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Impact of Water Fluctuation from a Dam on the Mekong River on the Hatching Success of Two Sandbar-Nesting Birds: A Case Study from Bueng Kan Province, Thailand

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Abstract: Dam construction for the provision of hydropower and a stable water supply poses a major threat to freshwater biodiversity. Water fluctuation due to dam management has adverse effects on local people and biodiversity in downstream areas, including sandbar-nesting birds. The aim of this research was to determine the effect of water levels controlled by upstream dams on the breeding success of two sandbar-nesting birds, the little ringed plover, *Charadrius dubius*, and little pratincole, *Glareola lacteal*, along the Mekong River in Bueng Kan Province, Thailand. During January–May 2018, we found 160 active nests of only two species, the little ringed plover (n = 26 nests, 288 exposure days) and the little pratincole (n = 134 nests, 890 exposure days). Their nest success rates were 19.49 ± 7.52% and 5.54 ± 1.61%, respectively. Predation was a major cause of nest failure for both species (n = 82), followed by flooding (n = 44). We found a significantly increased probability of nest flooding when the water level was higher than when the nest was initiated for those located closer to the water, particularly during March and April, when water levels fluctuated. Our results indicate that dams threaten sandbar-nesting species.

Keywords: Mekong River; dam; breeding success; water fluctuation; sandbar-nesting birds

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Citation: Keithmaleesatti, S.; Angkaew, R.; Robson, M.G. Impact of Water Fluctuation from a Dam on the Mekong River on the Hatching Success of Two Sandbar-Nesting Birds: A Case Study from Bueng Kan Province, Thailand. *Water* **2022**, *14*, 1755. https://doi.org/10.3390/w14111755

Academic Editors: Yuankun Wang and Feng Huang

Received: 19 April 2022
Accepted: 27 May 2022
Published: 30 May 2022

1. Introduction

The transboundary Mekong River, which is 4909 km in length, is the longest river in Southeast Asia. A drainage area of ~795,000 km^2 supports unique biodiversity, fisheries, and the livelihoods of more than 300 million people in six countries: China, Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam. The Mekong River encompasses a number of BirdLife International's Important Bird and Biodiversity Areas (IBAs). The river basin is divided into two parts: the Upper Mekong Basin (from Tibet to Yunnan, China) and the Lower Mekong Basin (from Yunnan through the Southeast Asian countries) [1–5]. There are seven operating hydroelectric dams in the Upper Mekong Basin: the first one, the Manwan Hydroelectric Dam, began operating in the Lancang (Mekong) River in Yunnan Province, China, in 1993 [6], and the last one, the Jinghong Hydroelectric Dam, began operating in 2009. In the Lower Mekong Basin, a total of 11 dams have been proposed [7]. Of these, two were completed in 2019: the Xayaburi Hydroelectric Dam in Lao PDR and the Don Sahong Hydroelectric Dam in Cambodia (Figure 1).

Figure 1. Dams and proposed dams on the mainstream Mekong River in 2010. Star (★) represents the location of study area in Bueng Kan, Thailand. Map was adapted from the MRC Strategic Environment Assessment Map [8]. Initially proposed as a 3300 MW project, 465 and 2600 MW options have also been studied.

Many studies have reported that dams threaten fish diversity and aquatic and riverine ecosystems. Artificial reservoirs or impoundments created by dams can be linked to many adverse ecological impacts, such as interruptions in river continuity, downstream flow and water quality, and water level fluctuations [6,9–12]. Artificial flood waves from a dam in the Vistula River, Poland, destroyed the bird nests and hatchlings of many bird species, including those in the Charadriidae and Laridae families, which nest on riverine sandbars [13]. Ground-nesting species of conservation concern recorded in the Mekong River, including the endangered black-bellied tern, *Sterna acuticauda*, the vulnerable river tern, *S. aurantia*, and the near-threatened great thick-knee, *Esacus recurvirostris*, and river lapwing, *Vanellus duvaucelii* [14–16], could potentially face a similar threat from water fluctuations resulting from dam operations. Moreover, dams serve as barriers that prevent fish from migrating upstream to spawning grounds [17]. An evident population decline has been observed in the endemic Mekong giant catfish, *Pangasianodon gigas*, one of the world's largest freshwater fish species [18–21], and in Cantor's giant softshell turtle, *Pelochelys cantorii,* which lays eggs in sandbars [22]. Agricultural areas have also been damaged by water fluctuations (e.g., in December 2013, when the water level fluctuated in a cycle of approximately 10 days, rising 0.5 m daily on three days) [23].

Bueng Kan Province (the study area) is located in northeastern Thailand, bordering Lao PDR. There were some nest monitoring efforts in 2016 and 2017 by a local bird conservation group, Bueng Kan Rak Nok, which found that the little pratincole and little ringed plover were the only species nesting on sandbars along the Mekong River in the area [24]. While the little pratincole is distributed in central and mainland Southeast Asia [25,26], and the little ringed plover is widely distributed in ranges across Europe, Africa, and Asia [27,28], information on their nesting behavior is limited [29]. Moreover, although the little pratincole was listed as a least-concern species globally, according to the IUCN [15,26], the suggested declining population trend in Thailand caused them to be listed as a near-threatened species nationally [30]. In this study, we therefore aimed to document the number of species breeding on the Mekong River sandbar in Bueng Kan Province, Thailand, and to determine their breeding success rates related to the effect of water levels altered by dam management in the upper Mekong River, i.e., the Jinghong Hydroelectric Dam in Yunnan Province, China.

2. Materials and Methods

2.1. Ethics Statement

This study was conducted in accordance with the recommendations of the Wildlife Preservation and Protection Act, B.E. 2535, and the Animals for Scientific Purposes Act, B.E. 2558. The research was conducted with permission from the Department of National Parks, Wildlife, and Plant Conservation, Ministry of Natural Resources and Environment (permit number DNP 0909.6/5222), and the Khon Kaen University Committee on the Ethics of Animal Experiments (permit number ACUC-KKU-15/61).

2.2. Study Site

We studied the breeding ecology of sandbar-nesting birds in the Mekong River in Bueng Kan Province, northeastern Thailand, along the border with Lao PDR (18° 3770′ N, 103°6437′ E to 18°3780′ N, 103°6482′ E), covering an area of ~75 ha, during the breeding season from January to May 2018 (Figure 2). After the Jinghong hydroelectric dam began operating in 2009, the water flow downstream started to fluctuate, particulary during the dry season, when the water level descended to the lowest levels. Jinghong Hydroelectric Dam is the nearest dam in the Upper Mekong River, located approximately 1000 km upstream from the study site, and the dam may affect water levels there. The dams in the upper Mekong River can affect water levels downstream, but these levels can diminish and become insignificant in Mukdahan Province, Thailand (~250 km from the study site) and further downstream [31]. During the study period, the Xayaburi Hydroelectric Dam (~500 km upstream from the study site) was constructed and began operation in 2019.

The sandbar in our study area is present only in the dry season every year, from December to late May, and is normally flooded from June to November [32]. Before the Mekong Dam began operation, February to late April was the period when the river water was at its lowest level. The lowest level, recorded on 9 April 1992, was 1.23 m (a.s.l.). Plant succession in the sandbar began to occur in January, but it was sparse, with Poaceae and Fabaceae as the dominant plant families in the area. Furthermore, the sandbar, which is a site for nesting birds, is used in the Songkran Festival every April and in other tourism events during the dry season.

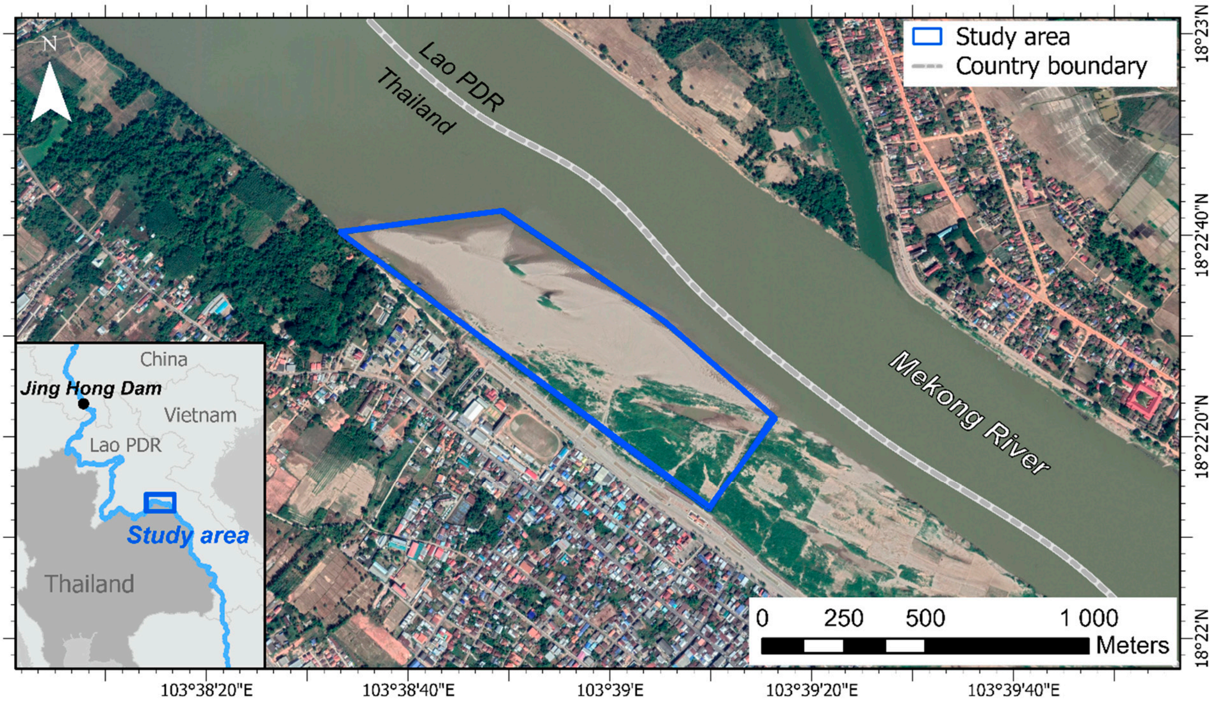

Figure 2. Map showing the location of study area, a sandbar along the Mekong River in Bueng Kan Province, Thailand. In 2018, Jinghong Hydroelectric Dam was the closest upper dam (~1000 km). Satellite-based maps were retrieved from Google Earth Pro, version 7.3.4.8248, and the imagery date was 19 December 2018.

2.3. Finding and Monitoring Nests

During the dry season of the Mekong River (January to May 2018), we systematically searched for nests of sandbar-nesting birds every 2 days, and the little pratincole and the little ringed plover were the only two species found in the area. Once the nests were found, we monitored all nests every 1–2 days, depending on the stage, until failure or success was determined. Successful nests were defined as those where at least one hatchling was observed; unsuccessful nests were defined as those where eggs were destroyed or depredated, or eggs disappeared before the presumed hatching date. Causes of failure (e.g., predation, flooding, abandonment, egg harvesting, and others) were also recorded, if possible. All nest locations were marked with small ribbons and recorded by a Global Positioning System (GPS) unit. The distance from each nest to the river was also measured using GPS. Nest diameters were measured using a measuring tape, and nesting materials and vegetation within about 20 cm around the nest sites were recorded. All eggs were marked with a pencil and measured using a Vernier caliper (±0.01 mm) and weighed on a digital scale (0.01 g). All measurements were conducted in the field.

2.4. Data Analysis

We modeled the daily nest survival rate of the little pratincoles and little ringed plovers using the R program, version 4.1.0 [33] with the RMark package [34]. Due to the small sample size of successful nests, the nest survival rates of the two species were calculated based on nesting periods described in [35]: 21 days for the little pratincole and 26 days for the little ringed plover. In addition, we compared daily survival rates between the two using the program CONTRAST 2.0.

To assess factors influencing the probability of failure due to flooding and predation, we used logistic regression and fit models with binary response variables (not flooded = 0, flooded = 1; not depredated = 0, depredated = 1). The potential factors used in the models were as follows: (1) water levels: weekly average water level (m), fluctuation (presence of rapid changes in daily water levels from nest initiation to nest outcome = 1, absence = 0), difference in water level (m) between nest initiation and nest outcome, maximum water level (m) during observation interval, increase in water level from nest initiation to nest outcome (yes = 1, no = 0); (2) distance to water (m) when nest was first found; and (3) Julian date of nest initiation. Only unsuccessful nests of the little pratincole were used in the models because of an insufficient quantity of the little ringed plover nests. Average weekly water levels were calculated from 7 days before the date when nest outcome was defined (success/failure) using mean daily water levels from the Paksane Hydrological Station, the closest station, located about 5 km away on the opposite side from the study area, in Lao PDR. Data are available on the Mekong River Commission (MRC) website. The data from the dry season on the MRC website, shown in Figure 3, consist of three daily average water levels: (1) between January and May 1992, 2003, and 2016–2021 (only available data), (2) in 1992 (the first year of MRC reporting), and (3) in 2018 (study year). However, rainfall was not included in the models because there was no correlation with water levels ($r = 0.35$). The discarded water and water flow from the Jinghong Hydroelectric Dam, China, were not considered in the models because the data were not reported on the MRC website.

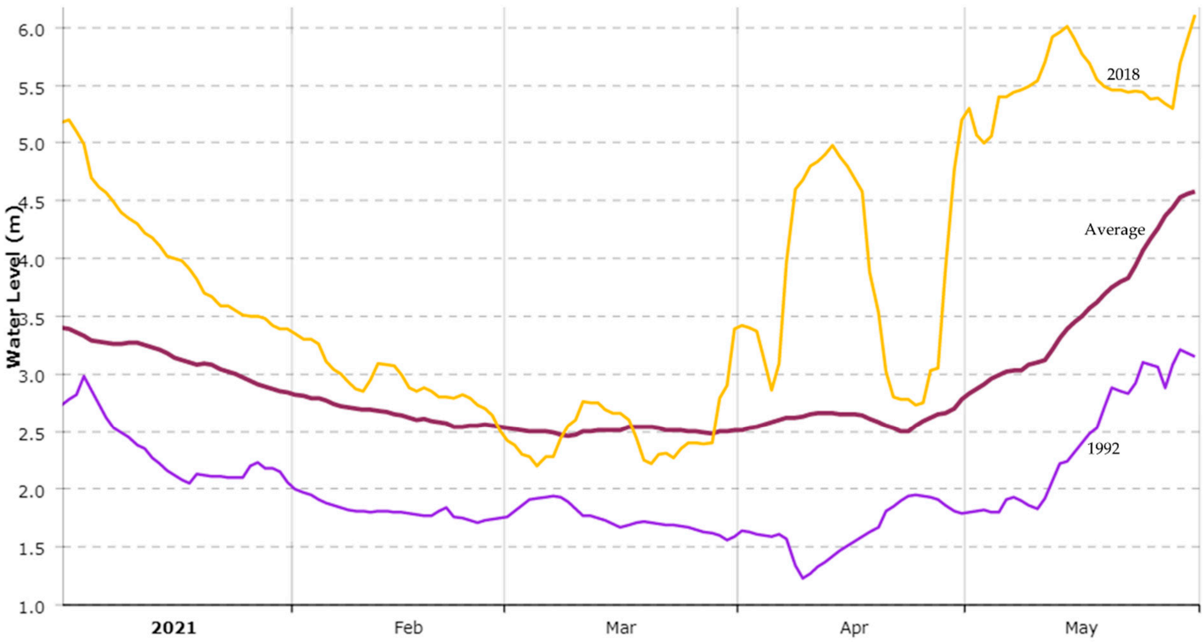

Figure 3. Water levels from January to May 1992 and 2018 and average (only available data in MRC database) at Paksane Hydrological Station, Lao PDR. Maroon line represents daily average water level in 1992, 2003, and 2016–2021 (only available data). Purple and yellow lines represent daily average water level in 1992 (first year of MRC report) and daily average water level in 2018 (study year), respectively. Source: http://ffw.mrcmekong.org/stations.php?StCode=PAK&StName=Paksane (accessed on 1 March 2022).

Prior to running the models, all covariates were standardized by subtracting the mean and dividing the values by two standard deviations [36]. All variables were tested for correlation before running the models, and variables with a high correlation coefficient ($r > 0.6$) were removed and not included in the model to minimize multicollinearity among covariates. To construct the best-fitting model for both model sets, we first fit the models to separately rank the most influential subvariables related to water levels using single variable models. The most influential water level variable, nest distance from water, and the Julian date of nest initiation were then inputted in each model set; in total, there were eight candidate models for both model sets, including the null model. The Akaike information criterion, adjusted for small sample size (AICc), was used for model selection [37]. We used model averaging with the MuMIn package [38] to estimate parameter values if $\geq$1 model was within two ΔAIC of the top model. Egg size and nest diameter were analyzed using descriptive statistics of the mean and standard deviation (SD).

3. Results

3.1. Daily Survival Rates and Hatching Success

During the breeding season, we found 160 active nests of only 2 sandbar-nesting species, the little ringed plover (n = 26 nests, 288 exposure days) and the little pratincole (n = 134 nests, 890 exposure days), at the Mekong River in Bueng Kan Province, Thailand. The nesting periods (calculated from clutches with known initiation and hatching dates) were 22.86 ± 0.40 SE days for the little ringed plover (n = 7 nests) and 18.25 ± 0.85 days for the little pratincole (n = 4 nests). We calculated nesting periods based on hatching success because chicks normally remain in the nest for only one day, and the chicks were all huddled together and cryptic under wood slivers. Here, nesting occurred from mid-January to late April and mid-February to mid-May for the little ringed plover and little pratincole, respectively, and these dates are related to the water dynamics and availability of the sandbar (nesting site) during the dry season. Based on constant models, the daily survival rate of the little ringed plover was 0.939 ± 0.014 SE (95% CI = 0.905–0.961), which translates to 19.49 ± 7.52% nest success. The daily survival rate of the little pratincole was 0.871 ± 0.011 SE (95% CI = 0.848–0.892), or 5.54 ± 1.61% nest success. The daily survival rate of the little ringed plover was significantly higher than that of the little pratincole (χ^2 = 14.587, p = 0.0001).

3.2. Nest and Egg Morphology

The little ringed plovers nested on bare ground with grass and wood slivers. The nest diameter and nest depth (n = 20) were 8.43 ± 2.21 cm and 2.75 ± 0.94 cm, respectively. The clutch size was 2 eggs, ranging from 1–4 eggs *(n = 26)*. Mean egg size (width × length) was 20.49 ± 0.54 mm × 27.41 ± 0.83 mm, and mean egg weight was 5.73 ± 0.39 g (n = 56). Little pratincoles, which are colony nesters, nested on bare ground, and sometimes built nests using grass, plants, wood slivers, and rubbish, such as pieces of plastic buckets and foam. The nest diameter (n = 62) was 9.85 ± 1.75 cm, and the nest depth was 2.28 ± 1.07 cm. The clutch size was 2 eggs, ranging from 1–3 eggs *(n = 134)*. Mean egg size (width × length) was 20.43 ± 0.52 mm × 26.05 ± 1.07 mm, and mean egg weight was 5.60 ± 0.43 g (n = 122).

3.3. Cause of Failure

The little ringed plover nest failures (n = 19) were caused by predation (57.9%), followed by flooding (21.1%), abandonment (15.8%), and other causes (heavy rain, 5.2%). The little pratincole nest failures (n = 120) were caused by predation (59.1%), followed by flooding (33.3%), abandonment (3.3%), egg harvesting by humans (0.9%), and other causes (road kill and sandslides, 3.4%). The only nest depredation evidence observed in the area was from the migratory pied harrier, *Circus melanoleucos*; we observed that this species regularly depredated nests of both the little ringed plover and the little pratincole every morning and evening in February and mid-April, and then disappeared in late April. In addition to predation, which was the main cause of failure, we found that flooding was another significant cause of failure in our study. In contrast, another study conducted along the Mekong sandbar [16] reported much less failure caused by flooding (Table 1).

The probability of nest flooding: The best supported model included the difference in the water level between nest initiation and nest outcome, and the distance from the nest to the water (Table 2 and Figure 4a). The probability of nest flooding increased if the water level was higher than when the nest was initiated (β = 2.605, 95% CI = 1.539–3.834), and decreased when nests were located farther from the water (β = −2.832, 95% CI = −4.742 to −1.232). The probability of nest predation was calculated by averaging the variable with a significantly positive influence on the probability of predation based on the distance from the nest to the water (β = 1.679, 95% CI = 0.356 to 3.000), while the difference in water levels (β = −2.135, 95% CI = −3.230 to −0.971) and the date of nest initiation (β = −1.532, 95% CI = −2.721 to −0.342) were negatively correlated in the model (Table 2 and Figure 4b).

Table 1. Causes of failure of the little ringed plover and little pratincole in this study compared to a study in Cambodia conducted by Claassen et al. [16].

Cause of Failure	Little Ringed Plover		Little Pratincole	
	This Study (*n* = 19 Nests)	**[16] (*n* = 56 Nests)**	**This Study (*n* = 120 Nests)**	**[16] (*n* = 258 Nests)**
Predation	57.9%	61.0%	59.1%	69.0%
Flooding	21.1%	7.0%	33.3%	4.0%
Abandonment	15.8%	5.0%	3.3%	9.0%
Egg harvesting by humans	-	25.0%	0.9%	15.0%
Other (e.g., sandslide, rain)	5.2%	2.0%	3.4%	3.0%
Total	100.0%	100.0%	100.0%	100.0%

Table 2. Logistic regression models of factors related to probability of flooding and predation of little pratincole nests on a sandbar in Bueng Kan Province, northeastern Thailand. Only models with differences in corrected Akaike information criterion (ΔAICc) values < 2.0 are shown. For each model, the number of parameters (K), difference in AICc model scores relative to the top-ranked model (ΔAICc), model weight (w_i), and log-likelihood (LL) are given.

Models [a]	*K*	ΔAICc	w_i	LL
(a) Probability of flooding				
Difference in water level + Distance to water	3	0	0.92	−42.1
(b) Probability of predation				
Difference in water level + Distance to water	3	0	0.59	−50.89
Difference in water level + Julian date	3	0.89	0.38	−51.34

[a] Definitions of model variables: difference in water level (m) between nest initiation and nest outcome; distance to water (m) when nest was first found; Julian date of nest initiation.

3.4. Mekong River Water Level during Dry Season 2018

The water level data of the Mekong River in the dry season were gathered from the Paksane Hydrological Station, Lao PDR, including the time period between 1 January and 31 May 2018. In January, the water level was 5.20 m and rapidly declined until the last week of February to 2.51 m. The water level decreased to its lowest level, approximately 2.20 m, on 5 March. The water fluctuated 4 times from early March to early May. After the lowest level, the water increased to 2.76 m after 6 days and decreased to the lowest level after 9 days. On 28 March, the water level was 2.40 m, and it increased 1.02 m over 4 subsequent days. Then, the water level decreased 0.56 m over 5 days. On 5 April 2018, the water level was 2.86 m, then increased to 4.60 m on 8 April. The data show that the water level rapidly increased by 1.74 m over 3 days, then remained over 4.50 m for 10 days and decreased to 2.73 m after 7 days. On 25 April, the water level was 2.75 m, and then increased to 5.30 m over 7 days and decreased to 5.00 m after 2 days. After 12 days, the water level increased to 6.01 m, which was the highest level in the dry season. However, it then decreased 0.70 m over 14 days. The water level on 28 May was 5.30 m. On the last day of the dry season (31 May 2018), the water level increased to 6.11 m. Moreover, the sandbar at the study site was flooded. A comparison of water levels at Paksane Hydrological Station showed that the pattern of water in the 2018 season was dissimilar to the average of the daily water levels (Figure 3).

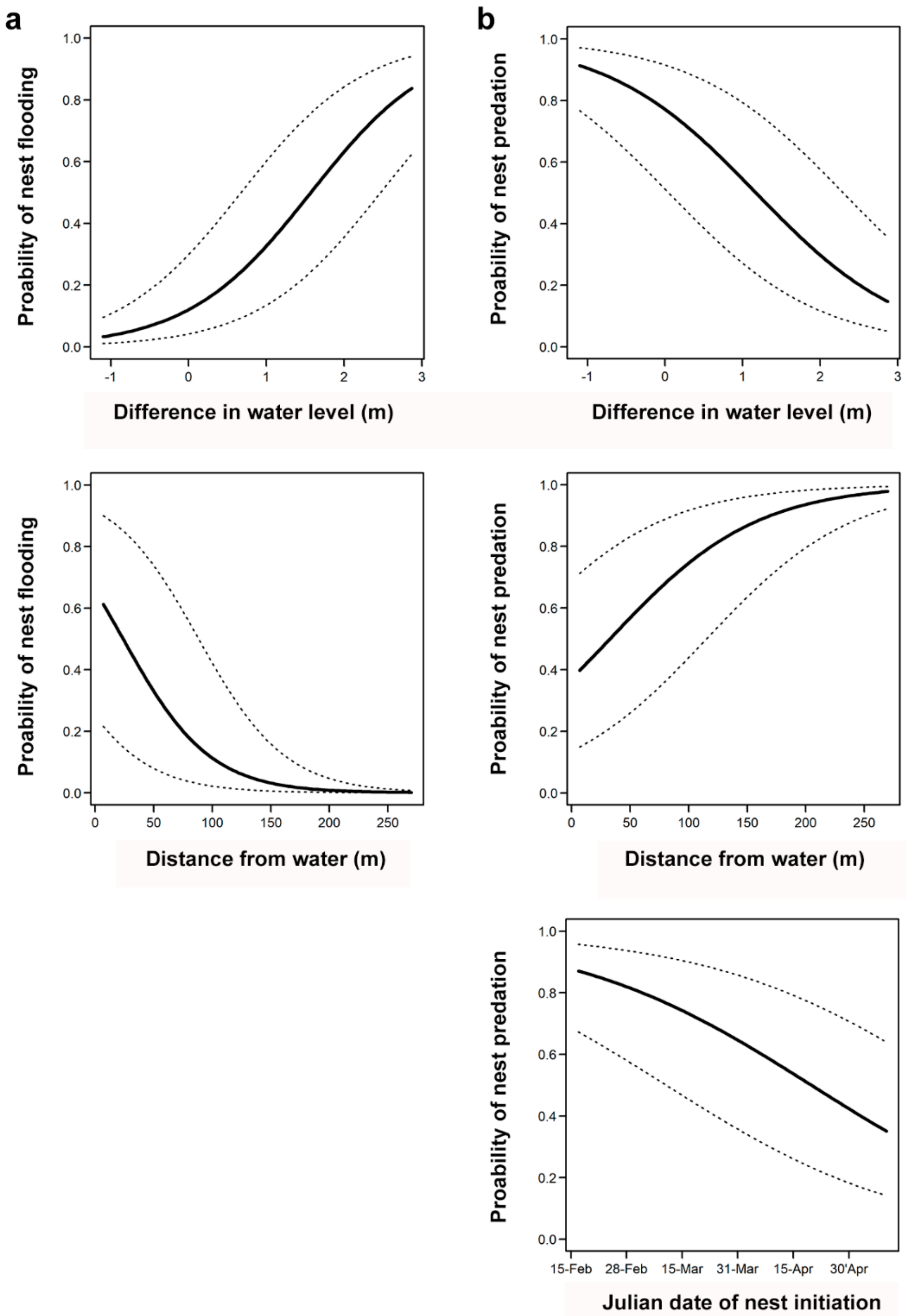

Figure 4. Estimate regression lines for factors influencing probability of (**a**) nest flooding and (**b**) nest predation for the little pratincole on a sandbar in Bueng Kan Province, northeastern Thailand.

The Mekong River water level data showed that rapid fluctuations occurred from late March to late April. The Jinghong Hydroelectric Dam drainage data in the 2018 dry season were not published on the MRC website. However, in Thailand, these drainage data were reported on 5 to 17 April 2018. The drainage of the Jinghong Hydroelectric Dam decreased from 1500 m^3/s to 1000–1200 m^3/s on 9 April and increased to 2000 m^3/s on 17 April [38]. The water fluctuation from March to April was abnormal, based on water level trend data of the Mekong River before 1992, which showed that the water level slowly decreased to its lowest value from March to April and then increased in May. Therefore, we concluded that the water fluctuation in the river between March and April 2018 was related to Jinghong Hydroelectric Dam control.

3.5. Rapid Fluctuation and Nest Flooding

The first little ringed plover nest in the breeding season was found on 18 January, when the water level was 3.91 m. The distance from the first nest to the water surface was approximately 250 m. The bird selected the first level of the sandbar as a nest site. The last nest was found on 20 April, when the water level was 3.02 m. The distance from the last nest to the surface water was approximately 150 m. The average ± SD distance from the nest (n = 21) to the surface water was approximately 115.95 ± 64.02 m. This nest flooded on 12 May 2018, when the water level was 5.92 m. The water level increased 2.90 m in 22 days from 20 April to 12 May. The flooding of the nest was related to the nest's location (distance from the water level). The flooding incident of the little ringed plover nest was discovered to be due to water fluctuations from early to mid-April, because the bird laid the egg in late March, when the water level was less than 3.0 m.

The first little pratincole nest was found on 17 February 2018. The Mekong River water level on that day was 2.85 m. The first distance from the nest to the surface water was approximately 100 m. The peak breeding season in 2018 was between mid-March and April. The first flood occurred in late March, when the water level was between 2.40 and 2.79 m. The two little pratincoles (codes SPR52 and 54) laid their eggs nearly at the edge of the water, at approximately 15.0 m. The first water fluctuation occurred between 29 March and 5 April 2018, and the peak was at 3.42 m on 1 April. Most nests failed due to rapid water fluctuation after 25 April. After 18 April until the end of the breeding season, 52 nests were found and 73.07% of them (38 nests) flooded because the majority of birds laid their eggs after the water level had rapidly declined to a low level (Figure 5).

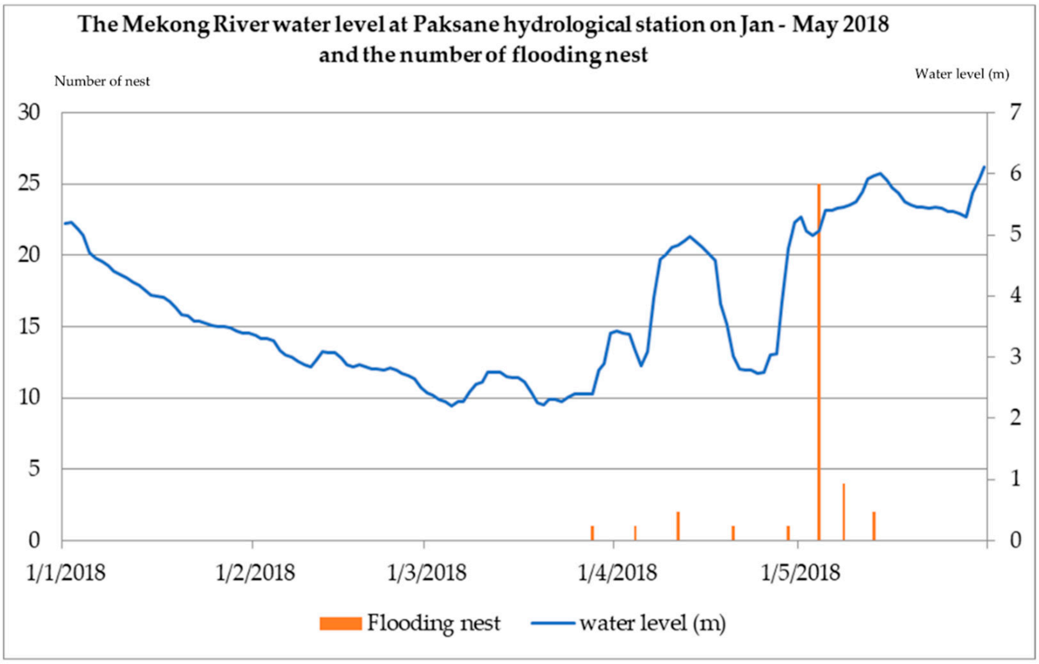

Figure 5. Comparison of water level (m, line) and number of flooding nests (bars) during breeding season of the little pratincole, 1 January to 31 May 2018.

Data for both birds show that the birds selected the sandbar as their nesting site because of the distance to the water's edge, which was 100–200 m, and the distance to the road, which was 200–300 m. However, rapid fluctuation in the Mekong River in April and May was an adverse effect that caused damage to both species that laid their eggs in the sandbar.

4. Discussion

Our findings indicate that the status of sandbar-resident birds in the Mekong River at the Thailand–Lao PDR border is that they are at risk of local extinction. Although the little pratincole and little ringed plover were the only species recorded breeding on riverine sandbars in the area during the study period, four sandbar-nesting species are thought to have bred in the area historically: the nationally threatened great thick-knee, the river tern, and the black-bellied tern, all listed as critically endangered; and the river lapwing, listed as vulnerable [30,39–47]. Most of these species, with the exception of the black-bellied tern, were recorded as breeding along the Mekong River between Stung Treng and Kratie in northeastern Cambodia in 2016 [16,47]. We suspect that the species of sandbar-resident birds have declined, and the causes of the disappeareance of other sandbar-nesting birds are unclear.

The clutch sizes of the little pratincole and little ringed plover were found to be similar to those reported elsewhere: typically 1–3 eggs (average 2) for the former [16,47,48], and 1–4 eggs (average 2–3) for the latter [16,47,49,50]. The bird that laid more eggs in the area in 2018 was the little pratincole, which was the dominant species reported in [16] likely due to it tendency to nest in colony. The sandbar of the Mekong River between Thailand, Lao PDR, and Cambodia is likely an important nesting little pratincole at present. It was reported that egg harvesting by humans and predation were the major causes of nest failure in Cambodia, with nest flooding being a less detrimental threat [51,52]. This is likely due to less fluctuation in downstream water levels caused by upstream dam operation, as evident in Mukdahan Province (~250 km downstream from the study site) [31]. A similar situation was found in the Lapwing River in India, where nest predation and flooding contributed up to 55% and as little as 1%, respectively, of nest failures [53].

In this study, nest flooding was different from in Cambodia [16] in that The flooding rate of the Mekong River in Bueng Kan Province was higher than that reported in the Cambodian study because the Mekong River in Thailand, Lao PDR, and Cambodia had no dams before 2015. Dam control and discarded water were thought to be related to the nesting success of both sandbar-nesting birds. The altered water flow had a negative impact on riverine species and ecosystems, and of 165 studies, 92% reported habitat degradation and biodiversity loss. Moreover, our results support that hydropower development has significant impact on river ecosystems, including freshwater organisms, fish, and birds [54–57].

Our data indicate that natural water flow was altered by dam management in China. The data between January and late May 1992 show that the water level at the Pakse Hydrological Station in Lao PDR was the lowest on 9 April and reached more than 1.50 m prior to the dams construction. In 2003, construction began on the Jinghong Hydroelectric Dam in Yunnan Province, China. The 1750 MW dam became operational in 2008, and it is the nearest Chinese dam upstream of the Thailand–Lao PDR border. After the dam started operating, the water flow impacted the water level and fluctuation in the Mekong River in Myanmar, Thailand, and Lao PDR (Figure 3).

We could not retrieve the weekly data of water discarded from the dams in China on the MRC website. Water fluctuation in the study area was reported widely by the MRC and news outlets. It was reported that the decreased water flow data from the Jinghong Hydroelectric Dam due to power grid maintenance [58].

Water discarded from dams in the dry season of 2018 altered the normal water level patterns in the Mekong River. The rapid fluctuation of water level in April resulting from dam management affected the hatching success of nesting birds that laid eggs in sandbars. We confirmed that hydropower dams have a strong impact on river ecosystems because water management by dams interrupts the natural flow regime. This study shows that dam management in China threatens biodiversity in the Mekong River. There is a transboundary effect on wildlife from the upper stream to the downstream area. Future mainstream hydroelectric dam construction projects on the Mekong River are planned in China, Lao PDR, and Cambodia, and rapid blasting projects are planned in Thailand–Lao

PDR. Additionally, a new Thailand–Lao PDR Friendship Bridge is planned in the Mueang district, Bueng Kan Province. These mega-projects and dams will cause biodiversity loss and negatively impact the ecological services of the Mekong River. Therefore, the Mekong River Commission (MRC) and all nations in the basin should be aware of the development of such mega-projects. All projects should be considered to have a transboundary impact on people and ecosystems downstream.

Management Implications

Our results suggest that water fluctuation by the Jinghong Hydroelectric Dam negatively affected the reproductive success of sandbar-nesting birds. In addition to the effects on aquatic organisms, fish and bird species that depend on sandbar availability need to be considered in conservation management plans, as they are directly affected by rapid changes in water levels due to dam manipulations. Sandbar-nesting bird populations could be a strong indicator of the success or failure of river management practices with regard to biodiversity conservation.

5. Conclusions

The transboundary Mekong River is rich in biodiversity. The river supports food security, water supply, and other ecological services for millions of people in the river basin Mega infrastructure like hydroelectric dam threaten biodiversity and humans in the basin. This study presents another issue regarding the impact of dams on the nesting areas of birds in the Mekong River. Both species of sandbar-nesting birds represent examples of human activity threatening wildlife species in the river. Although the dam is located approximately 500 km upstream from the study area, the results indicate that the birds' breeding success was negatively affected.

Author Contributions: Conceptualization, S.K.; methodology, S.K.; software, R.A.; formal analysis, S.K. and R.A.; writing—original draft preparation, S.K.; writing—review and editing, S.K., R.A. and M.G.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by Khon Kaen University, Khon Kaen, Thailand (grant number 6100151). Support was also received from the New Jersey Agricultural Experiment Station at Rutgers University, NIH-NIEHS P30 ES005022.

Institutional Review Board Statement: The research was conducted with permission from the Department of National Parks, Wildlife, and Plant Conservation, Ministry of Natural Resources and Environment (permit number DNP 0909.6/5222), and the Khon Kaen University Committee on the Ethics of Animal Experiments (permit number ACUC-KKU-15/61).

Informed Consent Statement: Not applicable.

Acknowledgments: We are especially thankful to Aitsaret Boromwit, Noppadol Buaroey, and Ratchaneekorn Buaroey (Bueng Kan Rak Nok group) for the field survey and data. We are grateful to the Department of Water Resources, Ministry of Natural Resources and Environment, for water level data from the Mekong River.

Conflicts of Interest: The authors declare to conflict of interest.

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