

Natural history observations on the endangered turtle *Geoemyda spengleri* in Tay Yen Tu Nature Reserve (Vietnam), with notes on other sympatric species

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ABSTRACT - Vietnam is one the most biodiverse countries of the world in terms of turtle species richness, with 27 species being freshwater and terrestrial. The natural history of these species is very little known, but it is thought that the great majority of them are seriously threatened by habitat loss and overhunting. Here, we report on a survey employing both interviews with local people and field transects through the forest in the Tay Yen Tu Nature Reserve, on natural history information on *Geoemyda spengleri* and on other sympatric species. Using pictures of 14 different species of chelonian, at least 10 % of the interviewees recognised seven species. Of these *G. spengleri* and *Cuora mouhotii* were by far the most frequently recognised by interviewees, and were also the most frequent in a sample of 40 turtle individuals that were observed on local trade. Both species were also the only two species that were observed during field transects. Individuals of *G. spengleri* were observed from 10:47-13:45 h, in all cases in sunny weather after rain, at 25-30 °C temperature range. All individuals were seen in montane bamboo forests, often inside or nearby rocky caves, and in sites with forest cover being 70 %-90 %, at slope angles varying from 5-45 °.

INTRODUCTION

The Socialist Republic of Vietnam is ranked 9th among the most biodiverse countries of the world in terms of turtle species richness with a total of 32 species, 27 being freshwater and terrestrial and five being marine (Turtle Taxonomy Working Group et al., 2017). Unfortunately, the conservation status of the Vietnamese turtle fauna is uncertain as 85.1 % of the native freshwater and terrestrial taxa are currently listed as Threatened in the IUCN Red List (IUCN, 2018). For most species, habitat loss and overhunting (for consumption as human food, traditional medicine, religious merit) have been the main threats (Stanford et al., 2018). Indeed, the forest cover in Vietnam has decreased from 43 % to 36 % from 1945-1990 (De Jong & Hung, 2006). Although the country's forest cover has been recently increased due to the national-scale reforestation of Vietnam since 1992 (Meyfroidt & Lambin, 2009), the forest quality still remains poor. Indeed, the recovery of forest coverage was due in part to the ban of industrial logging in natural areas and the displacement of wood extraction to neighboring countries, but also to extensive programs of homogenous tree plantations (Meyfroidt & Lambin, 2009). The latter are clearly unsuitable for turtles, whereas the suitable remnant natural forest is still heavily fragmented and isolated (Fox et al., 2004). The second main threat to Vietnamese turtles is trade for domestic consumption, with massive numbers of individuals being exploited in the 1980s-2000s (Van Dijk et al., 2000; Nijman, 2010) also to supply the food and traditional medicine markets of China (Cheung & Dudgeon, 2006; Turtle Conservation Fund, 2002). According to IUCN (2018) assessments, the populations of most Vietnamese turtle species have declined by from 50-90 %. The Black-breasted leaf turtle (*Geoemyda spengleri*), that is the main

target of this paper, is not an exception and we also present some comments on the other sympatric turtle species.

Geoemyda spengleri (Fig. 1) is among the smallest *Geoemydidae* species worldwide. It is native to southern China, Northern Vietnam and Laos (Yasukawa & Ota, 2010; Turtle Taxonomy Working Group et al., 2017), and is classified as endangered by IUCN (2018) due to habitat loss and trade (Gong et al., 2005, 2009). However, the population size and distribution are poorly known; for instance, *G. spengleri* has recently also been recorded in Laos (Stuart et al., 2011) but there have been as yet no ecological studies (Yasukawa & Ota, 2010) with behavioural data being recorded only in ex-situ research (Henze et al., 2004). In Vietnam, the presence of *G. spengleri* has been documented in Tam Dao National Park, (Bourret, 1934; Nguyen & Ho 1996; Yasukawa et al., 2001), Tuyen Quang, Son La, Yen Bai, Vinh Phuc, Bac Giang, Quang Ninh, Thanh Hoa, Nghe An, and Ha Tinh provinces (Bourret, 1934; Le, 2001; Nguyen et al., 2010). The southernmost boundary of its distribution range lies in Da Nang and Quang Nam (Le, 2000; Le & Nguyen, 2003). However, the coastal city of Da Nang may serve as a collection center rather than a field locality (Yasukawa & Ota, 2010). Few conservation actions have been implemented to manage the remnant free-ranging populations of this species. Our aim in this paper is to present natural history data on *G. spengleri* in a protected area of Vietnam (Tay Yen Tu Nature Reserve) to give a better understanding of the field ecology and conservation of this threatened species and also to present additional notes on the turtle fauna of the study area.

Study area – We conducted the field survey in the Tay Yen Tu Nature Reserve (coordinates: 21°10'N and 106°43'E; Fig. 2). In this nature reserve (NR), a remnant portion of the natural habitat of the study species still



Figure 1. Black-breasted leaf turtle (*G. spengleri*) in the wild (male top image, female bottom image)

exists (Fig. 3) (Forest Protection Department of Bac Giang Province, 2010). Established in 2002 with a total area of 13,002 ha, the Tay Yen Tu NR consists of two parts: Tay Yen Tu and Khe Ro. The NR is the largest remnant natural forest patch in the Quang Ninh and Bac Giang provinces, and is mainly located in Luc Nam and Son Dong Districts, Bac Giang Province. In the Tay Yen Tu section, the mountain peak is 1068 m a.s.l. (Mount Yen Tu) while in the Khe Ro section the mountain peak is 886 m (Khe Ro; Forest Protection Department of Bac Giang Province, 2010). The main forest type of Tay Yen Tu is the lowland evergreen broad-leaved tropical forest (Averyanov et al., 2003). The NR is known to be home of 728 plant and 285 animal species (Dong, 2016; Forest Protection Department of Bac Giang Province, 2010), including 76 species of amphibians and reptiles (Hecht et al., 2013). There are five types of forest cover in the NR. Shrub and grassland are dominated below 100 m a.s.l., followed by small trees mixed with bamboo at the elevation of 100-200 m. From 200-900 m the forest is evergreen broad-leaf tropical forest mixed with bamboo forest. Above 900 m is the broad-leaved forest with large trees dominant (Forest Protection Department of Bac Giang Province, 2010).

METHODS

We decided to carry out field surveys for *G. spengleri* at the study area after having verified, in the years 2017-2018, that many individuals were offered for sale on the internet (Facebook, etc.) and were reported to come from Tay Yen Tu NR by the interviewed traders. Thus, the research consisted

of both interviews with selected people and field surveys in natural habitats that were potentially inhabited by the study species.

Interviews – We conducted semi-structured interviews, with identification photos of *G. spengleri* (from hatchling to adult) and 13 other potentially sympatric chelonian species (*Platysternon megacephalum*, *Mauremys sinensis*, *Mauremys mutica*, *Cuora galbinifrons*, *C. cyclornata*, *C. mouhotii*, *C. zhoui*, *Indotestudo elongata*, *Sacalia quadriocellata*, *Palea steindachneri*, *Pelodiscus sinensis*, *Rafetus swinhoei* and *Pelochelys cantorii*) with 72 people in 11 communes in June and July, 2018. The dominant interviewees were traditional medicine collectors and hunters, who were presumed to be familiar with the species (Online Appendix 1). There were 11 interview days from 17th-27th June 2018 and 28th July 2018. We also interviewed 38 randomly selected people (neither traders, traditional medicine practitioners nor hunters by profession). We used the following nine questions to each interviewee:

- (i) Do you recognise any turtle from your region?
- (ii) If yes, what is their local name?
- (iii) What do they look like (carapace colour, hardshell or softshell, size of the animal, aquatic or terrestrial)?
- (iv) What do they eat?
- (v) When did you see it?
- (vi) How many people buy/sell turtles or what do they do with the turtles obtained?
- (vii) Which morphological characteristics do you use to determine the different species (hinged (for *Cuora* spp.), serration, size of the head, length of the tail (for *Platysternon megacephalum*)?)
- (viii) What is the habitat in which the turtle is found?

After completing the interview, to confirm their description, we showed them the ID photos of turtle species. Each interview lasted from 5-30 minutes. We then recorded the location of the interview sites using a GPS device (see Fig. 2 for the map of the study sites).

During the interviews, we also recorded captive turtles held by villagers. For each individual, we asked how do they intend to use the animal, for how much they sell/buy it, and we measured carapace length, carapace width and shell height by a caliper (30 mm), and weight by an electronic kitchen scale, with the accuracy of 0.1 g.

Field research – We conducted the first section of the field survey in Dong Ri commune, Son Dong district from 19th-22nd July 2018 with 5 people and two hunting dogs and the second section in a forest in Tuan Mau commune, Son Dong district from 23rd-27th July 2018 with 6 people and 3 hunting dogs. Following Dawson's (2016) data, combining with local experience, we selected only forest patches situated at above 400 m elevation as field survey sites.

To locate wild turtles, we used local people (researchers/assistants), and two or three hunting dogs in eight days, all of them being employed to follow non-linear transects crossing through the potential turtle habitats (see Fig. 2 for the spatial arrangement of the non-linear transects). The beginning and ending time of each survey, and the GPS points were recorded at the beginning and at the end of the transect. Each person followed the transect by keeping a nearly constant five metres distance between each surveyor. Hunting dogs were used to improve the searching effort.

We also recorded for each individual (i) the GPS

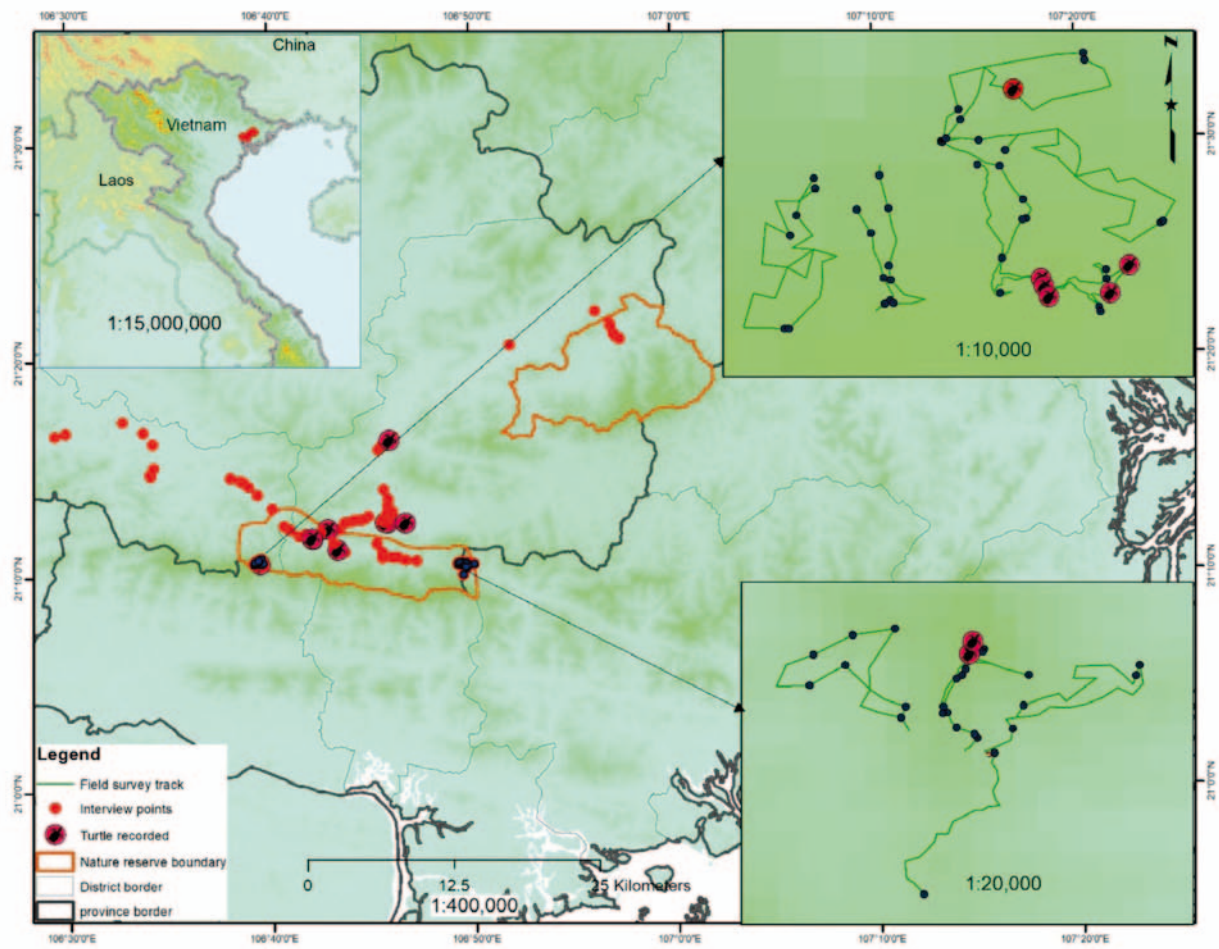


Figure 2. Map of Vietnam, showing the position of the interview points and of the presence sites of turtles at the Tay Yen Tu Nature Reserve. The field survey tracks are also indicated.

Table 1. Synopsis of the results of the interview surveys at Tay Yen Tu Nature Reserve, by species and by type of usage as declared by the hunters/traders, including the turtle price. No. Individuals = Number of turtle individuals observed during the interview surveys; Pet = number of individuals used as pet; For sale = number of individuals that will be sold in China; Food = number of individuals used as food; Medicine = number of individuals used for traditional medicine; No. People confirming presence = number of interviewees (and their relative percentage, %; total $n = 72$) claiming the presence of the various turtle species at the study area. The price of *C. cyclornata* and *C. zhoui* claimed to be 1990s, the rest are current price.

Species	No. Individuals	Pet	Sell to China	Food	Medicine	No. People Confirming Presence	%	Price Range (\$)
<i>Geoemyda spengleri</i>	10	3	7	0	0	30	41.7	4.55-9.09
<i>Cuora mouhotii</i>	14	2	12	0	0	32	44.4	27.27-40.92
<i>Cuora cyclornata</i>	1	0	0	1	0	7	9.7	3076.90- 3846.12
<i>Cuora galbinifrons</i>	7	0	1	1	5	18	25.0	68.13-150.00
<i>Indotestudo elongata</i>	1	0	1	0	0	1	1.4	unknown
<i>Palea steindachneri</i>	5	0	2	3	0	20	27.8	29.50-31.82
<i>Pelodiscus sinensis</i>	2	0	0	2	0	15	20.8	22.72-27.27
<i>Platysternon megacephalum</i>	0	0	0	0	0	10	13.9	181.81-227.22
<i>Sacalia quadriocellata</i>	0	0	0	0	0	11	15.3	90.90-136.31
<i>Mauremys mutica</i>	0	0	0	0	0	5	6.9	unknown
<i>Cuora zhoui</i>	0	0	0	0	0	2	2.8	307.61-1538.42
<i>Cyclemys oldhamii</i>	0	0	0	0	0	2	2.8	90.91
Total	40	5	23	7	5			

coordinates, (ii) the time (Hanoi Standard Time), (iii) the weather, (iv) the ground temperature (°C) the habitat type, (v) the elevation (m a.s.l.), (vi) slope, and (vii) forest cover. We also determined its (a) sex and (b) age class. We determined sex by secondary sexual characteristics (tail morphology and head patterns; Yasukawa & Ota, 2010; see Fig. 1), and classified the age classes as follows: carapace length ≥ 80 mm = adult, 60-80 mm = subadult, 40-50 mm = juvenile, < 40 mm = hatchling. When a turtle individual was found, we recorded (i) habitat type, (ii) slope angle, (iii) forest cover, (iv) ground temperature (°C). Slope angle was determined by the Angle Meter version 1.0 software in an Android 8.0 system smartphone. Forest cover was estimated by Canopy Cover 1.03 version software, also in an Android 8.0 system smartphone. The ground temperature was measured by a thermometer, by placing the tip of the thermometer on the surface in the exact position of the turtle.

The dogs are commonly used by local villagers, especially minority ethnics to hunt for the wildlife in protected areas in Vietnam and trained to bark when they find a turtle (Espenshade & Le, 2002). However, we could not include them in our calculations of survey efforts as they run to search without control from the owner. A mean of 45.67 hours survey effort was made per person, with the searching team including 5-6 people and 2-3 dogs on each day. Thus, excluding dogs and considering the searches by each person as independent along the transects, the total field effort was 251.2 h. Field surveys were conducted in two areas of Tay Yen Tu NR, with 11,280 m of transects being walked by the researchers. The minimum and maximum elevation of our transects were 416 m and 795 m a.s.l. respectively, with the average elevation being 604.5 m a.s.l. Transects were walked in all weather conditions, from sunny and dry to cloudy and rainy, including also sunny weather after heavy rains. When a free ranging turtle was encountered, it was photographed and measured as mentioned above. We released all individuals unharmed after data processing. We did not survey any aquatic species

Statistical analyses – To calculate turtle relative frequency of observation for each transect, we used the following formula:

$$S = \frac{x}{a \cdot b}$$

with S = turtle relative frequency of observation, x = number of turtles found in a given transect; a = number of people involved in the time search along a given transect; b = total time spent for a trip along a given transect.

The χ^2 test was used to evaluate (i) the frequency differences of occurrence of the various species in the hands of hunters/traders, and (ii) the frequency differences among the various turtle species in terms of the number of interviewees reporting them to be present at the study area. Differences between wild-caught and traded samples of *G. spengleri* in terms of body size measurements (carapace length, carapace width, shell height and weight) were assessed by Student t-test. In the text, the means are given with ± 1 standard deviation. All statistical analyses were performed by Past 3.0 software, with alpha set at 5 %.

RESULTS

Interview surveys: At least 10 % of the interviewees identified the presence of seven species, whereas for the other seven species the number of people claiming their

presence was very low and thus considered unlikely (Table 1). The various species differed significantly in terms of frequency of the interviewees reporting them to be present ($\chi^2 = 133.6$, $df = 11$, $P < 0.0001$), with significantly more interviewees knowing well *G. spengleri* and *Cuora mouhotii*. Interestingly, no species was confirmed to be present by more than 50 % of the interviewees (Table 1), thus indirectly suggesting that all species should be rare in the study area. Concerning *G. spengleri*, the various interviewees concurred that the species weighs less than 100 g, has serration, lives in bamboo forest (they called it 'the bamboo turtle' (rùa trúc)) and, because of the reddish skin coloration, is also called the 'fire turtle' (rùa lửa). According to their information, the species inhabits the evergreen forest at high elevation, even on the top of the mountains. Hunters also claimed that the species is normally seen when weather change from rain to sunny or vice versa, and that they can be located more easily in the rainy season (April to July) when turtles are very active above-ground while searching for food. Based on the interviewees' reports, it appeared that *G. spengleri* was the cheapest of all the locally traded species (Table 1).

During the interviews, we observed 40 individuals, belonging to seven native species (*G. spengleri*, *Cuora mouhotii*, *C. cyclornata*, *C. galbinifrons*, *I. elongata*, *P. steindachneri*, and *P. sinensis*) in the hands of the hunters/traders (Table 1). The frequency of occurrence of the various species was significantly different from equality ($\chi^2 = 142.2$, $df = 6$, $P < 0.0001$), with *G. spengleri*, *C. mouhotii* being the two dominant species. Overall, 57.5 % of the observed individuals were going to be sold to China, followed by the local consumption as food (17.5 %), traditional medicine (15 %) and pet (12.5 %) (Table 1). In our observed sample, six individuals of three species (one *G. spengleri*, four *C. mouhotii* and one *I. elongata*) were confiscated by rangers of the NR (Online Appendix 2). Body size measurements taken from both wild-caught and traded turtle individuals are reported in Online Appendix 3. All the observed species were listed as Threatened species by IUCN (2018).

Field surveys: During the field transects, we recorded seven individuals of *G. spengleri* and one of *C. mouhotii* (Online Appendix 4). Individuals of *G. spengleri* were observed at an average elevation of 699.7 ± 31.6 m a.s.l. (range = 651-725 m, median = 710 m). Their relative frequency of observation was 0.037 individual/person/hour. Among our observed *G. spengleri* individuals, four were adults, one sub-adult, one juvenile and one hatchling. Two were males (one adult and one sub-adult), four were females (all adults) and one was a hatchling of unidentified sex.

Out of seven free-ranging *G. spengleri*, only one individual was found by a hunting dog. The turtles were found from 10:47-13:45 h, in all cases when the weather was sunny following heavy rains. Turtles were observed at 25-30 °C temperature range. Three turtles were found in rocky caves while four turtles were found in a forest patch dominated by bamboo (*Arundinaria* sp) (Fig. 3). The individuals found outside of rocky caves were not too far from a rocky area (range from 10-50 m) when first seen and all were found on but not hiding under leaf litter. The forest cover at the location of *G. spengleri* ranged from 70 %-90 % (mean = 76.4 ± 7.4 %, median = 75 %), thus showing that this species inhabits dense forest patches. However, there were no turtles found in wet forest areas with canopy cover higher than 90 %. The slope angles where turtles were found varied considerably, from 5-45 °, with an average of 24.6 ± 17.5 ° (median = 25 °).



Figure 3. Some typical habitat types where *G. spengleri* were encountered during the field surveys. Live turtles were found in forest dominated by bamboos, with three individuals found in small rocky caves, and four individuals found on leaf litter.

The single individual of *Cuora mouhotii* was an adult male. Two subspecies of *C. mouhotii* are currently recognised. The plastron markings and carapace shape of this specimen agree with published descriptions of the subspecies *C. m. mouhotii* (Das et al., 2016). This individual was observed at 607 m a.s.l., in secondary forest dominated by bamboo trees, with a 5 % slope and 50 % forest cover. It was found by a hunting dog.

DISCUSSION

Overall, seven turtle species were observed during our surveys, including field records and animals encountered while interviewing people. All of these species are listed as Threatened by IUCN (2018). Five other species (*Platysternon megacephalum*, *Sacalia quadriocellata*, *Mauremys mutica*, *C. zhoui* and *Cyclemys oldhamii*) were mentioned as occurring in the study area by at least one interviewee, but without any firm evidence. Three of these species (i.e. *M. mutica*, *C. zhoui* and *Cyclemys oldhamii*) were mentioned to occur by so few respondents (< 7 % of the interviewed sample) that we consider their presence in the study area very unlikely. Concerning *C. zhoui*, this species has never been observed in the wild until now, and the two interviewees claiming its presence were elderly, reporting that they had collected it in the 1980s. However, their descriptions could

have been of similar species that may now be extinct.

Among the interviewees, there were three former turtle hunters who quitted their activity due to the significant reduction of wildlife inside the NR. One of these collectors claimed that he would collect a bag of 10-20 kg of turtles per hunting day in 1980s-1990s, whereas he was able to find fewer animals since the 2000s. He also claimed that, during 1980s-1990s, there were several hundred tons of turtles being collected to sell to China. Nowadays, collectors can only find a single turtle occasionally. One also claimed that he was forced to give up the job because there were too few turtles in the Tay Yen Tu NR due to overharvesting whereas, in 2010-2015, he was able to fill a tank with 150-200 *G. spengleri* individuals to sell as pets or for religious release in Tay Yen Tu Buddhist festival from February to April annually.

Our study suggests that *G. spengleri* and *C. mouhotii* are the least rare among the various terrestrial turtle species of the Tay Yen Tu Nature Reserve as they (i) were the most frequently cited species to be present according to our interviewees (>40 % of the responders), (ii) were the most abundant species in the hands of the hunters/traders (accounting for 68.3 % of the total recorded sample), and (iii) were the only species directly observed by us in the field. The presence of adults of both sexes and of a hatchling in our small sample suggests that the *G. spengleri* population is still viable although more field research is needed to assess its conservation status.

All of our *G. spengleri* sightings were on the ground, thus confirming anecdotal literature claiming that this species is primarily terrestrial, but occasionally enters streams (Fang, 1930). The linear distance of our observed turtles from the nearest streams ranged from 50-80 m. Moreover, our habitat data showed that this species is clearly linked to hilly and montane forests with dense canopy. In this regard, our data mirror Pope's (1935), who considered that this turtle prefers intact, forested, montane environments (indeed we did not find any individual at 416-704 m a.s.l.). Regarding the elevation, Dawson (2016) considers that these turtles in Hainan normally inhabit sites ranging 700-1200 m elevation. Our results, although fitting well with Dawson's (2016) observations, also would indicate that *G. spengleri* can be found even at slightly lower elevations than supposed (two individuals found at 651 m and 659 m, respectively). In Vietnam, according to Hendrie (2000), *G. spengleri* is a highland, terrestrial and forest species, that is replaced at lower altitudes by *C. mouhotii*. Our study demonstrates that the two species can be at least contiguously sympatric in Vietnamese montane forests. Indeed, the *C. mouhotii* individual was still found at a slightly lower elevation than all *G. spengleri* individuals, so there is likely not a firm cutoff between the species but rather a transition where they overlap slightly (the same being observed in Hainan; J. E. Dawson, unpublished data). In addition, the forest habitat of our *C. mouhotii* individual was less covered than that of *G. spengleri*, although also bamboo forest. So, it is not certain that the populations of these species can be completely sympatric. Further studies should explore how frequently truly sympatric populations of these two species occur in Vietnam. In conclusion, our study documents that *G. spengleri* is still found with likely viable populations in Tay Yen Tu NR, but all the evidence presented here would suggest a decline in population sizes of turtles inside the protected area. The full extent of this supposed decline remains unknown.

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