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FARMING CHARACTERISTICS AND THE ECOLOGY OF *Palea steindachneri* (TRIONYCHIDAE) IN VIETNAM

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Breeding turtles in farms for offering them in the food market is a profitable market in Vietnam. Here we study, through structured questionnaires with 73 owners of turtle farms, the social and economic contexts of this business activity. We also collected ecological data for the most intensely bred species, the Wattle-necked softshell turtle, *Palea steindachneri*. *Palea* farms were typically small family-owned companies, with just 1 to 4 employees working just 1 – 2 h per day but almost every day in the week, and with 1 to 4 ponds available in the facilities. Sex ratio of farmed turtles was heavily skewed to females in both *P. steindachneri* and *Amyda cartilaginea* (the secondly most frequently bred species), and their clutch size was very similar. Inside farms, mating of *P. steindachneri* occurred in February, egg deposition in March – July with a peak in May, and egg hatching in May – October, with a peak in July. In Vietnam, the typical owner of *P. steindachneri* farms is a self-made man who had enjoyed very little management and support from government for his/her business.

Keywords: turtle farms; softshell turtles; ecology; social sciences; Vietnam.

INTRODUCTION

In Vietnam, wildlife farming started in 1986 when the country opened the gate to the free trade after some decades of pure socialist economy (Quang and Kammeier, 2002). Today, several wildlife species are farmed

for commercial purpose in Vietnam, including deer (*Cervus* spp.), wild pigs (*Sus scrofa*), porcupines (*Hystrix brachyura*), birds (e.g., *Coturnix coturnix*, *Anas poecilorhyncha*), and reptiles such as crocodiles (*Crocodylus siamensis*, *Crocodylus porosus*), snakes (e.g., *Ptyas* spp., *Naja* spp., *Python bivittatus*, *Python reticulatus*) and turtles (e.g., *Pelodiscus sinensis*, *Palea steindachneri*, *Heosemys grandis*, etc.). According to FAO (2014), during 2013 in twelve provinces in Southern Vietnam, there were 996, 731 individuals of 175 wildlife species, with the highest numbers of farmed animals being crocodiles and softshell turtles, that accounted for 618,540 individuals. This number of turtles was anyway just a tiny fraction if compared to the approximately 300 million turtles housed in Chinese farms (Haitao et al., 2008). To date, the economic value from farming wildlife in Vietnam is not documented but the commercial value of turtle farming in China was estimated to be around 750 million US dollars per year (Haitao et al., 2008). Due to scarce and poorly skilled human resources and widespread corruption, wildlife farming is still complicated in Vietnam. These farms have become means used to “wash” illegally

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caught in “legal” wild animals born in captivity before they are spread to local and international markets (FAO, 2014; Sigouin et al., 2017). Indeed, despite Vietnam has severe environmental laws, their regulation and implementation remain weak, thus making the country one of the world hotspots of illegal wildlife trade (Brunner, 2012; Van Song, 2008).

Vietnam is among the top ten countries of the world in terms of turtle fauna richness, with a total of 32 species (27 terrestrial and freshwater turtles and 5 marine turtle) being recorded so far inside the country (Turtle Taxonomy Working Group et al., 2017). This number of species is however instable because of the debated taxonomic status of several taxa: for instance, *Cuora galbinifrons* and *Cuora bourreti* were recently reassessed as conspecifics (Liu et al., 2019), whereas a new species of *Pelodiscus* was described (Farkas et al., 2019). Because of their high economic value (Haitao et al., 2008; Van et al., 2019), turtles are also target of massive farming in Vietnam (Pham et al., 2018; Sigouin et al., 2017; Van et al., 2019), with Trionychidae species being the most abundantly farmed turtles in the country (FAO, 2014). Three softshell turtle species (Trionychidae) commonly occur in Vietnamese farms: the Wattle-necked softshell turtle (*Palea steindachneri*) in the North and Central regions, the Asiatic softshell turtle (*Amyda cartilaginea*) in the Southern regions, and the Chinese softshell turtle (*Pelodiscus sinensis*) all throughout the country (Pham V. T., personal observations).

Palea steindachneri has a wide range in Vietnam, China and Laos (Asian Turtle Trade Working Group, 2000), and has been introduced to Mauritius (Asian Turtle Trade Working Group, 2000) and the Hawaii islands (Markus, 2011; Pham et al., 2018; Radford, 2011). The ecology of *P. steindachneri* is totally unknown: Radford (2011) presents the only field data available on this species, but his study concerned the introduced Hawaiian populations. In Hawaii, nesting probably takes place in June and the eggs hatch in late August or September. Each clutch consists of 3 – 28 spherical eggs (22 mm in diameter), and the hatchlings are 54 – 58 mm in carapace length (Radford, 2011). In China, this species can inhabit mountain streams up to 1500 m a.s.l. (Pope, 1935). Currently, *P. steindachneri* is a species of conservation concern as it has been listed as Endangered by IUCN (2018) according to the criteria (A1cd+2cd) (Asian Turtle Trade Working Group, 2000). The status of the Vietnamese populations is unknown, as neither field studies nor conservation assessments are available. Anyway, *P. steindachneri* is protected by law in Vietnam (category IIB in national decree 06/2019/NP-CP): capture of free-ranging individuals is prohibited and trade is regulated so that unauthorized farming is sanctioned with jail. In Vietnam,

this species is particularly valuable for farming because of its high value (currently 15 US dollar/kg in market price), large size (up to 45 kg weight and up to 450 mm carapace length; Marchetti and Engstrom, 2016) and good productivity in captivity (e.g., Asian Turtle Trade Working Group, 2000; Shi et al., 2004; Haitao et al., 2008; Radford, 2011;). During the early 1990s, *P. steindachneri* was initially successfully farmed in Yen Bai and Son La provinces, before spreading to many provinces in Northern and Central Vietnam (Hai Ha, 2017). In this paper, we analyze the social, economic, and ecological aspects related to the farming of *P. steindachneri* in northern Vietnam by a standardized and structured questionnaire distributed to farm owners.

MATERIAL AND METHODS

The field survey was carried out, in June 2019, in three communes of Northern Vietnam: Cat Think, Nghia Tam, and Tran Phu of Van Chan district, Yen Bai (21°27'43.27" N 104°46'18.29" E) (Fig. 1). These study areas are known as being the first provinces for *P. steindachneri* farming activities in Vietnam since the 1990s (Hai Ha, 2017). Within the three above-mentioned communes, Van Chan district is particularly relevant for turtle farming as it currently houses about 200 – 300 *P. steindachneri* farms, with their size differing greatly from site to site (Yen Bai Fisheries department, 2019).

Farms were selected randomly from those that were potentially available for our interviews. We performed structured interviews with farm owners. The interviews were conducted by four students of the Vietnam National University of Forestry, Hanoi, under the supervision in the field of four of the co-authors (Olivier Le Duc, Thong Pham Van, Luu Quang Vinh, and Lo Van Oanh). No minors were interviewed, and the interview protocol followed the ethical recommendations of the British Sociological Association. After collecting the basic information on personal details of the respondents such as name, age, interview location, GPS point, marriage status, and education level, the students started with the structured questionnaire, that consisted of the following twenty-eight questions:

1. How many people work on your farm?
2. How many hours per day do they work?
3. How many days per week do they work?
4. How many ponds do you have in your farm?
5. What is the size of each ponds?
6. Which species do you breed? (a) *P. steindachneri*, (b) *Amyda cartilaginea* (c), *Pelodiscus sinensis*? Others?
7. How many individuals do you have for breeding for each species?

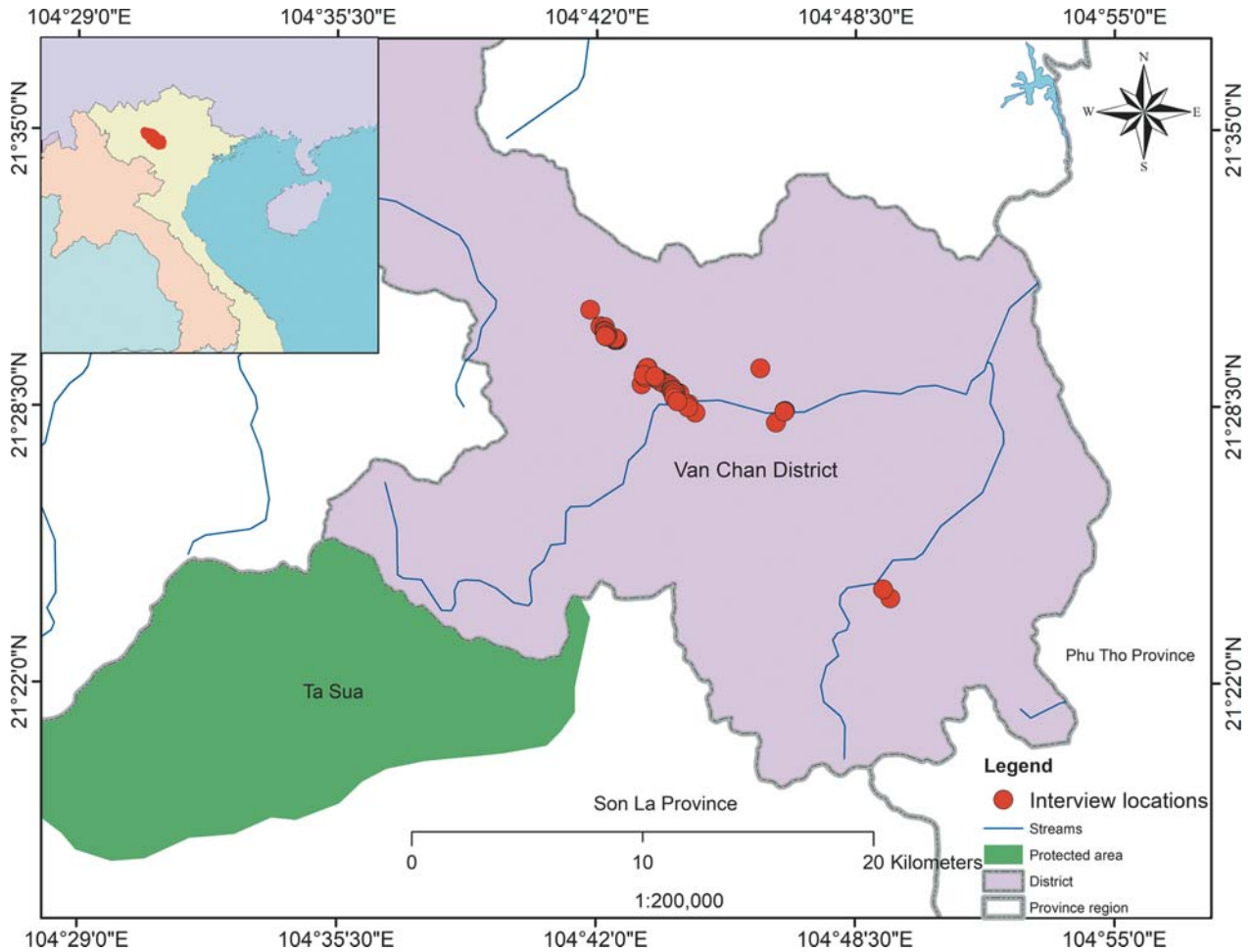


Fig. 1. Map of northern Vietnam showing the sites of the surveyed farms (= interview locations).

8. What is their sex ratio?
9. What is the average clutch size of the females?
10. In which month did you observe mating of turtles?
11. In which month did you observe egg-laying by turtles?
12. In which month do the eggs hatch?
13. How many hatching do you get in each year?
14. What is the food type that you give to the turtles?
(a) Earthworms, (b) fish, (c) pellets (d)? others?
15. What is the methodology that you use for incubating eggs? (a) Sand bank, (b) incubator, (c) other.
16. What was the source of the turtle at the beginning of your farming? And from where did they come?
17. On which year did you start your business?
18. Who is the typical buyer of your turtles? a) An individual person, (b) a trader, (c) a retailer, (d) others (please specify).
19. What is current price for turtles?
20. Are you aware of what kind of use the buyers of your tortoises have made?
21. How much is the current yearly average net income from turtle farming?
22. How many turtle farms do you know around your area?
23. How many neonate turtles do the farms in the area produce?
24. Do the turtles hibernate? If yes, when?
25. Do you belong to any society or association of farm breeding? (a) Yes, (b) No.
26. Do the institutions or government give any supports? (a) Yes, (b) No. If yes, (a) technical, (b) financial, (c) other.
27. How much did you invest for construction and initial cost for the farm?
28. How much money did you invest annually for raising the farm (food, water, medicine, labours)?

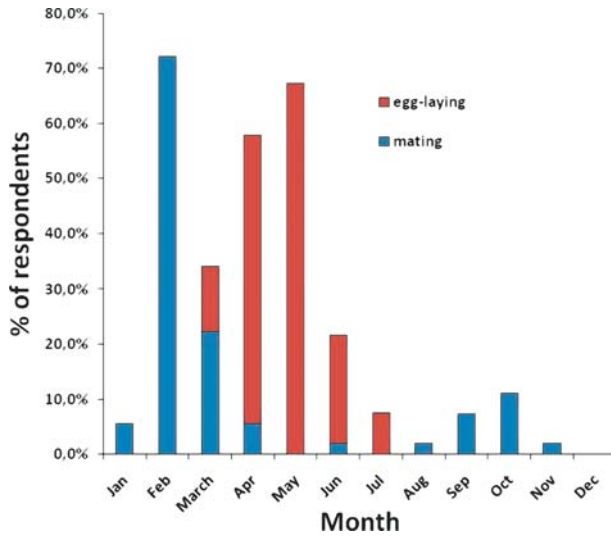


Fig. 2. Seasonality of mating activity and of egg deposition in *Palea steindachneri* in the breeding farms, according to the interviewees. Percentages would refer to the percent of respondents reporting that the turtles mate/lay eggs in each given month.

The interspecific differences in the mean number of turtle individuals per farm were analyzed by one-way ANOVA; χ^2 tests were used to explore frequency differences among the various potential answers to each given question, and to explore the sex ratio of turtles inside the breeding farms. All tests were performed with Past 3.0 statistical software (Hammer, 2012).

RESULTS

In total, 73 farm owners were interviewed, 82.2% being men and 17.8 being women. Their ages ranged 28 to 86 years old (see Fig. 6 for the age distribution of the observed samples). All interviewees were married, with illiterates being 1.4% of the sample, 6.8% having primary school degree, 80.8% secondary school degree, and 11% having university degree. The interviewees were Chinese (1.4% of the sample), Kinh (90.4%), Thai (1.4%), and Tay (6.8%).

TABLE 1. Synopsis of the Range and Mean Number of Turtles Bred in Each Farm by Species, According to the Interviewed Farm Owners at the Study Areas

Species	Min	Max	Average	Total all farms
<i>Palea steindachneri</i>	9	700	146.6	9673
<i>Amyda cartilaginea</i>	60	60	60	60

How many people work on your farm?

Palea farms were typically small family-owned companies, with just one (39.7% of the interviewees) or two workers (57.5%), and three workers reported only by a minority (2.7%) of the interviewees. Four or more workers were never reported by the interviewees. Most of the farm were run by members of the family.

How many hours per day do they work?

How many days per week do they work?

According to interviewees, people at *P. steindachneri* farms work for a high number of days but a low number of hours. Indeed, the great majority of the interviewees answered that employees worked for just one hour per day (81.2% of the answers) or 2 h per day (5.8%; range of worked hours per day being 1–8), but for four days a week (49.3% of the interviewees) up to seven days per week (49.3%).

How many ponds do you have in your farm?

What is the size of each pond?

The number of ponds per farm varied substantially, with most farms having one (28.8%), two (24.7%), three (15.1%) or four ponds (15.1%). The overall area of all ponds in the 73 pooled farms was 43,555 m², and the average pond area per farm was 597 m² (Table 4).

Which species do you breed?

100% of the interviewees answered that they breed *P. steindachneri*, whereas 1.4% of the respondents bred *Amyda cartilaginea* and another 1.4% bred other species, i.e. *Cuora mouhotii* (bred by two farms) and *Mauremys mutica* (bred by more than 20 farms).

How many individuals do you have for breeding

for each species? What is their sex ratio?

The mean number of turtle individuals per farm varied significantly across species (one-way ANOVA, $P < 0.0001$), with *P. steindachneri* being by far the most abundant species in turtle farms (Table 1). Interviewees consistently reported that the sex ratio was heavily skewed to females in both *P. steindachneri* (Male: 33%/Female 67%) and *A. cartilaginea* (Male: 17%/Female 87%) (in both species, intersexual differences at χ^2 test, $P < 0.0001$).

What is the average clutch size of the females?

In which month did you observe mating of turtles?

Based on the information provided from our interviewees, the average clutch size was nearly identical in both *P. steindachneri* and *A. cartilaginea* (Table 2). Concerning the mating phenology, interviewees only reported this information for *P. steindachneri*. According to most of them, *P. steindachneri* would mate in February,

with many respondents also reporting March as a turtle mating period (Fig. 2).

In which month did you observe egg-laying by turtles? In which month do the eggs hatch?

Interviewees only reported this information for *P. steindachneri*. Egg deposition would occur from March to July with a peak in April – May (Fig. 2). Egg hatching would occur from May to October, with a high peak in July (Fig. 3).

How many hatching do you get in each year?

The number of hatched *P. steindachneri* turtles per farm varied from about 70 to 7000, with an average of 1514.1, and a total of 77,220 hatchlings if we pool all the surveyed farms.

Do the turtles hibernate? If yes, when?

According to the interviewees, *P. steindachneri* individuals hibernate in winter, from November to February on each year. However, the hibernation is interrupted during the hot sunny days, and may vary in a range of about 10 – 30 days depending on the winter temperatures in each year. The adults go under the mud to hide themselves when the temperature get below 14°C while the hatching and juvenile start hide themselves at below 16°C.

Characteristics of care systems in the farms

Fishes (mostly *Hypophthalmichthys* spp.) were used as food for the turtles by 100% of the interviewees, with earthworms and snails (*Achatina fulica*) being used as additional food types by 27.4% of them (Fig. 4). Sand bank inside a roof was used as the incubator method by 96.9% of the interviewees and artificial incubation was applied only by 4.6% of the interviewees. The various turtle stages, from hatching to sub-adults and to adults, were kept separately into different ponds (Fig. 4). There were 12 interviewees stating that newborn individuals are housed into plastic containers with shallow water (5 – 10 cm) before being housed, when larger in size, into larger concrete 4 – 5 m² tanks with deeper water (20 – 30 cm). The water needs to be clean, and therefore it is changed weekly. Two of the respondents claimed that, the newborn turtles should be kept out from rain during their first week of life. The hatchlings are fed with small pieces of worms and fish. Overall, all the farms provided similar conditions for breeding turtles.

What was the source of the turtle at the beginning of your farming? And from where did they come?

Most of the *P. steindachneri* individuals were obtained from other farms (86.3% of the respondents), whereas wild caught provided at least part of the original stock according to 23.3% of the respondents. In this latter

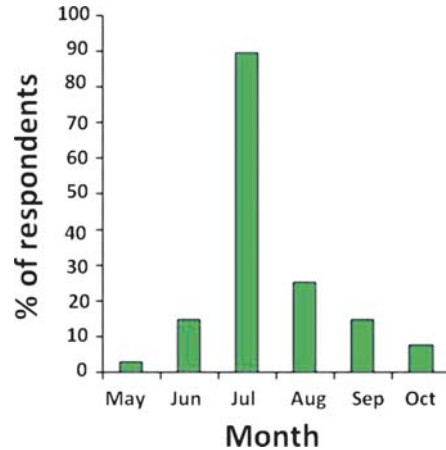


Fig. 3. Seasonality of egg hatching in *Palea steindachneri* in the breeding farms, according to the interviewees. Percentages would refer to the percent of respondents reporting that the turtles breed in each given month.

case, the interviewees claimed that the initial turtle source were wild caught individuals from streams surrounding their own villages. Some of them indicated that Ngoi Lao, Khe Tho, and Thoong streams were the main locations where farmers caught the turtles for their farms. Instead, *A. cartilaginea* sources were mainly individuals from farms situated in the Southern provinces in Vietnam.

On which year did you start your business?

Who is the typical buyer of your turtles?

Interviewees started their turtle farm business in 1992 – 2019, with the majority of them in 2000, 2005 and 2009 (Table 5). On average, the farmers have bred *P. steindachneri* for 13 years. Farmed turtles were mainly sold to individual persons for farming purpose (54.3% of the respondents) and to turtle traders (82.9%) before heading to the Chinese market.

What is current price for turtles? Are you aware of what kind of use the buyers of your tortoises have made?

Average price of *P. steindachneri* individuals varied considerably on the basis of the size and age of the turtles (Table 6), and was consistent among the different farms. 100% of the interviewees reported that their farmed tur-

TABLE 2. Synopsis of the Data on Clutch Size of the Studied Turtles in the Breeding Farms, According to the Interviewees

Species	Min	Max	Average
<i>Palea steindachneri</i>	2	52	21.5
<i>Amyda cartilaginea</i>	14	28	21



Fig. 4. Top left: Juvenile *Palea steindachneri* and the tank for the juveniles. Top right: an adult male from plastron view. Middle left: sub-adult male and female. Middle right: an adult male from carapace view. Bottom left: the farmer is carrying food (fish and worms) to feed the turtles in his farm. Bottom right: the large pond for adults and the palm roof for the nesting location for the female. Photo credits: top left, middle left, bottom left and right, to Olivier Le Duc, photos top right and middle right, to Pham Van Thong.

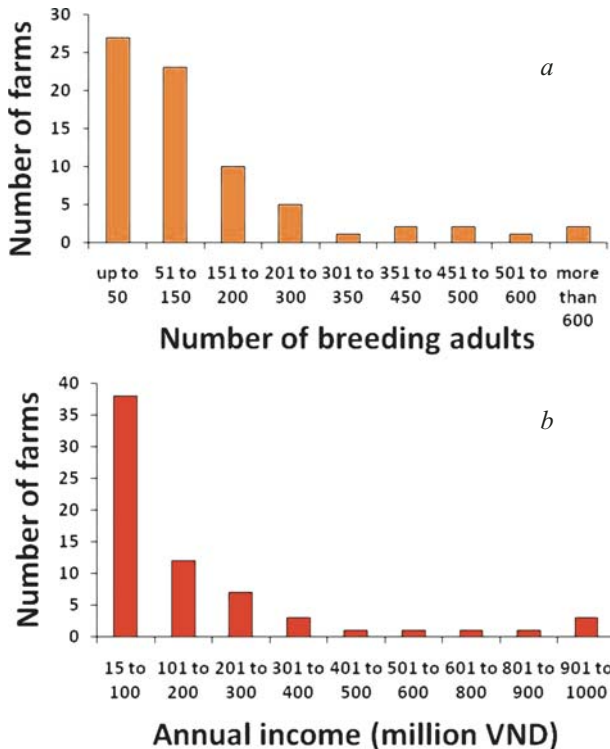


Fig. 5. a, Scale of *Palea steindachneri* farms in Van Chan district, Yen Bai province, on the basis of the number of breeding adults (total $n = 73$ respondents); b, annual income by farms ($n = 67$ respondents).

tles are used as food by the customers, but 4.4% of them also reported that turtles are used for traditional medicine.

How much is the current yearly average net income from turtle farming? How many turtle farms do you know around your area?

Most of the farms housed less than 150 breeding adults (Fig. 5a). Declared yearly income for the breeding farms by the respondents varied substantially, with a peak of over 384,000,000 VND (~16,507 USD) in net income and 1,000,000,000 VND (~42,918 USD) for the large

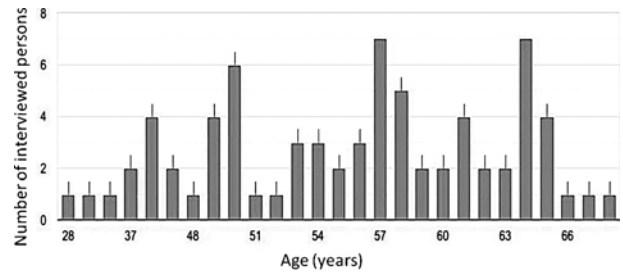


Fig. 6. Age distribution of the interviewed samples.

farms (Table 3). Most farms had a yearly income of 15 – 100 millions VND (Fig. 5b). If we calculate the gross income based on number of hatching produced annually from 73 farms (77,200 individuals), since the average current hatchling price is 80,000 VND/individual (= 3.4 USD), then we got 61,760,000,000 VND (2,650,643 USD) as gross income for the surveyed farms. Since there are currently about 200 to 300 turtle farms in the study areas, this represents a noteworthy income for the rural economy of the region.

How many neonate turtles do the farms in the area produce? Do you have any society or association of farm breeding?

According to our interviewees, the total number of turtle neonates per year produced in the area should range from 70,000 to 100,000 individuals. In addition, 59.4% of the respondents had a society/association of farm breeding, whereas 40.6% did not have any.

Do the institutions or government give any supports?

The great majority of the interviewees (93.1%) did not receive any support from government, and the few receiving support obtained financial, and not technical, help by the government.

Costs of construction and maintenance

The quantification of the initial investment costs and of the annual costs for raising the farm are presented in

TABLE 3. Declared Net Yearly Income for Breeding *P. steindachneri* Farms by the Respondents

	Min	Max	Average	Total
Gross annual income	15,000,000	1,000,000,000	199,492,308	12,967,000,000
Annual expenditure	2,000,000	500,000,000	53,125,000	3,718,750,000
Initial cost	10,000,000	1,500,000,000	167,191,176	11,369,000,000
Convert initial cost to yearly cost*	769,231	115,384,615	12,860,860	874,538,462
Net yearly income	12,230,769	384,615,385	133,506,448	8,373,711,538

Notes. The money currency is VND with an used exchange rate of 23,300 VND/USD. Symbols: (*) we used initial cost/average number of years (= 13 years) that people start breeding *P. steindachneri* (see Table 4). Net yearly income = Gross annual income-annual expenditure-convert initial cost to yearly cost. The annual expenditure include the cost for food, medicine, labours, electricity, and so on while the initial cost include the cost to buy the *P. steindachneri* for breeding, construction of the ponds, and system.

TABLE 4. Raw Data on the Total Number of Ponds per Farm and Relative Size of Each Ponds by Interviewee

Interviewee No.	Pond 1, m ²	Pond 2, m ²	Pond 3, m ²	Pond 4, m ²	Pond 5, m ²	Pond 6, m ²	Pond 7, m ²	Total size of all ponds, m ²
A1	4	48	48	60	40	320		520
B1	60	60	60					180
A2	700	150	80					930
B2	30	30						60
B3	150	75	75					300
B4	150	20	20	20				210
B5	6000	300	200	500				7000
A3	200	6	674	500	120	1000		2500
A4	10	50	190	100	150	200		700
A5	20	50	80	200				350
A6	10	20	10	50				90
A7	20	20	20	20	20	20		120
A8	30	35	35					100
A9	150	50	100					300
A10	600	500						1100
A11	20	20	20	60	180			300
A12	20	50	100	120	100	10	200	600
B6								250
B7								10
B7								10
B8	200	200	300	400				1100
B9	500	100						600
A13	370							370
A14	50	150						200
A15	200	50	70					320
A16	360							360
A17	240	120						360
A18	120	110	120					350
A19	23	23	24	5	5	15	5	100
A20	10	15	20	25	80	30	20	200
A21	140	25	25	25	25			240
A22	300	250						550
A23	400	800						1200
A24	700	50	50					800
A25	400	100	100					700
A26	200							200
A27	30	30	45	45				150
A28	110							110
A29	400	20	20	60				500
B10	50	50	50					150
B11	25	100	55	250				550
A30	500	200						700
A31	50	50						100
A32	50	80						130
B12								200
B13								200
A33	200	100	200					500
B14	100	45						145
A34	100	30						130
A35	150							150
B15								80
A36	500	200	250	100	150			1200

TABLE 4 (continued)

Interviewee No.	Pond 1, m ²	Pond 2, m ²	Pond 3, m ²	Pond 4, m ²	Pond 5, m ²	Pond 6, m ²	Pond 7, m ²	Total size of all ponds, m ²
B16	160	50						210
B17								270
B18	150	250						400
B19								80
B20	500	250	150					1000
B21								160
B22								300
B23								200
B24	1000	800	750	450				3000
B25	700	800	1000	800	100	300	400	5000
B26								10
B27	70	70						140
B28								200
B29	250	250						500
B30	250	150	100	100				600
B21	1000	500						1500
B2								200
B33								100
B34	150	100						250
B35	700	500	500	300				1000
B36								160
Average size	343.54	155.81	162.97	190.45	88.18	236.88	156.25	596.64

Total size of all ponds is 43,555 m².

Table 3. The initial cost to establish a *P. steindachneri* is relatively high (167,191,176 VND ~ 7176 USD) if compared to the average income of Vietnamese people (2563.8 USD/annum; The World Bank, 2018). Thus, it is difficult for the farmers to start with large farms. Some farmers can start large farms as they borrow the money from friends, relatives, and local banks.

DISCUSSION

Natural History of *P. steindachneri*

The ecology and natural history of *P. steindachneri* is very little known: there are no field studies available on any native population whereas preliminary studies on the species in the wild in the Hawaii islands, where the species has been introduced since 1800s (McKeown and Webb, 1982; Marchetti and Engstrom, 2016; Pham et al., 2019). Thus the data presented herein can be of some value. Indeed, most of the available information regards the species’ genetics (Meylan, 1987; Chen et al., 2006), its presence in the Asian turtle trade (Gong et al., 2004; Shi et al., 2004; Markus, 2011; Pham et al., 2018; Van et al., 2019), and its diseases in captivity (Tong et al., 2009).

Based on the preliminary studies on the species in the wild in the Hawaii islands, it seems that it prefers forest streams over other habitats (McKeown and Webb, 1982; Marchetti and Engstrom, 2016), the adults are highly aquatic and rarely bask while the juveniles spend time in heavily vegetated areas that limit their exposure (McKeown and Webb, 1982; Ernst and Bogadek, 2005). Shyness and low propensity to basking would suggest that the chances of meeting with these turtles are quite low in nature. Thus, it is possible that the species is less rare than presently supposed (“Endangered” is its red list status according to IUCN, 2018). Our study would indicate that *P. steindachneri* does hibernate in winter time in Vietnam, whereas the species is active year round due to warm temperature in the Hawaii (Ernst and Lovich, 2009). Mating, egg-laying and egg hatching appeared quite synchronized and seasonal, and can probably be considered as typical for the annual cycle of reproduction of South-East Asian Trionychidae. The isotope food niche analysis (carbon and nitrogen) shows that the species mostly consume fish and snails in the Hawaii (Marchetti and Engstrom, 2016), similarly as the food preferences exhibited by captive individuals from Vietnam. This result was expected, as fish and invertebrates represent the main prey types for all the softshell turtle species

studied so far (e.g., see Cochran and McConville, 1983; Akani et al., 2001).

Turtle Farms and *P. steindachneri* Conservation

There are about 500 *P. steindachneri* farms in the Yen Bai province, with an estimated farm area of 16.058ha. These farms produce about 12,000 – 15,000 hatching and about 50 tons of *P. steindachneri* meat per year. This amount of meat spreads to different districts of the province, including Tran Yen, Luc Yen, Van Chan, Yen Binh, Yen Bai city, Nghia Lo districts (Yen Bai Fisheries department, 2019). In Song Ma district, Son La province, there are 11 large-sized farms that breed 2500 *P.*

steindachneri adults and produce 50,000 hatching yearly (Song Ma fisheries department, 2018). Thus, it is clear that *P. steindachneri* farming is a profitable and substantial business in rural Vietnam. Our study clearly shows that owning a turtle farm makes a whole family to survive easily and with a relatively small working effort.

Generally, the owner of a *P. steindachneri* farm in Vietnam is a self-made man that enjoyed very little management and support from government. The success of the farmers in breeding *P. steindachneri* was based merely on their own knowledge and personal experience, being facilitated in this task by that *P. steindachneri* is an easy species to breed in captivity. Farmers also know well the basic characteristics of the species' ecology and behavior because they used to capture them from the wild in the surroundings of their homes, and this experience in the field is certainly positive for their success in breeding this species.

Despite *P. steindachneri* is protected by national decree 06/2019/NP-CP (category IIB) forcing the farms to be under management by government, its farming and trade are still virtually not managed by any local governmental authority. As the consequence of this lack of management, the farm industry is still quite free to expand to larger scales with detrimental effects on the market. For instance, the uncontrolled growth of farm size lead to the crisis in 2014, when the price of turtle meat decreased by 10 times causing an extensive crisis to the point that many farms of *P. steindachneri* went bankrupt (Pham V T observation). It is hoped that, in the future years, the governmental control may be more strict than in the present day, thus assuring adequate policies for the farm business in a way to balance the economic and conservation aspects. An enhanced governmental control would be positive also from the conservation point of view, given that *P. steindachneri* is globally threatened (IUCN, 2018) and it seems to be rare in the wild in Vietnam (Ernst and Bogadek, 2005; Radford, 2011; Pham, unpublished observations).

The meat of *Palea steindachneri* is an expensive food (13 – 26 USD, see Table 5) in Vietnam, given that daily spend for food of a Vietnamese person range from 3 – 4 USD (see <http://www.sunkissedsuitcase.com/daily-food-expenses-hanoi>). Thus, there are very few

TABLE 5. Starting Years of Farming for the Interviewees Targeted During the Present Study in northern Vietnam and Average Number of Years Since the Farmers Have Started Their Business

Starting year	Number of farms	Number of years
1992	1	28
1993	2	26
1996	1	23
1997	1	22
1999	2	20
2000	9	19
2001	3	18
2002	5	17
2003	1	16
2004	4	15
2005	7	14
2006	4	13
2008	5	11
2009	8	10
2010	2	9
2011	4	8
2012	1	7
2013	3	6
2014	2	5
2015	4	4
2016	2	3
2018	1	2
2019	1	1
Total	73	
Average number of years		13

TABLE 6. Average Price of *P. steindachneri* in Different Stages of Life and in Different Yearly Periods as Indicated by the Interviewees

	2008 – 2014	2015 – 2019
Hatching price range (per individual)	800,000 – 850,000	50,000 – 200,000
Juvenile price range (per individual)	600,000 – 1,500,000	100,000 – 400,000
Adult price range (per 1 kg)	2,300,000 – 3,500,000	300,000 – 600,000

Note. The money currency given in VND with an exchange rate being 23,300 VND/USD.

restaurants serving *P. steindachneri* meat in the study area (e.g., see <http://monngonvietnam.vn/bai-viet/Tong-hop-nha-hang-ba-ba-ngon-va-uy-tin-tai-nha-Noi-41>). Most of *P. steindachneri* individuals were sold to China (Pham et al., 2018) to serve a bigger market. It is reasonable that the trade of *P. steindachneri* going to China depends on that the price in Vietnam is lower in comparison to that of the Chinese market (13 – 26 USD/kg in Vietnam versus 700 USD/kg in China; Gaillard et al., 2017). Although *P. steindachneri* is listed in category II (CITES, 2017), there were almost no legal exports from Vietnam to China during the last decades according to the CITES database (WCS Vietnam, 2012). Thus, the massive trade of *P. steindachneri* from Vietnam to China remains generally illegal and should be urgently monitored by the competent authorities.

CONCLUSIONS

Palea steindachneri is native to Yen Bai province, where (i) a great abundance of farms has been observed, and (ii) the local wild populations are possibly declining. Therefore, hereby we recommend (1) to carry out accurate field surveys in order to evaluate the true abundance and distribution of *P. steindachneri* throughout the study region, and (2) to implement a science-based reintroduction operation for the species to recover the wild population in the appropriate habitats across the region. In addition, the implementation of long-term field surveys dedicated to the study of the ecology, demography and habitat use by *P. steindachneri* populations in the wild in Vietnam would be essential for enhancing the survival probability of this species in the next decades.

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