

Two remnant populations of the roofed turtle *Kachuga trivittata* in the upper Ayeyarwady River system, Myanmar

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Abstract The endemic roofed turtle *Kachuga trivittata* has been extirpated over most of its former range in the Ayeyarwady River system of Myanmar. Only two small remnant populations are known to survive. In a small stretch of the upper Chindwin River *K. trivittata* persists because local Shan villages traditionally ban the killing of large adult *K. trivittata*. The population has nevertheless declined dramatically during the last few years because of the erosion of the ban by migrant fishermen from central Myanmar who do not observe the local regulation, and because of the overexploitation of eggs. The traditional regulation of the Shan villages offers a basis, through its reinforcement and education of migrants, for a species recovery programme. Further actions will include the protection of nests and eggs, and eventually the banning of camps and seasonal settlements on sandbanks used by *K. trivittata* for nesting. *K. trivittata* also

still persists in the Dokhtawady River in a small area subjected to low exploitation pressure in the recent past because of the dangers of a frontline between the government army and an army of insurgents. The opening of this area following a truce brought this population close to extinction and a hydroelectric dam under construction will alter the ecology of this stretch of river. We propose to assess the potential use of the future impoundment lake for the recovery of this *K. trivittata* population.

Keywords Conservation status, exploitation, *Kachuga trivittata*, Myanmar, natural resource management, Testudines.

This paper contains supplementary material that can only be found online at <http://journals.cambridge.org>

Introduction

The roofed turtle *Kachuga trivittata* is a large-bodied, aquatic river turtle endemic to Myanmar. It is known from the Ayeyarwady, Chindwin, Sittaung and lower Thanlwin rivers, where it was historically abundant (Theobald, 1868; Maxwell, 1911; Iverson, 1992). In the Ayeyarwady River it was once common from the river delta (Maxwell, 1911) to as far north as Bahmo in Kachin State (Smith, 1931). Morris (1936) collected several nesting females near Kaung hein village at the upper Chindwin River, the largest tributary of the

Ayeyarwady, in 1935. No further specimens were collected during the rest of the 20th century. Although it is categorized as Endangered on the IUCN Red List (IUCN, 2004), the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group & Asian Turtle Trade Working Group (2000) recommended that it should be categorized as Critically Endangered or even Extinct, considering that it had not been reliably recorded since 1935.

Recent surveys suggested that *K. trivittata* has been extirpated along the whole main channel of the Ayeyarwady River: in the delta (Thorbjarnarson *et al.*, 2000b), along the Ayeyarwady between Pyay (Prome) and Bahmo and in the lower Chindwin up to Monywa (Platt *et al.*, 2005) and in the upper Ayeyarwady River in the area of Myitkyina (Kuchling *et al.*, 2006). However, during surveys of the lower Dokhtawady River, a tributary of the Ayeyarwady, in 2001 Platt *et al.* (2005) obtained a large empty *K. trivittata* shell from a fisherman and suggested that a remnant population of *K. trivittata* may survive in the headwaters of the river. Two empty shells of juveniles were also collected in the lower Dokhtawady in 2002 and 2003 (Kuchling *et al.*, 2006). A preliminary survey of the upper Chindwin River, the largest tributary of the Ayeyarwady, between Homelin and Kaung hein village in 2002 suggested that *K. trivittata* has been extirpated down-river of Kaung hein, but may still persist in

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the Chindwin River from Kaung hein up-river to Khamti (Kuchling *et al.*, 2006).

In this paper we present results of surveys along the upper Chindwin and Dokhtawady rivers in early 2004 to evaluate the species' habitat and population status, survival prospects, and any threats. We address three main questions. Firstly, which special conditions of the upper Chindwin and the Dokhtawady rivers allow these remnant *K. trivittata* populations to persist, given the extirpation of the species in other areas? Secondly, is there a threat that the same processes that extirpated the species in its former core habitats and throughout most of its range will in the future also affect these relict populations? Thirdly, what are the most appropriate conservation and recovery strategies for these populations and for the species?

Study areas

The Chindwin River arises in extreme north-western Myanmar and flows 800 km south before joining the Ayeyarwady River. Our study area is down-river of Khamti on the upper Chindwin (Fig. 1), a wide, meandering lowland river with a sandy bed, flood plains and exposed sand banks in the river bed during the dry season. Two main groups of fishermen operate on the upper Chindwin. Local Shan farmers, who mostly fish part-time, and full-time professional fishermen, primarily from central Myanmar, who have moved to the upper Chindwin in the last few years or decades. Fishermen typically live in temporary houses on the sandbanks of the river during the dry season (October–June). During the wet season, when the sandbanks are flooded,

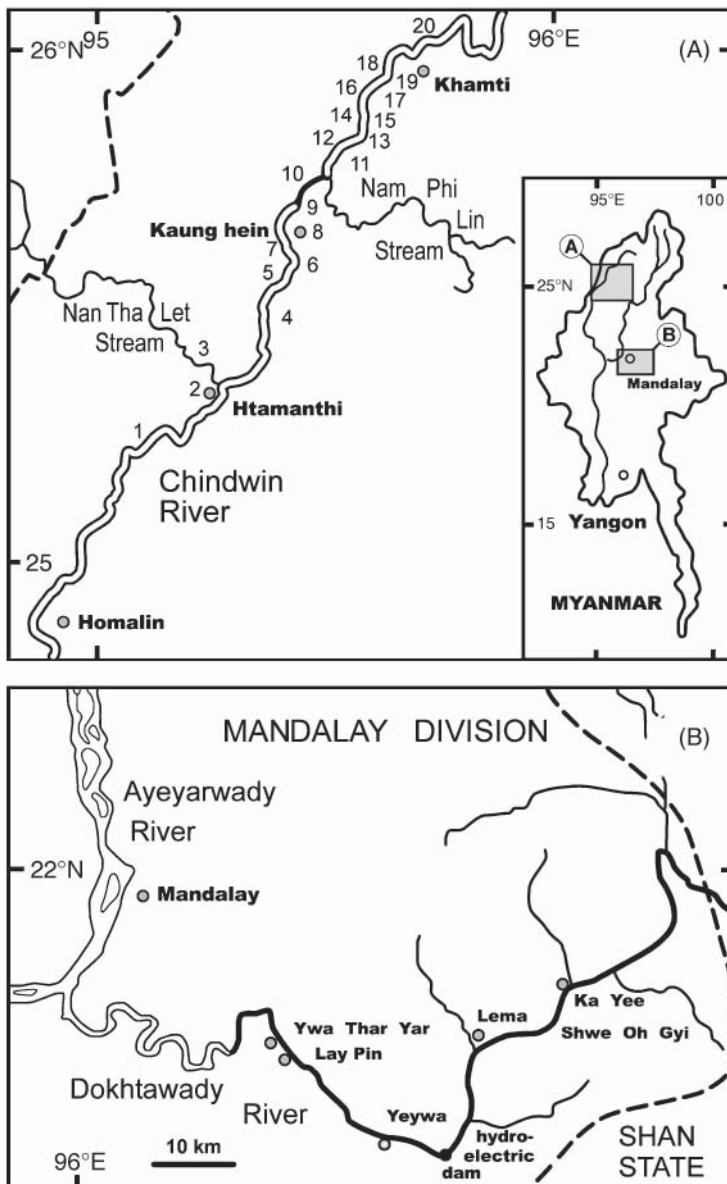


Fig. 1 (A) Map of the study area along the upper Chindwin River. The localities of interviews are indicated by numbers corresponding to those in Table 1. (B) Map of the study area along the lower Dokhtawady River, showing the localities mentioned in the text and in Table 4. The inset indicates the locations of the two main maps in Myanmar.

they either stay in adjacent villages or move to their native towns and villages in central Myanmar.

The Dokhtawady (also known as the Myitnge or Namtu) River is an important tributary of the Ayeyarwady arising in the Shan Plateau in Shan State. Approximately 150 km up-river from its confluence with the Ayeyarwady it enters the Mandalay Division (Fig. 1). Our study area was at the western edge of the Shan Plateau, on the lower Dokhtawady, where the river flows generally westwards. In the up-river part of the study area the water rushes through several rapids and riffle zones in a valley surrounded by steep hills. The river bed consists mostly of gravel and boulders, interspersed with some long, deep pools with some sandbanks. In the lower part of the study area the river is a meandering lowland river with flood plains, which are used for agriculture. A hydroelectric dam is currently under construction (Fig. 1) near the centre of our study area. It is projected to inundate *c.* 30 km of river valley and will create an impoundment of *c.* 23,886 ha.

The lower section of the Dokhtawady in Shan State is controlled by the Shan United Army. Until a few years ago this region and the adjacent border area of Mandalay Division was subject to insurgency, was off limits to foreigners and Burmese from central Myanmar, and had a low human population. After a cease-fire between the Myanmar government and the Shan army the area was opened and large-scale movement of Burmese from central Myanmar took place along the Dokhtawady. All the fishermen we interviewed were not native to the area; most had moved from villages in central Myanmar within the last few years. Nearly all used electro-fishing equipment to catch fish and softshell turtles. One of our informants had made his living as a professional turtle hunter for the last 30 years, catching turtles mainly with baited traps.

Materials and methods

Along the upper Chindwin River between Yat Nar village and Kin Taw village we conducted 30 interviews with fishermen and villagers regarding the local occurrence of turtles and exploitation patterns and methods from 27 January to 7 February 2004, and 11 interviews at the Dokhtawady River between Ye Ywa village and a camp up-river of Ka Yee over 12–24 February 2004. Interviews lasted 1–2 hours. A set of standard questions (Appendix) was asked by the senior author and translated by the co-authors, who translated all answers. The sequence of the questions was flexible and depended upon the progress of the conversation. We were particular about species identification and enquired carefully about sizes, appearance and habits. Black and white photographs of the different turtle species and empty shells of *K. trivittata* were used to seek confirmation

of identification. Turtle shells in the possession of informants were measured and, if possible, acquired for a reference collection. In the Dokhtawady River we also dived with mask and snorkel and by using locally built underwater breathing equipment to assess the habitat.

Results

Upper Chindwin River

In a 50 km stretch of the upper Chindwin fishermen reported that they had caught or at least seen live, large *K. trivittata* and collected their eggs during 2003 (Table 1). Fishermen in villages and on sandbanks down-river and up-river of this area also knew the species, but had not caught or observed any for several years. The data in Table 1 do not include juvenile *K. trivittata* smaller than *c.* 30 cm carapace length, mainly because of the potential confusion of small *K. trivittata* with other hard-shelled turtle species (e.g. *Cyclemys dentata*). Some fishermen also claimed they have never seen the young of *K. trivittata* and obviously considered the juveniles to be a different species.

Most Shan villages in the area where *K. trivittata* persists implement a traditional ban on the killing of *K. trivittata* (Table 1). This ban is a long-standing tradition, in existence because *K. trivittata* is of no danger to humans, its flesh is unappealing to smell and taste according to our Shan informants, and its eggs are delicious and thus valuable. Hence, rather than killing turtles it makes more sense to release all accidentally captured individuals to ensure future egg harvests. People who kill *K. trivittata* are fined by the headmen. However, in practice Shan villagers cannot control fishermen of other ethnicities who often live on sandbanks away from the villages and usually kill, eat (despite its unappealing smell and taste) or sell this species.

Table 2 shows the specimens of *K. trivittata* we examined and/or collected in the upper Chindwin. All informants claimed that the species and its eggs are declining (Table 3). Older fishermen reported that 30 years ago many females nested on certain sandbanks over several nights, but did not recall any mass-nesting events. All informants reported that the eggs of each *K. trivittata* female are not laid in one nest hole, but situated in seven holes close together in the pattern of a star sign. Some said that early in the nesting season females may lay eggs in only three or four holes. The nesting season of *K. trivittata* was reported to last from December/January to March (i.e. the cool part of the dry season).

Dokhtawady River

We examined seven specimens of *K. trivittata* captured in the Dokhtawady between Ywa Thar Yar village and Pan

Table 1 Interview results regarding occurrence of *K. trivittata* and of *K. trivittata* eggs in villages and camps (numbers refer to locations in Fig. 1) along the upper Chindwin River in 2003.

Village/Camp	Latitude (N)	Longitude (E)	No. seen ¹	Eggs ²	Ban on killing	Last seen
1 Painneikhone ³	25°12.91'	95°05.56'			No	c. 1994
2 Htamanthi ³	25°19.62'	95°17.40'			No	c. 1992
3 Sar Mi ^{4,5}	25°22.54'	95°16.25'			No	1998
4 Malin ³	25°29.52'	95°22.91'			No	c. 1989
5 Nauk pe	25°32.26'	95°24.30'			No	c. 1989
6 Yat Nar Sandbank ⁵	25°36.78'	95°26.70'			No	
7 Na Maine Taung ⁵	25°38.19'	95°25.71'	4	30	No	
8 Kaung hein ⁵	25°40.45'	95°24.92'	5		Yes	
9 Kauak Taung ^{5,6}	25°43.78'	95°26.87'	10	300	No	
10 Sandbank ⁵	25°47.03'	95°31.50'	10	65	Yes	
11 Lin Pha ⁵	25°48.28'	95°31.71'	10	100	Yes	
12 Sandbank ⁶	25°49.31'	95°32.77'	3		No	
13 Mine Naung ⁵	25°50.92'	95°35.43'	3–4	65	Yes	
14 Sandbank ⁶	25°52.07'	95°34.97'		45	No	2001
15 Hein Soon ^{5,6}	25°52.75'	95°34.87'	9	55	Yes/No	
16 Sein Nan ^{5,6}	25°56.56'	95°36.09'	10	70	No	
17 Sandbank ⁵	25°57.00'	95°37.49'		48	No	c. 1995
18 Nan Khan ⁶	25°57.64'	95°39.09'			No	2000
19 Aung Tha ^{5,6}	26°00.79'	95°39.69'			Yes	2000
20 Kin Taw ⁶	25°59.48'	95°42.22'			No	Never

¹Number of large (>300 mm carapace length) *K. trivittata* seen or caught during 2003

²Number of *K. trivittata* eggs collected during 2003

³Results from interviews in July 2002 by GK and SAM

⁴Sar Mi village is at the Nan Tha Let Stream, a tributary of the Chindwin

⁵Local Shan tribe

⁶Migrants from the dry zone of central Myanmar

Table 2 Examined specimens of *K. trivittata* from the upper Chindwin River, with carapace length (CL), capture locality, year caught and specimen details. For latitudes and longitudes of capture localities see Table 1.

ID	CL (mm)	Capture locality	Year caught	Details
9 ¹	501	18 Nam Khan	2000	Bony shell
10 ¹	508	16 Sein Nan	2001	Shell + scutes
11	502	9 Kauak Taung	c. 1994	Bony carapace
12	512	? (Bought at Khamti)	1999	Bony shell
13 ¹	515	3 Sar Mi (Nan Tha Let Stream)	1998	Bony shell
15 ^{2,3}	305	? (Confiscated from trader at Po Aung)	2004	Live male
16 ^{2,3}	510	? (Confiscated from trader at Po Aung)	2004	Live female

¹Acquired for reference collection

²Specimens provided by U Myint Aung, Park Warden, Forestry Department Office, Homelin

³Transferred to captive breeding colony at Yadanabon Zoo

Table 3 Examples of decline of *K. trivittata* and their eggs along the upper Chindwin River, estimated by local people.

	2003	5 years ago	10 years ago	30 years ago
No. of adult <i>K. trivittata</i> observed at Hein Soon	9		45	
No of <i>K. trivittata</i> eggs collected, Hein Soon	55		550	
No. of adult <i>K. trivittata</i> observed between Kauak Taung & Lin Pha	50		200	1,000
No. of <i>K. trivittata</i> eggs collected, Lin Pha	100	300	1,000	

Pu Chaung (c. 71 km; Fig. 1; Table 4). Three of the fishermen we interviewed reported that they had each caught a large (>40 cm carapace length) *K. trivittata* during 2001 at or near the Shwe Oh Gyi sandbank but had not seen a large turtle since. Many informants believed juveniles were a different species. Although many informants indicated they eat adult and juvenile *K. trivittata*, most do not collect eggs and are not aware of nest sites.

Two professional divers who recover teak logs lost in the river reported they occasionally see *K. trivittata* (approximately two times per year) during their dives. Large adults are mainly caught or observed close to

Table 4 Specimens of *K. trivittata* collected at the Dokhtawady River since 2001, with sex, carapace length (CL), locality, year caught and specimen details.

ID	Sex	CL (mm)	Capture locality	Latitude (N)	Longitude (E)	Year caught	Details
1 ¹	Female	473	Shwe Oh Gyi ²	21°49.05'	96°35.59'	2001	Shell with scutes
2 ³	Juv.	232	Ywa Thar Yar	21°48.58'	96°15.50'	2002	Carapace + scutes
7 ⁴	Male	292	Ka Yee	21°52.00'	96°37.23'	Jan. 2003	Shell with scutes
8 ^{4,5}	Juv.	198	Lay Pin	21°47.11'	96°16.29'	Oct. 2003	Live juv. male
14 ⁴	Juv.	c. 257	Lay Pin	21°47.11'	96°16.29'	Oct. 2003	Shell remains, skull
18 ^{4,5}	Juv.	120	Pan Pu Chaung	21°52.86'	96°41'01'	May 2004	Live juv. female
19 ^{4,5}	Juv.	236	Lay Pin	21°47.11'	96°16.29'	Sep. 2004	Live juv. male

¹Specimen collected by Platt *et al.* (2005)

²According to interview in present study

³Specimen referred to in Kuchling *et al.* (2006)

⁴Specimens collected by Thin Thin Khaing (1) & Ni Ni Win

⁵Transferred to captive breeding colony at Yadanabon Zoo

sandbanks in deep river pools or holes, called *ei*, where the water flows relatively slowly. We hired the divers and dived with them at river pools at the Shwe Oh Gyi sandbank, but did not see any turtles. Many pools are deeper than 15 m, and in many places we could not reach the bottom; thus, turtles may have been present but undetected in the deeper areas of the pools.

Discussion

K. trivittata was once common and occurred in high numbers throughout the Ayeyarwady River system, with the exception of its mountainous headwaters, but today only a few small remnant populations survive in marginal habitat close to the boundaries of the species' former distribution. The major threat to the persistence of *K. trivittata* is the over-harvesting of adult turtles and their eggs for human consumption (Thorbjarnarson *et al.*, 2000b; Platt *et al.*, 2005; Kuchling *et al.*, 2006). Most *K. trivittata* and/or their eggs are consumed locally in the villages or sold at markets in nearby towns. International trade seems to play only a minor role in the disappearance of *K. trivittata*. Despite the massive illegal trade of turtles from Myanmar into China (Platt *et al.*, 2000), relatively few *K. trivittata* have been recorded in Chinese markets. The monetary value of *K. trivittata* (as opposed to softshell turtles) is generally too low to make it worthwhile to sell the species to traders.

River turtles at relatively low densities are difficult to locate. In such cases interviewing local fishermen, turtle hunters and divers is a suitable method to gain information (Kuchling, 1997; Kuchling *et al.*, 2006). A rigorous and structured interview technique is imperative if the objective is to use the results for conservation planning. For example, Platt (2001) collected a single shell of an adult *K. trivittata* from a fisherman at Ye Ywa village (Table 4) and reported that this turtle was captured 'from a sandbar at the headwaters of the Dokhtawady near

the Chinese border'. This information was surprising because the small, fast flowing mountain creeks and streams there do not appear to be *K. trivittata* habitat. Using our questionnaire we re-interviewed the fisherman (U Htoo) who had originally captured this specimen and learned that he had actually captured it at the Shwe Oh Gyi sandbank (Table 4), c. 250 km from the closest Chinese border. This profound discrepancy demonstrates the potentially low reliability of informal interviews. Although it is difficult to determine the accuracy of our interviews, consistencies of information from separate interviews, as well as the specimens we examined, support the reliability of our interview results.

The upper Chindwin is not a pristine habitat. It has a relatively dense human population and has been degraded by gold mining, deforestation, agriculture, overfishing and siltation. For this reason Platt *et al.* (2005) asserted that the upper Chindwin is 'unlikely to support significant numbers of *K. trivittata*'. Our data indicate, however, that although the species has been extirpated (apart from occasional dispersing juveniles) throughout most of the Chindwin, a breeding population of *K. trivittata* persists in a stretch of c. 50 km but at a reduced density. This is the largest population presently known and seems to persist because of the traditional ban on the killing of adult *K. trivittata* in Shan villages.

Most turtles, including *K. trivittata*, have delayed sexual maturity, high longevity, iteroparity, and high adult survivorship, combined with relatively high clutch sizes and low egg and hatchling survival (Kuchling, 1999). Harvesting systems based on the collection of eggs are thus less likely to have negative impacts than those based on killing adults and large juveniles (Thorbjarnarson *et al.*, 2000a). Although the traditional custom of the Shan villages not to kill large adults is not sufficient to make the exploitation of the species sustainable, it has allowed the species to persist. This offers a chance to support Shan villages to improve their

traditional natural resource management and to coerce immigrant fishermen to observe the local regulations, thereby promoting the recovery of *K. trivittata*.

K. trivittata has persisted in the Dokhtawady for different reasons. No Shan fishermen operate along the surveyed river stretch and no traditional regulations exist regarding turtle exploitation. A breeding population persists, or at least persisted until recently, in the border area between the Mandalay Division and Shan State. Until c. 3 years ago there was only limited exploitation in the area up-river of Salin village and the hydroelectric dam under construction, because of the dangers associated with the frontline between the government army and a powerful army of insurgents. The main threat to the remnant *K. trivittata* population in the Dokhtawady now comes from the massive influx of people from central Myanmar into the area following the truce between the government and the Shan army. The entire area we surveyed has been heavily deforested in the past 3 years and fish, prawns and softshell turtles have been largely removed from the river through electro-fishing. Commercial electro-fishing is generally illegal in Myanmar, but this law is not enforced on the Dokhtawady.

Exploitation and extirpation patterns of the river turtle *Erymnochelys madagascariensis* showed that, in habitats where fishing pressure suddenly increases because of an influx of people with better fishing technologies, adults are the first cohort to be extirpated. Although no further recruitment of hatchlings takes place after this event, turtles are still caught for several years because small size classes from previous reproductive seasons are still growing to a size at which they become attractive for human consumption. Once all these growing turtles have also been removed, extinction is abrupt (Kuchling, 1997). This scenario currently seems to operate in the Dokhtawady. Although we did not obtain reports that large adult *K. trivittata* have been caught or observed during the last 3 years, juveniles were still being caught.

The status of *K. trivittata* is the most precarious of all the endemic turtles in Myanmar. The traditional regulation regarding *K. trivittata* along the upper Chindwin provides a unique opportunity for the implementation of a comprehensive species recovery programme (Kuchling, 2003, 2004). Proposed conservation actions include: (1) reinforcement of the traditional ban on killing adult *K. trivittata*; (2) education of migrants to observe this traditional regulation; (3) assessment of status and reproductive output of *K. trivittata* (and of the other large, endemic river turtles *Chitra vandijki* and *Nilssonina formosa*) through a nest, egg and hatchling monitoring programme that will include direct remuneration of local people for their help in finding nests; (4) the protection of nests and eggs, and headstarting of wild hatchlings at Yadanabon Zoo; (5) the banning of camps and seasonal settlements on sandbanks used by

K. trivittata for nesting. In the Dokhtawady *K. trivittata* seems to be close to extirpation and in a few years the hydroelectric dam will greatly alter the ecology of this stretch of river. The impoundment lake will stretch up-river to approximately the area of the Shwe Oh Gyi sandbank that seems to be the primary remaining breeding area of *K. trivittata* in the Dokhtawady. The large turtles generally prefer deep, slow-flowing river sections. Thus the impoundment itself may not be catastrophic for the species, particularly if some nesting sandbanks remain up-river of the future lake and if human disturbance of *K. trivittata* in the area can be prevented or minimized. An education programme for local people will highlight the benefits of turtle conservation. Research on movement and dispersal patterns of *K. trivittata* prior to the impoundment will be the basis for management recommendations regarding the use of the future impoundment in the recovery of this *K. trivittata* population (Kuchling, 2004). Recovery will be achieved by reintroducing turtles bred at Yadanabon Zoo (Kuchling, 2003).

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Appendix

The appendix for this article is available online at <http://journals.cambridge.org>

Biographical sketches

Gerald Kuchling is Principal Investigator of the Western Swamp Turtle *Pseudemydura umbrina* Recovery Team in Western Australia. He planned, designed and implemented a conservation programme for the critically endangered river turtle *Erymnochelys madagascariensis* and collaborates on tortoise and turtle research in Madagascar, South Africa and Malaysia.

Win Ko Ko is Myanmar's foremost turtle and crocodile surveyor and specialist and leads the WCS Myanmar Turtle Program Team.

Sein Aung Min is wildlife manager and park warden at Mount Kyauktiyo. He has extensive experience in wildlife surveys and monitoring and was a partner in the 2002 survey that rediscovered *Kachuga trivittata*.

Zoo veterinarian Tint Lwin specializes in the captive breeding of tortoises and turtles, in particular the critically endangered Myanmar endemics *Geochelone platynota* and *Kachuga trivittata*.

Khin Myo Myo has research experience with sea turtles and crocodiles. She is now a staff member of the Chindwin River Project and leads a Village Awareness Program to encourage local participation in turtle conservation.

Thin Thin Khaing (1), Thin Thin Khaing (2), Win Win Mar and Ni Ni Win are carrying out research on the ecology of Myanmar's endemic river turtles.