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Abundance and habitat suitability of Siamese crocodiles (*Crocodylus siamensis*, Schneider 1801) in Phetchaburi River, Kaeng Krachan National Park, Thailand

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Abstract. *Chanpradub K, Pattanawibool A, Saisamorn A, Bhumpakphan N, Chanthana S, Thongsong C, Ouansing Y, Suksawate W, Sukmasuang R. 2023. Abundance and habitat suitability of Siamese crocodiles* (Crocodylus siamensis, *Schneider 1801*) *in Phetchaburi River, Kaeng Krachan National Park, Thailand. Biodiversitas 24: 4755-4765.* The Siamese crocodile (*Crocodylus siamensis*, Schneider 1801) is one of the critically endangered species with a remnant population reported in Kaeng Krachan National Park. This study aimed to investigate Siamese crocodiles' abundance and habitats along the Phetchaburi River. Thirteen rafting trips from December 2021 to July 2023 were conducted at a total distance of 315 kilometers, recording 68 encounters with an encounter rate of 0.22 per kilometer. It was estimated that the population size of Siamese crocodiles was four individuals. Environmental factors that influenced crocodile distribution, with slope, elevation, forest types, cumulative flow rates upstream, and land use patterns, were identified. These findings underscore the significance of the Phetchaburi River area for freshwater crocodile conservation, as indicated by a highly reliable model with a reliable score of 0.99±0.02. Important recommendations include habitat protection, development of a crocodile threat surveillance system, ongoing population studies, and community involvement, which are essential for sustainable conservation practices, public awareness campaigns, captive breeding and reintroduction programs, and population restoration efforts. This research provides valuable insights into the habitats and environmental factors impacting Siamese crocodiles, highlighting the critical role of preserving Kaeng Krachan National Park as an important habitat for this species.

Keywords: Freshwater crocodile, rafting and spotlight survey, species distribution model, track and sign identification, unmanned aerial survey

INTRODUCTION

The critically endangered Siamese crocodile, *Crocodylus siamensis* (Schneider, 1801), is one of the most threatened crocodilians in the world (Bezuijen et al. 2013; Ihlow et al. 2015; Behler et al. 2018; Platt et al. 2019). Historically, Siamese crocodile was widely distributed across mainland Southeast Asia and on some islands of Indonesia and Malaysia (Platt et al. 2019). Presently, the global population of the species likely consists of fewer than 1000 individuals in the wild (Platt et al. 2019). The Siamese crocodile occurs in slow-flowing rivers, swamps and marshes (Bezuijen et al. 2012; Bezuijen et al. 2013; Sam et al. 2015; Behler et al. 2018; Ratanakorn et al. 2021). It can feed on a variety of prey, including insects, small aquatic animals, fish, reptiles, amphibians, terrestrial animals, birds, aquatic plants, and carcasses (Sam et al. 2015). Thus, it provides a stable balance between producers and consumers of wetlands, rivers, streams, and marshes habitats and is considered a keystone species for the conservation of the wetland ecosystem (Somaweera et al. 2020; Ratanakorn et al. 2021). Nevertheless, this species was driven out of 99% of its former range (Schueman 2023). The main causes of threats to the existence of freshwater crocodiles include habitat loss, poaching, direct persecution perceived as a threat to humans and livestock, incidental take in fishing gear, illegal trade to stock crocodile farms, populations small and isolated (Chitchamnong et al. 2016; Khumseemuang et al. 2019; Platt et al. 2019). They are also affected by the decline of prey species and populations in the wetland bodies and the natural decline in the prey population of other land animals, as well as the degradation of water habitats, pollution, and accumulation of toxins, diseases, and parasites (Bezuijen et al. 2012; Bezuijen et al. 2013). Siamese crocodile is the least-studied freshwater crocodile species in the world (Grigg and Kirschner 2015). Sudrajat and Saleh (2019) reported Siamese crocodile sightings in Lake Mesangat in the areas of Long Balau, Loah Toh, and Abang, Indonesia. A total of 17 individuals with sizes between 30-50 cm were distinguished, living in low current lake waters in depths between 30-110 cm and covered with aquatic plants. Nests were found in the form of plant mounds with an average height of 45 cm and an average width of 75 cm. One has 20 eggs with an average

length of 8.45 cm and an average width of 4.9 cm. Siamese crocodiles used burrows excavated along the banks of rivers or lakes (Platt et al. 2019; Muslim and Suba 2021) with up to five individuals sharing a single burrow. Nesting occurs at the end of the dry season during March and April or the early wet season during May and June, with females constructing a mound nest on mats of floating vegetation or along the banks of lakes and rivers (Sam et al. 2015).

Kaeng Krachan National Park (KKCNP) is the largest national park in Thailand, encompassing an expansive area of 2,914.70 km^2. The park's terrain is primarily characterized by intricate mountain ranges, making it a prominent natural landscape. KKCNP holds the distinction of being registered as a core area within the Natural World Heritage Site (UNESCO World Heritage Centre 2023). One of the park's notable ecological features is its role as a crucial habitat for Siamese crocodiles in Thailand. The lifeblood of KKCNP is the Phetchaburi River and its numerous tributaries, originating from the Tanaosri Mountains located within the park's boundaries. These waterways traverse the central region of KKCNP, forming a complex network of tributaries that offer significant potential as habitats for Siamese crocodiles (Kanwatanakid-Savini et al. 2012). Despite the park's importance in conserving Siamese crocodile populations, there has been a notable absence of studies dedicated to understanding the habitat and ecology within the area. The results of this study provide invaluable insights into the effective management and conservation practices of this endangered species. The purpose of this study was to investigate the abundance and the habitats, the relationship between the presence of the species, and the environmental factors that have a significant effect on the appearance of spatial distribution by surveying the river systemically. The results of this study can, therefore, provide the information needed for species conservation in their natural areas.

MATERIALS AND METHODS

Data collection

The study area was the upper Phetchaburi River from the area of the Khao Panoen Thung Forest Protection Unit to the Mae Saliang Forest Protection Unit (Figure 1). The length of this river section is approximately 35 kilometers. The study area was divided into 160 m x 160 m square grids or pixels, covering rivers, riverside plains, beaches, and forests along the 35-kilometer study route of the upper Phetchaburi River. Field surveys were conducted during the day, including nightly spotlight surveys to detect crocodile eye shine, using both rubber rafts, a 3-4 m long non-motorized canoe-like boat (Figure 2), going along the river at a speed of less than 5 kilometers per hour and walking along the river. Survey stops were selected according to the recorded evidence from the Spatial Monitoring and Reporting Tool (SMART) Patrol system (Wildlife Conservation Society 2023). Surveys were conducted monthly, except during the flooding season. Each survey spanned 4 nights and 5 days. In total, there were 13 surveys conducted between December 25, 2021, and July 19, 2023, each lasting 5 days. Each survey had a minimum duration of 96 hours, resulting in a total of at least 1,248 hours spent on the study. A combination of search methods was employed during both daytime and nighttime, as described by Simpson (2006).

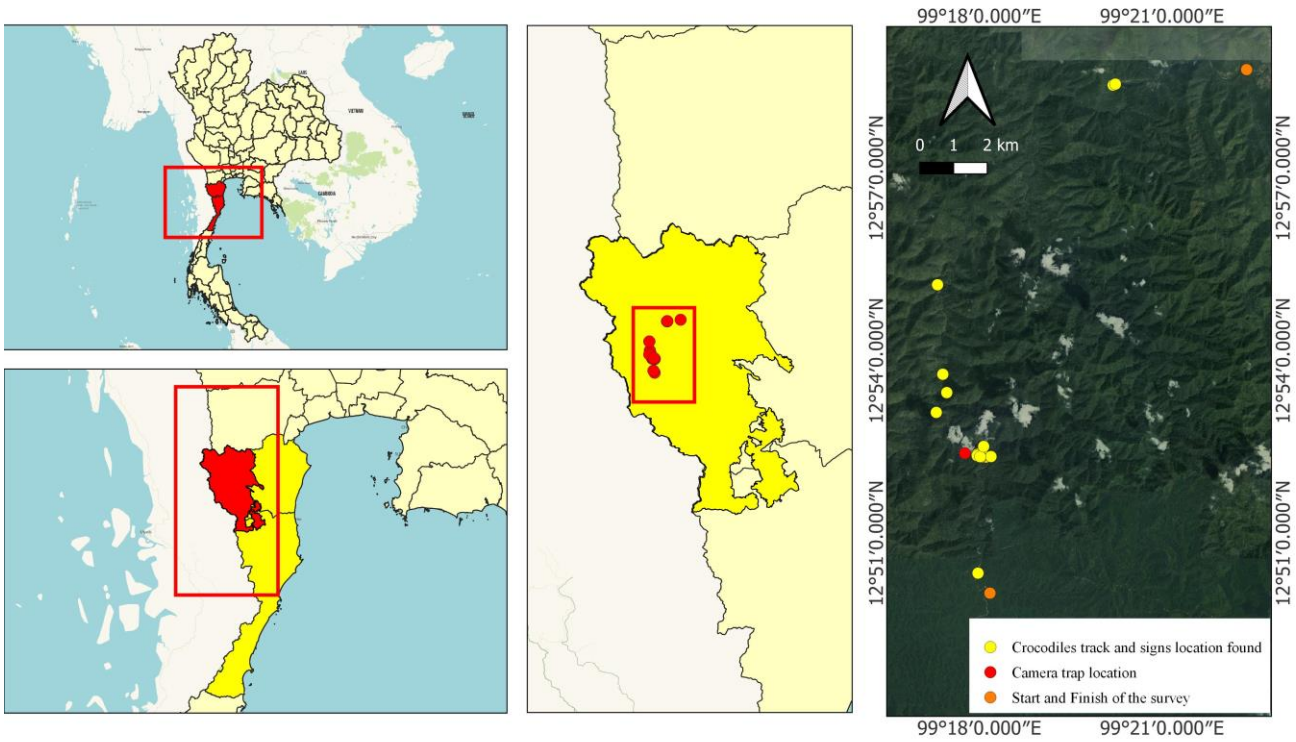

Figure 1. Map of Kaeng Krachan National Park, Thailand as a part of Kaeng Krachan Forest Complex and the location of the study area along the river within the park

Figure 2. Exploration, including rafting and trekking in the area along the Phetchaburi River inside Kaeng Krachan National Park, Thailand

A total of 13 surveys were performed exploring the upper Phetchaburi River from the area of the Khao Panoen Thung Forest Protection Unit to that of the Mae Saliang Forest Protection Unit, adding up to a total length of 315 kilometers, which is similar to the survey method conducted by Behler et al. (2018) to study Siamese crocodiles in the Mesangat Swamp, Kalimantan, Indonesia.

Signs of Siamese crocodiles that were looked for during the surveys include body traces, footprints, crawling and tail dragging marks, dung piles, and nests. When traces of crocodiles are found, measurements including Total Hand Width (THW), Total Hand Length (THL), Total Foot Width (TFW), Total Foot Length (TFL), stride length and straddle width were taken and recorded, as well as the details of the ground or sand where the traces are imprinted. The evidence of traces and signs was identified and photographed with a ruler placed alongside a scale, as described by Simpson (2006). The date, time, and location of these traces were duly recorded. The estimation of the Total Length (TL) was carried out in accordance with the method outlined by Platt et al. in 2020.

When a dung pile was found, photographs were taken with a ruler placed alongside it for comparison of aspect ratios. The geographic position was recorded using a Global Positioning System (GPS) instrument. Additionally, the following details were recorded: date, time, location, surface appearance, and consistency of the dung pile (liquid or solid). Dung color was used to assess the age of the dung pile, and the Maximum Scat Diameter (MSD) was measured according to the method described by Platt et al. (2020).

The crocodile nest will be classified based on Simpson's (2006) observations. It can sometimes be confused with the nests of king cobra (*Ophiophagus hannah*) and wild pig (*Sus crofa*), but it is typically located near waterways. To accurately identify a crocodile nest, we should also be vigilant for other signs of crocodiles in the immediate area, such as crocodile dung or a path leading to the water. Furthermore, it is essential to gather specific information about the nest, including its size, width, and length. Additionally, document the precise location where the nest was discovered. To monitor and gather more data on the nest and its inhabitants, consider installing camera traps in the vicinity.

When a nest was found, detailed photographs of the area were taken and the date, time, and geographic location were recorded. The width, length, height, and diameter of the nest were recorded, as well as the distance from the nearest water source. The type of material used to build the nest was classified. The surroundings of the nest and whether it was exposed to sunlight during daylight hours were recorded in detail. Camera traps were installed near the nest to monitor hatching without disturbance (Sam et al. 2015).

The camera traps used in this study were the Spartan GoCam 4G/LTE and BolyGuard SG2060-D models. They were strategically placed in areas where crocodile activity was observed or expected. These areas included well-used crocodile trails on sandy beaches, rocky beaches, forests along the water's edge, nesting sites, and basking areas, as described in studies by Simpson (2006) and Mohd-Azlan et al. (2016). In total, ten camera traps were deployed for this research, and they were regularly checked at 30-day intervals.

Unmanned Aerial Vehicles (UAVs), also known as drones, have received momentous consideration in different disciplines of wildlife study and management (Gonzalez et al. 2016). A UAV, brand DJI model Mavic AIR 2S, was used to survey following the method of Thapa et al. (2018). The UAVs were flown at an altitude of 90 meters from the ground in the morning (0800-1100) and evening (1500-1700 hours) along the curvature of the river and along the center line of the river with a total path length of approximately 1 km. A uniform average cruise speed of 2.5 meters per second or 9 km per hour with a Ground Sampling Distance (GSD) of 1.30 cm. per pixel was used. The recorded images were used to examine the presence of Siamese crocodiles in detail.

Data analysis

The dung pile diameter was used to calculate the total body length (TL) of the crocodile following the equation reported by Platt et al. (2020) as follows:

$$TL = 131.58 + 70.98 (\log MSD) \pm SE\ 23.73$$

Where:

TL : Length of the body in centimeters

MSD: Maximum scat diameter

The relative abundance of Siamese crocodiles based on camera trap data was calculated from the camera trap images by calculating using the percentage of success in the camera traps each month following the formula of Sollmann et al. (2013), as follows:

$$\text{Relative abundance (\%)} = \left(\frac{\text{Trap success x 100}}{\text{Trap nights}}\right)$$

Where trap success is the number of crocodile images that were recorded, and trap nights are the number of days the camera was left in the total area.

While the relative abundance of Siamese crocodiles was calculated based on camera trap data, the observed data (track signs and dung piles) during the survey were recorded and used to calculate the number of crocodiles observed per kilometer (Ratanakorn et al. 2021).

The distribution of Siamese crocodiles was analyzed using MaxEnt (Phillips et al. 2017), a species distribution model, to quantify the relationship between the occurrences of Siamese crocodiles based on the geographic locations observed in this study using the Geographic Information System (GIS), and the environmental covariates. The suitable habitat was analyzed using a method adapted from Mobaraki et al. (2018), which was used to study crocodiles' suitable habitats in western Iran. The efficiency of the species distribution model was evaluated by taking the predicted value obtained from the model to plot a Receiver Operating Characteristic (ROC) curve to show the predictive performance of the model and calculate the Area Under the Curve (AUC) of the ROC of the model with possible values between 0.0 and 1.0. If the value is close to 1.0, it is reliable. The academic criteria for evaluating the efficiency of the model using the AUC value that if the AUC value is between 0.00-0.09 it means not suitable, 0.10-0.25 means slightly not suitable, 0.26-0.50 means slightly suitable, 0.51-0.74 means moderately suitable, and 0.75-1.00 means very appropriate. In each model, 25% of the total data is allocated for use to test the model performance (test data), which can be used with data on the appearance of wild animals with a large number of samples. The data set is selected from all data at random and without replacement. Numerical map data and parametric variables used in the model for this analysis were 11 relevant ecological and land use factors, namely: (1) Downslope Index, (2) Elevation, (3) non-deciduous forest, (4) Deciduous Forest, (5) Slope, (6) Upstream cumulative flow rate (D8FA), (7) Agriculture Fruit, (8) Agriculture Crop, (9) Horticulture, (10) Downstream cumulative flow rate (DrinffA), and (11) Terrain Roughness Index (TRI).

RESULTS AND DISCUSSION

The 9 rubber rafting field surveys, together with the deployment of 10 camera traps and 5 flights of UAV surveys from January 2022 to December 2022, resulted in a total of 68 Siamese crocodile' encounters. Detailed study results are as follows.

Dung piles

A total of 18 crocodile dung piles were found during the surveys along the river (Figure 3), which had a total distance of 315 kilometers, with a detection rate of 0.05 piles/km. The dung was mainly found on sandy and rocky beaches, which represent the main habitat of Siamese crocodiles along the Phetchaburi River. The results of the number of encounters were similar to the results of the study of Kanwatanakid-Savini et al. (2012), who surveyed crocodiles in the Phetchaburi River by spotlight count at night and interviewed villagers along the Phetchaburi River in Kaeng Krachan National Park between 2009 and 2011, which found that the Siamese crocodiles occasionally used the area in the Kaeng Krachan Dam reservoir. Nevertheless, the crocodiles were not seen directly during the study, and no crocodiles were found in the Mae Pradon River. The traces of crocodiles were found 10 times along the Phetchaburi River and the rate of encounters was less than 0.30 times/km. In this study, dung piles were found 18 times and tracks were found 8 times, adding to a total of 26 times, representing an encounter rate of 0.08 times/km.

Estimated size of the crocodile from the dung pile

From the dung piles found in this study, 2 piles (number S-0106 and S-0203) were in the form of solid lumps and the Maximum Scat Diameter (MSD) was able to be measured and was used to calculate the total body length with dimensions of 40 mm and 24 mm, respectively. The calculated total lengths of the body from the tip of the nose to the tip of the tail were 393.42 cm and 357.16 cm, respectively. The number of Siamese crocodiles in the study area could be confirmed to be at least 2 due to the size of the dung piles differing and being found in distant areas. The length of the Siamese crocodile obtained from this study represents an adult crocodile. Usually, Siamese crocodiles are medium-sized crocodiles. Adult males are reported to reach a total length of 4.0 m, but most are around 3.50 m (Platt et al. 2020).

Footprints

A group of footprints (Figure 3), crawling marks, and tail traces of crocodiles were found along the creek floor. A total of 8 recorded events of footprints were found. The complete print measured 13.2 and 14.5 cm in width and length, respectively. When compared to the total length of the body according to Platt et al. (2020), it was found that the crocodile was estimated to have a total length of 2 meters. The rate of crocodile tracks found was 0.02 times per kilometer.

Crocodile nest and eggs

A nest of Siamese crocodiles was discovered in the Wang Kha area along the Phetchaburi River (Figure 4). The crocodile chose to bite the reeds (*Arundo donax*) in the area into small pieces and then stacked them together until the nest resembled a low hill. Judging by the freshness of the nesting plants. The nest had a diameter of 147 cm and a height of 43 cm. A freshwater crocodile was seen keeping guard near the nest, which accounted for a total of 1 direct count of freshwater crocodile sighting events from the

crocodile surveys. From observation, it was found that the crocodile was about 200 cm in length and about 50 cm in width. A camera trap was installed above the nest to monitor the crocodile's behavior. The camera trap was set to continuously monitor for 4 months, but did not see any hatchlings. A detailed examination revealed 16 crocodile eggs in the nest. However, upon closer examination, it was found that all crocodile eggs found were non-fertile.

The abundance of the crocodile

From the installation of 10 camera traps in 10 locations (see Figure 1) for a period of 242 days, totaling 1,988 trap nights, a total of 41 images, which yielded 33 independent images of Siamese crocodiles, were recorded (Figure 5). The number of Siamese crocodiles in the area was predicted to be only 4 unique individuals based on the camera trap data. The 41 images of Siamese crocodiles were recorded by only 3 camera traps from a total of 10 camera traps installed, representing 30% of the total number of camera trap locations and having a relative abundance of 1.66%.

Figure 3. Mounds of crocodile excrement and crocodile footprints were found in the area

Figure 4. A Siamese crocodile's nest was found and camera traps were placed to monitor hatching activity, as well as the behavior of the Siamese crocodile

Figure 5. Freshwater crocodiles encountered directly and captured by camera traps in the study area

Table 1. The number of flights, distance, duration, number of photos taken, crocodile recorded and the surface of area covered over the Kaeng Krachan River, Kaeng Krachan National Park, Thailand by the UAVs during the study period

Flight_ID	Date	Time	Distance (km)	Flight duration	Total no. of captured photos	Crocodile recorded	Surface area covered (m^2)
Flight_01	Dec 26, 2021	2.10 - 2.25 PM	2.18	15	86	1	6,205.23
Flight_02	Jan 19, 2022	1.20 - 1.35 PM	2.15	15	85	0	6,119.84
Flight_03	Feb 17, 2022	11.15 - 11.30 AM	2.07	14	82	0	5,892.12
Flight_04	Mar 23, 2022	1.30 - 1.45 PM	2.11	15	88	0	6,005.98
Flight_05	Mar 24, 2022	2.00 - 2.14 PM	2.05	14	85	0	5,835.19
Total			10.56	73	426	1	30,058.36

Table 2. Percent contribution and permutation importance between the environmental factors and the Siamese crocodile occurrences

Variable	Percent contribution	Permutation importance
Downslope Index	47.8	17.8
Elevation	24.8	44.2
Non-Deciduous Forest	15.2	22.3
Deciduous Forest	7.9	1.8
Slope	1	0
Upstream cumulative flow rate	1	0.2
Agriculture Fruit	1	0.2
Agriculture Crop	0.7	9.1
Horticulture	0.7	4.4
Terrain Roughness Index	0	0
Downstream cumulative flow rate	0	0

Unmanned aerial survey

From the 5 surveys conducted, which covered a total surveying distance of 10.56 km, with an average flight distance of 2.11 km per flight along the Phetchaburi River, a total of 426 images were recorded covering a total area of 30.05 km^2. When all the photos obtained were classified, One Siamese crocodile could be identified. The details of UAVs are shown in Table 1 and Figure 6.

Habitat suitability of Siamese crocodiles

Considering the results of the study, it was found that the study area along the Phetchaburi River, starting from Thorthip Waterfall, Khao Panoen Thung Forest Protection Unit to Mae Saliang Forest Protection Unit, with a distance of about 35 kilometers, is an area with high levels of ecological factors suitable for the habitat of Siamese crocodiles. The suitable habitats of Siamese crocodiles were categorized into 5 levels: very suitable (red) (1.00-0.75), moderately suitable (yellow) (0.74-0.51), moderately appropriate (green) (0.50-0.26), slightly appropriate (blue) (0.25-0.10) and unsuitable (black) (0.09-0.00). The results of the analysis in Figure 7 show the reliability of the value below the line. The Area Under the Curve (AUC) value is 0.99, which represents a very high level of reliability (Figure 7).

From the results of the MaxEnt model, the environmental variable group that has the most significant impact on the occurrence of Siamese crocodiles is topographic variables, namely, the downslope index followed by the elevation (Table 2). The other contributing covariate is the distance-to-the-nearest forest land cover. For the marginal response of the model, we found that stream downslope index, elevation, and distance-to-the-nearest non-deciduous forest patch are negatively associated with the occurrence of Siamese crocodiles while distance-to-the-nearest deciduous forest patch is negatively correlated with Siamese crocodile's occurrence (Figure 8). These effects are similar in the model representation based on only one corresponding variable (Figure 9 and Figure 10) for downslope index, elevation, and distance-to-the-nearest non-deciduous forest patch, which implies a low correlation of these two distinguishing contributing variables with the others. On the other hand, the pattern of the response curve for distance-to-the-nearest deciduous forest patch was changed from the marginal response, showing an unimodal pattern. This could imply the confounding interaction of this variable with the others.

It can be concluded that the distance from the river is the main factor in determining the habitat suitability of Siamese crocodiles in the Phetchaburi River. This is affected by weather fluctuations, which affect the amount of water in the river. Human activities in the area may cause conflicts between freshwater crocodiles and local communities regarding resources, including cultivation, use of water resources for local fisheries and chemical contamination. They interfere with the freshwater crocodile's journey between separate habitat areas. This is more common in the dry season, especially when there is drought. Increasing monitoring of population dynamics, habitat protection, and population rehabilitation through re-release, as recommended by the IUCN Species Survival Commission (2013) (Guidelines for Reintroductions and Other Conservation Translocations) is urgently needed. Public relations, public education, as well as promoting the participation of local communities in conservation operations are also important for the survival of this species.

Discussion

In this survey, the adult crocodile seen in the marsh area presented with a fat appearance with a length of approximately 2 meters. The adult crocodile in the Wang Kha area was slim and about 2 meters long. The images obtained from both spots were approximately 25 kilometers apart and were within 4 days of each other. Compared with the results of the study of the size of crocodiles from the dung pile, it was found that the total length of the crocodiles was 393.42 cm. and 357.16 cm. The crocodiles were found at a distance of more than 20 km apart. This study found no juvenile Siamese crocodiles or small crocodiles. Although the study confirmed the existence of freshwater crocodile populations of at least 4 individuals,

no juvenile crocodiles were found. Although a nest was found, there were no hatchlings, indicating population instability, and there is a high risk of the population being lost from the area. The report of Ratanakorn et al. (2021) who reported the results of a study on the number and distribution of crocodiles in Bueng Boraphet, Nakhon Sawan Province between November 2017 and August 2018 by flashlight night survey and daytime survey by motorboat, at least 17 crocodiles were found, with a density of 2.24 animals/km^2. The calculated population of crocodiles in Bueng Boraphet is about 17-37 individuals. Human activities directly affect crocodile encounters. Compared to the results of this study, there were very few crocodiles living in the Phetchaburi River. The dung encounter rate was only 0.08 times/km, confirming the population and chances of natural Siamese crocodile population regeneration in the study area. Therefore, knowledge management is an urgent need. In addition, the fish populations in the Phetchaburi River, which are the main prey of Siamese crocodiles, should be studied and used in conjunction with population and habitat management. Furthermore, the study of species and numbers of wild animals living along the river that are likely to be natural prey of crocodiles should also be studied. Chitchamnong et al. (2016) found that the diet items of the crocodile based on the 31 dung piles were fish (64.52 %), followed by Indochinese lutung (*Trachypithecus germaini*) (16.13 %), rat (*Rattus* sp.) (6.45 %), some species of birds (6.45 %), water monitor (*Varanus salvator*) (3.23 %) and crab-eating Macaque (*Macaca fascicularis*) (3.23 %). Understanding the principles and reasons for acceptance by local communities is important for planning the conservation management in Kaeng Krachan National Park, as well as considering the impact of human activities and construction of public utilities that may affect habitats and populations, especially the area along the Phetchaburi River in Kaeng Krachan National Park, which is considered the country's top priority area for Siamese crocodile conservation.

Figure 6. Images from a UAV survey showing the study area and an image of a Siamese crocodile captured during the study on December 26, 2021, at 14:18 hour (2:18 PM)

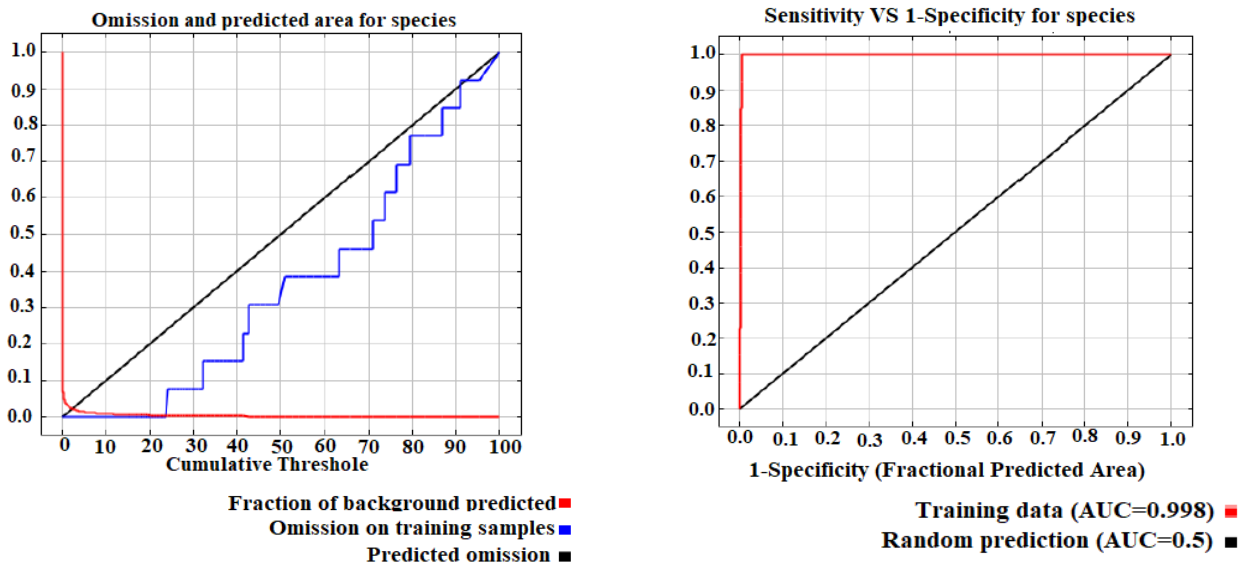

Figure 7. Illustration of omission curves (*left*) and Receiver Operating Characteristic (ROC) curve representing the performance of binary classification of MaxEnt model (*right*). The area under curve (AUC) value of the ROC curve demonstrates the model performance under the tradeoff between the rate of true-positive and false-positive

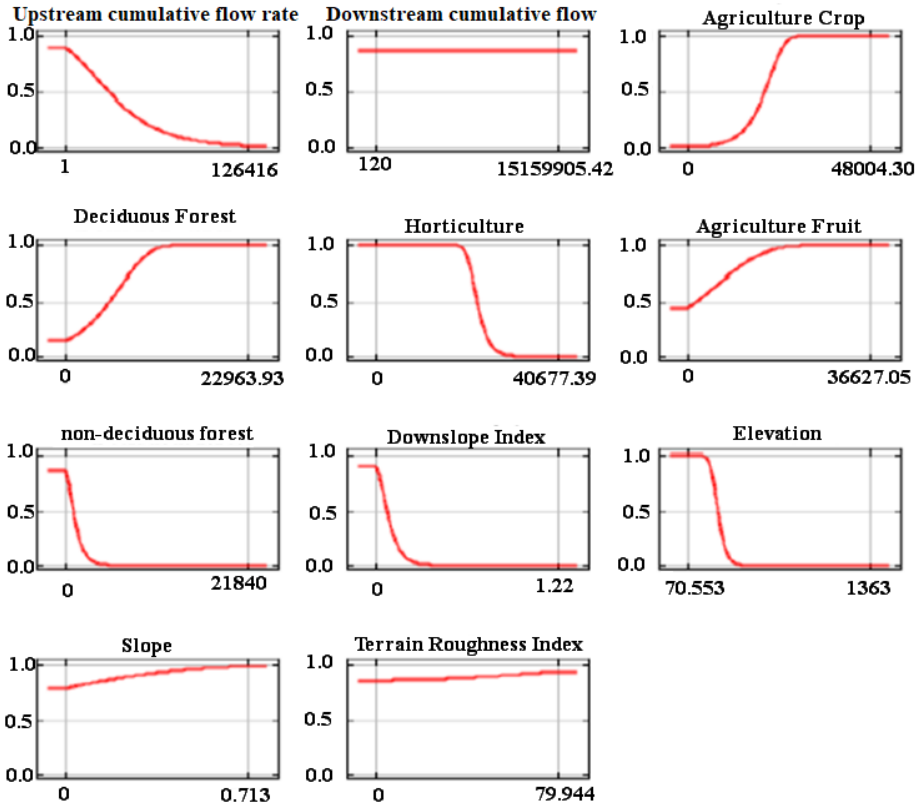

Figure 8. Marginal response curve of the MaxEnt model of Siamese crocodile in relation to each environmental covariate (topography and distance-to-landcover) while keeping all others at average sample value

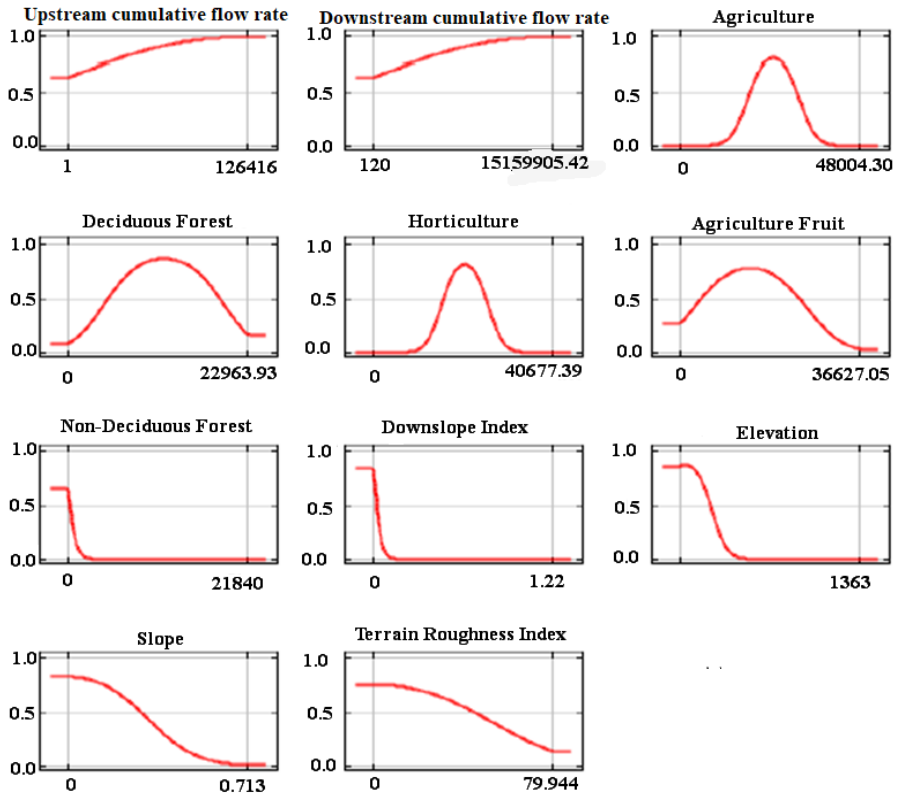

Figure 9. Response curve of the MaxEnt model of Siamese crocodile in relation to each environmental covariate by the separate model created using only the corresponding variable to remove the correlation effects between variables

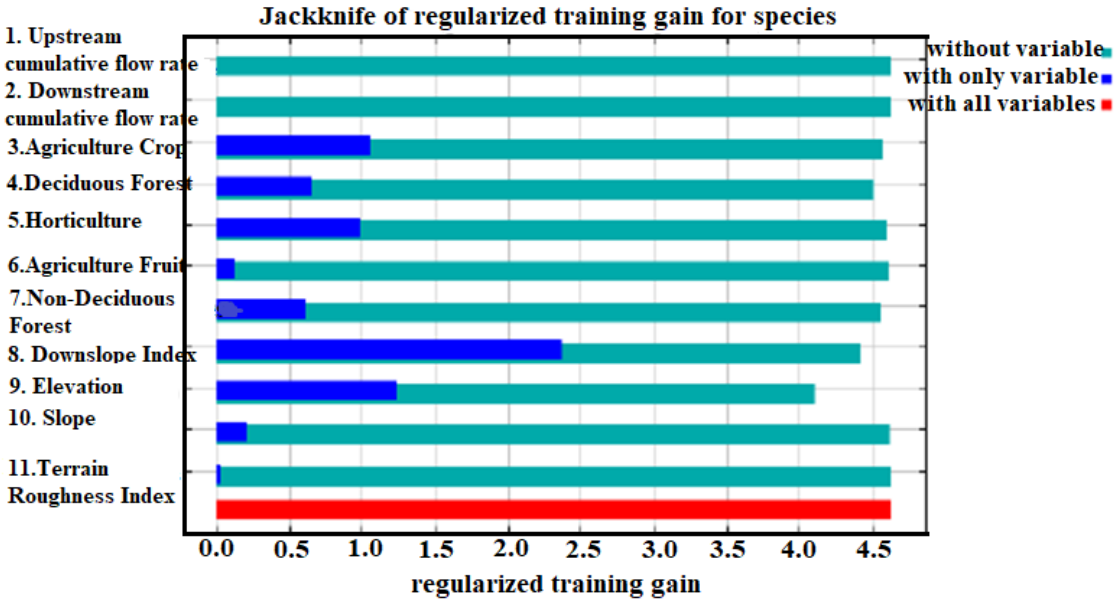

Figure 10. The results of the jackknife test of variable importance. The environmental variable with the highest gain when used in isolation is downslope_index, which therefore appears to have the most useful information by itself

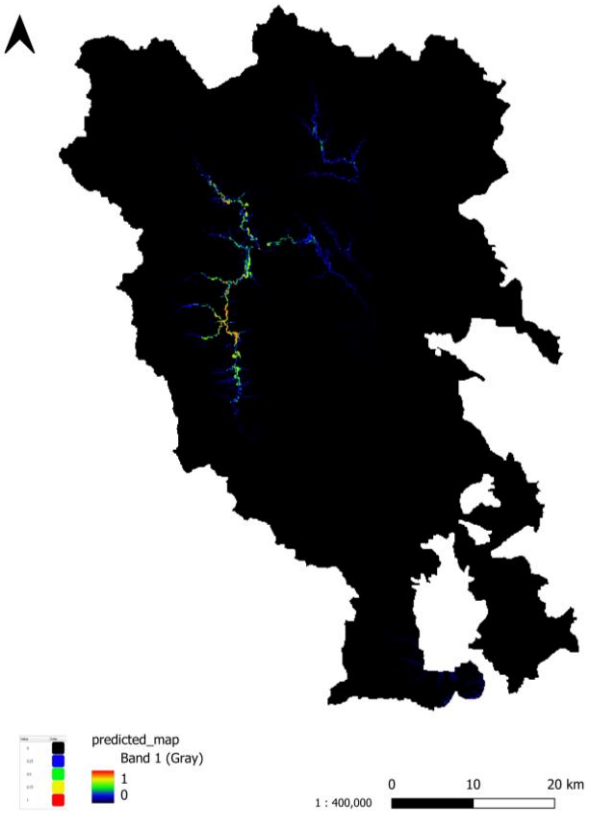

Figure 11. A suitable habitat for Siamese crocodiles is found along the Phetchaburi River in Kaeng Krachan National Park, Thailand

The study found that the areas along tributaries of the Phetchaburi River also have the potential for Siamese crocodile conservation (Figure 11). Therefore, breeding crocodiles in captivity and then releasing them to restore the population in the area, according to IUCN Species Survival Commission (2013) guidelines, is necessary for conservation. Implementation of measures according to the protection system to monitor threats to Siamese crocodiles, especially along the Phetchaburi River in Kaeng Krachan National Park, is the first priority project. This needs to be done before population restoration can be carried out through the reintroduction of crocodiles to the Phetchaburi Basin in the Kaeng Krachan National Park, which can be developed into a natural crocodile conservation area for the country. Continuous population studies should be undertaken to monitor the population dynamics, as well as the strengthening of community participation (Ratanakorn et al. 2021) for a systemic sustainable conservation on a scientific basis.

In conclusion, Siamese crocodiles are important for the ecosystem. Population dynamics of other wildlife in water bodies and in the area in relation to both large and small wildlife create sustainable integrity. The species preserve biodiversity and ecosystem services in freshwater resources from deterioration. Siamese crocodiles are critically endangered species and must be managed with effective preservation to protect and restore the population. Habitat management and outreach education programs for the public about the importance of Siamese crocodiles on the basis of scientific knowledge are necessary for successful conservation. The results of the study from various survey methods found the presence of freshwater crocodiles in the Phetchaburi River. A total of 18 dung piles and 8 traces were found, adding to a total of 26 encounters, equivalent to 0.08 times/km. Based on 41 photos from 10 camera traps, the relative abundance was 1.66%. Pictures were also obtained from a survey with a UAV. The total number of crocodile encounters was 68 times, representing an

encounter rate of 0.22 encounters per kilometer. The results of the study reveal that Siamese crocodile eggs were laid in nests. Sixteen eggs were found in one nest; however, they were not fertile. The results show that the reliability of the area under the curve is 0.99, which is considered a very high level of reliability. The results also found that the slope along the creek showed the most positive influence on the appearance of Siamese crocodiles. This was followed by the elevation of the area along the banks of the Phetchaburi River and the forest that covers the deciduous forest and evergreen forest, which also showed a positive result. The variables that negatively affect the appearance of Siamese crocodiles include horticulture and field crops, which are human activities and have a negative effect on the presence of freshwater crocodiles.

The results of the study confirmed the importance of the area along the Phetchaburi River and therefore, it must be protected and maintained for the conservation of the country's important Siamese crocodile population. Population follow-up studies should be conducted. Continuous Siamese crocodile population dynamics surveys using unmanned aerial vehicles are an appropriate method for monitoring crocodiles in the area. The Siamese crocodile population restoration project should be implemented through propagation and reintroduction back into the Phetchaburi River in Kaeng Krachan National Park to increase the population and maintain a viable Siamese crocodile population in the area.

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