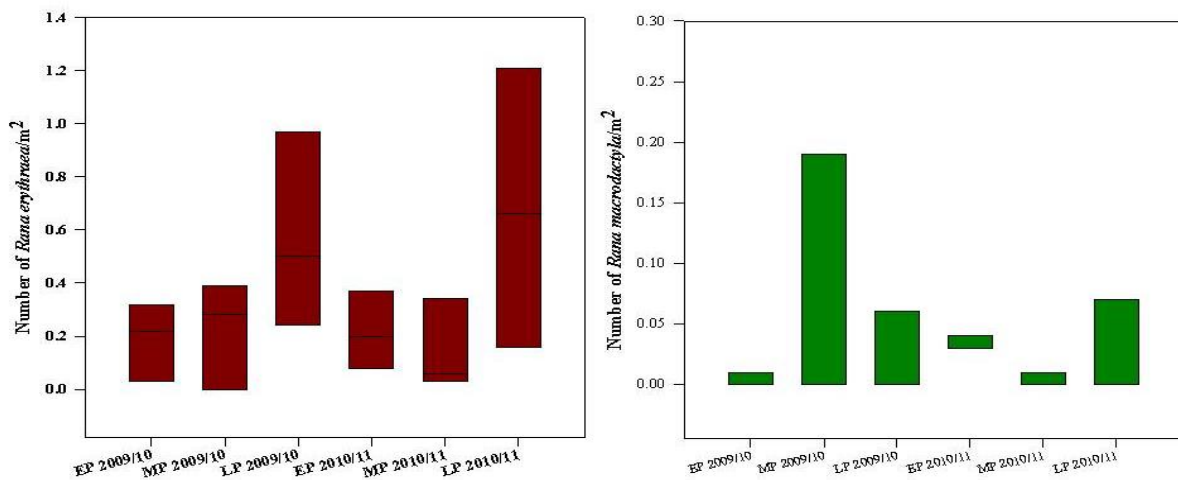
**Table 16:** Total number of *Rana erythraea* and *R. macrodactyla* per square meter

Station	Number of <i>R. erythraea</i> /m <sup>2</sup>			Number of <i>R. macrodactyla</i> /m <sup>2</sup>			Number of <i>R. erythraea</i> /m <sup>2</sup>			Number of <i>R. macrodactyla</i> /m <sup>2</sup>		
	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)
1. HPT	0.44	0.36	1.24	0.4	0.08	0.56	0	0	0	0.04	0	0
2. DST	0.04	0.48	0.88	0.2	0.52	0.76	0	0.16	0	0	0.04	0
3. DMT	0	0	0.32	0.08	0	0.04	0	0	0.04	0.04	0	0
4. BCS	0.16	0.36	0.28	0.2	0.04	0.2	0	0.28	0.12	0.04	0	0.04
5. NEY	0.28	0.2	0.12	0.08	0.04	1.2	0.04	0	0	0.04	0	0.16
6. DSW	0.28	0	0.68	0.36	0.28	1.24	0	0	0	0.04	0	0
<b>Total</b>	<b>0.76</b>	<b>1.04</b>	<b>2.28</b>	<b>0.92</b>	<b>0.88</b>	<b>3.44</b>	<b>0.04</b>	<b>0.44</b>	<b>0.16</b>	<b>0.16</b>	<b>0.04</b>	<b>0.20</b>

Kruskal-Wallis one-way ANOVA on ranks shows that in the first migratory season the abundance of *R. erythraea* was significantly higher than that of *R. macrodactyla*. Similar observation was made in the second migratory season ( $p < 0.001$ ; Figure 25). However, the number of *R. erythraea* was not significantly different between the first and second migratory season ( $p = 0.12$ ). Similarly, the number of *R. macrodactyla* did not differ significantly between the first and second migratory season ( $p = 0.326$ ). Figure 26 shows the number of *R. erythraea* and *R. macrodactyla* in both migratory seasons. *R. erythraea* was higher in the late period compared to the other two periods of both migratory seasons, whereas *R. macrodactyla* was found to be higher in the middle period of the first migratory season.



**Figure 25:** Number of *Rana erythraea* and *R. macrodactyla* per square meter in two migratory seasons



**Figure 26:** Number of *Rana erythraea* (left) and *R. macrodactyla* (right) per square meter in different periods of two migratory seasons



### 4.3.3 Biomass of food supply

The biomass of the probable preys was considered as the basic food requirement that Purple Heron needs to meet its energy demand. Therefore, the assessment of biomass of food items from all sources (fish, shrimp, insect larvae, and amphibians) was done during the second migratory season. Biomass ( $\text{g/m}^2$ ) of all types of food in early, middle, and late period is shown in Table 17, 18, 19, respectively. In the early period, the highest biomass was  $317 \text{ g/m}^2$  at Huai Pong Tao; the lowest  $35 \text{ g/m}^2$  on average at Don Seo Tai; the total from six stations  $767 \text{ g/m}^2$  on average (Table 17).

**Table 17:** Total biomass of all kinds of preys in early period (October 2010)

Day	Weight ( $\text{g/m}^2$ )						Sum
	HPT	DST	DMT	BCS	NEY	DSW	
1	668.70	1.41	2.27	2.94	1.27	2.74	679.33
2	5.80	4.17	1.28	1.85	0.68	71.21	84.99
3	106.59	3.24	151.72	73.08	32.71	803.67	1,171.01
4	1,127.16	2.93	2.88	241.79	10.46	4.97	1,390.19
5	319.28	185.85	193.54	114.58	309.28	5.70	1,128.23
6	397.39	51.87	252.33	4.04	125.57	6.37	837.57
7	159.90	1.94	1.72	0.42	35.73	2.16	201.87
8	0.33	0.70	1,201.24	0.24	0.38	0.76	1,203.65
9	4.83	96.85	0.79	231.03	110.52	3.07	447.09
10	376.63	2.15	35.95	3.54	0.33	104.47	523.07
<b>Sum</b>	<b>3,166.61</b>	<b>351.11</b>	<b>1,843.72</b>	<b>673.51</b>	<b>626.93</b>	<b>1,005.12</b>	<b>7,667</b>
<b>Mean</b>	<b>316.66</b>	<b>35.11</b>	<b>184.37</b>	<b>67.35</b>	<b>62.69</b>	<b>100.51</b>	<b>766.70</b>

In the middle period, the highest biomass was  $250 \text{ g/m}^2$  at Huai Pong Tao; the lowest  $0.57 \text{ g/m}^2$  at Noan Eee Yord; the total from six stations  $338 \text{ g/m}^2$  (Table 18). In the late period, the highest biomass was  $173 \text{ g/m}^2$  at Huai Pong Tao; the lowest  $1.79 \text{ g/m}^2$  at Ban Chareon Suk; the total from six stations  $375 \text{ g/m}^2$  (Table 19). Total biomass of all preys in mid and late period was approximately 0.5 times of early period.

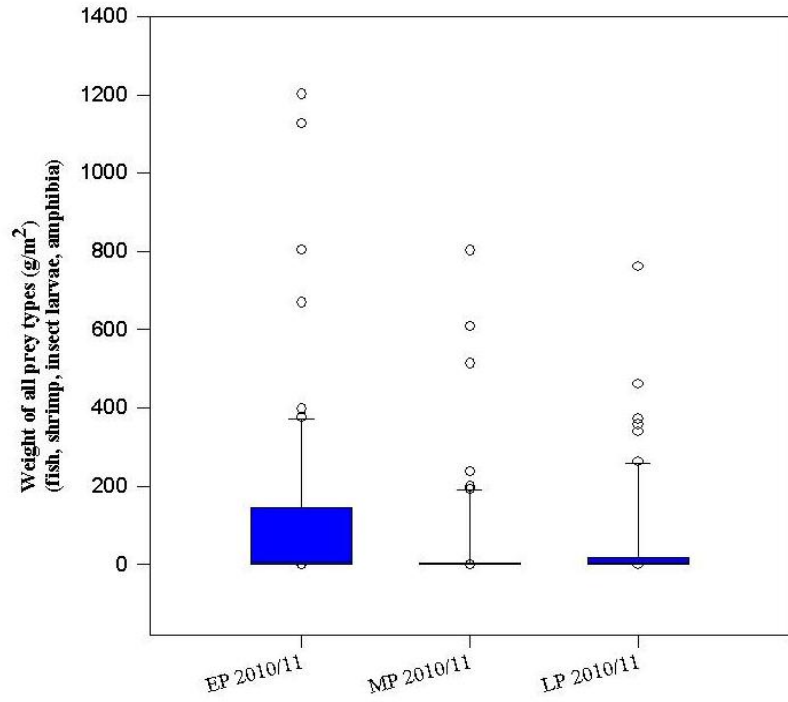
**Table 18:** Total biomass of all kinds of preys in middle period (January 2011)

Day	Weight (g/m <sup>2</sup> )						Sum
	HPT	DST	DMT	BCS	NEY	DSW	
1	1.42	7.54	0.48	0.52	0.84	0.53	11.33
2	142.47	3.03	0.59	0.27	1.36	2.38	150.10
3	1.70	2.64	0.52	105.20	1.69	3.91	115.66
4	191.55	2.76	0.19	0.34	0.16	2.05	197.05
5	236.87	71.40	0.78	0.47	0.82	3.23	313.57
6	1.30	5.20	153.73	0.15	0.13	1.42	161.93
7	513.90	2.67	0.32	1.39	0.11	5.05	523.44
8	607.94	2.41	0.84	0.85	0.22	3.06	615.32
9	1.63	3.53	0.45	0.78	0.17	2.46	9.02
10	802.46	88.67	0.31	198.92	0.18	188.31	1,278.85
<b>Sum</b>	<b>2,501.24</b>	<b>189.85</b>	<b>158.21</b>	<b>308.89</b>	<b>5.68</b>	<b>212.4</b>	<b>3,376.27</b>
<b>Mean</b>	<b>250.12</b>	<b>18.99</b>	<b>15.82</b>	<b>30.89</b>	<b>0.57</b>	<b>21.24</b>	<b>337.63</b>

**Table 19:** Total biomass of all kinds of preys in late period (April 2011)

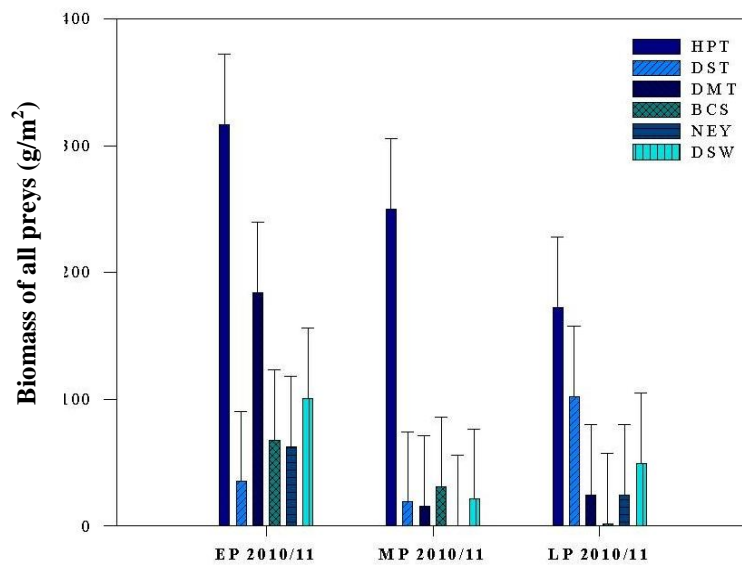
Day	Weight (g/m <sup>2</sup> )						Sum
	HPT	DST	DMT	BCS	NEY	DSW	
1	2.61	3.03	0.73	2.43	8.56	11.58	28.94
2	3.52	8.88	0.36	2.03	2.87	92.77	110.43
3	117.80	7.77	34.02	2.05	3.62	217.52	382.78
4	461.49	340.02	84.51	2.20	213.99	108.20	1,210.41
5	357.78	3.06	0.48	2.02	4.75	18.20	386.29
6	761.63	5.24	1.35	2.18	3.78	16.52	790.70
7	3.65	372.50	0.49	0.34	0.16	0.15	377.29
8	9.58	7.34	123.09	1.60	3.58	14.50	159.69
9	6.52	9.56	0.44	0.28	0.16	0.20	17.16
10	0.94	263.54	0.48	2.72	5.90	15.43	289.01
<b>Sum</b>	<b>1,725.52</b>	<b>1,020.94</b>	<b>245.95</b>	<b>17.85</b>	<b>247.37</b>	<b>495.07</b>	<b>3,752.70</b>
<b>Mean</b>	<b>172.55</b>	<b>102.09</b>	<b>24.60</b>	<b>1.79</b>	<b>24.74</b>	<b>49.51</b>	<b>375.27</b>

Figure 27 shows the total biomass (g/m<sup>2</sup>) of food supply from all kind of preys in early, middle, and late period. Kruskal-Wallis one-way ANOVA on ranks shows that the average per day of total biomass including fish, shrimp, insect larvae, and toads is significantly different among periods ( $p < 0.001$ ). Tukey test shows that the average of total biomass in the early period was significantly higher than that of the other two periods.



**Figure 27:** Total biomass from all prey types among periods in the second migratory season (for abbreviation, see Table 2)

Kruskal-Wallis one-way ANOVA on ranks shows that in the early period the average of total biomass from all preys was not significantly different among stations ( $p = 0.208$ ). However, the average biomass for the middle and late period was significantly different among stations ( $p < 0.001$ ,  $p < 0.004$ , Figure 28). Two-way ANOVA was used to create a diagram of the biomass from all preys at each station in the different periods (Figure 28).



**Figure 28:** Total biomass from all prey types at each station within the same period in the second migratory season measured at a day on average (for abbreviation, see Table 1, 2)

Kruskal-Wallis one-way ANOVA on ranks shows that the biomass of preys is significantly different among different types in every period ( $p < 0.001$ ) with the biomass of medium size fish being the highest in every period ( $p < 0.05$ ). However, the biomass of each prey type among periods shows different results as shown in Table 20. Biomass of small size fish was not significantly different among periods whereas that of medium size was significantly different. The biomass of medium size fish is the highest in the early period. Shrimp and insect larvae show similar results and were significantly different among periods and highest in the early period. Amphibians were also significantly different among periods with the highest in the late period.

**Table 20:** One-way ANOVA test for different biomass of each prey type among different periods

Prey types	Test	P value, F
Fish of small size	Kruskal-Wallis	$p = 0.051$
Fish of medium size	Holm-Sidak	$p = 0.044, F = 3.528$
Shrimp	Kruskal-Wallis	$p < 0.001$
	Tukey	$p < 0.05$
Insect larvae	Kruskal-Wallis	$p < 0.001$
	Tukey	$p < 0.05$
Amphibians	Kruskal-Wallis	$p < 0.001$
	Tukey	$p < 0.05$

The biomass from different kinds of food, and the seven species of fish measured within a day at the different stations in different periods are shown in Table 21, 22, 23, respectively. All species of medium size fish follow the trend of total biomass from all prey types. Biomass of fish from traps is the highest;  $750 \text{ g/m}^2$  in the early period, whilst the lowest from insect larvae of all periods;  $< 1 \text{ g/m}^2$  (Table 21). *Channa lucius* was the highest biomass among other species;  $345$  and  $193 \text{ g/m}^2$  in the early and late period, respectively (Table 22). *Channa striata* was the highest biomass in mid period;  $160 \text{ g/m}^2$  (Table 22). *Xenentodon cancila* was not observed in the early and late period whereas *Channa micropeltes* was the highest ( $22 \text{ g/m}^2$ ) in the early period and could not be observed in the middle and late period; the biomass of *Notopterus notopterus* and *Xenentodon cancila* was lowest in the middle period (less than  $1 \text{ g/m}^2$ ) whereas the biomass of *Anabas testudineus* was lowest in the late period ( $16 \text{ g/m}^2$ , Table 22). The highest biomass of seven species of medium size fish was at Huai Pong Tao,  $298 \text{ g/m}^2$  in the early period,  $187 \text{ g/m}^2$

in the mid period, 159 g/m<sup>2</sup> in the late period (Table 23). The lowest biomass was 26 g/m<sup>2</sup> at Don Seo Tai in the early period, 0 g/m<sup>2</sup> at Don Mor Tong and Noan Eee Yord in the mid period, 0 g/m<sup>2</sup> at Ban Chareon Suk in the late period (Table 23).

**Table 21:** Biomass from different kinds of preys (g/m<sup>2</sup>)

Day	Type of prey (g/m <sup>2</sup> )														
	Fish (Net bag)			Fish (Trap)			Shrimp			Insect larvae			Amphibians		
	EP	MP	LP	EP	MP	LP	EP	MP	LP	EP	MP	LP	EP	MP	LP
1	1	1	1	667	0	0	2.57	1.00	1.65	0.08	0.01	0	8.64	9.28	26
2	2	2	2	68	140	88	1.27	0.58	1.08	0.06	0.01	0	13.68	7.36	19.36
3	1	1	3	1,148	105	357	1.47	0.86	0.81	0.04	0	0	19.84	8.72	21.88
4	2	2	9	1,358	190	1,177	1.97	0.51	1.01	0.05	0	0	28.04	4.52	24.16
5	2	3	3	1,108	305	345	3.11	0.79	1.00	0.04	0.02	0	16.88	4.52	36.92
6	2	1	6	820	153	753	1.92	1.24	1.33	0.04	0	0	14.04	6.24	30.36
7	1	1	3	188	513	368	1.08	0.26	1.77	0.04	0	0	11.04	8.84	3.84
8	1	5	2	1,200	603	122	1.65	0.33	1.04	0.03	0.10	0	0.6	6.36	35.12
9	1	1	1	433	0	0	1.53	0.53	0.78	0.02	0	0	10.8	7.44	15.24
10	1	9	3	510	1,260	262	0.67	0.55	1.59	0	0	0	11.2	9.68	23.08
<b>Sum</b>	15	27	33	7,502	3,270	3,472	17.24	6.65	12.06	0.40	0.14	0	134.8	72.96	236
<b>Mean</b>	<b>1</b>	<b>3</b>	<b>3</b>	<b>750</b>	<b>327</b>	<b>347</b>	<b>1.72</b>	<b>0.67</b>	<b>1.21</b>	<b>0.04</b>	<b>0.01</b>	<b>0</b>	<b>13.48</b>	<b>7.30</b>	<b>23.60</b>

**Table 22:** Biomass of the seven species of fish altogether from six stations

Species	Weight (g/m <sup>2</sup> )		
	EP	MP	LP
<i>Anabas testudineus</i>	45.50	17.79	15.67
<i>Channa lucius</i>	344.74	61.05	193.33
<i>Channa micropeltes</i>	21.50	0	0
<i>Channa striata</i>	31.35	160.33	53.86
<i>Clarias</i> sp.	81.67	17.5	38.83
<i>Notopterus notopterus</i>	112.67	0.06	41.68
<i>Xenentodon cancila</i>	0	0.02	0
<b>Sum</b>	<b>637.43</b>	<b>256.75</b>	<b>343.37</b>

Kruskal-Wallis one-way ANOVA on ranks shows that the biomass of the seven species of fish was significantly different among periods ( $p = 0.002$ ) with that observed in the early migratory period being the highest ( $p < 0.05$ ).

**Table 23:** Biomass of seven species of medium size fish per square meter at each station in the second migratory season

<b>Migratory periods</b>	<b>Weight (g/m<sup>2</sup>)</b>					
	<b>HPT</b>	<b>DST</b>	<b>DMT</b>	<b>BCS</b>	<b>NEY</b>	<b>DSW</b>
EP	297.83	26	97.5	65	59.83	91
MP	187.17	15.33	0	26.17	0	18.33
LP	158.67	96.67	23.83	0	20.83	43.33

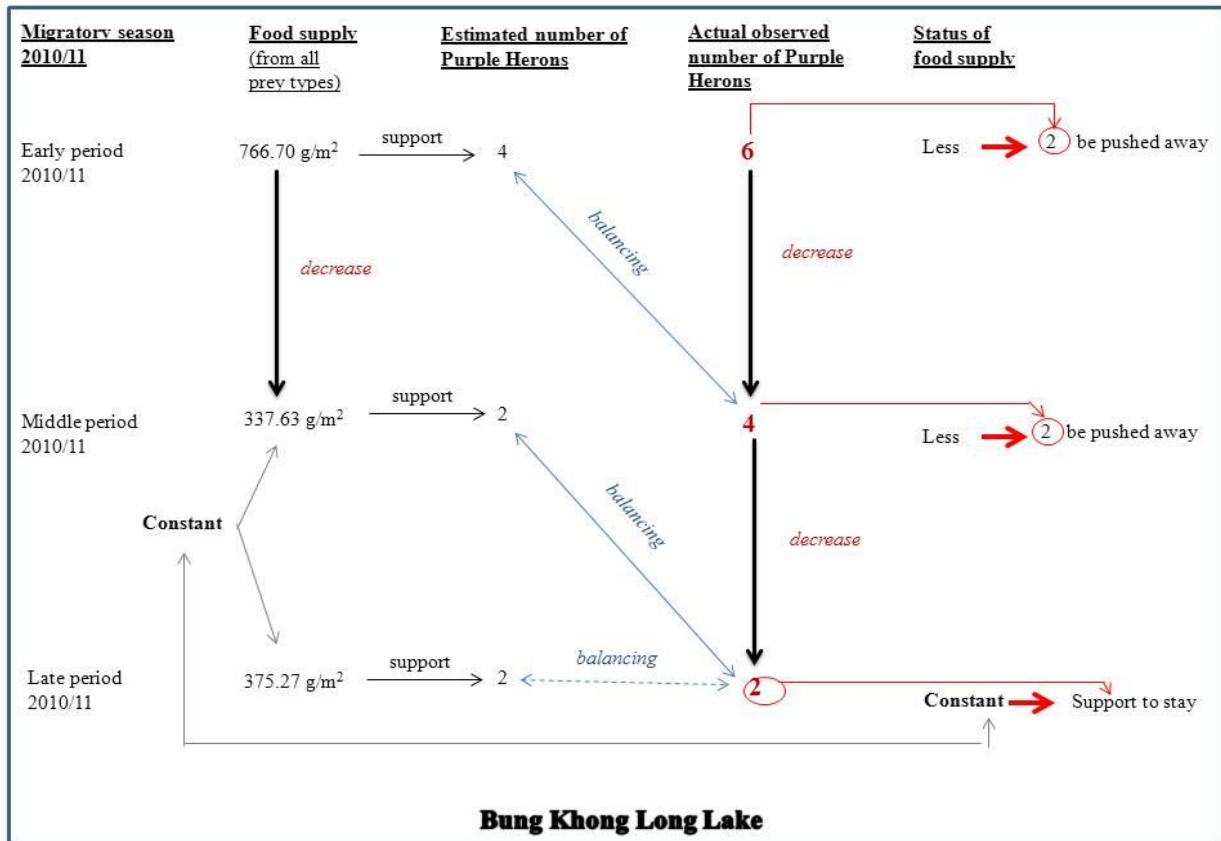
The biomass of each type of prey was compared with the probable number of Purple Herons that it could support (Table 24). The biomass from all prey types could support a maximum of four individuals of Purple Herons in the early period and two individuals in the middle and late periods, respectively. The major source was from the medium size fish, which could support the maximum number of Purple Herons compared to other prey types.

The estimations shown in Table 24 are based on an extrapolation of the actual food supply likely to support Purple Herons in the second migratory season. In the early period the maximum number of Purple Herons observed was six (Table 12) whereas the estimated number that could be supported by the biomass of all kinds of preys is only four (Table 24). This suggests that the actual food available in early migratory period is inadequate to support the maximum population size of Purple Heron. In the middle migratory period, four birds (Table 12) were observed whereas the estimated biomass of preys could meet the food requirement of two individuals (Table 24). This suggests that the present actual food is below the food requirement of the birds. Thus, the food could not support the maximum number of Purple Herons which is similar to the early period. However, in the late period two Purple Herons were the maximum number observed which could be supported by the estimated biomass of prey. This scenario is illustrated in Figure 29.

**Table 24:** Biomass of the probable food items that can support a maximum number of Purple Herons during the second migratory season

Type of preys	Number of Purple Herons and average biomass of preys		
	EP	MP	LP
1. All kinds (fish, shrimps, insect larvae, amphibians)	4 (766.70 g/m <sup>2</sup> )	2 (337.63 g/m <sup>2</sup> )	2 (375.27 g/m <sup>2</sup> )
2. Fish (small size from net bags)	0 (1 g/m <sup>2</sup> )	0 (3 g/m <sup>2</sup> )	0 (3 g/m <sup>2</sup> )
3. Fish (medium size from traps)	4 (750 g/m <sup>2</sup> )	2 (327 g/m <sup>2</sup> )	2 (347 g/m <sup>2</sup> )
4. Seven species of fish (small and medium size)	3 (637.43 g/m <sup>2</sup> )	1 (256.75 g/m <sup>2</sup> )	2 (343.37 g/m <sup>2</sup> )
5. Seven species of fish (medium size)	3 (637 g/m <sup>2</sup> )	1 (247 g/m <sup>2</sup> )	2 (343 g/m <sup>2</sup> )
6. Seven species of fish and amphibians	3 (650.91 g/m <sup>2</sup> )	1 (264.05 g/m <sup>2</sup> )	2 (366.97 g/m <sup>2</sup> )
7. Amphibians	0 (13.48 g/m <sup>2</sup> )	0 (7.30 g/m <sup>2</sup> )	0 (23.60 g/m <sup>2</sup> )
8. Shrimps	0 (1.72 g/m <sup>2</sup> )	0 (0.67 g/m <sup>2</sup> )	0 (1.21 g/m <sup>2</sup> )
9. Insect larvae	0 (0.04 g/m <sup>2</sup> )	0 (0.01 g/m <sup>2</sup> )	0 (0 g/m <sup>2</sup> )

Note: The number at the first line refers to the maximum number of Purple Herons that could be supported; the number at the second line refers to the biomass of food that could supply the birds



**Figure 29:** Food supply for Purple Herons during the second migratory season under the scheme of the conceptual framework

The main box represents Bung Khong Long Lake. The differences in food supply from each period of the second migratory season are shown. The thin black arrows represent the estimated number of Purple Herons that could be supported by the food supply of each period. The thick black arrows represent the decline in the observed number of Purple Herons from early to late period and food supply from early to middle period. The thin gray arrows represent continuous food supply from middle to late period. The normal thin blue arrows represent the ecological strategy of balancing adaptation between food supply and number of birds. The dot thin blue arrow represents the final balancing adaptation. The red thin arrows represent some of observed Purple Herons may be driven away to other wetlands or remain at Bung Khong Long Lake.

In order to consider the potential feeding areas that could provide the required biomass from the four types of preys to support the maximum number of Purple Herons, the number of birds at each station was estimated as shown in Table 25. In the early period, around 44,280 individuals of Purple Herons and 22,140 individuals in the middle and late periods could be supported within the total potential feeding areas. Considering the sampling stations that Purple Herons visited



most often, it could be deduced that around 17,520 individuals of birds that could be supported in early period, and 8,760 individuals in the middle and late period.

**Table 25:** Estimated maximum number of Purple Herons to be supported at the potential feeding areas at Bung Khong Long Lake

Sampling Stations	Estimated area (m <sup>2</sup> )	Maximum number of Purple Herons to be supported	
		EP	MP and LP
		(max. 4 inds./m <sup>2</sup> )	(max. 2 inds./m <sup>2</sup> )
Total potential feeding areas	11,070	44,280	22,140
HPT	577.57	2,310	1,155
DST	962.61	3,850	1,925
DMT	818.22	3,273	1,636
BCS	288.79	1,155	578
NEY	770.09	3,080	1,540
DSW	962.61	3,850	1,925
<b>Sum sampling stations</b>	<b>4,379.89</b>	<b>17,520</b>	<b>8,760</b>

The available biomass of prey within area size (per m<sup>2</sup>) was considered for the probable food supply for Purple Herons (see Table 24) during the second migratory season. The major probable food items for Purple Herons are particular from fish of the medium size of all species and both small and medium size of seven species (see Table 24). For this reason, these two types of preys are also considered in volume (per m<sup>3</sup>). Table 26, 27, and 28 shows total biomass of medium size fish of all species per volume in the early, middle, and late period. Mean values of each period are used to estimate the number of Purple Herons that could be supplied with the medium size fish of all species and the seven species (small and medium sizes).

Table 26 shows the average of the total biomass of medium size fish of all species in the early period. The averaged biomass was 3,215 g/m<sup>3</sup>, which are higher than the average biomass per area in Table 17 (766.70 g/m<sup>2</sup>).

**Table 26:** Total biomass of medium size fish of all species in early period (October 2010)

Day	Weight (g/m <sup>3</sup> )						Sum
	HPT	DST	DMT	BCS	NEY	DSW	
1	2,857	0	0	0	0	0	2,857
2	0	0	0	0	0	293	293
3	7	0	643	307	114	3,429	4,921
4	43	0	0	1,021	0	0	5,821
5	14	786	821	479	1,321	0	4,750
6	43	221	1,079	0	514	0	3,514
7	14	0	0	0	143	0	807
8	0	0	5,143	0	0	0	5,143
9	0	407	0	979	471	0	1,857
10	43	0	150	0	0	436	2,186
<b>Sum</b>	<b>13,393</b>	<b>1,414</b>	<b>7,836</b>	<b>2,786</b>	<b>2,564</b>	<b>4,157</b>	<b>32,150</b>
<b>Mean</b>	<b>1,339</b>	<b>141</b>	<b>784</b>	<b>279</b>	<b>256</b>	<b>416</b>	<b>3,215</b>

Table 27 shows the average of total biomass of medium size fish of all species in the middle period. The averaged value is 1,401.43 g/m<sup>3</sup> and it is higher than the average biomass per area in Table 18 (337.63 g/m<sup>2</sup>).

**Table 27:** Total biomass of medium size fish of all species in middle period (January 2011)

Day	Weight (g/m <sup>3</sup> )						Sum
	HPT	DST	DMT	BCS	NEY	DSW	
1	0	0	0	0	0	0	0
2	600	0	0	0	0	0	600
3	0	0	0	450	0	0	450
4	814	0	0	0	0	0	814
5	1,007	300	0	0	0	0	1,307
6	0	0	657	0	0	0	657
7	2,200	0	0	0	0	0	2,200
8	2,586	0	0	0	0	0	2,586
9	0	0	0	0	0	0	0
10	3,414	357	0	843	0	786	5,400
<b>Sum</b>	<b>10,621</b>	<b>657</b>	<b>657</b>	<b>1,293</b>	<b>0</b>	<b>786</b>	<b>14,014</b>
<b>Mean</b>	<b>1,062</b>	<b>66</b>	<b>66</b>	<b>129</b>	<b>0</b>	<b>79</b>	<b>1,401.43</b>

Table 28 shows the average of the total biomass of medium size fish of all species in the late period. The average biomass is 1,487.86 g/m<sup>3</sup> which are higher than the average biomass per area in Table 19 (375.27 g/m<sup>2</sup>).

**Table 28:** Total biomass of medium size fish of all species in late period (April 2011)

Day	Weight (g/m <sup>3</sup> )						Sum
	HPT	DST	DMT	BCS	NEY	DSW	
1	0	0	0	0	0	0	0
2	0	0	0	0	0	379	379
3	479	0	143	0	0	907	1,529
4	1,957	1,443	357	0	893	393	5,043
5	1,479	0	0	0	0	0	1,479
6	3,229	0	0	0	0	0	3,229
7	0	1,579	0	0	0	0	1,579
8	0	0	521	0	0	0	521
9	0	0	0	0	0	0	0
10	0	1,121	0	0	0	0	1,121
<b>Sum</b>	<b>7,143</b>	<b>4,143</b>	<b>1,021</b>	<b>0</b>	<b>893</b>	<b>1,679</b>	<b>14,879</b>
<b>Mean</b>	<b>714</b>	<b>414</b>	<b>102</b>	<b>0</b>	<b>89</b>	<b>168</b>	<b>1,487.86</b>

The seven species of fish is another major prey type that could support Purple Herons, thus the total biomass of these fish per volume is calculated. Table 29 shows the total biomass of the seven species of fish in the early, middle, and late period. The medium size of *Channa lucius* has highest biomass per volume in the early period (1,479 g/m<sup>3</sup>) and the late period (828.57 g/m<sup>3</sup>), followed by the medium size of *Channa striata* (686 g/m<sup>3</sup>) in the middle period.

**Table 29:** Total biomass of seven species (small and medium size)

Species	Weight (g/m <sup>3</sup> )					
	EP		MP		LP	
	Medium size	Small size	Medium size	Small size	Medium size	Small size
<i>Anabas testudineus</i>	192.86	0	78.57	0.07	67.14	0
<i>Channa lucius</i>	1,478.57	0.15	257.14	0.14	828.57	0
<i>Channa micropeltes</i>	92.86	0	0	0	0	0
<i>Channa striata</i>	135.71	0.01	685.71	0	228.57	0.02
<i>Clarias</i> sp.	350	0	78.57	0	164.29	0
<i>Notopterus notopterus</i>	485.71	0	0	0.04	178.57	0.01
<i>Xenentodon cancila</i>	0	0	0	0.01	0	0
<b>Sum</b>	<b>2,735.72</b>	<b>0.16</b>	<b>1,100</b>	<b>0.26</b>	<b>1,467.14</b>	<b>0.03</b>

Table 30 shows the total biomass of small size fish of all species. The biomass of these fish is low in every period. The maximum weight is in the late period (2.10 g/m<sup>3</sup>). The average biomass of the small size fish of all species and of the seven species as well as the medium size fish of these two groups is used to estimate the number of Purple Herons that could be supported in the early, middle, and late period (Table 31).

**Table 30:** Total biomass of small size fish of all species

Day	Weight of Small size fish (g/m <sup>3</sup> )		
	EP	MP	LP
1	0.87	0.66	0.82
2	1.05	1.37	1.06
3	0.84	0.69	2.18
4	1.15	1.29	5.46
5	1.19	2.06	2.15
6	0.99	0.71	3.62
7	0.88	0.64	2.13
8	0.87	3.31	1.18
9	0.90	0.67	0.73
10	0.76	5.49	1.70
<b>sum</b>	<b>9.51</b>	<b>16.90</b>	<b>21.03</b>
<b>means</b>	<b>0.95</b>	<b>1.69</b>	<b>2.10</b>

Total biomass by average of medium size fish of all species and seven species, small size fish of all species and seven species from Table 26 – 30 was used to estimate the number of Purple Herons that could be supported in the early, middle, and late period (Table 31). The total biomass of the small size fish per volume shows similar results, as shown in Table 24; fish of this size could support none of Purple Herons. On the other hand, the biomass of medium size fish of all species could support 16 individuals of birds in the early period, seven individuals in the middle and late period. Similarly, the medium size fish of seven species indicates the major supply and could support 14 birds in the early period, five in the middle and seven in the late period (Table 31).

**Table 31:** Possibility of fish biomass per volume available from all stations of potential feeding areas and the potential maximum number of Purple Herons to be supported

	Small size of fish (< 5 cm) g/m <sup>3</sup>			Medium size of fish (5-15 cm) g/m <sup>3</sup>		
	EP	MP	LP	EP	MP	LP
Maximum number of Purple Heron to be supported	0	0	0	16	7	7
<b>All fish</b>	0.95 g	1.69 g	2.10 g	3,215 g	1,401 g	1,488 g
Maximum number of Purple Heron to be supported	0	0	0	14	6	7
<b>Seven species of fish</b>	0.16 g	0.26 g	0.03 g	2,736 g	1,100 g	1,467 g

The food mainly from fish of medium size suggests that Bung Khong Long Lake has capacity to supply more Purple Herons compared to the observed number during the second migratory season.

Additional measurement of fish from the Peitz Ponds, Germany showed that fish size of Cyprinidae and Perciformes altogether was 14.91 cm on average and the wet weight was average 35.57 g. These fish fall into the medium size group of fish in Bung Khong Long Lake. It suggests that Purple Heron likely has to catch five or more fish to reach the daily food requirement. On the other hand, *Channa* sp. (estimated about 90 g) has been observed to be caught by Purple Heron in Bung Khong Long Lake. This suggests that two or more fish of this size could be sufficient for Purple Heron probably was underestimated. It is likely that Purple Heron needs more fish in Bung Khong Long Lake to fulfil its energy requirement.

#### **4.4 Influence of local fishery on food supply of Purple Heron**

In total, 82 local fishermen are active at shallow areas around the lake overlapping with the feeding areas of Purple Herons. Twenty-six people catch fish everyday. This group was used for analysis.

##### **4.4.1 Fishing time of fishermen and feeding time of Purple Herons**

Fishermen who fish everyday were observed within a day. Table 32 illustrates the duration of fishing, number of fishermen, and active time of Purple Heron. The highest numbers of fishermen is between 4.00 - 10.00 hours and 15.00 - 18.00 hours which are the same with the

most active feeding time of Purple Herons. Five fishing gears are frequently used including net, long-lined fish hook, fish trap, harpoon, and dip-net, respectively. Shrimp trap is the only gear used to catch shrimp in this lake, but many traps were used and were widely spread across the sampling stations.

**Table 32:** Frequency of fishing during a day

Period of time	Number of fishermen	Active time of Purple Heron (field observation, October 2010)
4.00-7.00	17	●
7.00-10.00	13	●
10.00.-12.00	4	
12.00-15.00	10	
15.00-18.00	15	●
18.00-22.00	5	
22.00-4.00	3	

Note: The bullet (●) means the most active feeding time of Purple Heron

The overlapping between fishing and feeding time shows that it might be difficult for Purple Herons to reach the food resources. Moreover, the fishing areas are also the same as the feeding areas of the birds. Table 33 shows the number of fishermen at each station during the day. The highest number of fishermen observed at Don Sa Wan is during the active feeding time of Purple Herons (4.00-10.00 a.m. and 3.00-6.00 p.m.) followed by Noan Eee Yord (3.00-6.00 p.m.). None of these local fishermen fish at Ban Chareon Suk. Huai Pong Tao, Don Seo Tai and Don Mor Tong have almost the same number of fishermen.

**Table 33:** Numbers of fishermen at each station during the day

Period of time	Sampling stations/Number of fishermen					
	HPT	DST	DMT	BCS	NEY	DSW
4.00-7.00	3	1	1	0	3	6
7.00-10.00	2	3	2	0	3	6
10.00-12.00	2	3	2	0	1	1
12.00-15.00	2	3	4	0	4	4
15.00-18.00	3	2	3	0	5	5
18.00-22.00	0	0	1	0	1	3
22.00-4.00	1	0	1	0	0	3

The opportunity of Purple Heron to predate the fish during the day might be disturbed by fishing activity especially at the same period between the most active time of the birds and the peak of fishing activity. The minimum time difference for Purple Heron to catch fish at the same area for the first and second time is approximately five minutes, but the maximum could be over an hour. In this respect and due to the feeding time of Purple Heron that was observed from 7.00 a.m. to 6 p.m. It is assumed that Purple Heron needs at least 11 hours in a day to search for fish, thus, the availability of fish was 6 individuals/m<sup>2</sup>/11 hours at Huai Pong Tao in the early period of the second migratory season (based on data obtained from field observation in Table 14). The minimum weight observed of fish that Purple Heron could catch was about 50 g (see page 36). Thus, the bird might obtain food of about 300 g/m<sup>2</sup>/11 hours. However, the average wet weight of fish from the Peitz Ponds, Germany was 35.57 g. Thus, Purple Heron has merely to obtain food of about 213.42 g/m<sup>2</sup>/11 hours. Nevertheless, owing to the disturbance by fishing activity at the same time at Huai Pong Tao during the most active feeding time of the bird, the chance of catching fish might be lower than expected, especially when this situation is applied at Don Sa Wan where there is the highest number of fishermen. With this regards, the difficulty to reach the daily food requirement probably drives Purple Herons to leave the lake or spend longer time to search for food in the lake.

#### **4.4.2 Fish caught by fishermen**

At least 23 species of fish have been caught by local fishermen (Appendix IV, Table 2). Species which have been caught most often by fishermen were *Hampala dispar*, *Notopterus notopterus*, *Osteochilus lini*, *Channa striata*, *Oreochromis niloticus*, *Barbonymus goniootus*, *Clarias* sp., and *Channa lucius*, respectively. The seven species of fish regarded as food of Purple Herons from catching by fishermen has average wet biomass of about 66,707 g/m<sup>2</sup> as shown in Table 34. *Xenentodon cancila* was not caught by local fishermen whereas *Notopterus notopterus* could be caught with the highest grams per square meter during one day. The biomass of these seven species of fish from the fishermen caught is obviously higher than those of assuming for Purple Herons in every period.

With regards to the higher amount of catching, the seven species of fish caught by fishermen could be an obscured food supply for Purple Herons. This amount (66,707 g/m<sup>2</sup>) could support about 333 Purple Herons. On the other hand, the maximum number of Purple Herons was only six individuals, but throughout the migratory season all birds could not remain in the lake. It

suggests that because these fish were exploited by fishermen, thus fishing seems to be one factor making Purple Herons difficult to reach the food resources.

**Table 34:** Biomass (g/m<sup>2</sup>/day) of seven species of fish caught by local fishermen

Species of fish	Fish caught by fishermen (g/m <sup>2</sup> /day)	Fish available at feeding area assuming for Purple Herons (g/m <sup>2</sup> /day)		
		EP	MP	LP
<i>Anabas testudineus</i>	1,000	45.5	17.79	15.67
<i>Channa lucius</i>	12,575	344.74	61.05	193.33
<i>Channa micropeltes</i>	3,348	21.50	0	0
<i>Channa striata</i>	6,848	31.35	160.33	53.86
<i>Clarias</i> sp.	2,450	81.67	17.5	38.83
<i>Notopterus notopterus</i>	40,486	112.67	0.06	41.68
<i>Xenentodon cancila</i>	0	0	0.02	0
<b>Total</b>	<b>66,707</b>	<b>606.08</b>	<b>256.75</b>	<b>343.37</b>

In addition to catch fish, frogs or toads were also caught by some of these fishermen. It usually took place from 20.00 hours for about one to two hours. Sometimes it was between 18.00-20.00 hours. However, the catching time is not overlapping with the active feeding time of Purple Herons. Yet, the consequence of catching frogs or toads during the night could result in the decline in their number of over time. It might also influence food supply changes of Purple Herons.

#### **4.4.3 Other activities of local fishery**

Other activities of local fishery expected to affect the feeding behavior of Purple Herons include the boats used. The motor boats normally make loud noise. During the investigation time, most often the birds flew away immediately when the motor boats got close to the feeding areas. Until the birds could find some places to camouflage (e.g. emergent hydrophytes around or very dense areas of reed), they would start to search for food again after the noise subsides. Besides, boats without motor do not make noise, but the way that fishermen stand and use a long stick to paddle could make Purple Herons fly away when the boat gets closer (about 10 m - 50 m).



#### **4.4.4 Knowledge of lake and birds management of local fishermen**

The knowledge of lake and birds management of local fishermen was done through interview using questionnaires. The result suggests that most fishermen know that Bung Khong Long Lake is under the conservation as a non-hunting area. However, even though some of them are aware that the lake is a Ramsar Site, they do not really understand much about the concept. Moreover, 28 % of the fishermen thought that not more than three individuals of Purple Herons could be observed at Bung Khong Long Lake. Twenty-seven percent thought there are no Purple Herons at Bung Khong Long Lake at all. About 21 % and 2 % of fishermen thought that about 4 to 5 and 6 to 10 individuals of Purple Herons respectively could be observed at Bung Khong Long Lake. Only 4 % thought that more than 10 individuals of Purple Herons could be observed at this lake. However, 18 % of fishermen completely have no knowledge about Purple Herons.

At least 23 species of birds could be simultaneously observed with Purple Herons. Resident birds comprise Bittern (*Ixobrychus cinnamomeus*), Black Drongo (*Dicrurus macrocercus*), Cinnamon Yellow Bittern (*Ixobrychus sinensis*), Common Moorhen (*Gallinula chloropus*), Cotton Pygmy-goose (*Nettapus coromandelianus*), Lesser Whistling-Duck (*Dendrocygna javanica*), Little Grebe (*Tachybaptus ruficollis*), Purple Swamphen (*Porphyrio porphyrio*), and White-Throated Kingfisher (*Halcyon smyrnensis*). Breeding visitor is Watercock (*Gallicrex cinerea*). Winter/non-breeding visitors are Cattle Egret (*Bubulcus ibis*), Chinese Pond Heron (*Ardeola bacchus*), Common Kingfisher (*Alcedo atthis*), Eastern Marsh Harrier (*Circus spilonotus*), Great Egret (*Casmerodius albus*), Grey-headed Lapwing (*Vanellus cinereus*), Grey Heron (*Ardea cinerea*), Hen Harrier (*Circus cyaneus*), Intermediate Egret (*Mesophoxy intermedia*), Little Egret (*Egretta garzetta*), Pheasant-tailed Jacana (*Hydrophasianus chirurgus*), and Pied Harrier (*Circus melanoleucos*). These birds feed on similar food sources of Purple Herons. They are known by local people especially for the resident group. Even though the local fishermen know the name of those winter/non-breeding birds, they have never been interested in the trends or the fluctuation in changes of the number of these birds.

## **5 Discussion**

### **5.1 Feeding area characteristics at wintering ground**

According to Hockey et al. (2005), Bung Khong Long Lake is a suitable feeding area for Purple Herons. The variety of plant cover provides Purple Herons and other birds materials for camouflage and feeding. At least 29 species of birds including 27 species of waterfowls and shorebirds are found in this ecosystem (Pichaisiri et al. 2007) whereas 28 species were the maximum number that could be observed in December and January (DNP 2011). However, only 23 species of birds were able to be recorded during the observation for the migratory season of Purple Herons (2009/10 and 2010/11). Besides, at least ten species of reptiles and six species of amphibians are found in the lake area (ONEP 2002). Land surrounding the lake is cultivated with economic plants including *Dipterocarpus* spp., *Lagerstroemia calyculata*, *Pterocarpus macrocarpus* and *Hopea odorata* (Wetlands International 2007). Other indigenous plants including Black Plum (*Eugenia cumini*), Banyan tree (*Ficus* spp.), and Cashew (*Lagerstroemia siamica*) are also present (Wetlands International 2007). Plants found in the dry evergreen forests, are Almond (*Irvingia malayana*), White Mangrove (*Avicennia alba*), White Cheesewood (*Alstonia scholaris*), Ironwood (*Fagraea fragrans*), Kanu (*Anisoptera costata*), and sedges (*Scirpus grossus*) (Wetlands International 2007). These terrestrial plants are expected to serve as a resting area of some birds including Purple Herons even though it is yet to be proved. However, most often Purple Herons are attracted to these terrestrial trees in the evening during the migratory season.

Physical characteristics of Bung Khong Long Lake during the migratory seasons of Purple Herons were not different between the first and the second year of study. Throughout the migratory season the pH of the lake water remained in neutral range. The water temperature is highest in the early period and lowest in the middle period. However, it was comparatively similar between the two migratory seasons. Temperature (Table 35) followed a similar trend as reported for north-eastern Thailand during the same periods (The Meteorological Department Thailand 2011). *A* refers to the general temperature of the area reported by the Meteorological Department. *B* refers to the water temperature from the field observation in this study. These variables suggest that throughout the migratory season of Purple Herons Bung Khong Long Lake has a stable condition.

**Table 35:** Temperature at Bung Khong Long Lake

Migratory season	Temperature (°C)					
	EP		MP		LP	
	A	B	A	B	A	B
First (October 2009-April 2010)	27.6	30.02	24.8	25.08	31.1	28.75
Second (October 2010-April 2011)	26.4	28.47	21.7	21.11	28.6	28.13

Note: A: Data source from the Meteorological Department, 2011; B: Data source from the field observation

The water level at feeding areas of Purple Herons in Bung Khong Long Lake throughout the migratory seasons did not rise over 1.50 m. The maximum level was observed in the early period and the minimum in the late period, which was not over 1 m. The shallow areas of the lake may be of advantage to Purple Herons in the search of preys (Granado – Lorenzo 1996). Even though the middle period of the second migratory season experienced drought condition (The Meteorological Department Thailand 2011), the water level of the lake was not much different from that of the early period when precipitation was the highest. In addition, Jewyam (2011) reported that the water quality in Bung Khong Long Lake was good and suitable for aquatic fauna. This suggests that the physical and chemical characteristics of the lake water at the feeding grounds seem not be an important factor to drive Purple Herons away to other wetlands.

Biological characteristic at the feeding areas of Purple Herons especially plant species composition indicates that Bung Khong Long Lake is a suitable temporary habitat for the birds. According to Tucker et al. (1994) the lake is a permanent freshwater marsh suitable as a feeding area for Purple Herons. The areas out of the lake margin is characterised by the rice fields and small canals which serve as a habitat for birds (Fasola et al. 1996; Fasola and Ruiz 1996; Round 2008). Purple Herons prefer flooded lowlands with intensive reed beds (Grewal et al. 2003; Huntsman 2009; Tan 2001), especially *Phragmites* reedbeds (Hockey et al. 2005). Even though *Phragmites* was not observed at the feeding areas at Bung Khong Long Lake, the dominant species of plants have the same structure as the graminoid growth form. Moreover, not only reed swamp is important for Purple Herons, but also emergent hydrophytes areas within the lake. These areas could provide alternative food sources for Purple Herons and other birds. Other

aquatic plants including water lily (*Nymphaea odorata*), lotus (*Nelumbo nucifera*) and morning glory (*Ipomoea* spp.) were found in the middle of the lake together with at least 23 other species of aquatic plants (ONEP 2002). These communities provide important habitats and nursery areas for aquatic fauna which serve as food sources for animals including Purple Herons.

## 5.2 Behavior of Purple Heron

According to BirdLife International (2008) Purple Heron is classified as shown in Table 36. *Ardea purpurea manilensis* is the only subspecies that have been observed in Thailand (Lekagul and Cronin 1974).

**Table 36:** Purple Heron taxonomy (IUCN, 2011)

Kingdom	Animalia
Phylum	Chordata
Class	Aves
Order	Pelecaniformes (Ciconiformes)
Family	Ardeidae
Genus	<i>Ardea</i>
Species	<i>Ardea purpurea</i>
Subspecies	<i>Ardea purpurea manilensis</i>

Further information on the characteristics of Purple Herons can be found in Behrens 2003, Grewal et al. 2003, Lekagul and Cronin 1974, Robson 2002, Round 2008, Takano 1985, and Tan 2001.

Some reports indicated that Purple Herons hunt during the night until early morning (Wilson 2011) whereas Kanjanasaka et al. (1987) reported that they can be found throughout the day during breeding period. The observation of Kanjanasaka et al. (1987) is in line with observations at Bung Khong Long Lake where Purple Herons are active during the day time. Kanjanasaka et al. (1987) reported that at dawn is the most active time of Purple Heron. This is in agreement with what pertains at Bung Khong Long Lake where the bird starts to search for food before 7.00 a.m. However, at Bung Khong Long Lake, Purple Herons were also observed to be active in the late afternoon. They are less tolerant to disturbances and artificial habitats (Tan 2001) and sensitive to the loud noise of motor boats and fishing activities in general.

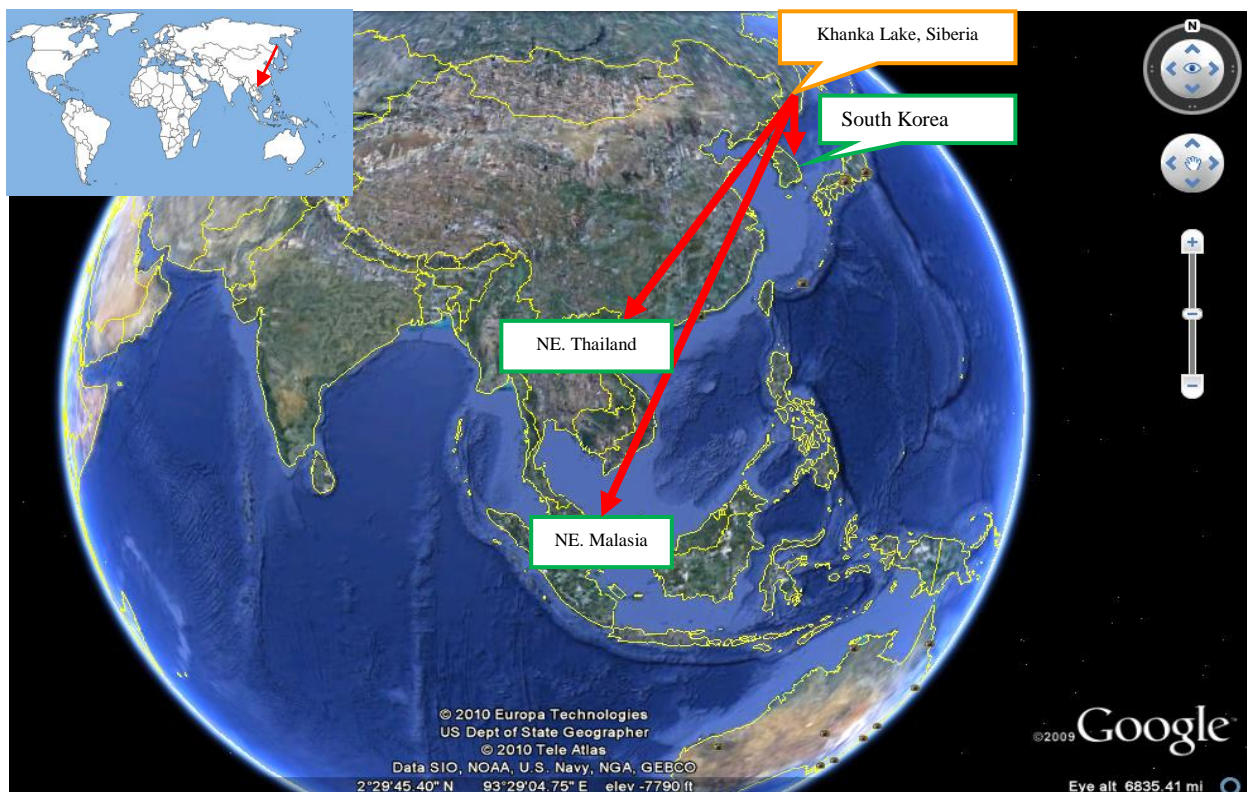
Purple Heron is usually found foraging alone in the wide range of distribution of reed swamp or emergent hydrophyte communities at Bung Khong Long Lake. They prefer to stand and wait for the prey in bushes along shallow water where the water level does not inundate their legs. At one sampling station such as Huai Pong Tao (approximately 577.57 m<sup>2</sup>), not more than two individuals was found feeding simultaneously. This could be attributed to internal competition for space (Campos and Lekuona 1997; Krebs 1994). However, the exact distances of making territorial defensive behaviour by Purple Herons was not studied. The signal of another obtrusive bird might be by optical notice which was observed from the response of Purple Heron when the boat got closer.

### **5.3 Number fluctuation**

The number of Purple Herons at Bung Khong Long Lake is small (Appendix III) and thus expected to be the only migrant group because no breeding nests have been found around the lake environ which is consistent with Robson (2002). The group of Purple Herons is expected to have migrated from Russia (McClure 1974a). The fluctuation in the number of this bird has been recorded since 2004 with the maximum number of 20 individuals observed in February (DNP 2011). Even though statistical analysis did not reveal any trend of decreasing numbers over the years, the number of the birds in the migratory seasons was significantly different among the migratory years. Especially, the number of birds between the migratory year 2004/05 and 2009/10 was different. However, the maximum number decreased in the year 2004 from 20 to 11 individuals in March 2005, and in the subsequent years not more than 10 individuals have been observed at Bung Khong Long Lake. For instance, the maximum number of Purple Herons observed in 2009, 2010, and 2011 was six individuals. Several reasons may account for this phenomenon.

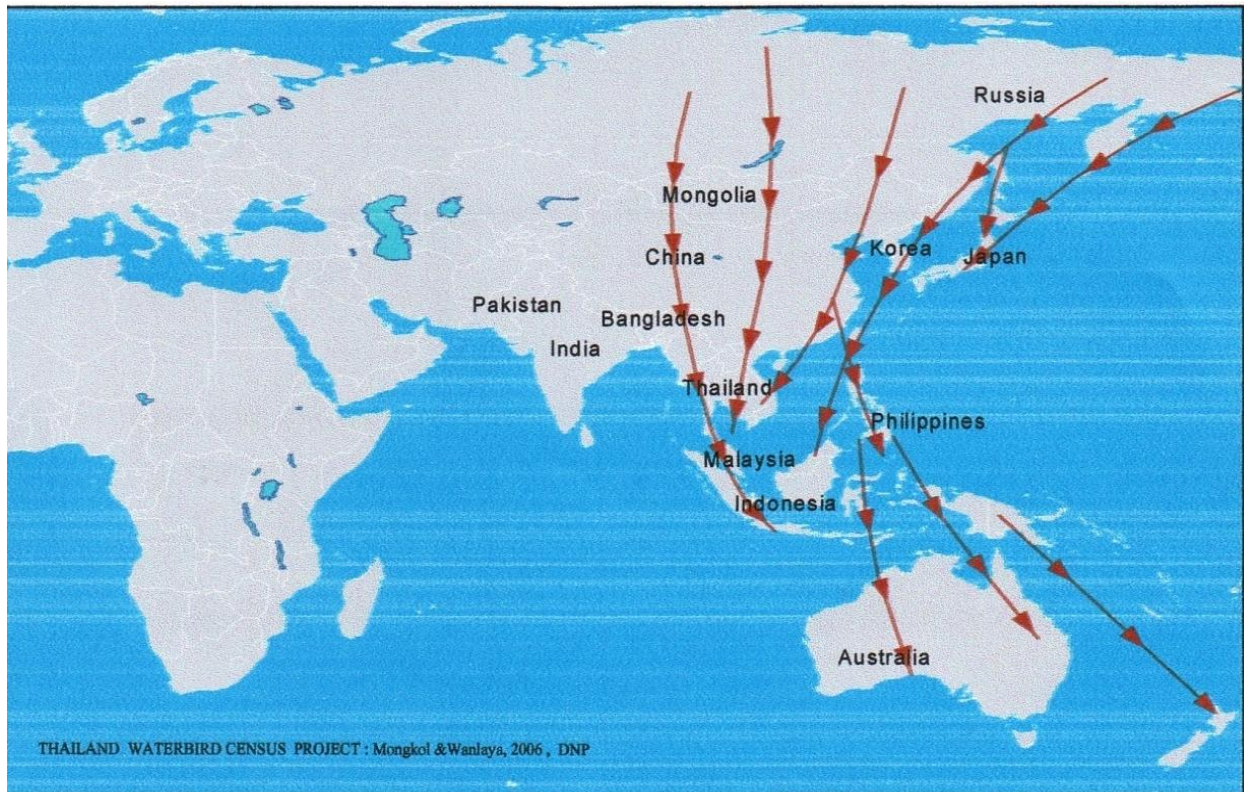
First, the decline in the number of Purple Herons at Bung Khong Long Lake could occur at the origins before migrating to the resting areas. Its migratory route is from Russia and northern China to southern Korea, Thailand, and Malaysia (Figure 30, McClure 1974a). Kushlan and Hancock (2005) reported that *Ardea purpurea manilensis* also migrate to join the non-migratory populations in southeast China, Korea, Taiwan, Japan (Ryuku Islands), Pakistan, Thailand, Malaysia, and Indonesia to the Lesser Sunda Islands. These follow the route of water birds in South East Asia known as the East Asian-Australasian Flyway (EAAF 2008) and it has been illustrated by Chaibhakdee and Chaibhakdee (2006) as shown in Figure 31. Meanwhile, BirdLife

International (2011) reported that the population size of Purple Herons in Russia reveals a decreasing trend since 1994. Thus it is possible that the population of *Ardea purpurea manilensis* also decreased even though their migratory route or distribution range is different from other two subspecies (Cramp and Simmons 1977; McClure 1974b). In addition, in recent times, the migrants group from Russia is comparatively lower compared to breeders found in Singapore (Tan 2001). For these reasons, the result is a decline in the number of Purple Herons at Bung Khong Long Lake.



**Figure 30:** Migratory routes of Purple Heron (Google Earth 2009), from South East Siberia, Khanka Lake to South East Asia. They were ringed by Russian biologists. (Source of map: Modified from MacClure (1974a) with Google Earth on 1 March 2010)

The second reason could be changes in area distribution. In general, Purple Herons are widespread and can be found in Africa, Europe, India, China, Tai Wan, Myanmar, Thailand, Cambodia, Laos, Vietnam, Malaysia, Indonesia, and Philippines (BirdLife International 2009b). They can also be found in southern Ryukyu Island, Japan as an uncommon resident, but in other areas they are rare migrants or winter visitors (Takano 1985). In India they are locally common breeding resident throughout the lowlands (Grewal et al. 2003). It might be possible that some migrants change the resting areas.



**Figure 31:** Routes of water birds in South East Asia (Chaibhakdee and Chaibhakdee 2006)

In Thailand, according to DNP (2011) the birds could be observed in 29 areas in 2004 and 79 areas at present (2011). During the migration time of year 2004/05, 22 sites were reported as places where Purple Herons could be observed, and increased to 42 sites in year 2007/08. Similarly, in year 2008/09 19 observed sites were reported and increased to 36 sites in year 2009/10. Meanwhile, the number of Purple Herons decreased in certain areas such as at Bor Lor Non-Hunting Area in year 2009/10 whereas it increased at 17 observed areas from year 2008/09. Table 37 shows the number of observed sites during the migratory seasons of Purple Herons in Thailand. For some sites where Purple Herons were observed in year 2004/05, the birds were not observed anymore in the following years. Instead, Purple Herons were reported to have been found in other new areas. However, 19 sites were reported in the year 2008/09 as common areas where the birds could be seen since 2004/05. This situation may indicate that the birds tend to visit areas following their ancestors (Krebs 1994). The new observed sites might be more suitable foraging areas for Purple Herons than the ancestral discovered areas (Fasola and Alieri 1992), thus in some years the distribution range was wider.

**Table 37:** The number of locations where Purple Herons could be observed during the migratory seasons in Thailand (DNP 2011). Year 2003/04 refers to January to April 2004

<b>Migratory year</b>	<b>Number of observed sites</b>	<b>Maximum observed number of Purple Herons at Bung Khong Long Lake</b>	<b>Total number of Purple Herons in Thailand</b>
2003/04	-	20	469
2004/05	22	11	1,112
2005/06	32	9	839
2006/07	39	8	1,204
2007/08	42	6	1,113
2008/09	19	9	2,039
2009/10	36	6	920

Other factors that may influence the fluctuation in the number of Purple Herons at Bung Khong Long Lake include hunting, loss orientation during migration, small numbers of new born, or climate change (Den Held 1981). Kayser (1994) reported that Purple Heron is a vulnerable species in Europe, and its population is to a large extent declining over the years. He suggested that the probable causes of the observed population decline might be as a result of habitat loss and climate changes, which may induce drought condition at its wintering ground, particularly in West Africa. Even though Bung Khong Long Lake does not experience similar level of drought condition as found in West Africa, scarce food supply might be the driving factor that influences the number of Purple Herons across periods during the same migratory season.

#### **5.4 Food supply**

The number of species of fish that were observed in Bung Khong Long Lake within a square meter in the first migratory season was less than that of the second migratory season. However, the number of fish species was not different among periods within the same migratory season. In addition, the number of fish available within the same area was higher compared to amphibians. This suggests that the possibility of Purple Herons preying on fish is also likely to be higher than amphibians, and it has been observed that the birds feed mainly on fish (Grewal et al. 2003; Montesinos et al. 2008; Round 2008; Tan 2001). Therefore, fish seems to be the first preference among other preys to hunt.

Fish and other animals that serve as food for Purple Herons (Barbraud et al. 2001; Campos and Lekuona 2001; Correia 2001; Fasola 1994; Hocky et al. 2005; Kanjanasaka et al. 1987; Kushlan



and Hancock 2005; Montesinos et al. 2008; Moser 1984; Round 2008) from different areas worldwide are shown in Table 38. Mukherjee (1976) reported that Purple Herons in India feed 57 % on fish, 20.57 % on reptiles (mostly snakes), 14.34 % on shrimps and crabs, and 7.65 % on insects. However, Barbraud et al. (2001) obtained an interesting data, which indicate that Purple Herons are also able to shift from fish (*Anguilla anguilla*, *Lepomis gibbosus*, *Rutilus rutilus*) as the main food to insects (*Hydrous* sp. larvae) but this is unlikely at Bung Khong Long Lake since Purple Herons found here are migrant group without chicks to feed. Kushlan and Hancock (2005) suggested that Purple Herons feed mostly on fish in the group of *Esox*, *Cyprinus*, *Tinta*, *Abramis*, *Scardinius*, *Perca*, *Anguilla*, *Acerina*, *Lota*, and *Mugil*. Other probable prey items including frogs, aquatic insects (Barbraud et al. 2001; Montesinos et al. 2008; Round 2008; Tan 2001) as well as shellfish, small mammals, reptiles and small birds (Barbraud et al. 2001; Tan 2001) have been reported. However, the number of amphibians at Bung Khong Long Lake was not high during the migratory seasons of Purple Herons. Moreover, only two species of Frogs were found at the potential feeding areas at Bung Khong Long Lake, which might not be sufficient as an alternative food source for Purple Herons.

Other reports indicate that crayfish (*Procambarus clarkii*) is a major prey for adult Purple Heron in Portugal (Correia 2001), and sunfish and insect larvae in Italy (Moltoni 1936). Hockey et al. (2005) reported that six species of fish in Africa have been found as food for Purple Herons; *Clarias* sp. (catfish), *Labeo altivelis* (Rednose Labeo), *Labeo cylindricus* (Redeye Labeo), *Oreochromis macrochir* (Greenhead Tilapia), *Tilapia rendalli* (Redbreast Tilapia), and *Brycinus imberi* (Spot-tail). Even though these species of fish may not be attractive to Purple Herons, they predate on the fish because of the size. According to Kushlan and Hancock (2005), Purple Herons prefer to feed on large fish with size varying from 2 to 35 cm. Other researches suggest that Purple Herons in France feed on carp (*Cyprinus*: 2-5 cm), mullet (*Mugil*: 4-5 cm), and eel (*Anguilla*: 25-35 cm) (Moser 1984). Moltoni (1936) also found that they feed on fish of size 2-10 cm but the groups of fish were not specified. These researches were carried out mainly at the breeding areas of Purple Herons, and it is more likely that the birds may catch small size preys to feed their chicks. Contrary, Purple Herons at Bung Khong Long Lake are not expected to hunt for smaller fish at the wintering area. As observed in the present study they catch fish of size between 6 and 13 cm even though the size of fish in the lake varied between 2 cm and 30 cm. This suggests that the birds do not need smaller size fish to feed their chicks since Bung Khong Long Lake seems not to be a breeding ground. Thus, the birds are more selective in preying on

relatively larger fish to meet their food requirement. According to Bauer et al. (2005) average daily food uptake of Purple Heron is estimated to be around 200 g per day. In this respect, shrimps and insect larvae which are very small size were excluded because they are not expected to prey priority for Purple Herons at the migratory resting area.

Kanjanasaka et al. (1978) studied the food of Purple Heron during breeding period in Thailand by collecting food samples from the nests and food dropping under the nests. They found that the source of food for feeding their young comes from at least eight families of fish: *Cyprinidae: Rasbora aurotaenia (Rasbora retrodorsalis)*, *Channidae: Channa striata (Ophicephalus striatus)*, *Anabantidae: Anabas testudineus*, *Notopteridae: Notopterus notopterus*, *Clariidae: Clarias sp.*, *Belonidae: Xenentodon cancila*, *Aplocheilidae: Aplocheilus panchax*, and *Mugil sp.* At least five of these species were observed in Bung Khong Long Lake: *Anabas testudineus*, *Channa striata*, *Clarias sp.*, *Notopterus notopterus*, and *Xenentodon cancila*. Other two species of *Channidae (Channa lucius and Channa micropeltes)* were also observed and are expected to be probable preys similar to *Channa striata*. The number of these seven species observed at Bung Khong Long Lake during the first migratory season was lower than that of the second season. Therefore, in the second migratory season, Purple Herons should have higher possibility of preying on these seven species than in the first migratory season. Besides, the birds at the breeding area also feed on crustaceans, namely *Metapenaeus sp.*, and reptiles, mainly snakes (*Acrochordidae: Acrochordus javanicus* and *Homalopsinae: Enhydryis enhydryis*) (Kanjanasaka et al. 1987). However, Kanjanasaka et al. (1987) did not provide information on the size of *Metapenaeus sp.*, which is expected to be small in size, and thus, suitable for feeding the chicks but less likely to be the preference of Purple Herons at the migratory areas such as Bung Khong Long Lake.

**Table 38:** Fish and other prey items as food of Purple Herons in different areas worldwide (see also Appendix III)

No.	Area	Group	Common Name	Scientific Name
<b>Fish</b>				
1	Italy	Centrarchidae	Sunfish	Not specified *
2	Not specified	Belonidae, Cyprinidae,	Perca, Anguilla, Acerina, Lota, Mugil	Not specified Not specified
3	Thailand	Cyprinidae	Pale rasbora	<i>Rasbora aurotaenia</i> ( <i>Rasbora retrodorsalis</i> )
		Channidae	Murrel	<i>Channa striata</i> ( <i>Ophicephalus striatus</i> )
		Anabantidae	Climbing perch	<i>Anabas testudineus</i>
		Notopteridae	Bronze	<i>Notopterus notopterus</i>
		Clariidae	featherback	<i>Clarias</i> sp.
		Belonidae	Catfish	<i>Xenentodon cancila</i>
		Aplocheilidae	Freshwater	<i>Aplocheilus panchax</i>
		Mugilidae	garfish Blue panchax Mulletts	<i>Mugil</i> sp.
4	Africa	Clariidae	Catfish	<i>Clarias</i> sp.
		Cyprinidae	Manyame labeo	Not specified
		Cyprinidae	Rednose labeo	<i>Labeo altivelis</i>
		Cichlidae	Greenhead tilapia (Longfin tilapia)	<i>Oreochromis macrochir</i>
		Cyprinidae	Redeye labeo	<i>Labeo cylindricus</i>
		Cichlidae	Redbreast tilapia	<i>Tilapia rendalli</i>
		Alestidae	Spot-tail	<i>Brycinus imberi</i>
5	Southern France	Anguillidae	European eel	<i>Anguilla anguilla</i>
		Centrarchidae	Pumpkinseed	<i>Lepomis gibbosus</i>
		Cyprinidae	Roach	<i>Rutilus rutilus</i>
		Cyprinidae	Crucian carp	<i>Carassius carassius</i>
6	Spain	Cyprinidae	Common carp	<i>Cyprinus carpio</i>
<b>Crustaceans</b>				
1	Thailand	-	-	<i>Metapenaeus</i> sp.
2	Spain	-	Crayfish	<i>Procambarus clarkii</i>
3	Portugal	-	Crayfish	<i>Procambarus clarkii</i>

No.	Area	Group	Common Name	Scientific Name
<b>Insects</b>				
1	Southern France	Larvae	-	<i>Hydrous</i> sp.
		Larvae (Coleoptera)	-	<i>Cybister lateralimarginalis</i>
2	Spain	Gryllotalpidae	-	<i>Gryllotalpa gryllotalpa</i> Not specified
		Orthoptera	-	
		Odonata nymphs (Aeshnidae)	-	
		Aquatic Coleoptera	-	<i>Cybister</i> sp., <i>Dryops</i> sp.
3	Africa	Orthoptera (Acrididae)	-	Not specified
		Odonata (dragonflies)	-	Not specified
<b>Amphibians</b>				
1	Spain	Salamanders	Spanish Ribbed Newt	<i>Pleurodeles waltl</i>
<b>Reptiles</b>				
1	Not specified	Salamanders ( <i>Pleurodeles</i> , <i>Pelobates</i> , <i>Xenopus</i> )	-	Not specified
		Snakes	-	<i>Natrix</i> sp.
2	Thailand	Snakes	-	<i>Acrochordus javanicus</i>
			-	<i>Enhydryis enhydryis</i>
3	Southern France	Snake	-	<i>Natrix maura</i>
4	Spain	Snake	-	<i>Natrix</i> spp.
<b>Birds</b>				
1	Not specified	Rallidae, <i>Tachybaptus</i> , <i>Rallus</i> , <i>Anas</i>	-	Not specified
			-	Not specified
2	Southern France	Passerines	-	Not specified
3	Spain	Rallidae	-	<i>Fulica atra</i>
4	Africa	Ploceidae	Village	<i>Ploceus cucullatus</i>

No.	Area	Group	Common Name	Scientific Name
		-	weaver adults Southern masked- weaver chicks	<i>Ploceus velatus</i>
<b>Mammals</b>				
1	Southern France	Microtidae	-	Not specified

Note: \* Maybe, it is *Lepomis macrochirus* which occurs in freshwater and widely introduced (www.fishbase.org)

Although the number of fish in the second migratory season was higher than in the first season, the actual food on the basis of wet biomass was too low to meet the average food requirement of the maximum number of Purple Herons observed (see Bauer et al. 2005). Considering food from four prey types, they have potential to supply a maximum of four birds out of six observed individuals in early migratory period. In the middle period, the potential food supply could support a maximum of two birds from the observed four individuals. In the late period, the potential food supply could meet the food requirement of two birds observed. The potential food supply is mainly from the seven species of fish and also other fish, whereas the biomass of other prey types is not enough to supply even one bird within the same area. This suggests that the lake has scarce food supply for Purple Herons during the migratory season. It may account for the decline in the number of Purple Herons in the middle and late migratory period. Presumably, the birds may have left Bung Khong Long Lake to other wetlands to forage. Large scale estimation suggests that the total potential within the feeding areas could support a maximum of around 44,280 individuals of Purple Herons in the early period, and 22,140 individuals in the middle and late periods. Thus, theoretically Bung Khong Long Lake seems to have enough carrying capacity to meet the food requirement of Purple Herons during the migratory season. However, the six areas at Bung Khong Long Lake where the birds are frequently observed could support a less number. Therefore, other factors besides food availability may account for a maximum number of birds observed even though the lake seems to have a higher carrying capacity.

Correia (2001) reported that Purple Herons could change the major source of food to crayfish or insect larvae, however, this seems unlikely at Bung Khong Long Lake due to an inappropriate size and abundance of shrimps and insect larvae (Kushlan and Hancock 2005), and when the purpose of hunting is not for feeding their chicks. According to Bauer et al. (2005), Purple

Hérons require around 200 g/day of food to meet metabolic rate of between 4.36 and 5.21 kcal/day (Kendeigh 1970; see Appendix V). Therefore, Purple Herons would prefer catching medium size fish rather than smaller size. Another reason might be due to the profitability of fish for Purple Heron in the foraging area. Campos and Lekuona (2001) suggested that in breeding area, fish size between 1 cm and 12.5 cm has the most profitability than size of 12.5 cm - 25 cm. Similarly, at Bung Khong Long Lake, the observed Purple Heron predated on fish between 5 cm and 12.75 cm which is roughly within the range of medium size fish in the present study, but they were classified as the small size fish in the report of Campos and Lekuona (2000). Moreover, Campos and Lekuona (1997) suggested that Purple Heron captured fish of the size 12.5 cm - 25 cm more often than the size 1 cm - 12.5 cm in breeding areas whereas larger fish were caught in small numbers. Therefore, at Bung Khong Long Lake, the medium size of fish (5 - 15 cm) may be more profitable for Purple Herons since this is not a breeding area, and there is no need to select smaller size fish to feed the young birds. This implies that Purple Herons might have difficulty of consuming and meeting their daily food demand due to preferential size selection. This situation may also be confounded by the fact that fish of the medium size are frequently caught by fishermen operating at Bung Khong Long Lake. Thus, the influence of fishery could be one of the reasons driving the birds away from Bung Khong Long Lake. This suggests that besides food availability other factors may contribute to making accessibility of food resources in the early to middle periods difficult, compelling some birds to leave the lake to other wetlands. Moreover, it could also coincide with the time the birds migrate back to the origins.

### **5.5 Influence of fishery on food supply**

Fishing activity at Bung Khong Long Lake is at its peak in the early morning and afternoon which is likely the same period of feeding activity of Purple Herons (Ward and Zahavi 1973). The fishing activity, especially the movement of boat and its approach closer to the vicinity of feeding area of Purple Herons cause the birds to respond by fleeing (Pierce et al. 1993). According to Erwin (1989), Mueller and Glass (1988), and Watmough (1983) the observed flight reactions occurred between species and habitat. Since the feeding behavior of Purple Herons is sensitive to the disturbance (Tan 2001), the daily approaches of boats to their feeding area are likely to disturb the feeding efficiency (Cooke 1987; Mitchell et al. 1988; Mueller and Glass 1988; Tuite et al. 1984). Thus, disturbance as a result of fishing activity may impact negatively

on the ability of the birds meeting their daily minimum food requirement causing them to leave Bung Khong Long Lake to other feeding areas.

An opportunity of Purple Heron to reach the daily food requirement is likely underestimated. The bird would have about three or more fish when those fish are approximately 13 cm (about 90 g). This was likely underestimated due to sight observations which could cause error. Instead, the bird is likely to catch approximately six or more fish when the average of wet weight of fish was 35.57 g of the average size 14.91 cm as it was measured on fish from Peitz Ponds. Even though the daily food requirement of Purple Heron is about 200 g (Bauer et al. 2005), the maximum food that the bird is able to consume may be higher than the amount of the requirement. In this respect, Grey Heron is an example. The Grey Heron feed on fish of about 1 kg/day in the zoo (Wittig, Zoo of Cottbus, Germany, personal communication) whereas the daily requirement is only 330-500 g (Bauer et al. 2005). Groups of fish and their size that the Grey Heron feed on are similar to the targets of the Purple Heron (Bauer et al. 2005). Thus, this report also implies that Purple Heron is likely to catch fish as much as possible in the natural habitat. With this regard, it can be concluded that the lower chances to catch fish the higher chances to leave the lake.

The species of fish may not have an influence on foraging behaviour of Purple Herons, but density, size, and movement appearance of preys could be more or less attractive to the birds. Even though Kanjanasaka et al. (1987) reported that at least seven species of fish were fed by Purple Heron in breeding area, other species with similar characteristics such as eels have also been reported for other breeding areas on different continents (Barbraud et al. 2001; Hockey et al. 2005; Kushlan and Hancock 2005; Montesinos et al. 2008; Moser 1984). In addition to these seven species of fish, other fish species including *Trichopodus trichopterus* (*Trichogaster trichopterus*) and *Nandus oxyrhynchus* are likely to be food of Purple Herons in Bung Khong Long Lake. This is due to the fact that they exhibit similar behavioural characteristics as those seven species of fish. However, all these species of fish are likely to have been caught by fishermen. Therefore, overfishing may deplete the lake of fish stock and consequently, making it difficult for Purple Heron to catch preferred fish, especially the medium size fish. According to Jewyam (2011) the very large size of fish might not be abundant in this lake owing to overfishing. This supports the hypothesis that the fish size that could support Purple Herons is the medium size fish.

Overfishing in the lake exceeds the capacity of natural production rate (approximately 5.36 g/m<sup>2</sup>) which Bung Khong Long Lake has the potential to produce (Jewyam 2011). This natural production is not sufficient for local use and local demand (950 g/day and 418,300 g/day, respectively; WWF 2007) (Table 34). Catch per unit effort (CPUE) by using gill net is about 246 g/m<sup>2</sup>/day/fisherman (Jewyam 2011, Table 39).

**Table 39:** Fish used and demand of local people in Bung Khong Long Lake

<b>Potential fish yield</b>	<b>CPUE by gill net</b>	<b>Fish used</b>	<b>Fish demand</b>	<b>Fish caught by local people</b>
<b>(g/m<sup>2</sup>)</b>	<b>(g/m<sup>2</sup>/day)</b>	<b>(g/day)</b>	<b>(g/day)</b>	<b>(g/m<sup>2</sup>/day)</b>
5.36	246	950	418,300	66,707
(Jewyam 2011)	(Jewyam 2011)	(WWF 2007)	(WWF 2007)	(Personal interviewed 2010)

On the other hand, the probable availability of medium size fish for Purple Herons (Table 40) is less than the demand of local people. This suggests that Purple Heron may be threatened by overfishing at the feeding area, thus with time, the bird is likely to leave Bung Khong Long Lake to other wetlands. This could be the reason why during the middle and late migratory period, the number of Purple Herons observed were about 1-3 individuals even though there were six individuals in the early period. Carrying capacity of the lake suggests that it could support more than 100 individuals of Purple Herons, but overfishing likely limits the chances of Purple Herons to access to the fish.

**Table 40:** Comparison between the possible availability of fish in the potential feeding areas of Purple Heron, fish demand, and fish caught by local people

<b>CPUE in foraging area of Purple Heron (g/m<sup>2</sup>)</b>			<b>fish demand</b>	<b>fish caught by local people</b>
<b>migratory period</b>	<b>by trap (medium size)</b>	<b>by net bag (small size)</b>		
<b>early</b>	750	1	418,300	66,707
<b>mid</b>	327	3	(WWF 2007)	(Personal interviewed 2010)
<b>late</b>	347	3		

The food supply from other types of preys excluding fish, amphibians, shrimps and insect larvae may be underestimated. Reptiles or little mammals were not taken into account in this study. However, even though Purple Herons can feed on the wide range of preys, amphibians, shrimps and insect larvae found in Bung Khong Long Lake during the birds' migratory seasons seem not



to be sufficient to meet the minimum daily food requirement. Thus, the decline of fish as main food would have more influence on the fluctuation of the number of Purple Herons than the decline of other food sources.

## **5.6 Other factors**

Kushlan and Hafner (2000) suggest that industrialisation, urbanisation, agriculture, and aquacultures are the main factors driving changes in habitats and have influence on the feeding behaviour of birds. Even though these activities do not occur at Bung Khong Long Lake, there is likelihood of increasing fishery and aquacultures in the lake in the future in the quest to meet local demands (Jewyam 2011). In addition, aquatic plants and community of emergent hydrophytes are increasingly spreading in the lake, and may be considered as an obstacle to fishery. Thus, local people may eventually decide to remove them from the lake system. This may lead to habitat disturbance and consequently, rendering the site unsuitable as a temporary habitat for migratory birds including Purple Herons or even a permanent habitat for many diverse groups of animals. This kind of disturbance does not exist in any directives concerning birds' habitat protection; especially there is no habitat directive in Thailand. Even though Purple Herons prefer *Phragmites* reed bed (Hockey et al. 2005) or select old reed bed to nest (Barbraud et al. 2002) in their nesting area, a host of unspecified species of plants and their structures are rather more important for them to camouflage during foraging at migratory sites. A negative impact on Purple Herons due to rapidly declining reed beds, particularly for nesting has been reported by Moser (1984) and Tucker et al. (1994). Moreover, destruction and deterioration in wetlands are also on the increase and this affects the population of Purple Herons in most European countries (Moser 1983; Tucker et al. 1994). Therefore, the disturbance of plants communities in the lake is likely to cause habitat disturbance for the birds.

Besides, drought conditions at the wintering grounds in tropical West Africa also influences decline in population of Purple Herons in Western Europe (Cavé 1983; Den Held 1981). For instance, the population of Purple Herons in Netherlands from 1961 to 1979 decreased significantly and was well correlated with the annual amount of rainfall in West Africa (Den Held 1981).

Conservation of waterfowls and birds in Thailand is done through Ramsar Convention and a fundamental regulation of the Department of National Parks, Wildlife and Plant Conservation

underneath the Wild Animal Preservation and Protection Tax Act B.E. 2535 (A.D. 1992) (DNP 2011). This body regularly monitors the population of Purple Herons each year together with other birds because Purple Heron is one of other protected animals of the avian category in the Wild Animal Preservation and Protection Tax Act B.E. 2535 and 2546 (A.D. 1992 and 2003) (Wildlife Conservation Division n.d.). Nevertheless, the monitoring program in Thailand on migratory birds still lack effectiveness unless the birds are potentially vectors of the H5N1 disease (Amonsin et al. 2008). Moreover, though the Ramsar Convention aims to conserve the wetlands as well as migratory birds, special directives or any habitat regulation for birds are not yet developed. Particularly, wetlands are often seen as an alternative food source for local people. Therefore, several measures on wetland conservation focus on fishery and aquaculture promotion which are under the supervision of the Department of Fishery of Thailand. Meanwhile, non-hunting areas are under the protection measures of the Department of National Parks, Wildlife and Plant Conservation. Most of the measures focus on wild animals and plants species, especially in the forest. Thus, although the migratory birds found at lakes in non-hunting areas are monitored and protected, the duty to preserve these suitable habitats such as emergent hydrophytes communities for these birds, fall outside the mandate of the non-hunting area office. Thus, the two organizations have similar aims with regard to wildlife conservation but different direction resulting in conflicts and gap to conserve migratory birds in the same area. Spatial regulations should be integrated for a given purpose (e.g. habitat conservation for migratory birds). Moreover, an effort to conserve migratory birds will not be successful without the cooperation of other countries. An effective birds monitoring program such as EU directive (Council 1979) is a good example of a strategy for bird conservation at the continental scale. Increasing in the number of Purple Herons in Italy due to long term monitoring program for about four decades is an instance (Fasola et al. 2011). Even though an effort to conserve migratory birds in Asia has been developed through the Partnership for the East Asian-Australasian Flyway since 2006, Thailand only became a new member in 2010 (EAAF 2008).

Conservation on Purple Herons at Bung Khong Long Lake is likely to be overlooked because they are migratory birds. The reduction of the maximum number of the birds at the lake seems unimportant due to their widespread nature throughout Thailand. Thus, monitoring of Bung Khong Long Lake in order to assess whether it still remains to be a suitable habitat for migratory birds has also been overlooked. To conserve these birds at this area could begin with the

suggestion of Kayser (1994), who pointed out that the focus at the initial stages of birds conservation should be on habitat, especially the opportunity to forage on their prey items.

Further advance research is suggested to assess the exact amount of food intake of Purple Herons at migratory areas per day. This could give information how much food they need to store before they migrate back to the origin. Moreover, the energy spend within the lake should be considered. This could also provide information on whether food supply available in the lake is sufficient for the birds to store adequate energy before migrating back so that Purple Herons would not move to other wetlands within the same migratory season, and they are able to preserve more energy. In addition, the impact of overfishing in the lake on food supply for Purple Herons at other wetlands should be considered in order to assess whether habitat disturbance through fishing activity has a direct influence on the fluctuation in the number of Purple Herons, and other migratory birds in general.

## **6. Summary and conclusions**

Bung Khong Long Lake is a wildlife non-hunting area and has been under conservation underneath the Ramsar Convention since 2001. The lake serves as the resting area of migratory birds including Purple Heron, a vulnerable bird in Thailand at the present. The maximum observed number of Purple Herons at Bung Khong Long Lake has declined from 20 individuals in 2004 to 6 individuals in 2011 even though the status has changed from endangered to vulnerable. Therefore, the lake has been hypothesized that there are driving forces influencing the fluctuation in the number of Purple Herons. The driving forces are hypothesized to be the availability of insufficient food supply and the disturbance in food stock of Purple Herons by local fishery at the potential feeding areas in the lake. Particularly, the Purple Herons at Bung Khong Long Lake are likely migrants because the breeding nests could not be found around the lake. For this reason, food supply of Purple Herons in the lake including fish, amphibians, shrimps, and insect larvae which have been reported as main food were investigated in two migratory seasons (first season: October 2009 – April 2010; second season: October 2010 – April 2011). Besides, physical, chemical and biological characteristics at the potential feeding areas of Purple Herons were also observed. The disturbance in food stock of Purple Herons by local fishery was cross checked through questionnaires.

Physical characteristics (water temperature and water level) at the potential feeding areas have not changed over two periods of migratory season of Purple Herons. Moreover, the lake is shallow which is suitable for the birds to search for food in every period (early, middle, and late) of each migratory season. Chemical characteristic (pH) was also constant throughout the migratory seasons. In addition, biological characteristic, especially the structure and diversity of plants serves as a good temporal shelter for Purple Herons during the second migratory season. Thus, these factors have likely not influenced the fluctuation in the number of Purple Herons at Bung Khong Long Lake especially from October 2010 to April 2011.

On the other hand, food supply of Purple Herons considered as total biomass from various prey types influenced the fluctuation in the number of Purple Herons within the second migratory season. Even though the number of Purple Herons did not show a significant decrease over years from 2004 to 2011, within the same migratory season (e.g. October 2010 – April 2011) the numbers reduced from the early period (6 individuals) to the late period (1-2 individuals).

In the early period of the second migratory season, food was available to support approximately a maximum of four Purple Herons whereas the maximum observed number of the bird was six individuals. With this regard, all type of preys (fish, amphibians, shrimps, and insect larvae) that are expected to make the bird meets daily food requirement (200 g/day/individual) are considered. Thus, at least two birds were driven to move away from the lake, subsequently, the maximum number of observed birds was four in the middle period. Yet, the food supply during the middle period was sufficient for two birds, thus, other two Purple Herons were probably driven to move away from the lake similarly in the early period. Subsequently, the observed maximum number of Purple Herons during the late period was two individuals which finally could be supported by the food supply that has more or less similar amount to the middle period. Owing to the decline of food supply from the early to the late period, the number of Purple Herons in the late period is less than the early period despite the number of the birds was expected to remain the same at the lake throughout the migratory season. The medium size fish (5-15 cm) was the major food source; it has higher probability to make Purple Herons meet the daily food requirement.

Fish stock depletion by overfishing in the lake has been reported and it is likely to have influence on the fluctuation of the number of Purple Herons during the migratory season, particularly, the depletion in some fish (*Anabas testudineus*, *Channa lucius*, *Channa micropeltes*, *Channa striata*, *Clarias* sp., *Notopterus notopterus*, and *Xenentodon cancila*) which have been reported that Purple Heron feeds on and which of these are local economic targets. Even though *Xenentodon cancila* has not been reported to be caught by local fishermen simultaneously with the scarce availability at the potential feeding areas of the Purple Herons, fish such as *Clarias* sp. and *Notopterus notopterus* may have more influence on the food sources accessibility of the birds due to high frequency of local caught. Moreover, fishing time and fishing activities could disturb the foraging behaviour of Purple Herons at the feeding areas. In this case the birds have been driven to leave the lake to other wetlands.

The study suggests that migratory birds such as Purple Herons at Bung Khong Long Ramsar Site are often overlooked. Even though the vulnerable status of Purple Herons shows an increase in the numbers at the national level, the decrease in the number of these birds at Bung Khong Long Lake may lead to the different level of the Ramsar Site status; this is because the site may not meet the Ramsar criteria. Therefore, the birds monitoring program at Ramsar sites is need to be

seriously developed. Particularly, the conservation measures at each Ramsar site needs the clearer action plans to reduce conflicts between the nature conservation purpose and local wise used purpose.

However, advanced technologies to monitor all kind of migratory birds in all Ramsar sites are expensive. Thus, the long term monitoring program becomes the restriction in Thailand. However, the long term birds monitoring program at Ramsar sites and the global cooperation are still needed so that the appropriate birds and wetlands conservation measures can be developed in the rational direction.

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## **Appendix I**

### **Questionnaire**

## **Questionnaire of fishery production and lake management in Bung Khong Long Lake**

1. Address.....age..... How long do you stay?.....

### **Fishery**

2. How often do you fish in Bung Khong Long Lake?

- Everyday             Three times a week             Twice a week             Once a week  
 Once a month             Once a year             Others

3. How long do you fish per time?

- all day             all night  
 only 3 hours in the morning (from...am to...am)  
 only 3 hours in the afternoon (from...am to...am)  
 more than 2 hours after 6 pm  
 other answer.....

4. How many boats are there at the same time with you when you catch the fish?

- .....normal (every time)  
.....exceptional; max/min (sometimes)

No boats (  you are always alone)

5. What kind of fishing gears do you use? Please draw a picture

- Fish net bag (diameter....., mesh.....)             Net (length.....mesh.....)  
 Fish trap (mesh....length....)             Baited line (length.....)  
 Others (e.g. shrimp trap)

6. What kind of boat do you use for catching fish? And how many do you have?

- A paddle boat....     A boat with motor at the end.....     Others.....     No boat

7. What kind of aquatic fauna do you catch? (Can choose more than one choice)

- Fish             Shrimps             Crabs             Other.....(please specify)

8. Please identify the name of fish that you can catch each time

- 1).....            6).....  
2).....            7).....  
3).....            8).....  
4).....            9).....  
5).....            10).....

9. How much weight of fish can you catch per time, per day, per month and per year?

Fish	<u>weight (kg)</u>	Shrimps.....(kg)	➤ Caught fish in a week.....(kg)
.....	.....	Others.....(kg)	➤ Caught shrimp in a week.....(kg)
.....	.....		➤ Caught fish in a month.....(kg)
.....	.....		➤ Caught shrimp in a month.....(kg)
.....	.....		➤ Caught fish in a year.....(kg)
.....	.....		➤ Caught shrimp in a

10. Where do you usually fish? How often?

- Huai Pong Tao...times   
  Don Seo Tai...times   
  Don Mor Tong...times  
 Ban Chareon Suk...times   
  Noan Eee Yord...times   
  Don Sa Wan...times  
 Other places....., ....times

11. What kind of fish did you catch from each area? How much?

- 1) Huai Pong Tao    name.....amount.....
- 2) Don Seo Tai    name.....amount.....
- 3) Don Mor Tong    name.....amount.....
- 4) Ban Chareon Suk    name.....amount.....
- 5) Noan Eee Yord    name.....amount.....
- 6) Don Sa Wan    name.....amount.....
- 7) Others.....    name.....amount.....

12. How much do you earn from fishing?

.....per day                      .....per month                      .....per year

13. From which one can you earn most?

- Fish           
  Shrimps           
  Crabs           
  Frogs           
  Others

14. Do you think there is difference of amount of fish that you caught in the lake between past 5 years and current?

- Same .....about.....kg (estimated)  
 Different.....  
      decrease.....about.....kg (past).....kg (current)  
      increase.....about.....kg (past).....kg (current)



15. Do you think that something has changed in the lake? (explain)

.....  
.....

15.1  Characteristics  Yes  erosion  constructions  shallower (from sedimentation, drainage, others.....)  others .....(specify)  
 No

15.2  Pollutions  Yes  water  smell  air  noise  others .....(specify)  
 No

16. Have you ever seen some people collecting frogs or toads during evening?

Yes  everyday  No, never (**go to No. 21**)  
 once in a week  
 once in a month  
 other.....(specify)

**If yes please continue from next question**

17. What time do the people normally collect the frogs and toads?

Early morning (6.00-8.00 am)  
 During the day (8.00-18.00)  
 Evening (18.00-20.00)  
 Night (After 20.00)  
 Anytime (not regularly)

18. Do you/they take all frogs and toads to sell or cook at home?

Sell (**go to No. 19**)  Cook at home (**go to No. 20**)

19. How much kilos of frogs and toads do you/they catch per time? And how much do you/they earn from them?

Less than one kilo.....bath  
 Between 1-5 kilos.....bath  
 Between 5-10 kilos.....bath  
 More than 10 kilos.....bath  
 Others.....kilos.....bath

20. Frogs (or toads) which take to cook at home, how much kilos are they?.....(kg)

The rest also sell..... Yes  No

**Birds**

21. Have you ever seen birds hunting in Bung Khong Long Lake?

- Yes       Never

22. Which birds and when have been hunted? (specify also month and time)

.....  
.....

23. What are the measures of preventing birds hunting?

.....  
.....

24. Do you think migratory birds decreased in the past?

- Yes, they are decreasing     No, they are same     No, they are increasing     I don't know

25. Have you ever seen Purple Heron feeding in the lake?

- Yes, they feed in the lake     Yes, but they feed outside the lake

No, I never seen Purple Heron in this area

26. How many individuals of Purple Heron do you usually find in Bung Khong Long Lake?

- 0               3-5               more than 10

- 1-3             5-10             I don't know

**Lake Management**

27. How many times are the reed beds been cut?

- once per month     once per year     other.....(specify)

28. How do the people manage *Phragmites* (common reeds) in the lake?

.....  
.....  
.....

29. Do they have mosquito control management around the lake?  Yes  No

30. Have pesticides been used for insect control in the lake or around the reed beds?

- Yes  No

31. Do you think whether the structure of lake change or not? How? [In terms of landscape, become more tourist area, intensive use, and so on]

- Yes ..... (explain)

No

**Appendix II**  
**Physical and chemical characteristics of Bung Khong Long Lake**

**Abiotic parameters**

**Table 1:** Physical and chemical characteristics of Bung Khong Long Lake during Purple Heron’s migratory season

Station	Parameter	First migratory season			Second migratory season		
		Oct09	Jan10	Apr10	Oct10	Jan11	Apr11
<b>HPT</b>	Water level	1.4	1.1	0.3	1.25	1.08	0.79
	Water temp (° C)	31.5	27	26	28.3	20.95	27.8
	pH	8.7	7.0	6.0	6.0	6.0	6.0
<b>DST</b>	Water level	1.2	0.7	0.3	1.07	0.56	0.55
	Water temp (° C)	29.3	25.5	27	27.9	20.25	27.25
	pH	8.6	7.0	6.0	6.0	6.0	6.0
<b>DMT</b>	Water level	0.8	0.8	0.3	0.7	0.35	0.41
	Water temp (° C)	28.3	23.5	28.5	28.35	21.15	28.65
	pH	8.0	7.0	6.0	6.0	6.0	6.0
<b>BCS</b>	Water level	1.2	1.0	0.9	1.34	0.91	0.70
	Water temp (° C)	31.7	24.0	31.0	29.05	21.55	27.8
	pH	8.9	7.0	6.0	6.0	6.0	6.0
<b>NEY</b>	Water level	1.0	1.0	0.4	1.26	0.95	0.85
	Water temp (° C)	31.7	25.0	29.0	28.25	21.20	28.7
	pH	8.9	7.0	6.0	6.0	6.0	6.0
<b>DSW</b>	Water level	1.2	2.0	0.5	1.57	1.28	1.45
	Water temp (° C)	30.5	25.5	31.0	28.95	21.55	28.55
	pH	8.9	7.0	6.0	6.0	6.0	6.0

## **Appendix III**

### **Purple Heron**

**Table 1:** Purple Heron diet

No.	Group	Type	Size	Amount	Duration	Note	Research by
1	Fish	-	-	-	-	<i>Ardea purpurea manilensis</i> in Thailand	(Round 2008)
2	Frogs	-	-	-	-		
3	Aquatic insects	-	-	-	-		
1	Fish	<i>Esox, Cyprinus, Tinta, Abramis, Scardinius, Perca Anguilla, Acerina, Lota, Mugil</i>	Small to medium	-	Day time	Preferred larger fish	(Kushlan and Hancock 2005)
2	Insects	Beetles, dragonflies, bugs	-	-			
3	Spiders	-	-	-			
4	Crustaceans	<i>Vanna</i>	-	-			
5	Mollusks	-	-	-			
6	Frogs	-	-	-			
7	Salamanders	<i>Pleurodeles, Pelobates, Xenopus</i>	-	-			
8	Lizards	-	-	-			
9	Snakes	<i>Natrix</i>	-	-			
10	Small and juvenile birds	<i>Fulica, Tachybaptus, Rallus, Anas</i>	-	-			
11	Mammals	-	-	-			
1	Fish	Carp ( <i>Cyprinus</i> )	2-5 cm	-	-	In the south of France the most	(Moser 1984)
		Mullet (Mugil)	4-5 cm	-	-		

No.	Group	Type	Size	Amount	Duration	Note	Research by	
		Ells ( <i>Anguilla</i> )	25-35 cm	-	-	important prey		
Year 1998								
1	Fish	<i>Anguilla anguilla</i>	-	31.6%	-	<ul style="list-style-type: none"> <li>• Biomass</li> <li>• Chicks diet</li> </ul>	(Barbraud et al. 2001)	
		<i>Lepomis gibbosus</i>	-	20.9%	-			
		<i>Rutilus rutilus</i>	-	12.5%	-			
2	Insects	<i>Hydrous sp. Larvae</i>	-	18%	-	<ul style="list-style-type: none"> <li>• Mainly consistent nearly 32% of the biomass taken</li> </ul>		
		<i>Gryllotalpa gryllotalpa</i>	-	7.8%	-			
Year 1999								
1	Fish	<i>Lepomis gibbosus</i>	-	10.1%	-	<ul style="list-style-type: none"> <li>• Pellet analysis</li> <li>• 34% of the biomass taken</li> </ul>		
		<i>Carassius carassius</i>	-	6.8%	-			
		<i>Anguilla anguilla</i>	-	4.1%	-			
2	Insects	<i>Hydrous sp. Larvae</i>	-	35.6%	-	56% of the biomass taken		
		<i>Gryllotalpa gryllotalpa</i>	-	7.9%	-			
		<i>Cybister lateralimarginalis larvae</i>	-	6.8%	-			
3	Mammals	<i>Microtidae</i>	-	-	-			
4	Birds	<i>Passerines</i>	-	-	-			
5	Reptiles	<i>Natrix maura</i>	-	-	-			
1	Fish	<i>Cyprinus carpio</i>	4-10 cm (2001) 15.5-23 cm (2002)	84.6% 73.3%	Day time	(% of samples-regurgitates) (% of all prey item) *Diet of chicks	(Montesinos et al. 2008)	

No.	Group	Type	Size	Amount	Duration	Note	Research by
2	Insects	<i>Odonata nymphs</i> (Aeshnidae) (Aquatic insect)	-	13.5%		Samples collected from regurgitates 2001-2002 *Diet of chicks	
		Aquatic Coleoptera ( <i>Cybister</i> sp., <i>Dryops</i> sp.)	-	9.6%			
		Orthoptera (Acrididae)	-	2.0%			
3	Amphibians	<i>Pleurodeles waltl</i>	-	5.9%			
4	Crustacean	<i>Procambarus clarkia</i>	-	2.0%			
5	Bird	<i>Fulica atra</i>	-	2.0%			
1	Mammals				7 am -7 pm	Pray size was calculated in relation to the length of the PH's beak (12.5 cm)	(Campos and Lekuona 2001)
2	Reptiles	Only snake ( <i>Natrix</i> spp.)				Study area-an extensive flatland in northern Spain	
3	Amphibians						
4	Fish						
5	Insects						
6	Crustacean	Only Red swamp Crayfish ( <i>Procambarus clarkia</i> )					
1	Crayfish	<i>Procambarus clarkii</i>				Portugal	(Correia 2001)
1	Fish	<i>Rasbora aurotaenia</i>					(Kanjanasaka et al. 1987)
		<i>Notopterus</i>					



No.	Group	Type	Size	Amount	Duration	Note	Research by
		<i>notopterus</i>					
		<i>Ophicephalus striatus</i> *				* Currently is <i>Channa striata</i>	
		<i>Anabas testudineus</i>					
		<i>Clarias</i> sp.					
		<i>Aplocheilus panchax</i>					
		<i>Xenentodon cancila</i>					
		<i>Mugil</i> sp.					
1	Fish	<i>Clarias</i> (catfish)					(Iziko n. d.), (Hockey et al. 2005)
		<i>Labeo altivelis</i> (Manyane labeo)					
		<i>Labeo cylindricus</i> (Redeye labeo)					
		<i>Oreochromis machrochir</i> (Greenhead tilapia)					
		<i>Tilapia rendalli</i> (Redbreast tilapia)					
		<i>Brycinus imberi</i> (Imberi)					
2	Amphibians						
3	Reptiles						
4	Small mammals						
5	Birds	<i>Ploceus cucullatus</i> (Village weaver adults)					
		<i>Ploceus velatus</i> (Southern masked-					

No.	Group	Type	Size	Amount	Duration	Note	Research by
		weaver chicks)					
6	Crustaceans						
7	Insects	Odonata (dragonflies)					

**Table 2:** Purple Heron breeding period

Study Area	duration	Pairs population	Note	Research by
Guadalquivir Marshes, Spain	May-July	1,400-1,500	year 2001	
		1,200-1,300	year 2002	
The Camargue, southern France	April-June	118	year 1979-1982	(Barbraud et al. 2001)
		59	year 1997-1999	
			Breeding numbers in the Camargue represent about 30 - 60% of the breeding population in France	
			Colonies were situated in reed beds of <i>Phragmites australis</i> .	
			3 - 4 eggs were the most common in clutch or colony size	
The northern Spain	April-June	8 colonies, 242 pairs	1994 - 1995	(Campos and Lekuona 2001)
Europe and north Africa	April-May		Colony size depends on marsh area, particularly in reed beds of fewer than 30 - 40 ha. Nests are about 36 cm wide and 18 cm thick. In Europe. PH nests low, lower than expected	(Kushlan and Hancock 2005)
North Asia	June-October			
South Asia and east Java	November-March			
West Java	February-August			

Study Area	duration	Pairs population	Note	Research by
East Africa	April-May		on the basis of its size, 1 - 3 m above the water. When they nest in thickets or mangroves, nests are higher, 3 - 4 m. When nesting in trees, they can be up to 25 m high.	
South Africa	September-October			
			Eggs are laid at 1 - 3 day intervals. Eggs are incubated 25 - 27 days by both parents beginning with the first egg. The young begin to clamber from the nest at 7 - 10 days.	
			Many predators eat chicks, including otter ( <i>Aonyx</i> ), harriers ( <i>Circus</i> ), crakes ( <i>Limnocorax</i> ), and monitor lizards.	
Singapore	April-June		<ul style="list-style-type: none"> <li>- Year - round breeding</li> <li>- Incubation takes about 25 days and the young fledge in about 3 months.</li> <li>- They breed at about 1 year of age, and may live up to 23 years.</li> </ul>	(Tan 2001)
The Netherlands		400-1000	1961 - 1979 - Nests were counted in June in	(Den Held 1981)

Study Area	duration	Pairs population	Note	Research by
			<p>Nieuwkoop, and in breeding season in Maarssen</p> <ul style="list-style-type: none"> <li>- The average total number of breeding pairs in the Netherlands in the period 1961 - 1979 may be estimated, based on these data, to be about 750, the annual numbers fluctuating between 400 and 1000</li> </ul>	
<p>Thale Noi Non Hunting Area, South Thailand</p>	<p>December-July (8 months)</p>		<ul style="list-style-type: none"> <li>- nest size average is 10 cm depth and 48 cm wide and 63.5 cm length.</li> <li>- 2-5 eggs are found in a nest-incubation is about 24-25 days.</li> <li>- the young could go out of the nest after one month</li> </ul>	<p>(Kanjanasaka et al. 1987)</p>
<p>Africa (not specified)</p>	<p>July-February (8 months; egg laying season)</p>		<ul style="list-style-type: none"> <li>- nest is consisted of platform of bent Phragmites reeds or Bulrushes (<i>Typha capensis</i>).</li> <li>- 2-5 eggs</li> <li>- incubation is about 25-27 days</li> <li>- chicks leave the nest at about 20 days old</li> <li>- chicks fledge 10-15 days later (after leave the nest), become fully independent at 55-65 days old.</li> </ul>	<p>(Hockey et al. 2005)</p>

**Table 3:** Number of Purple Herons in migratory periods of year 2009/10 and 2010/11 at Bung Khong Long Lake


<b>Number of Purple Heron in migratory period</b>							
<b>Migratory season</b>	<b>October</b>	<b>November</b>	<b>December</b>	<b>January</b>	<b>February</b>	<b>March</b>	<b>April</b>
<b>Year</b>	6, 1	1, 1	2, 0	1, 0	2, 1	1, 1	1, 1
<b>2009/10</b>							
<b>Year</b>	2, 2, 4,0,2, 3,	1, 0	1, 0	3,2,4,0,3, 1,2,2,2,3,	1, 1	1, 0	2,0,1,2 ,0,0,0,
<b>2010/11</b>	4, 4, 3, 4, 6, 4, 4, 4, 3, 5, 6, 5, 5, 4			2,3, 0, 0,4,1,3,1, 4,4			0,1,1,2 ,1,1,2, 1,1,0,1 ,2,2

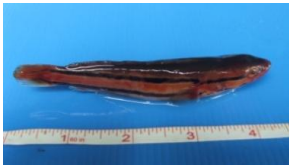





**Note:** The number of Purple Herons in October 10, January 11, and April 11 shows for 20 days. According to observation in these months, observers from Bung Khong Long Non-Hunting Area do not have their own observation. Therefore those numbers are obtained from this study.

## **Appendix IV**






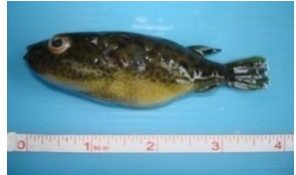

### **Fish and local fishery**









**Table 1:** Fish in Bung Khong Long Lake in migratory seasons of Purple Heron (2009-2011)








Name of fishes (Scientific name)	Migratory season							Picture
	Apr (09)	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)	
<i>Acantopsis choirorhynchos</i>	√	-	-	-	√	√	√	 (S ource: www.fishbase.org)
<i>Anabas testudineus</i>	-	√	-	-	√	√	√	
<i>Barbonymus gonionotus</i>	-	-	-	-	√	-	-	
<i>Betta splendens</i>	√	√	√	-	-	-	√	
<i>Boraras micros</i>	√	√	√	√	√	√	√	
<i>Catopra fasciata</i>	-	√	-	-	√	√	√	
<i>Channa lucius</i>	√	√	√	√	√	√	√	





Name of fishes (Scientific name)	Migratory season							Picture
	Apr (09)	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)	
<i>Channa micropeltes</i>	-	-	-	-	√	-	-	
<i>Channa striata</i>	√	-	√	√	√	√	√	
<i>Chitala ornate</i>	-	-	-	-	√	-	-	
<i>Clarias batrachus</i>	-	-	-	√	√	√	√	  ( Source: www.fishbase.org)
<i>Clarias macrocephalus</i>	-	-	-	-	√	√	√	
<i>Cyclocheilichthys armatus</i>	-	-	-	√	-	-	-	
<i>Dangila</i> sp.	√	-	-	√	√	-	-	Not specified species



Name of fishes (Scientific name)	Migratory season							Picture
	Apr (09)	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)	
<i>Esomus longimanus</i>	-	-	√	-	√	√	√	 <p>(source: <a href="http://www.nonsomboonschool.com/Koodting/P%20Pla.htm">www.nonsomboonschool.com/Koodting/P%20Pla.htm</a>)</p>
<i>Hampala dispa</i>	-	-	√	-	√	-	-	 <p>(from fish trap)</p>
<i>Henicorhynchus siamensis</i>	-	-	-	√	-	√	√	
<i>Indostomus spinosus</i>	-	√	√	-	√	√	√	
<i>Monopterus albus</i>	-	-	-	-	√	-	-	
<i>Monotretete suvattii</i>	-	-	-	√	√	√	√	
<i>Nandus oxyrhynchus</i>	-	√	√	√	√	√	√	

Name of fishes (Scientific name)	Migratory season							Picture
	Apr (09)	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)	
<i>Neodontobutis aurarmus</i>	-	√	√	√	√	√	√	
<i>Notopterus notopterus</i>	-	-	-	√	√	√	√	
<i>Ompok siluoides</i> ( <i>Ompok krattensis</i> )	-	-	√	-	√	√	√	
<i>Osteochilus vittatus</i> ( <i>Osteochilus hasselti</i> )	-	-	-	-	√	-	-	 (s) ource: www.fishbase.org)
<i>Parambassis siamensis</i>	-	-	-	-	√	-	-	 (s) ource: www.fishbase.org)
<i>Puntius partipentazona</i>	√	-	-	-	√	√	-	
<i>Rasbora borapetensis</i>	√	√	√	√	√	√	√	
<i>Rasbora lateristriata</i>	√	-	-	-	-	√	√	

Name of fishes (Scientific name)	Migratory season							Picture
	Apr (09)	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)	
<i>Rasbora daniconius</i> ( <i>Rasbora palustris</i> )	-	-	-	-	√	-	-	
<i>Rasbora paviana</i>	-	-	-	-	√	-	-	 ( Source: www.fishbase.org)
<i>Rasbora tornieri</i>	√	√	-	-	-	-	√	
<i>Rasbora trilineata</i>	√	√	√	√	√	√	√	
<i>Puntius brevis</i> ( <i>Systemus leiacanthus</i> )	-	-	-	-	√	-	-	
<i>Puntius orphoides</i> ( <i>Systemus orphoides</i> )	-	-	-	-	√	-	-	 ( Source: www.fishbase.org)
<i>Tetraodon abei</i>	√	√	-	-	√	-	√	

Name of fishes (Scientific name)	Migratory season							Picture
	Apr (09)	Oct (09)	Jan (10)	Apr (10)	Oct (10)	Jan (11)	Apr (11)	
<i>Trichogaster pectoralis</i>	-	-	-	-	√	√	√	
<i>Trichopodus trichopterus</i> ( <i>Trichogaster trichopterus</i> )	-	√	√	√	√	√	√	
<i>Trichopsis vittata</i>	√	√	√	√	√	√	√	
<i>Xenentodon cancila</i>	√	√	√	-	√	√	√	

**Table 2:** Species of fish which have been caught by local fishermen who catch fish everyday

No.	Species of fish	Frequency of catching by local fishermen
		(Number refers to the number of fishermen from total number of who do fishing everyday, n = 21)
1	<i>Hampala dispar</i>	13
2	<i>Notopterus notopterus</i>	12
3	<i>Osteochilus hasselti</i>	11
4	<i>Channa striata</i>	10
5	<i>Oreochromis niloticus</i>	9
6	<i>Barbodes gonionotus</i>	9
7	<i>Clarias</i> sp.	8
8	<i>Channa lucius</i>	7
9	<i>Henicorhynchus siamensis</i>	3
10	<i>Poropuntius melanogrammus</i>	3
11	<i>Pla Kao Pak Ban</i> (Unknown)	2
12	<i>Cyclocheilichthys apogon</i>	2
13	<i>Channa micropeltes</i>	2
14	<i>Osteochilus lini</i>	2
15	<i>Oxyeleotris marmoratus</i>	2
16	<i>Macrogathus siamensis</i>	2
17	<i>Proparbus jullieni</i>	1
18	<i>Trichogaster pectoralis</i>	1
19	<i>Systomus partipentazona</i>	1
20	<i>Labeo rohita</i> ( <i>Rohita rohita</i> )	1
21	<i>Monopterus albus</i>	1
22	<i>Ompok krattensis</i>	1
23	<i>Anabas testudineus</i>	1

## **Appendix V**

### **Energy requirement of Purple Heron**

The logarithmic forms of the allometric equations representing the variation at 30 °C of existence metabolism as a function of weight for non-passerine species by Kendeigh (1970):

$$\log M = -0.2673 + 0.7545 \log W \pm 0.0630 \dots \dots \dots (1)$$

where M = kcal/bird/day, W = weight in grams, and the ± value represents the standard error of the estimate of log M.

**Table 1:** Metabolic rate (logarithmic form) of Purple Heron per day

<b>Purple Heron weight (g):W</b>	<b>logW</b>	<b>0.7545logW</b>		<b>log M (+)</b>	<b>log M (-)</b>
500	6.215	4.689		4.485	4.359
600	6.397	4.826		4.622	4.496
700	6.551	4.943		4.738	4.612
800	6.685	5.044		4.839	4.713
900	6.802	5.132		4.928	4.802
1000	6.908	5.212		5.008	4.882
1100	7.003	5.284		5.080	4.954
1200	7.090	5.349		5.145	5.019
1300	7.170	5.410		5.206	5.080

The minimum metabolism rate of Purple Heron is 4.36 kcal/day when the bird has minimum weight about 500 g. The maximum metabolism rate of Purple Heron is 5.21 kcal /day when the bird has maximum weight about 1,300 g. For weight-range of Purple Herons see Bauer et al. (2005).