

**An Interview-based Survey to Investigate the Occurrence
of Swinhoe's Giant Softshell Turtle (*Rafetus swinhoei*)
in Huaphanh Province of Northern Lao PDR**



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Executive Summary

Swinhoe's Giant Softshell Turtle (*Rafetus swinhoei*) is considered the most critically endangered chelonian in the world. A combination of chronic over-harvesting, wetland destruction, construction of hydropower dams, widespread water pollution, and the development, sedimentation, and flooding of riverside sandbanks (critical nesting habitat) has pushed *R. swinhoei* to the brink of extinction. The current global population, including captive individuals and unconfirmed reports of wild turtles, is thought to consist of 10-20 adults, although this figure is could be significantly inflated as most reports of *Rafetus swinhoei* remain unconfirmed. With *Rafetus swinhoei* now tottering at the edge of the extinction abyss, finding new individuals in the wild is critical for the survival of this species. To this end, we conducted an interview-based survey in villages along the Xam, Et, and Ma rivers in Huaphanh Province of northern Lao PDR during March-April 2023.

We interviewed 251 people in 49 towns and villages along the Et, Ma and Xam rivers during our survey. Our interview data indicates that a species of large softshell turtle – most likely *Rafetus swinhoei* – formerly occurred in the Xam and Ma Rivers. The most recent credible reports date to the 1990s and early 2000s (last reported in 2007), although the majority of encounters occurred prior to 1990. Without additional corroborating evidence, more recent literature reports from Laos cannot be accepted as credible. Given the lack of recent credible reports, coupled with widespread and intense harvesting pressure, we consider it near-certain that *R. swinhoei* has been extirpated in the Xam and Ma rivers within Laos. We attribute the extirpation of *R. swinhoei* in Laos to chronic over-harvesting (both targeted and opportunistic) of turtles. Although we cannot rule out the possibility that one or two *R. swinhoei* survive in the Xam or Ma Rivers, the ability of a large softshell turtle to remain undetected in a landscape of high human occupancy is doubtful.

Our survey also documented the occurrence of *Palea steindachneri* (Critically Endangered) in the region, complementing a single earlier record from Huaphanh Province. Local ecological knowledge obtained during our interviews adds significantly to our understanding of the reproductive biology of *P. steindachneri*. Our survey also confirmed that softshell turtles are subject to ongoing, intense harvesting pressure, largely as a result of opportunistic capture incidental to fishing. Without exception, those persons we interviewed stated that softshell turtles were significantly more abundant in the past, suggesting widespread population declines have occurred. Population declines of softshell turtles (and other wildlife) are probably being driven by unchecked, transboundary wildlife trafficking in which wildlife harvested in Laos is illegally smuggled into Vietnam. We conclude by recommending continued survey effort on rivers and reservoirs of the Red River Drainage in northern Laos in hopes of locating surviving *R. swinhoei*.

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Introduction

With the demise of Lonesome George, the sole surviving Pinta Giant Tortoise (*Chelonoidis abingdonii*), Swinhoe's Giant Softshell Turtle (*Rafetus swinhoei*) became the most critically endangered chelonian in the world (Rhodin et al., 2011; Kuchling et al., 2012; Jian et al., 2013; Rhodin et al. 2018). *Rafetus swinhoei* historically occurred in China (Red and Yangtze river systems) and northern Vietnam (Red River and associated tributaries), although its former distribution remains poorly known and ill-defined (TTWG, 2021). *Rafetus swinhoei* inhabited large rivers, tributaries, and floodplain lakes and swamps (Jian et al. 2013; Le Duc et al. 2020a, 2020b; Van et al. 2019). A combination of chronic over-harvesting, wetland destruction, construction of hydropower dams, widespread water pollution, and the development, sedimentation, and flooding of riverside sandbanks (critical nesting habitat) has pushed *R. swinhoei* to the brink of extinction (Rhodin et al. 2011; Jian et al. 2013; Van et al., 2019). The current global population, including captive individuals and unconfirmed reports of wild turtles, is thought to consist of 10-20 adults, although this figure is could be significantly over-estimated as most reports of *Rafetus swinhoei* remain unconfirmed (Table 1). The conservation outlook for *R. swinhoei* is parlous, especially in light of the loss of three adults turtles during the previous eight years. These losses include a single turtle inhabiting Hoan Kiem Lake in Hanoi, Vietnam (Bettelheim, 2012) that perished in 2016, and most recently (April 2023), the only surviving female *R. swinhoei* in the world was found dead in Dong Mo Reservoir in northern Vietnam (Hance, 2023). In neither case could the cause of death be ascertained. Lastly, a female *R. swinhoei* succumbed during an artificial insemination procedure at the Suzhou Zoo (China) in 2019.

Ex-situ conservation efforts for *R. swinhoei* have to date fared poorly. After decades of living in separate facilities, two captive *R. swinhoei* in China were brought together at the Suzhou Zoo in 2008, with the female depositing large clutches (60-100 eggs) of non-viable eggs in subsequent years. Initially, the non-viable (likely infertile) clutches were attributed to years of inadequate nutrition and the advanced age (80 to > 120 years) of the pair (Rhodin et al., 2011). However, an examination of the male in 2015 found extensive scarring of the penis resulting from injuries sustained during an aggressive encounter with a conspecific that also damaged the posterior margin of the carapace. Although the male continued to produce small amounts of viable sperm, for mechanical reasons he appeared unable to successfully inseminate the female. Semen collection and artificial insemination was attempted from 2015 onwards, until the female succumbed in 2019. Although the female produced additional clutches following artificial insemination, none of the eggs proved viable. In accordance with the recommendations of Jian et al. (2013), attempts were made to capture a surviving adult from Madushan Reservoir and incorporate this turtle into the existing captive-breeding program (Kuchling and Lu, 2015). Ultimately however, these trapping efforts proved unsuccessful and to our knowledge there have been no recent sightings of this turtle (Platt et al., 2016).

With *Rafetus swinhoei* now tottering at the edge of the extinction abyss, finding new individuals in the wild is critical for the survival of this species (Le Duc et al., 2020b). To this end, recent field surveys identified several potential locations within the Red River

Table 1. Global population of surviving *Rafetus swinhoei* (May 2023). Province name in parentheses. Sources: Kuchling et al. (2012), Jian et al. (2013), Platt et al. (2016), Timmins and Minh (2016), Van et al. (2019), Le Duc et al. (2020).

Location	Status
China	
Suzhou Zoo	Single male; fertile but depressed sperm count.
Madushan Reservoir (Yunnan)	1-2 turtles; trapping (2012-16) proved unsuccessful; no recent reports, possibly extinct in this reservoir.
Vietnam	
Dong Mo Reservoir (Hanoi City)	Possibly 2-3 turtles; one female found dead in April 2023; cause of death undetermined; dead turtle had CL of 1.56 m and weighed 93 kg.
Xuan Khanh Lake (Hanoi City)	One turtle confirmed; sex unknown.
Yen Lap Reservoir (Quang Ninh)	Large Softshell Turtle in lake; possibly <i>Rafetus swinhoei</i> based on reported body size.
Cua Dat Reservoir (Thanh Hoa)	At least one large Softshell Turtle reportedly occurs in lake; possibly <i>Rafetus swinhoei</i> based on body size.
Huoi Na Reservoir (Nghe An)	Unconfirmed observational records of large softshell turtles; possibly <i>Rafetus swinhoei</i> .
Da River (Lai Chau, Hoa Binh, Son La)	Multiple unconfirmed reports of large softshell turtles.
Minh Quan Lake (Yen Bai)	Sighting in October/November 2019.
Mong Hoi Lake (Phu Tho)	Rumored to be present in the lake.

drainage of Vietnam (Van et al., 2019; Le Duc et al., 2020a, 2020b; Ducotterd et al., 2023) and Laos (Zuklin et al. 2021) where *R. swinhoei* may yet survive. Recognizing the urgency of the situation and in accordance with the recommendations of other researchers (Timmins and Minh, 2016; Le Duc et al. 2020b; Zuklin et al., 2021), we conducted a survey to assess the possible occurrence of *R. swinhoei* in northern Lao PDR (hereafter Laos) during March–April 2023. During this survey we attempted to confirm if *R. swinhoei* occurs (or formerly occurred) in northern Laos and determine the conservation status of this turtle. We also investigated the occurrence of other species of softshell turtles (Trionychidae) in the region, sought local ecological information (LEK) about *R. swinhoei* and other softshell turtles, and investigated the extent of illegal wildlife trafficking, particularly with regards to chelonians. We then make recommendations for future investigations in Laos.

Survey Area

Our survey was conducted along the Xam (Sam), Et, and Ma rivers in Huaphanh Province of northern Laos (Figure 1). These are relatively high gradient, swift, rocky rivers that flow through an otherwise mountainous landscape. These rivers are structurally complex with rock-sand substrates, deep pools alternating with fast-flowing stretches, extensive sandbanks in some places, and incised channels within narrow, restricted floodplains (Figure 2). Human settlement in the region is concentrated along the rivers, which are used for fishing and irrigation.

The Ma River originates in Dien Bien Province of northwestern Vietnam and then flows into Laos before reentering Vietnam and continuing to the Gulf of Tonkin. The complete length of the Ma River is approximately 528 km with approximately 80 km of the river within Laos (Zuklin et al., 2021). The Xam River (shown as “Sam” River on some maps) is the largest tributary of the Ma River. The Xam River originates below Houa Peak near Sam Neua (town), flows southeast, enters Vietnam, and meanders through Nghe An and Thanh Hoa provinces before joining the Ma River. Within Vietnam the Xam River is known as the Chu River. In total, the Xam River is ca. 325 km long (165 km in Laos) with a catchment area of ca. 7580 km². The Ma River originates in Dien Bien Province of northwestern Vietnam and then flows into Laos before reentering Vietnam and continuing to the Gulf of Tonkin. The complete length of the Ma River is approximately 528 km with approximately 80 km of the river within Laos (Zuklin et al. 2021). The Et River originates in the highlands of Nam Et Phou Louey National Park and flows northeastward before joining the Ma River at Meung Et in Huaphanh Province, Laos.

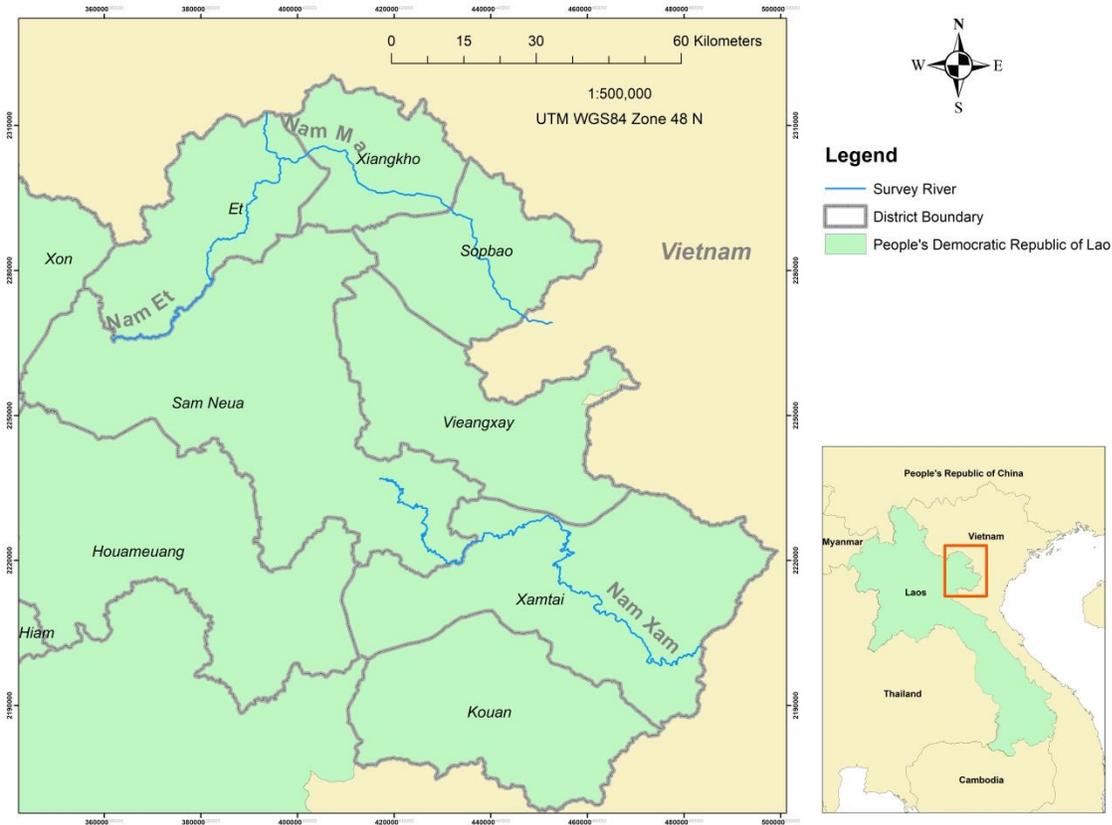


Figure 1: Map of survey area in Huaphanh Province of northern Laos. Interview surveys were conducted in villages along the Xam, Et, and Ma rivers (March–April 2023).

Methods

We conducted fieldwork in Huaphanh Province, Laos from 22 March to 2 April 2023. During this period we traveled along the Ma, Xam, and Et rivers by vehicle, and stopped at villages where we conducted semi-structured interviews (Martin 1995; Gilchrist et al. 2005) of fishermen, farmers, and other potentially knowledgeable individuals. We selected survey participants with the assistance of village leaders. In some cases, we used a “snowball” sampling method (*sensu* Bryman, 2012), whereby individuals with specific knowledge of turtles, recommended other potentially knowledgeable participants. We began each interview session by verbally describing the purpose and objectives of our survey to the participants, their role in our investigation, and then asked for their voluntary consent before continuing.

In accordance with the format of a semi-structured interview, we asked participants a series of closed– and open-ended questions that included standard questions prepared in advance and others that arose during the course of the interview. We guided the discussion, but the direction and scope of each interview was allowed to follow the participants’ train of thought (Huntington 1998). In practice, semi-directed interviews



Figure 2: Typical riverine habitat in Huaphanh Province of northern Laos. Two views of the Ma River.

are more of an informal conversation than a typical question and answer session, and rather than rigidly adhering to a set of prepared questions, the interview provides an opportunity for collecting and discussing unsolicited and often unanticipated information (Huntington 2000; Gilchrist et al. 2005; Nguyen et al. 2013). Our questions focused on the past and present occurrence of softshell turtles, folk taxonomy (*sensu* Berlin et al. 1966), perceptions of former and current abundance, harvest practices, possible reasons for perceived population declines, various aspects of natural history (particularly nesting), and illicit wildlife trafficking. We presented a photo array to those participants who claimed experience with softshell turtles in hopes of identifying what species were being referenced (Figure 3). These photographs were obtained from the private collection of SGP and online sources, such as iNaturalist, Wikipedia, and Google Images. The array consisted of photographs of trionychids likely to occur in northern Laos (*Rafetus swinhoei*, *Pelodiscus sinensis*, and *Palea steindachneri*) and others from outside of the region (*Apalone spinifera*, *Apalone ferox*, *Amyda ornata*, and *Dogania subplana*). We also asked to examine any living turtles or shells that might be available in the village. We determined the carapace length (CL in mm) and plastron length (PL in mm) of living turtles and shells with a tape measure, and then photographed each specimen. Unlike trade specimens for which the provenance can be difficult or impossible to reliably determine, living turtles and shells obtained in villages are generally from turtles collected nearby (Stuart and Platt, 2004).

We relied heavily on the Traditional Ecological Knowledge (TEK; defined as the cumulative body of knowledge concerning the relationship of organisms to one another and their environment, empirically acquired, and passed down by oral tradition; Berkes et al. 2000; Huntington, 2000) of survey participants during our investigation. Although science has been slow to embrace TEK as a research methodology (Gagnon and Berteaux, 2009), a growing body of evidence indicates indigenous peoples are keen observers of the natural world and can be reliable sources of information on local flora and fauna that often complements western science (Meijaard et al., 2011; Nabhan and Martinez, 2012). More specifically, our experience (e.g., Platt et al., 2018) and that of others working in the region (Thirakhupt and van Dijk, 1995; Rahman et al., 2015) indicates many rural dwellers are especially knowledgeable about the local chelonian fauna, particularly readily identifiable, large-bodied species of cultural or economic importance, such as *R. swinhoei*. Interviews of knowledgeable respondents offer a robust, cost-effective approach for assessing the conservation status of rare or elusive species across wide geographic areas (Meijaard et al., 2011). Furthermore, local communities are an excellent, and often the only source only of information on the last occurrence of threatened species and therefore essential to understanding extinction processes (Gray et al., 2017).

We conducted interviews of single individuals and groups ranging in size from two to 13 persons (Cover Photograph). Obtaining a precise count sometimes proved difficult because interviews were often conducted in a group setting (“focus group” of Jacques-Coper et al., 2019) and persons tended to wander in and out of the meeting venue, which was usually a public space (e.g., monastery, village office, domicile of the headman, etc.). One advantage of a group interview is “peer-review” whereby participants can



Figure 3: Survey participants were presented with photo arrays showing different species of softshell turtles to determine what species were being referenced during interviews. Most participants appeared confused and overwhelmed by the plethora of options and frequently selected species not known to occur with Laos.

critically assess and comment on the information being provided by other group members (Baird, 2006). Interviews were conducted by two Lao speakers, both of whom are also fluent in Hmong, the most common ethnic language in the region. Interviews were translated into English and transcribed. Interview transcripts are included in field notes that will be archived in the Campbell Museum, Clemson University, Clemson, South Carolina, USA. We determined geographic coordinates (India-Bangladesh Datum) of villages with handheld Garmin® Map 24 GPS unit. An annotated expedition itinerary and gazetteer (with geographic coordinates and elevation of localities visited) are provided in Appendix 1 and 2, respectively.

Results and Discussion

***Rafetus swinhoei* and other softshell turtles**

We interviewed 251 people in 49 towns and villages along the Et (N = 12), Ma (N = 25), and Xam (N = 12) rivers during March-April 2023 (Figures 4; Table 2; Appendix 2). The participants in our survey included 186 males and 65 females (Appendix 3). Because fishing is traditionally a male-dominated occupation, most of the persons we interviewed

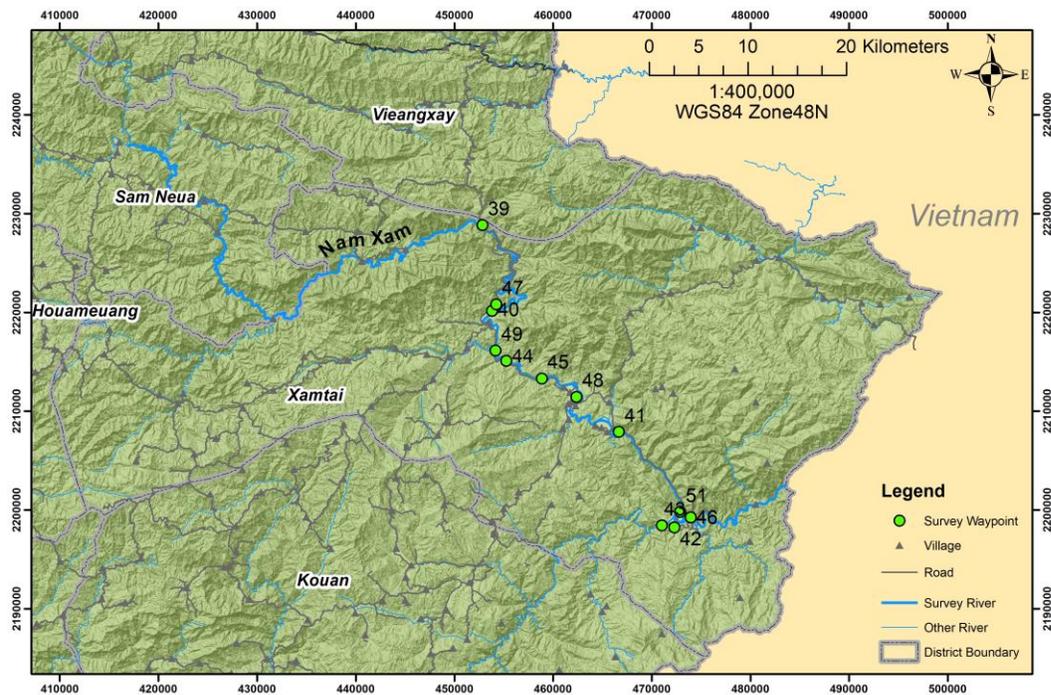
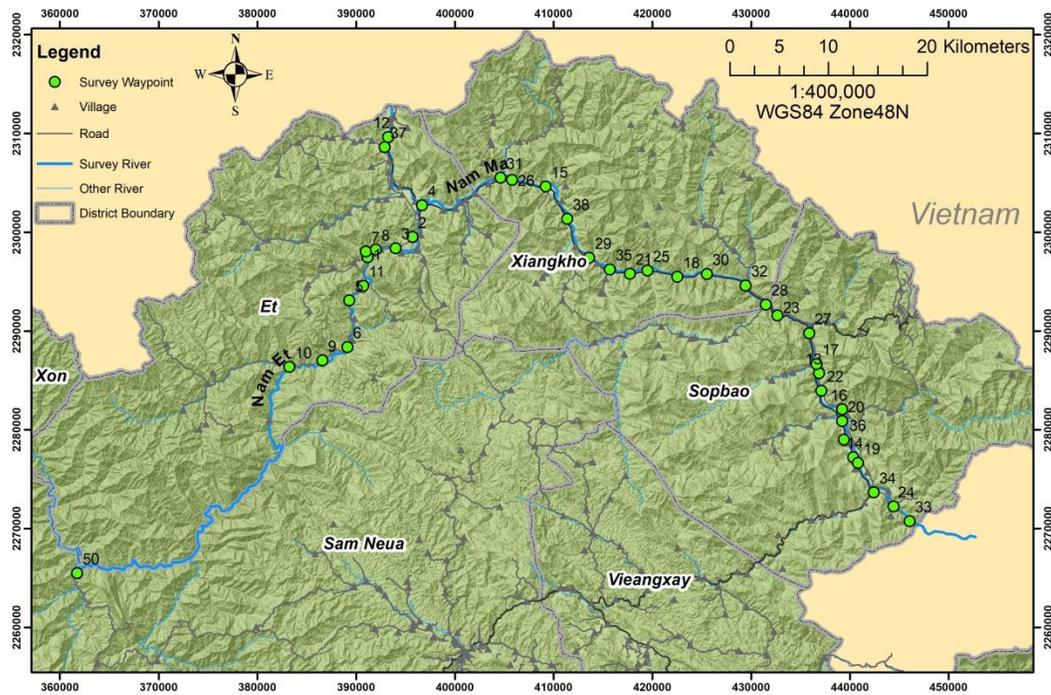


Figure 4: Villages where we conducted interview-based surveys for *Rafetus swinhoei* along the Ma and Et rivers (above) and Xam River (below). Names of the villages corresponding to the numbers on these maps can be found in Table 2.

Table 2: Numbers corresponding to villages shown on maps in Figure 4.

Numbers	River	Village
1	Et River	An Mak Dam
2	Et River	Boua Phou
3	Et River	Long Hoy
4	Et River	Meung Et
5	Et River	Na Poug
6	Et River	Na San
7	Et River	Nam Khan Nam Et
8	Et River	Ne Meam
9	Et River	Pha Dang
10	Et River	Sop Veak
11	Et River	Tham Song
12	Ma River	Bia
13	Ma River	Had Sorn
14	Ma River	Hao Sen
15	Ma River	Hap
16	Ma River	Meung Han
17	Ma River	Mouang Hom
18	Ma River	Na Kharm
19	Ma River	Na Xane
20	Ma River	Nan Ngoua
21	Ma River	Phieng Nyan
22	Ma River	Phieng Phuc
23	Ma River	Phieng Xay
24	Ma River	Phone Xay
25	Ma River	Phoun Thong
26	Ma River	Sae
27	Ma River	Sob Bao
28	Ma River	Sop Long
29	Ma River	Sop Mone
30	Ma River	Sop Quai
31	Ma River	Sop San
32	Ma River	Sop Say
33	Ma River	Songvang
34	Ma River	Sop Hao
35	Ma River	Ta On
36	Ma River	Vieng Hang
37	Ma River	Xieng Khoun
38	Ma River	Xieng Kor
39	Xam River	Dan Xay
40	Xam River	Mouang Kahn

41	Xam River	Mouang Phat
42	Xam River	Nak Keun
43	Xam River	Naxay
44	Xam River	Phieng Dai
45	Xam River	Phieng Hom
46	Xam River	Phieng Khoun
47	Xam River	Pheing Mai
48	Xam River	Som Tai
49	Xam River	Sop Kem
50	Xam River	Sop Kor
51	Xam River	Tao

were males (74.1%). A number of villages where we conducted interviews were inhabited by ethnic groups relocated from the surrounding mountains settled along the roads adjacent to rivers 20-30 years ago. These groups are for the most part, hill farmers with little cultural history of exploiting aquatic resources in the rivers. Consequently, scant information concerning turtles and other riverine fauna was forthcoming from these villagers. Nonetheless, a great deal of information relevant to the conservation and natural history of trionychids was obtained during our survey.

Although at least three species of trionychids (*Rafetus swinhoei*, *Pelodiscus sinensis*, and *Palea steindachneri*) are likely present in northern Laos (Iverson, 1992; TTWG, 2021), softshell turtles are collectively referred to as *Pa-fa* in the local folk taxonomy. The local folk taxonomy of trionychids is thus “under-differentiated”, i.e., multiple scientifically recognized taxa are grouped together as a single folk taxon (Berlin et al., 1966). This is somewhat surprising given the potential importance of softshell turtles as a food resource, coupled with the distinctive appearance of the three potentially sympatric species (e.g., unique coloration and extremely large body size of *R. swinhoei*, and the prominent tubercles covering the carapace of *Palea steindachneri*). One villager described two “types” of softshell turtle distinguished on the basis of body size, although both were referred to by the same name (*Pa-fa*). Moreover, the under-differentiated folk taxonomy among villagers in Laos stands in marked contrast to neighboring Vietnam where these softshell turtles are known by a variety of descriptive names that correspond to scientifically recognized species (Timmins and Minh, 2016; Van et al., 2019; Ducotterd et al., 2023).

Because villagers in Lao refer to all softshell turtles simply as *Pa-fa*, determining what species was being referenced during our interviews proved challenging. Moreover, when presented with our photo array, most participants appeared confused and overwhelmed by the plethora of choices and frequently selected species not known to occur in Laos (e.g., *Apalone spinifera*). Our experience stands in contrast to statements by Zuklin et al. (2020) claiming that respondents “positively identified *Rafetus swinhoei*” from a photo array. Unfortunately, Zuklin et al. (2020) provided few details concerning their interview techniques, including the use of photo arrays, making it difficult to evaluate such claims. Given the under-differentiated folk taxonomy of softshell turtles in

Laos, we used large body size (CL and body mass) as the key characteristic to distinguish reports of *R. swinhoei* from other species during interviews. The CL of *R. swinhoei* can exceed 1000 mm (possibly to 2000 mm) and the body mass ranges between 70 to >100 kg (Binh et al., 2010; Bettelheim, 2012). In comparison, both *Pelodiscus sinensis* and *Palea steindachneri* are smaller-bodied species with a maximum CL of 330 mm and 450 mm, respectively (Ernst and Barbour, 1989; Gong et al., 2018; Le Duc et al., 2020b).

We received nine potentially credible reports from villages along the Xam and Ma Rivers describing turtles that were possibly *R. swinhoei* (Table 3). Five of these reports originated in villages along the Xam River (single reports from Naxay, Phieng Khoun, and Phieng Dai, and two reports from Tao), while the remaining four reports were obtained during interviews conducted in villages along the Ma River (Phone Xay, Phone Thong, Sop Mone, and Xieng Khoun). These encounters occurred from 1973 to 2007, with most reports from the 1980s (44.4%) and 1990s (22.2%). We obtained no potentially credible reports of *R. swinhoei* from villages along the Et River, possibly because most people living along this river are primarily hill farmers with livelihoods focused on the extraction of resources from the surrounding uplands rather than the river.

Given the time elapsed since many of the reported encounters with large softshell turtles occurred, coupled with the tendency of persons to intentionally and unintentionally exaggerate past events owing to the active constructional nature of the human mind (Bates and Byrne, 2007), assessing the veracity of the information we received during interviews is challenging. In one case (Phone Xay), the estimated body size given by the respondent was inconsistent with the body mass supposedly determined with fish scales. Two other reports are based on second-hand information provided to the respondents by someone else; i.e., the respondents never actually observed the large turtles (Tao and Sop Mone). The estimated body size of the large softshell turtles described by respondents in Naxay and Phieng Dai was consistent with a small *R. swinhoei*, but only slightly larger than the maximum reported size for the sympatric *Palea steindachneri* (maximum CL = 450 mm). Because the asymptotic size limits of *P. steindachneri* are imperfectly known and lacking further corroborating information provided by the informants, we cannot be certain the turtles being described were actually *R. swinhoei*. This leaves four reports from villages along the Xam River (Phieng Khoun and Tao) and Ma River (Phoun Thong and Xieng Khoun) as potentially credible descriptions of *R. swinhoei*. That said, the report from the village pharmacist in Tao is difficult to assess as the respondent saw only a single, albeit very large leg of a butchered turtle. The other three reports all involved sightings made by the respondents of very large softshell turtles at a relatively close range with descriptions provided by respondents at Xieng Khoun and Phoun Thong being especially vivid.

In addition to the accounts collected during our interviews, Zuklin et al. (2020) reported that a fisherman along the Xam River near the border with Vietnam described a “large” softshell turtle that escaped from his fishing net in October 2019. The fishers account was endorsed by two other villagers who presumably witnessed the encounter and stated the turtle was “very large”; all three villagers “positively identified *Rafetus swinhoei* among the presented photographs”. This encounter is said to have occurred in

Table 3: Reports of large softshell turtles (possibly *Rafetus swinhoi*) obtained during interviews conducted at villages along the Xam, Ma, and Et rivers in Huaphanh Province, Laos (March-April 2023).

Location	Notes
Naxay	During the 1980s a large softshell turtle was captured in a bamboo fishing trap in Xam River. The estimated CL and body mass of the turtle were 400 to 500 mm and 10-20 kg. The turtle was captured by the respondents father who was a fisherman.
Phieng Khoun	Respondent stated that while fishing in the Xam River circa 1973, a large softshell turtle surfaced a short distance away. The head of the turtle was visible, although the respondent was unable to recall any details concerning the coloration. The respondent estimated the body mass of the turtle was 30-40 kg.
Tao	The village headman (age = 41 years-old) recalled hearing stories as a child about very large softshell turtles being captured in the Xam River. The estimated CL of some of these turtles was > 1000 mm.
Tao	Village pharmacist (age = 66 years-old) recalled another villager going door-to-door circa 1981 attempting to sell meat from a very large, freshly butchered softshell turtle captured in the Xam River. The respondent never saw the intact carcass; however, he was offered a disarticulated leg (possibly a foreleg) estimated to weigh about 1.0 kg.
Phieng Dai	Respondent observed a large softshell turtle basking on a horizontal log along the opposite bank while fishing in the Xam River (circa 2007). The turtle was said to be as large as a hand-tractor tire (ca. 50 cm in diameter). This observation occurred in a deep pool where others had reportedly encountered large turtles in the past.

Phone Xay

Participant stated that a very large softshell turtle was captured in Ma River at Song Vang (nearby village) in the 1980s. According to the respondent, the weight of the turtle determined with fish scales was 27 kg and the CL estimated to be 800 mm. These two values are inconsistent as a turtle this large would be expected to weigh a great deal more than 27 kg. The turtle was butchered and eaten in the village as no commercial market was available at that time.

Phoun Thong

Two older male (65 and 78 years-old) respondents reportedly encountered a large softshell turtle while fishing in the Ma River in late 1980s (ca. 1989). The two men were fishing in a boat and pulled up on a sandbank to inspect a fishing net. The man in the front of the boat stepped out and into shallow water and unknowingly placed one foot directly on top of a submerged turtle buried in the sand. The turtle burst forth from the sand and made for deeper water, upsetting the balance of the man who plunged into the water, almost capsizing the boat. The turtle surfaced after attaining deeper water. Both men saw the head which was said to be the size of a “man’s thigh”. This is perhaps the most credible report of *R. swinhoei* received during our survey.

Sop Mone

Group of six older adults (estimated age >50 years-old) recalled that as children, their parents frequently mentioned the occurrence of large softshell turtles in the Ma River. None of the group ever observed such turtles and assumed these were tales told to discourage children from playing in the river when unsupervised by adults.

Xieng Khoun

An older male (age = 51 years-old) reportedly encountered a large softshell turtle in the Ma River during the 1990s. The turtle was encountered in a deep pool near the village where the respondent was fishing. The head was visible from a distance when the turtle surfaced and said to be reddish with a diameter approximately the same as his forearm. The respondent estimated the body weight of the turtle at 30 kg. The shell was said to be the size of a rice threshing basket (about 700 mm in diameter).

The respondent believed only one turtle was present in the pool; this animal was shy, but many other people made similar observations. The turtle eventually disappeared.

the same area where we received potentially credible reports of *R. swinhoei* and suggests at least one large softshell turtle may yet survive in the Xam River. That said, methodological concerns over the use of photo arrays by Zuklin et al. (2020) have already been voiced (see above). Moreover, Zuklin et al. (2020) neglected to include any information concerning the estimated size (CL or body mass) of this turtle other than to use the relative terms “large” and “very large.” Because *P. steindachneri* can attain a CL of at least 450 mm (and possibly larger), informants would probably consider a turtle of this size “large” or “very large”, especially given the apparent rarity of softshell turtles near the asymptotic size limits in area rivers today. When we queried participants about “large” and “very large” softshell turtles, they frequently described encounters with turtles weighing 7-10 kg. Without additional corroborating information, we are unable to accept the account of Zuklin et al. (2020) as evidence for the continued persistence of *R. swinhoei* in the Xam River.

Although no recent, unequivocal evidence of *R. swinhoei* was forthcoming in our survey, we verified the occurrence of *Palea steindachneri* at two locations in Huaphanh Province, Laos. These include three *P. steindachneri* we examined in Mouang Hom, reportedly captured near the village. The first turtle was an extremely emaciated juvenile (CL = 110 mm; PL = 90 mm) caught in a basket trap set in the Ma River near the village in January or February 2022 (Figure 5). The relatively large, thickened tail suggested this turtle was a male. The turtle was being kept in a water-filled barrel and appeared near starvation with the ribs clearly visible beneath the skin of the carapace. Another individual in the village had two larger *P. steindachneri* (CL = 260 mm and 330 mm) in a concrete basin. Both turtles were said to have been captured after a nearby tributary of the Ma River was dammed to harvest fish. The person we interviewed claimed the two turtles were captured about eight years ago, although given the substandard sanitary conditions we consider this doubtful. More likely the turtles were being temporarily held pending sale to one of the many itinerant Vietnamese merchants that visit these villages to ply their wares and traffic in wildlife. Our fourth record of *P. steindachneri* originated at Sop Soy where the village pharmacist was keeping a small specimen as a pet (CL = 90 mm; PL = 71 mm). The relatively short, truncated tail suggested this turtle was a female (Figure 6). According to the pharmacist, the turtle was obtained about six months ago, after being captured by a hunter in a tributary stream that debouches into the Ma River across from the village. Our records compliment two previous reports of *P. steindachneri* from Oudomxai (Auer, 2011) and Huaphanh (Zuklin et al., 2020) provinces.

We received numerous accounts during our interviews of recent captures of softshell turtles in the Xam, Et, and Ma rivers as well as from associated tributary streams. Again determining what species of softshell turtle was being referenced during interviews was challenging owing to the under-differentiated folk taxonomy. However, based on the



Figure 5: Three *Palea steindachneri* found in Mouang Hom. The small turtle (above) was emaciated and near starvation. The two larger turtles (below) were being held awaiting sale to Vietnamese traffickers.



Figure 6: Two views of a small *Palea steindachneri* examined in Sop Soy. Note the prominent tubercles on the carapace of this turtle.

descriptions provided by interviewees, we concluded that most reports were referable to *P. steindachneri*. Furthermore, several participants described finding turtle nests that were likely those of *P. steindachneri*. In one case, the informant excavated the clutch, transferred the eggs to a secure sandbank, and later released the hatchlings. Such accounts are extremely valuable because virtually nothing is known about the reproductive biology of *P. steindachneri* in the wild (Le Duc et al., 2020). To briefly summarize these reports, nesting occurs during the dry season (participants gave March to May as the nesting season) with hatching at the beginning of the wet season (June). One interviewee reported encountering hatchlings in August and September, an observation consistent with dry season nesting. Nests are excavated on sandbanks a short distance from water, and usually found when interviewees followed the trackways left by the nesting females or noted disturbed sand, and in one case, eggshells left after predators excavated part of a clutch. Reported clutch size ranged from “about 10 eggs” to 39 eggs; the latter clutch was excavated in 2022, and transferred to a secure site with 15 (38.4%) of the eggs eventually hatching. Eggs were described as similar in size to domestic quail eggs or caps of 2-l plastic drink bottles. Local knowledge of nesting is in general agreement with observations of reproduction among captive *P. steindachneri* (Le Duc et al., 2020). With a single exception, those interviewees who found turtle eggs invariably cooked and ate them. No special medical properties or culinary value appears attached to turtle eggs.

Turtle harvesting

Interview participants described a variety of hunting methodologies employed to capture softshell turtles in northern Laos (Figure 7). Foremost is the use of multiple baited hooks suspended from long lines deployed in rivers and tributary streams. Another frequently mentioned method was using a slender pole – often tipped with a metal point – to probe sand substrates in shallow water where softshell turtles are often buried. When a turtle is detected, the pointed tip can be used as a harpoon to impale the turtle or the hunter can reach down and grab the turtle. The latter ploy is effective on smaller turtles, but larger individuals are difficult to restrain and therefore generally harpooned. Softshell turtles are often taken in baited and unbaited bamboo fish traps. These traps are cylindrical cages of varying diameter and length with a funnel built into one or both ends. Turtles and fish can readily enter the trap, but inward pointing, sharpened prongs prevent captured animals from exiting. Other bamboo fish traps are equipped with a sliding door that falls after the turtle takes the bait which is attached to a triggering mechanism. Triangular, hand-held nets woven onto a bamboo frame are widely employed to capture aquatic insects, small fish, and on occasion, softshell turtles. These “triangle nets” are held vertically in the water column, facing upstream, with one edge resting on the substrate. Fishers then move a short distance upstream, turn around, and move directly towards the net, making efforts to disturb the substrate as they walk. This disturbance flushes aquatic organisms from the substrate which swim into the net. Lastly, despite being strictly illegal, electro-fishing appears commonplace throughout the survey area. Although most interviewees declined to discuss electrofishing, one fisherman freely admitted to capturing a softshell turtle weighing about 2 kg when using electrofishing gear in 2022. The turtle was reportedly sold to Vietnamese traffickers. According to this



Figure 7: Triangle nets used to catch aquatic insects, fish, and on occasion small softshell turtles (above). Bamboo fish trap with sliding door (below). These traps are designed to capture large fish and softshell turtles.

informant, turtles are stunned and immobilized when shocked, facilitating capture. Shocking is said not to kill turtles, although a stunned and immobilized turtle would almost certainly drown.

Several important points concerning turtle harvesting emerged from our interviews. First, turtle harvesting (and fishing) is an overwhelmingly dry season pursuit. High river levels typical of the wet season destroy nets, traps, and other fishing gear, and boating on the river under flood conditions is hazardous. Second, turtle captures are now largely incidental to fishing activities; i.e., turtles are not being specifically targeted, but are instead captured in gear deployed to harvest fish. Indeed, according to several interviewees, softshell turtles are now so uncommon that specifically targeting turtles is not an economically viable harvesting strategy. Although estimating harvest rates is problematic without sustained monitoring, our interviews suggest 5-10 softshell turtles are opportunistically harvested by each village every year. Based on descriptions provided during our interviews, most of the harvested softshell turtles are probably *P. steindachneri*. Without exception, the consensus among survey participants was that softshell turtles are now much less common than in past years (10 to >20 years ago). This assessment is not unexpected given the suite of life history traits typical of turtles and other long-lived vertebrates that render populations extremely sensitive to harvest pressure (Congdon et al., 1993; Zimmer-Shaffer et al., 2014; Colteaux and Johnson, 2017), and suggests widespread, continuing declines among softshell turtles in our survey area.

Turtle trafficking

Some of the softshell turtles harvested by villagers are consumed locally, especially smaller turtles; however, our interviews suggest the vast majority of turtles are destined for wildlife markets in neighboring Vietnam. In the past, Vietnamese traffickers made regular visits to border villages specifically to purchase turtles and villagers often used the proceeds to make illicit purchases of opium. Now, with softshell turtles so rare, regular, scheduled visits in quest of turtles are unprofitable for traffickers. Instead, when turtles become available, these are sold to Vietnamese traders who regularly visit villages to ply a variety of cheap goods. The traders then move the contraband turtles across the international border and into Vietnam. Vietnamese traffickers are also said to have networks of agents within Laos, who notify them when a turtle becomes available for purchase. The agent then receives a small commission for locating the turtle. Information provided during our interviews suggests the Vietnamese shops present in many rural villages and larger towns in northern Laos function as local wildlife trafficking hubs. Vietnamese shopkeepers are said to purchase a variety of contraband wildlife, which in addition to turtles includes pangolins, civets, muntjac, and porcupines. Indeed, most of these mammals are now said to be locally rare or extirpated as a result of chronic commercial demand from Vietnam. Big-headed Turtles (*Platysternon megacephalum*) are in especially high demand and traffickers reportedly pay large sums for a single turtle. Prices quoted to us varied widely, ranging from 170-180,000 kip/kg to as high as 500,000 kip/kg for a living turtle (for comparison the accepted daily wage for an unskilled laborer is 100,000 kip; \$1US = 17,000 kip at the time of this writing). Big-headed Turtles occur

in upland hill streams in northern Laos and adjacent Vietnam (Iverson, 1992; TTWG, 2021). While we made few specific queries about Big-headed Turtles, participants occasionally mentioned capturing and selling this species. Moving turtles from Laos into Vietnam poses no special challenge to wildlife traffickers. The international border is porous and except at official border crossings, there are no inspections. Interviewees told us that traffickers routinely use unimproved trails through the forested hills to avoid border checkpoints when smuggling various forms of contraband, including wildlife. Contraband is either carried on foot or more typically, transported by motorcycle. During the recent COVID-19 pandemic, border control was tightened and according to several interviewees, these measures put a halt to trans-boundary wildlife trafficking. Travel restrictions were relaxed in mid-2022 and no longer hamper smuggling operations.

Conclusions

Our interview-based survey indicates that a species of large softshell turtle – most likely *Rafetus swinhoei* – formerly occurred in the Xam and Ma Rivers in Huaphanh Province of northern Laos. The most recent credible reports date to the 1990s and early 2000s (last reported in 2007), although the majority of encounters occurred prior to 1990. Without additional corroborating evidence, more recent reports (Zuklin et al., 2022) cannot be accepted as credible. Given the lack of recent reports, coupled with widespread and intense harvesting pressure, and easy access to larger rivers, we consider it near-certain that *R. swinhoei* has been extirpated in the Xam and Ma rivers within Laos. We attribute the extirpation of *R. swinhoei* in Laos to the chronic over-harvesting (both targeted and opportunistic) of turtles. Although we cannot rule out the possibility that one or two *R. swinhoei* survive in the Xam or Ma Rivers, the ability of a large softshell turtle to remain undetected in a landscape of high human occupancy is doubtful.

Our survey also documented the occurrence of *Palea steindachneri* (Critically Endangered) in the region, complementing a single earlier record from Huaphanh Province (Zuklin et al., 2022). Local ecological knowledge obtained during our interviews adds significantly to our understanding of the reproductive biology of *P. steindachneri*. Softshell turtles are subject to ongoing, intense harvesting pressure, largely as a result of opportunistic capture incidental to fishing. Without exception, those persons we interviewed stated that softshell turtles were significantly more abundant in the past, suggesting widespread population declines have occurred. Population declines of softshell turtles (and other wildlife) are being driven by unchecked, transboundary wildlife trafficking in which wildlife harvested in Laos is illegally smuggled into Vietnam.

Recommendations

The lack recent observations of large softshell turtles in the Xam, Ma, and Et rivers is alarming and strongly suggests *R. swinhoei* is no longer extant in these rivers. Nonetheless, given the parlous conservation status of *R. swinhoei* and the urgent need to locate additional individuals if *ex-situ* efforts are to have any hope of success, we consider it prudent to continue searching for this species in northern Laos. Because the



Figure 8: Locations of reservoirs and rivers in northern Laos where future investigations into the continued occurrence of *Rafetus swinhoei* are warranted. Map courtesy of R.J. Timmins.

occurrence of *R. swinhoei* is confirmed only from the Red River and tributary streams in northern Vietnam, future surveys should focus on rivers within this watershed, a number of which have been dammed as part of various hydroelectric schemes (Figure 8). Although reservoirs are considered suboptimal habitat, individual *R. swinhoei* are known to persist in impounded waters in both Vietnam and China (e.g., Kuchling et al., 2021; Platt et al., 2016).

Should a credible report of a surviving *R. swinhoei* be confirmed in Laos, no effort should be spared to bring this animal into captivity for use in an international captive-breeding program that incorporates turtles from all three range states (China, Vietnam, and Laos). While recognizing the dangers inherent in capturing wild animals, the consequences of doing nothing (near-certain extinction of *R. swinhoei*) far outweigh the risks involved in capturing the remaining wild turtles. As it currently stands, the few surviving wild *Rafetus swinhoei* are already "demographically dead" because opportunities for reproduction and continued population recruitment are non-existent. Rosenzweig (2003) described such species as "zombies", i.e., populations consisting of one or a few long-lived individuals ("the living dead") that are ultimately doomed to extinction because of continued lack of reproductive success.

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Appendix 1: Annotated expedition itinerary. Geographic coordinates for localities mentioned in itinerary provided in expedition gazetteer (Appendix 2).

- 19 March SGP travels from Vientiane to Phonsavan (0830–1600 hr).
- 20 March Visit Plain of Jars (Site 1) World Heritage Site on outskirts of Phonsavan (0845–1000 h). Leave POJ and drive to Headquarters of Nam Et Phou Louy National Park in Hiam District Capital (1000–1530 hr). Meet with Lao Government and WCS staff to discuss upcoming mission.
- 21 March Leave Hiam and drive to Sam Tai (0830–1630 hr). Very long drive over twisting and narrow mountain roads.
- 22 March Meet with Director at DAFO office. Conduct interviews at 7 villages along Nam Xam upstream from Som Tai (0830 – 1730 hr).
- 23 March Conduct interviews at five villages along Nam Xam downstream from Sam Tai (0830 – 1600 hr). Return to Som Tai and interview two persons living in town along the river.
- 24 March Travel from Sam Tai to Sob Bao (0900-1600 hr). Stop en route at Vieng Xay Cave Complex and tour the historical site.
- 25 March Conduct interviews at villages along the Ma River downstream from Sob Bao to Lao-Vietnam Border (0900-1700 hr). Inadvertently wandered into Vietnam while photographing the Ma River and briefly detained by Vietnamese Border Guards. Received first unequivocal report of *Rafetus swinhoei*; turtle taken in the 1980s.
- 26 March Conduct interviews at villages along the Ma River downstream from Sob Bao. A cooperative village headman guided us to the homes of two persons with *Palea steindachneri* in Mouang Hom. These persons allowed us to measure and photograph the turtles.
- 27 March Conduct interviews at Phieng Xay along the Ma River upstream from Sob Bao. Return to Sao Bao and conduct interviews before eating lunch. Travel to Xieng Kor in early afternoon (1200-1245 hr). Secure lodging and visit PAFO office to advise of our research. Reconnoiter town in late afternoon.
- 28 March Conduct interviews at villages along the Ma River, downstream from Xieng Kor. Received credible report from two “Old Timers” of a past encounter with *Rafetus swinhoei*. Examined and photographed a young *Palea steindachneri* collected from tributary stream on opposite bank of Ma River.

- 29 March Conduct interviews at villages along Ma River, downstream from Xieng Kor in the morning. After lunch, we conducted interviews at two villages upstream from town. Very little information on softshell turtles was forthcoming from any villages today.
- 30 March Initially we planned to transfer our base of operations from Xieng Kor to Muang Et. However, unable to secure lodging as the local guesthouses either had no vacancies or were operated by sex traffickers. Therefore we made arrangements to return to the guesthouse in Xieng Kor. After attending to this issue, we drove about 30 km along the Nam Et to Sop Vasek, arriving at 1200 h. We ate lunch and interviewed villagers. SGP was the first foreigner to visit the village. From Sop Veak, we returned along our earlier route, stopping at each village to conduct interviews.
- 31 March Conducted interviews at villages along the lower Et River beginning at An Mak Dam and continuing downstream. In mid-afternoon, we conducted interviews in villages along the Ma River, upstream from the confluence of the Et and Ma Rivers. We received a credible report of a very large softshell turtle from a respondent in Xieng Khoun. The encounter occurred during the 1990s.
- 1 April Travel from Xieng Kor to Sam Neua and secure lodging (0900-1230 hr). Our DAFO liaison officer unable to accompany us to conduct fieldwork in area villages today. Reconnoiter town on foot in late afternoon.
- 2 April Traveled from Sam Neua to Sop Kor over very rough roads. Conduct group interview of villagers, but gleaned little useful information. After lunch traveled a short distance to Phati Mountain and climbed steps to summit. Spent about two hours inspecting war debris at former radar station and firebase before climbing down the mountain and returning to Sam Neua. Haze resulting from region-wide burning was extreme by late afternoon.
- 3 April Visit market in Sam Neua and surreptitiously photograph wildlife being illegally offered for sale. Traveled from Sam Neua to Hiam (0930 to 1600 hr). Extremely hazy and air quality very poor owing to widespread burning by swidden agriculturalists.
- 4 April Travel from Hiem to Paksan (0930 to 1820 hr).
- 5 April Travel from Paksan to Vientiane; arrive 1200 h.
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Appendix 2: Expedition gazetteer: Geographic coordinates (latitude and longitude) and elevation (feet) of localities mentioned in the text. Place names in agreement with local usage; listed alphabetically in gazetteer. Geographic coordinates determined with Garmin GPS Map 24 (India-Bangladesh Datum).

Location	Latitude (N)	Longitude (E)	Elevation (feet)
Et River			
An Mak Dam	20.77381°	103.95441°	917
Boua Phou	20.79267°	103.99784°	915
Long Hoy	20.78228°	103.98177°	930
Meung Et	20.82166°	104.00712°	837
Na Poug	20.73408°	103.93684°	1043
Na San	20.69145°	103.93550°	1070
Nam Khan Nam Et	20.77895°	103.95264°	1040
Ne Meam	20.78089°	103.96246°	960
Pha Dang	20.67916°	103.91111°	1514
Sop Kor	20.48277°	103.67426°	1556
Sop Vasek	20.67299°	103.87908°	1127
Tham Song	20.74758°	103.95033°	958
Ma River			
Bia	20.88388°	103.97373°	1062
Had Sorn	20.66980°	104.39419°	774
Hao Sen	20.59307°	104.42759°	809
Hap	20.83948°	104.12737°	833
Meung Han	20.63684°	104.41677°	760

Mouang Hom	20.67817°	104.39176°	776
Na Kharm	20.75746°	104.25600°	900
Na Xane	20.58780°	104.43224°	730
Nan Ngoua	20.62600°	104.41677°	773
Phieng Nyan	20.76010°	104.20981°	786
Phieng Phuc	20.65378°	104.39634°	708
Phieng Xay	20.72237°	104.35337°	714
Phone Xay	20.54814°	104.46690°	643
Phoun Thong	20.76303°	104.22681°	814
Sae	20.84517°	104.09466°	868
Sob Bao	20.70625°	104.38437°	728
Songvang	20.53469°	104.48272°	680
Sop Hao	20.56090°	104.44776°	726
Sop Long	20.73238°	104.34220°	730
Sop Mone	20.77439°	104.17001°	840
Sop Quai	20.76016°	104.28474°	732
Sop San	20.84721°	104.08340°	844
Sop Say	20.74977°	104.32237°	801
Ta On	20.76388°	104.19020°	826
Vieng Hang	20.60900°	104.41855°	905
Xieng Khoun	20.87463°	103.97035°	954
Xieng Kor	20.80990°	104.14839°	810

Xam River

Dan Xay	20.15615°	104.54887°	1576
Mouang Kahn	20.07710°	104.44433°	1248
Mouang Phat	19.96725°	104.68160°	1033
Nak Keun	19.87983°	104.73553°	1099
Naxay	19.88173°	104.72346°	1002
Phieng Dai	20.03195°	104.57241°	1310
Phieng Hom	20.01591°	104.60679°	1220
Phieng Khoun	19.88910°	104.75127°	1157
Pheing Mai	20.08377°	104.56246°	1320
Som Tai	19.99924 °	104.64052°	1131
Sop Kem	20.04148°	104.56185°	1370
Tao	19.89421°	104.74113°	973

Appendix 3: Gender of survey participants interviewed in each village.

Village	Men	Women	Total
22 March 2023			
Dan Xay	1	0	1
Muang Khan	2	1	3
Peing Mai	1	0	1
Sop Kim	1	0	1
Phieng Dai	2	0	2
Phieng Ham	1	0	1
Hao Sen	4	1	5
23 March 2023			
Naxay	2	3	5
Nak Keun	3	0	3
Phieng Khoun	2	0	2
Tao	2	1	3
Maung Phet	4	0	4
25 March 2023			
Songvang	8	0	8
Phone Xay	9	2	11
Sop Hao	3	1	4
Hao Sen	3	0	3
Vieng Hang	2	0	2

26 March 2023

Na Xone	3	4	7
Nan Ngoua	8	0	8
Meung Han	2	11	13
Phieng Phuc	1	3	4
Had Sarn	5	0	5
Mouang Hom	7	0	7

27 March 2023

Phieng Xay	4	2	6
Sop Bao	6	2	8

28 March 2023

Na Kharm	2	0	2
Sop Quai	5	3	8
Sop Long	6	5	11
Sop Soy	2	1	3
Phoun Thang	5	0	5
Phieng Nyin	3	3	6

29 March 2023

Ta On	9	3	12
Sap Mone	6	2	8
Sop San	7	1	8
Sae	5	6	11
Hap	3	0	3

30 March 2023

Sop Viek	11	0	11
Pha Dang	5	0	5
Na Paung	4	4	8
Na San	3	0	3
Tham Song	4	0	4

31 March 2023

Nam Khan Nam Et	5	4	9
Na Meam	4	1	5
Long Hay	5	0	5
Boua Phou	1	0	1
Xieng Khan	1	2	3
Bia	3	0	3

2 April 2023

Sop Kor	5	1	6
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Total	186	65	251
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