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Food Supply of Purple Heron Disturbed by Local Fishing in Bung Khong Long Lake, Thailand

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Abstract

Abundant wetlands are generally considered providing the fundamental niche to multi- diet feeders like Purple Heron (*Ardea purpurea* L) whereas the realized niche may be over-looked. This study hypothesized that the fluctuation of observed number of *A. purpurea* at Bung Khong Long Lake (Ramsar Site) has influenced by local fishing since the maximum number was observed decreasing to 6 individuals between 2009/ 10 and 2010/ 11 even though the status is least concern for the country. Due to its feeding behavior on not specific preys, all possible food sources was sampled following the feeding route of Purple Heron and then was compared with fish-caught by local fishing per day, as well as observed fishing activities to cross check with feeding time of Purple Heron. Field investigation was conducted in early (EP), middle (MP), and late (LP) period of migratory season 2009/ 10 and 2010/ 11 and cross check with the official recorded number of Purple Heron obtained from the Department of National Parks, Wildlife and Plant Conservation, Bangkok. Size and type of preys (seven fish species; medium size ~5- 15 cm) appeared to be the priority preference for Purple Heron's feeding that was sampled higher in 2010/11 compared to 2009/10 migratory season ($p = 0.003$) and also seemed to be the common fish caught by local anglers. In addition, fish biomass has more or less influenced on the frequency of feeding rather than the number of fish and it showed significant highest in EP ($p = 0.002$) and less in LP as well as higher observed-number of Purple Heron in EP than LP. Based on daily required 200g/ day/individual, all food sources (mainly fish) sampling in the field insufficiently played a role as the hypothesized-realized niche for the maximum number of A. purpurea (606.08 g m^{-2} day^{-1}; EP, 256.75 g m^{-2} day-1; MP, and 343.37 g m-2 day^{-1} ; LP, respectively). Whereas, fish caught on the seven species by local anglers resulted around 66,707 g m 2 day^{-1}, which is higher than the hypothesized-realized niche that might push the birds to move out and shift to the better foraging places.

Keywords: Fishery; Foraging; Purple Heron; Ramsar; Wetland

Introduction

Purple Heron (*Ardea purpurea L.*) was globally classified as endangered to vulnerable and currently as least concern in the IUCN red list [1-3]. However, *Ardea purpurea manilensis* in Thailand was noted as vulnerable Sanguansombat [4] and it has been observed in small numbers at Bung Khong Long Lake (Ramsar Site). *A. purpurea* is reported to be commonly found as non-breeding visitor in the suitable environment and habitat across Thailand Robson [5] especially mostly found during the migratory season between Octobers to Aprils. During the migratory season in Thailand, the weather is comparatively warmer than original places in Russia that is the wintertime where they moved from McClure [6]. The non-breeding visitors have moved to join the resident in some areas in the north, northeastern, central, and south of Thailand [5]. Most research on *A. purpurea* were carried out in breeding grounds, thus information on their ecology and feeding behaviors at the migratory areas is still lacking and unclear. An attempt to study the food sources of Purple Heron at the breeding area in the south of Thailand was conducted by Kanjanasaka [7]. Their study serves as basic knowledge of a type of preys preferably fed by the Purple Heron that supported sampling design in this study. *A. purpurea manilensis* at Bung Khong Long Ramsar Site has not yet been clearly defined whether it is the resident or visitor or previously it used to be the visitor and had become resident until present. However, the maximum number observed at this Ramsar Site was ever high up to 20 individuals DNP [8] but there were only 6 individuals observed during migratory season of 2009/10 and 2010/11. The decrease in the maximum number of Purple Herons at Bung Khong Long Lake was hypothesized that has been influenced from local fishing that likely making the birds have difficulty to access to food sources or insufficient food supply or both cases.

Reviewed Literatures

Study Site

Bung Khong Long Lake, the largest freshwater lake (approximately 22. 4 km^2), is located in the Northeastern Thailand (17°18´-17°58´ N and 103°59´-104° E; 160-170 m) and was dominated as the second Ramsar Site in Thailand, whilst it has been also holding the status wildlife non-hunting area in 1982 proclaimed by the Royal Forest Department [9]. The lake has a narrow oxbow shape and has backed up the drainage of streams and rivers especially Songkram River before flooding into Mekong River. Adjacent areas around the lake are paddy fields, Para rubber crops, and local inhabitants. The lake also serves as natural food and income sources for local people living in this area through fishing or wild resource collecting.

Scattered emergent hydrophytes covered water surface in wide area in the lake that becomes an important factor attracting many kinds of animals to survive. They play a role of being habitat and food sources of some fish, invertebrates, little birds, and others, as well as being a pathway for some birds to rest and camouflage during foraging time such as Purple Heron. The lake was eligible for being a Ramsar Site due to the threatened fish species, namely *Betta smaragdina and B. splendens, as well as other crucial fish, such as Kryptopterus bicirrhis and Clarias batrachus* that have been also classified as the national vulnerable species of Thailand [10]. Bung Khong Long also serves as an important habitat of the endemic fish species such as Boraras micros, *Brachygobius sp. , Clupeichthys aesarnensis, Monotrete leiurus (previous named Tetraodon leiurus), Neodontobutis auramus, and Rasbora spilocerca* ONEP [11] Wetlands International [10] and they play significant role as economic fish that provide income to local fishers. Several kind of avian species have been observed at this place both residences and passing- visitors. Some of those birds have been reported as the nationally endangered species including *Ardea cinerea*, *A. purpurea*, and *Milvus migrans*. Some vulnerable species observed at the lake such as *Aythya nyroca* and *Vanellus duvaucelii* [10]. *A. nyroca* has been also globally recorded as a near threatened species and three species are nationally near threatened species namely *Haliastur indus, Nettapus coromandelianus, and Vanellus cinercus* [10].

Food of Purple Heron

A. purpurea has been observed and reported feeding mainly on fish [12-15] but also have other alternative food sources [7,13,14,16-23]. In India, *A. purpurea* has been reported fed on mainly fish about 57%, reptiles 20.57% which are mostly snakes, shrimps and crabs 14.34%, and insects 7.65% [24]. Barbraud [16] reported that *A. purpurea* are able to shift the preys from fish like *Anguilla anguilla, Lepomis gibbosus, Rutilus rutilus* to insects such as larvae of *Hydrous sp*. The study of Kushlan and Hancock (2005) also indicated the group of fish mostly fed by *A. purpurea* included *Esox, Cyprinus, Tinta, Abramis, Scardinius, Perca, Anguilla, Acerina, Lota,* and *Mugil*. However, other food types are included frogs, aquatic insects [16,13-15], shellfish, small mammals, reptiles and small birds Barbraud [15,16]. Kanjanasaka [7] also reported that other food sources found at the breeding areas in Thailand are crustaceans (*e.g. Metapenaeus sp.*) and reptiles (mainly snakes of family Acrochordia e. g. *Acrochordus javanicus and Homalopsinae e.g. Enhydris enhydris*). Crayfish (*Procambarus clakii*) was reported as a major prey for adult *A. purpurea* in Portugal Correia [18] whereas sunfish and insect larvae were reported as a major prey in Italy [25]. Hockey [21] defined mainly fish species fed by *A. purpurea* in Africa comprise with Clarias sp. (catfish), *Labeo altivelis (Rednos Labeo), Labeo cylindricus (Redeye Labeo), Oreochromis macrochir* (*Greenhead Tilapia*), *Tilapia rendalli* (*Redbreast Tilapia*), and *Brycinus imberi* (*Spot-tail*).

According to Kushlan and Hancock [22], *A. purpurea* predate on large fish with size varied between 2 and 35 cm. As well as the study of Moser [23], he reported that Cyprinus of size 2-5 cm, mullet or Mugil of size 4-5 cm, and eel (*Aguilla*) of size 25-35 cm were mainly fed by *A. purpurea* in France. Moltoni [25] also reported the fish of size 2-10 cm were fed by this bird but not mentioned the species or group of fish. However, it is likely possible that Purple Heron feed on the small size of fish because they need such a size for feeding their chicks since most researches were conducted at the breeding grounds [26]. In Thailand, Kanjanasaka [7] reported the fish from 8 families fed by young *A. purpurea* at the nest included *Cyprinidae (Rasbora aurotaenia or Rasbora retrodorsalis), Channidae (Channa striata or Ophicephalus striatus), Anabantidae (Anabas testudineus), Notopteridae (Notopterus notopterus), Clariidae (Clarias sp.), Belonidae (Xenentodon cancila), Aplocheilidae (Aplocheilus panchax), and Mugil sp*.

Food uptake of *A. purpurea* was estimated 200 g per day Bauer [27] that make the bird to meet metabolic rate of between 4.36 and 5.21 kcal per day [28]. Campos and Lekuona [17] suggested that in breeding area, fish size between 1 and 12.5 cm have the most profitability than size of 12. 5 – 25 cm where frequently observed in Bung Khong Long Lake that *A. purpurea* mostly predate on fish size between 5 and 12.75 cm [26]. However, Campos and Lekuona [29] suggested that *A. purpurea* captured fish of size 12.5-25 cm more frequent than the size of 1-12.5 cm in the breeding areas. In case of capturing larger fish, high number of fish is not the matter.

Methodologies

Field Observation

Field investigation was conducted within the area of Bung Khong Long Lake in 2 migratory seasons of year 2009/10 and 2010/11 (October to April). An entire area of the lake was estimated 22.14 km^2 or 22,140 m^2. To make the feeding area comparable with the lake area, gridding was applied for creating a section covering on the body of lake as shown in Figure 1. One grid was counted as 1 unit and the area covered by a half of grid was counted as 0.5 unit, and other proportions depended on the areas presented in the grid. The potential feeding areas of *A. purpurea* were calculated as a proportion of the total area of lake. Abbreviations present in the Figure 1 represent the name of investigated stations (DMT = Don Mor Tong, DST = Don Seo Tai, BCS = Ban Chareon Suk, HPT = Huai Pong Tao, DSW = Don Sa Wan, NEY = Noan Eee Yord).

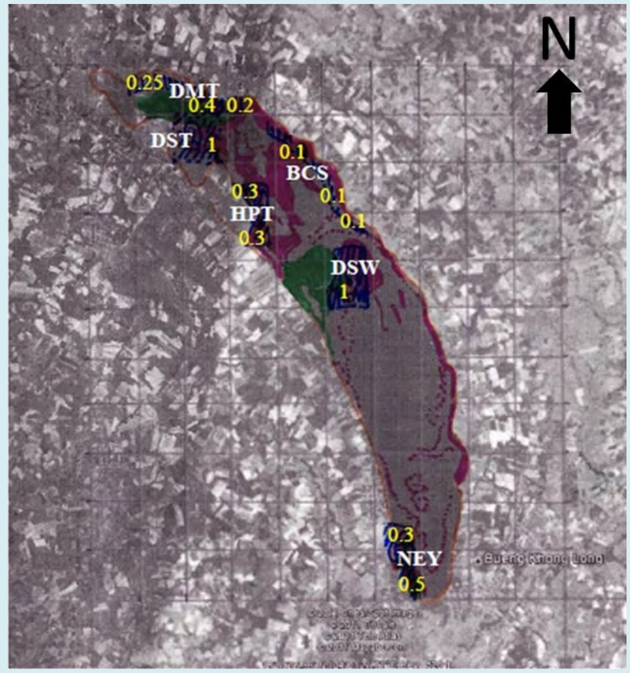

Figure 1: Gridding measurement overlaid on Bung Khong Long Lake created by Kanongdate [26].

All grids were 23.9 units in total covering the entire area of lake. Only 11.5 grids cover the potential feeding areas of *A. purpurea* that implies for about 50% of entire lake (11.07 km^2 or 11,070 m^2). Area size of each station presents in Table 1.

Station	Grids (units)	Calculation	Area size (m2)
Don Mor Tong (DMT)	0.85	(11,070/11.5)x0.85	818.22
Don Seo Tai (DST)	1.00	(11,070/11.5)x1.00	962.61
Ban Chareon Suk (BCS)	0.30	(11,070/11.5)x0.30	288.79
Huai Pong Tao (HPT)	0.60	(11,070/11.5)x0.60	577.57
Don Sa Wan (DSW)	1.00	(11,070/11.5)x1.00	962.61
Noan Eee Yord (NEY)	0.80	(11,070/11.5)x0.80	770.09

Table 1: Area size in approximately at each station of the potential feeding areas of *A. purpurea*

Bird observation in the field aimed to investigate on feeding behaviors, time- spent on predation, a pathway, and frequency of visiting at the potential feeding areas within the lakes (when applicable). However, the observation was conducted manually with limited resources that we therefore spent time for this activity only in 20 days between 7.00

am and 6.00 pm during October 2010-April 2011. Mainly primary data on the bird regular observation obtained officially from Bung Khong Long Non-Hunting Area Office and the Department of National Park Wildlife and Plant Conservation Thailand.

Fish Sampling

Due to the shallow areas (water level less than 1. 5 m) characterized around the potential feeding stations, fish traps and fish net-bags were applied in this study during the 2 migratory seasons of *A. purpurea* at Bung Khong Long Lake between 2009/ 10 and 2010/11. A sampling was conducted in 3 periods (early period (EP) in October; middle period (MP) in January; late period (LP) in April. Fish identification and counting a number of individuals including wet biomass measurement were done in the field.

Two fish traps at each station were placed in between the hypolimnion and benthic zone by covering with aquatic plants. The mesh size is 4 cm2 and volume of a fish trap is 0.14 m3 (r2 x length x number of traps, see equation 1). These traps expected to catch bottom feeder fish and living around the hypolimnion zone. Some particular species were expected such as *Anabas testudineus, Channa striata, Clarias sp., Notopterus, and Xenentodon cancila* because they were reported predating by *A. purpurea* in other places. Most of these fish performed economic value for local anglers including *Channa lucius and Channa micropeltes*.

A fish net-bag with a volume of 157 m^3 (r^2 x length x distance, see equation 2) was dragged along the shoreline about 100-200 m of distance at the depth around 30-50 cm at each station. It targeted the small pelagic fish that likely move freely from the surface to the hypolimnion zone.

Volume of a fish trap = πr^2 x length (m) x number of traps 1

= 3.14 x 0.15 x 0.15 x 1 x 2 m^3

= 0.14 m^3

Volume of a fish net-bag = πr^2 x length (m) x distance (m) 2

= 3.14 x 0.5 x 0.5 x 1 x 200 m^3

= 157 m^3

In this study aimed to compare available preys per area that *A. purpurea* likely explored and spent time for foraging rather than the volume of water. Therefore, areas from fishing gears were estimated following equation 3 and 4. The width of a fish net-bag implies the water depth of 50 cm from surface.

Areas of a fish trap= width (m) x length (m) x number of traps 3

= 0.3 x 1 x 2 m^2

= 0.6 m^2

Area of a fish net-bag = width (m) x length (m) x distance (m) 4

= 0.5 x 1 x 200 m^2

= 100 m^2

Amphibians, shrimps, and insect larvae were also sampled in addition at the same station of fish sampling within the area of approximately 25 m^2. However, they were not the focus as the major preyfor *A. purpurea* in this study.

Fish catch by local anglers was collected data through interview from 82 local fishers who do fishing every day.

Data Analysis

The biomass of preys was analyzed compared with the daily requirement of *A. purpurea* (200 g/day/individual, Bauer [27], which interpreted the expected number of *A. purpurea* to be available. One-way ANOVA on ranks for non-parametric data was a tool for statistical analysis in this study. It used to measure the difference in number of fish and amphibians between 2 migratory seasons of *A. purpurea* and the difference of total biomass of preys among periods within the second migratory season. Wet weight (g) represented biomass of preys that expected to be food of *A. purpurea* in a day that categorized in 7 types
including:

(1) All preys
(2) All fish of size between 5-15 cm
(3) All fish of size less than 5 cm
(4) Only Seven species of fish (*Anabas testudineus*, *Channa striata*, *Channa Lucius*, *Channamicropeltes, Clarias* sp., *Notopterus notopterus*, and *Xenentodon cancila*) of all size
(5) Amphibians
(6) Shrimps
(7) Insect larvae

Results

Purple Heron Observation

Six individuals of *A. purpurea* were observed as the maximum in both migratory seasons in EP (October). The numbers decrease to one in the MP (January) and LP (April) of the first migratory year, and decrease to four in the MP and two in LP of the second year. A pathway of *A. purpurea* for foraging from 7 am to 6 pm in Bung Khong Long Lake was shown in Figure 2. DST was the station observed the mostvisiting frequency by *A. purpurea* (65%) follow with HPT 60%, DST 50%, DMT 15% within 20 days. The pathway for foraging within Bung Khong Long Lake of *A. purpurea* was observed for 3 patterns Figure 2. ***Pattern 1:*** the bird from HPT moved to small patches of floating plants nearby for a while then moved ahead to BCS and sometimes to DST. Then, the bird moved further to DMT or returned to the floating plants nearby HPT. It moved back to HPT before DSW in the evening of the day. ***Pattern 2:*** the bird started their fly from DSW and directed to HPT and after that, it followed the pattern 1. ***Pattern 3:*** the bird started from the floating plant in between HPT and DSW namely Lad Taae which was excluded as a sampling station in this study. This pattern the bird took quite long distance directed to the north of the lake at DST or DMT and then followed the same pathway of pattern 1. During the observation period for 20 days, we did not find any *A. purpurea* at NEY.

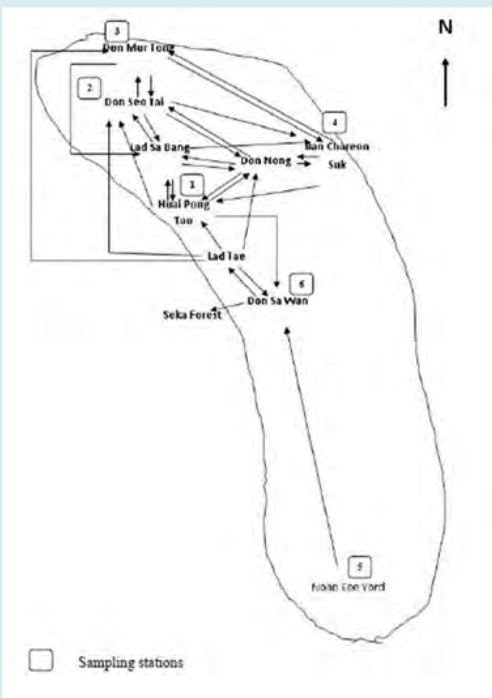

Figure 2: A foraging pathway of *A. purpurea* observed in Bung Khong Long Lake [26].

Foraging behavior of *A. purpurea* observed at Bung Khong Long Lake during its migratory season was not much different from other reports at the breeding grounds. It was habitually standing among dense vegetation of reed swamp or emergent hydrophytes for camouflage by making its height to the same level of the vegetation. It normally predated alone, kept a distance from each other, and mostly observed one individual at one station. This bird was sensitive to a motorboat, which used for fishing or commuting in the lake that it had reflection to the noise from the distance approximately 50 meters or less. It also responded to the paddle by moving away to the vicinity or perching on the big tree. It could stand waiting for a prey quite a long time among the reeds and did not move to anywhere at least within 5 minutes. In case it was unable to find a prey, it moved to the distance approximately one meter away from the last point. When it sighted a prey, it took about 10 minutes to rise up head before bend down its neck very fast to catch a single prey. The difference breaking time between first catch and the next was about 5minutes depending on a size of prey that sometimes could be for an hour. It took also about 5 minutes to get a prey in the mouth and swallow. At least *Clarias* sp. of size approximately 5 cm, *Channa* sp. of size 13 cm were observed caught by *A. purpurea* during the observation.

Fish Sampling and other food sources

There were 40 species of fish in total caught in both migratory years (Appendices). In the first year, the number of fish caught less than the second year in all periods (Table 2). *Trichopsis vittata* was the highest number caught in every period of the first year whereas *Channa Lucius* was the highest in the middle period of the second year. *Channa micropeltes and Nandus oxyrhynchus* were highest in LP of the second year. Kruskal-Wallis one-way ANOVA on ranks indicated that the average number of fish per square meter among different periods in both migratory years was significantly different ($p<0.001$). Holm-Sidak one-way ANOVA tested the number of seven fish species (*Anabas testudineus, Channa striata, Channa lucius, Channa micropeltes, Clarias sp., Notopterus, and Xenentodon cancila*) per square meter showing the significant higher numbers in the first year than the second year ($F = 4.545$, $p < 0.05$). In addition, the size of fish from traps was about 10- 30 cm, which was larger than the ones caught by a fish net- bag especially those among seven fish species such as *Channa Lucius*.

Migratory year	EP (October)	MP (January)	LP (April)
2009/10	15	13	15
2010/11	35	22	27

Table 2: The number of fish caught at sampling stations in migratory years of *A. purpurea.*

Kruskal-Wallis one-way ANOVA on ranks resulted that the average of biomass from all prey types was not significantly different among periods ($p<0.001$). However, in EP resulted that the biomass of all prey types was not significantly different among sampling stations ($p < 0.5$), but was significantly different among sampling stations in MP and LP ($p < 0.001$, $p < 0.004$, respectively). This result shows in Figure 3.

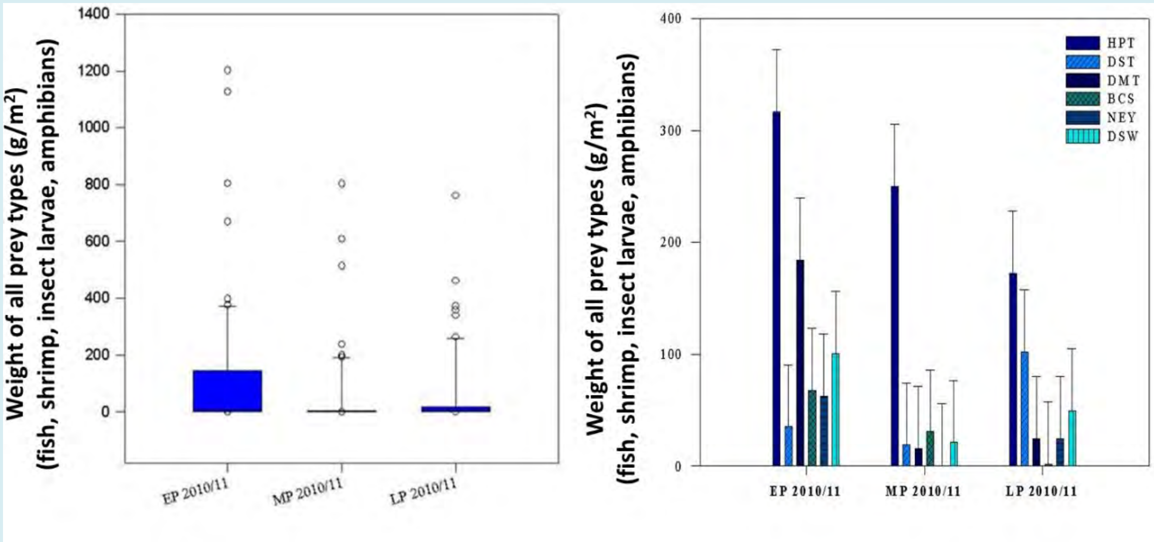

Figure 3: Biomass of all prey types among periods in the second migratory year of *A. purpurea* atBung Khong Long Lake [26].

All fish of size between 5 and 15 cm played a major role for biomass from all preys. The highest biomass of fish was from traps for 750 g/m^2, which caught in EP. The lowest biomass was from insect larvae in all periods, which was less than 1 g/m^2. *Channa lucius* was the highest biomass among other species counted for 345 g/m^2 in EP and LP. The highest biomass of *Channa striata* was measured in MP counted for 160 g/m^2, and of *Channa micropeltes* was counted for 22 g/m^2 in EP. In the MP, *Notopterus notopterus and Xenentodon cancila* had the lowest biomass counted for less than 1 g/m^2. In the LP, *Anabas testudineus* has the lowest biomass counted for 16 g/m^2. In addition, the studied found that the highest biomass of the seven fish species was at HPT station (298 g/m^2 in EP; 187 g/m^2 in MP; 159 g/m^2 in LP). The lowest biomass was measured at DST station in EP counted for 26 g/m^2; at DMT and NEY stations in MP counted for 0 g/m^2; and at BCS station in LP counted for 0 g/m^2. Biomass of the seven fish species and other food sources in the different periods of the migratory season of *A. purpurea* is shown in Table 3.

Fish species	Biomass (wet weight: g/m2)		
	EP (October)	MP (January)	LP (April)
Anabas testudineus	45.50	17.79	15.67
Channa lucius	344.74	61.05	193.33
Channa micropeltes	21.50	0	0
Channa striata	31.35	160.33	53.86
Clarias sp.	81.67	17.5	38.83
Notopterus notopterus	112.67	0.06	41.48
Xenentodon cancila	0	0.02	0
Sum	637.43	256.75	343.37
Shrimp	1.72	0.67	1.21
Insect larvae	0.04	0.01	0
Amphibians	13.48	7.30	23.60

Table 3: Biomass of the seven fish species as a result from sum of six stations in different periods ofthe migratory season of *A. purpurea*

Kruskal-Wallis one-way ANOVA on ranks resulted in the significant difference of biomass ofthe seven species of fish among the periods and highest in EP (p<0. 5). Moreover, the biomass of the seven species of fish was also highest at HPT station (Table 4).

Sampling Station	Migratory period /Weight (g/m^2)		
	EP (October)	MP (January)	LP (April)
HPT	297.83	187.17	158.67
DST	26.00	15.33	96.67
DMT	97.50	0.00	23.83
BCS	65	26.17	0.00
NEY	59.83	0.00	20.83
DSW	91	18.33	43.33

Table 4: Biomass of the seven fish species at sampling stations in different periods of the migratoryseason of *A. purpurea.*

Food supply for supporting the number of *A. purpurea*

Food supply (g/m^2) as categorized in the method was analyzed by comparing with the minimum daily requirement for one individual of Purple Heron (200 g/day/individual, Bauer [27] (Table 5). This is an extrapolation of food available for *A. purpurea* of the migratory season 2010/2011 at Bung Khong Long Lake. Total biomass from all preys was 766.70 g/m^2 suggested that it was likely to make only 4 individuals of *A. purpurea* as the maximum numbers to meet the daily requirement in EP; 337.63 g/m^2 and 375.27 g/m^2 for 2 individuals of *A. purpurea* as the maximum numbers in MP and LP, respectively. This was extrapolated in the same direction when considered only the seven fish species only as a prey.

Category of prey	Extrapolation of number of *A. purpurea* by food suuply/ Periods					
	EP (October)		MP (January)		LP (April)	
	A. purpurea	Wet weight (g/m^2)	*A. purpurea*	Wet weight (g/m^2)	*A. purpurea*	Wet weight (g/m^2)
1. All preys	4	766.70	2	337.63	2	357.27
2. All fish (5-15 cm)	4	750.00	2	327.00	2	347.00
3. All fish (less than 5 cm)	0	1	0	3	0	3
4. Only seven fish species	3	637.43	1	256.75	2	343.37
5. Amphibians	0	13.48	0	7.30	0	23.60
6. Shrimps	0	1.72	0	0.67	0	1.21
7. Insect larvae	0	0.04	0	0.01	0	0

Table 5: Extrapolation of the number of *A. purpurea* due to food supply in different periods of the migratory season 2010/2011 of *A. purpurea*

Local Fishing

Active local anglers responded to the questionnaires for 82 in total. They normally fished at the shallow areas overlapping with the foraging areas of *A. purpurea* around the lake. Out of these numbers, 26 local anglers catch fish every day and this group sample was the focus of analysis. The higher number of anglers have had active fished at 7.00 to 10.00 am and 3.00 to 6.00 pm, the same of active feeding time observed in *A. purpurea*. A common fishing gear used by these anglers was a net, a long-lined-fish hook, a fish trap, a harpoon, and a dip-net. In addition, they widely placed several shrimp traps across the lake. The highest number of local anglers fishing between 4.00 and 10.00 was at DSW and followed at HPT, NEY, DST, and DMT as same as the fishing between 3.00 and 6.00 pm.

Local anglers caught fish for at least 23 species including *Hampala dispar, Notopterus notopterus, Osteochilus lini, Channa stratia, Oreochromis niloticus, Barbonymus gonootus, Clarias sp.,* and *Channa Lucius*. These mentioned species were highly frequency of local catching. The seven fish species caught by the anglers around 66,707 g/m^2 in average per day. Especially, *Notopterus notopterus* was the highest biomass among other fish caught. The high biomass of fish caught by local anglers in particular those seven fish species was higher than what extrapolated to be available for observed numbers of *A. purpurea* in all periods during its migratory season. With regarded to the amount of fish caught by local anglers (66,707 g/m^2/day), it was extrapolated to be supply about 333 individuals of *A. purpurea* following the minimum daily requirement for 200 g/m^2/day [27]. This should be sufficient to support the maximum number of *A. purpurea* (6 individuals) observed during the migratory season, but the observed number of this bird rather decreased to the minimum of one individual throughout the season. It suggested that fishing by local anglers was likely an influence to make *A. purpurea* had difficulty to access to their food supply in this lake. Fish caught per day by local anglers and fish available extrapolation at the feed area were shown in Table 6. In addition, this group of local anglers also hunted the same prey with *A. purpurea* such as frogs or toads. This activity was normally at night that likely caused the reduction in number of these prey for other daytime.

Species of fish	Fish caught by local anglers (g/m^2/day)	Fish available extrapolation for *A. purpurea* (g/m^2/day)		
		EP	MP	LP
Anabas testudineus	1,000	45.50	17.79	15.67
Channa Lucius	12,575	344.74	61.05	193.33
Channa micropeltes	3,348	21.50	0	0
Channa striata	6,848	31.35	160.33	53.86
Clarias sp.	2,450	81.67	17.50	38.83
Notopterus notopterus	40,486	112.67	0.06	41.68
Xenentodon cancila	0	0	0.02	0
Total	66,707	637.43	256.75	343.37

Table 6: Local fish caught and fish available extrapolation in the migratory season of *A. purpurea*

Apart from fishing gears and catching frequency of local anglers, a vehicle such as a motor boat or even non-motor boat was also observed that disturbed *A. purpurea* during foraging time in the Bung Khong Long Lake. *A. purpurea* was sensitive with the noise making by the motor boats from 10-50 meters away. The noise forced the bird to camouflage whereas non-motor boats did not make noise but the angler stood on and move the paddle had driven the bird to also camouflage or move away from the feeding areas.

Discussion

Abundance wetlands especially for those of holding a status as a Ramsar site normally provide enormous food for both resident and migrant birds from all over the world. Bung Khong Long Lake is a Ramsar site in Thailand expected to support the migrant birds during their migratory time such as Purple Herons *(A. purpurea)*. However, the maximum observed numbers of these birds at Bung Khong Long Lake had decreased since 2004 to 2011 [8]. This is probably due to several factors such as mortality at the origins before migrating to the resting areas or during the migration, which has the route from Russia and Northern China to Southern Korea, Thailand, and Malaysia [6]. *A. purpurea* observed in this study at Bung Khong Long Lake was more likely only a migrant group rather than a resident because no breeding nests observed around the lake and vicinity that is in line with Robson [5]. This could be another reason for the small number of individuals observed during the migratory seasons at Bung Khong Long Lake. *A. purpurea* manilensis migrates to join the non-migratory populations in southeast China, Korea, Taiwan, Japan (Ryuku Islands), Pakistan, Thailand, Malaysia, and Indonesia to the Lesser Sunda Islands Kushlan and Hancock [22] but there was no report on the number of individuals visiting at each place including at Bung Khong Long Lake. The migratory route of this bird follows the route of other water birds in South East Asia known as the East Asian-Australasian Flyway EAAF [30] illustrated by Chaibhakdee and Chaibhakdee [31]. Another cause of the decreasing in number of *A. purpurea* could be due to the decreasing trend of a size of the bird's population in Russia since 1994 [32]. *A. purpurea manilensis* observed at Bung Khong Long Lake was also probably decreasing even though this particular subspecies has a different migratory route from other two subspecies [33,34]. Interestingly, the migrant groups from Russia have been reported comparatively lower than the breeders in Singapore that hypothesized the migrants have gradually changed to the residents [15]. Therefore, the decreasing in number of individuals around the world could also influence the maximum observed number of *A. purpurea* at Bung Khong Long Lake but the question of this study was "Why not the number of individuals of *A. purpurea* remain equally from the early to late period of its migratory season at Bung Khong Long Lake?" The finding of this study explained that amount of food supply might not be the cause but the difficulty to access preys was more reasonably. It is in line with the study of Fasola and Alieri [35] that the distribution of heronries was determined by food competition with neighboring heronries which could be local anglers for the case of Bung Khong Long Lake.

According to Kanjanasaka [7], fish species as food of *A. purpurea* at the breeding areas included *Rasbora aurotaenia (Rasbora retrodorsalis) , Channa striata (Ophicephalus striatus) , Anabas testudineus, Notopterus notopterus, Clarias sp., Xenentodon cancila, Alocheilus panchax and Mugil sp*. Five species among these fish were also observed at Bung Khong Long Lake. In addition to *Channa striata, C. lucius and C. micropeltes* were observed at this Ramsar site that were likely possible to be a source of food for *A. purpurea* as same as *C. striata*. These seven fish species could play a major role of being preferable prey of *A. purpurea* at Bung Khong Long Lake, compare to other types of food sources such as amphibians, larvae insects, etc. In addition, other species with similar characteristics such as eels were reported for other breeding areas on different continents [13,16,21-23]. However, specific species for feeding might not be the main factor to make *A. purpurea* meet the daily food require of average 200 g/individual [27], but total biomass of feeding was rather the case that influenced its shifting places of foraging. In this case, it was likely due to higher biomass and larger size of those seven fish species than other preys or due to abundancy of these species, made *A. purpurea* frequently fed on before predated on another prey to full fill the requirement. In this study found that food from all preys per a square meter provided approximately 766.70 g that can support at least 4 individuals of *A. purpurea* in early period of migratory season (EP); 337.63g and 357.27g for at least 2 individuals in MP and LP. It suggested that the reduction in food available at the feeding area had likely influenced the decrease in number of *A. purpurea* actively feeding in the same area throughout the migratory season.

Bauer [27] also reported that Grey Heron (*Ardea cinerea*) required approximately 330-500g a day per individual but the fish to feed for this bird per day was approximately 1,000 g in the Wittig Zoo of Cottbus, Germany. This suggested that the birds including *A. purpurea* needs more food than the average of requirement for feeding per day in the natural environments and likely, more frequent predating the preys or prolong feeding time in case there is scarce food in the feeding areas. We also observed this situation at Bung Khong Long Lake. Frequently observed in this study, *A. purpurea* caught the fish of size between 5 and 15 cm which weight was average of 90 g that it needs at least 3 to 4 fish of this size or more. This could be due to larger size of fish were not abundant at Bung Khong Long Lake as reported in Jewyam [36]. However, the difficulty of get this size of fish could be the reason making the birds spent considerably long at feeding areas and move around from one to other stations all day at Bung Khong Long Lake. Other wetlands close to Bung Khong Long Lake could be alternative food sources for *A. purpurea* such as rice fields [37]. *A. purpurea* starts predating quite early morning and spending time all day until evening Ward and Zahavi [38] that also observed at Bung Khong Long Lake. They were comparatively active quite early morning since before 7.00 to 10.00am and between 3.00 and 6.00pm, which was the same time of higher number of local anglers to do fishing. Since the *A. purpurea* was quite sensitive to the movement of things around [15], fishing activity by boats caused the bird flee Pierce [39] that suggested the disturbance making them difficult to access to food sources [40-43]. Apart from fishing frequency, types and sizes of fish caught by local anglers were mostly the major preys of *A. purpurea* that likely caused overfishing of this size and resulted in only small and medium sizes of fish available in the lake [36]. Jewyam [36] reported that the overfishing in Bung Khong Long Lake was exceeds the capacity of natural production rate (approximately 5.36 g/m^2) that commonly insufficient for local use and demands (950 g/day and 418,300 g/day, respectively) [44]. The catch per unit effort (CPUE) of local fishing by using a gill net was about 246 g/m^2/ day/one local angler [36] that was exceeded the availability for one individual of *A. purpurea* to forage especially when there were high number of local anglers and high frequency of fishing at the same area.

For all these reasons, the difficulty to access to food sources of *A. purpurea* at Bung Khong Long Lake during its migratory season could be influenced by local fishing. It likely caused the decline in number of individuals from early to late period when considering Bung Khong Long Lake as the resting and feeding area since they migrated to the place. However, the fluctuation of number of these birds in vicinity area of Bung Khong Lake was not studied at that time. This is suggested for further studies as well as application of advance technologies to investigate and monitor the birds' behaviors in longer time.

Conclusion

In conclusion, local fishing was our finding in the study that it relatively disturbed the feeding area of *A. purpurea* at Bung Khong Long Ramsar Site, Thailand resulted in the bird had difficulty to access to its prey. Even though this bird species has multi-foraging on several kinds of prey, fish of size between 5 and 15 cm had rather more important for predating in order to full fill daily requirement of approximately 200 g/ day/ individual. Specific species predated by *A. purpurea* from other breeding grounds were also observed abundance in Bung Khong Long Lake especially Anabas testudineus, Channa striata, Channa lucius, Channa micropeltes, Clarias sp., Notopterus notopterus, and Xenentodon cancila which were also reported as major food of this bird in the south of Thailand at its breeding ground. However, a number of fish fed by *A. purpurea* seem not to be a case to explain the decline of its number of individuals from early to late period of the migratory season. Wet weight (g) of fish and other food sources was rather the hint of that situation. In this study we measured biomass of prey from all types mainly fish of size 5-15 cm and found that this food available likely support for 4 individuals of *A. purpurea* in early period (EP) of the migratory season and for 2 individuals in mid and late periods (MP, LP). Meanwhile, the maximum number of *A. purpurea* observed during the study was 6 individuals in EP and became left only 1 in LP, thus insufficient food available was relatively clear as one factor that drove these birds moved out of the lake. In addition to the insufficient food available at the feeding area, local fishing per day suggested that large amount of fish caught per day was exceeded the supply that should make at least one individual of *A. purpurea* met the daily require food. As well as the active time of feeding of *A. purpurea* that was the same time for active fishing with higher frequency of number of local anglers, this rather made the bird had difficulty to access to its prey.

The results of this study suggested that even though the feeding area of the migrant birds is holding a Ramsar site status, which expected to be under conservation programs and provide abundance food, the highly competitive foraging between birds and humans might be overlooked. In particular, with the bird of least concern status globally, its global population was not the problem but it could be one indicator to express the status of its feeding area at the local level especially for the Ramsar wetlands. Therefore, monitoring program of the migrant birds at the resting areas during their migratory seasons should be considered. In addition, advance technology to study food intake of this bird species could be applied regularly at the migratory feeding areas so that the more data collection the more understanding the behaviors of *A. purpurea*, and that can lead to the better conservation program on wetlands in their resting areas during the migratory season.

Conflicts of Interest

This study is a part of dissertation entitled ***Driving forces influencing the fluctuation of the number of Purple Herons (Ardea purpurea) at Bung Khong Long Ramsar Site, Thailand***, graduated for PhD of Environmental Science (General Ecology) in 2012 from Brandenburg University of Technology Cottbus-Senftenberg, Germany. Some results were presented in the virtual annual meeting ESA Conference 3-6 August 2020- Harnessing the ecological data revolution. The presentation titled ***Impact of local fishing on food supply of Purple Heron in Bung Khong Long Lake, Thailand***.

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